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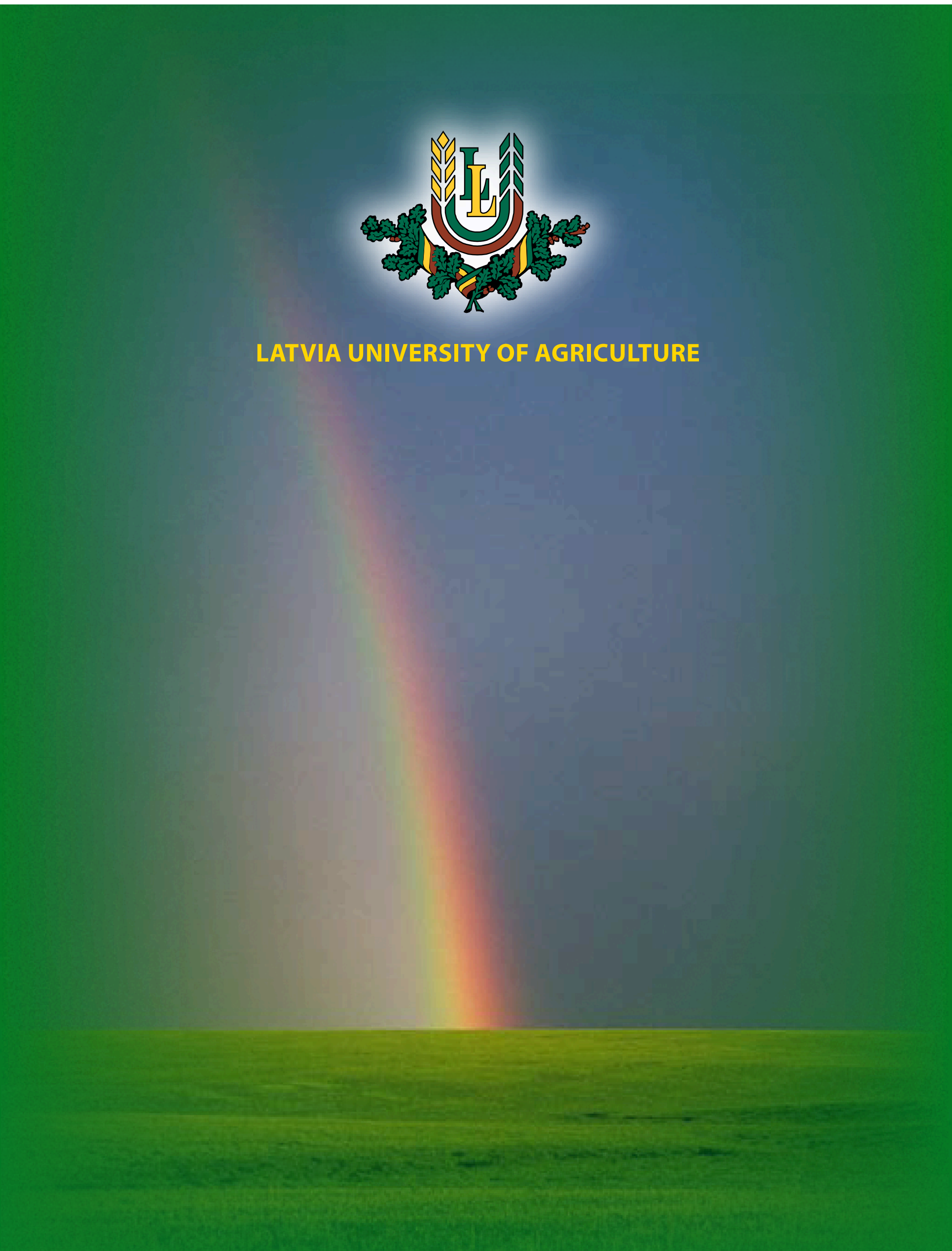

LATVIA UNIVERSITY OF AGRICULTURE

RESEARCH FOR RURAL DEVELOPMENT 2009

Annual 15th International Scientific Conference Proceedings

JELGAVA 2009

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EDITORIAL

With this issue of 2009, we bring 52 proceedings of the 98, which started life as presentations at the Annual 15th International Scientific Conference "Research for Rural Development 2008" held at the Latvia University of Agriculture, in Jelgava, on 20 to 22 May 2009.

In the retrospect of four months later, we can count the Conference as a great success. The theme – Research for Rural Development - attracted participation of 321 researchers with very different backgrounds. There were 4 presentations from Ukraine 3 from Sweden, 2 from Belarus, 3 from Estonia, 1 from Belgium, 1 from India, 1 from Turkey, 10 from Lithuania and 64 from Latvia.

Four independent reviewers estimated each report.

The proceedings of the Annual 15th International Scientific Conference "Research for Rural Development 2009" is intended for academics, students and professionals researching in the area of crop production, animal breeding, agricultural engineering, agrarian and regional economics, food sciences, veterinary medicine, forestry, wood processing, water management.

The proceedings will also be useful for researchers in educational sciences.

CHARACTERISTIC OF GRAIN PHYSICAL TRAITS OF SPRING BARLEY

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Abstract

The objective of this study was to examine the range of variation and correlation relationships of some grain physical traits of different barley types. Field experiments were carried out at the State Stende Cereal Breeding Institute from 2004 to 2006. Grain samples of 52 spring barley (*Hordeum vulgare* L.) genotypes were analysed for 1000 grain weight, test weight, relative hardness index and hull content. The mean value of 1000 grain weight and test weight for two-row barley was significantly higher than for six-row barley. Test weight for hulless barley was significantly higher than for covered ones (mean values - 774.6 g l^{-1} and 669.8 g l^{-1} respectively). The hull content was higher for six-row barley type (10.4%) than for two-row (8.6%) barley. There was not significant difference in relative hardness index between different types of barley. The coefficient of variation for grain hardness ranged from 13.7% for six-row barley to 18.7% for hulless barley. Among varieties bred in Latvia relative hardness index ranged from 47.1 for two-row variety 'Sencis' to 80.4 for only six-row variety 'Druvis'. Significant ($p<0.05$) positive correlation was detected between grain hardness index and β-glucans for covered two-row head types of barley ($r_{2\text{-row, covered}}=0.418>r_{25;\,0.05}=0.396$).

Key words: barley genotypes, 1000 grain weight, test weight, grain hardness, hull content, variation.

Introduction

Barley is the primary livestock feed grain in the areas where it is grown. The nutrient composition of barley is variable. This variation may be caused by geographic location, year of production and variety. Grain quality is important consideration in all cereal crop improvement. Breeders must use the available genetic variability in the development of new varieties. Barley quality complex consists of wide range physical and chemical criteria.

Barley is one of only four commercial cereal species that retain a hull after harvest. The hull amount is approximately 13% of grain weight, but can range between 7 to 25% depending upon type, growing environment and grain size (Evers et al., 1999). The hull plays an important role before and after harvest. During the later stages of grain ripening, the hull has been considered to have a role in grain dormancy and therefore preharvest sprouting resistance (Benech-Arnold et al., 1999). During harvest, the hull acts to protect the germ during the abrasive threshing process in the harvester. Post harvest, the hull plays a role in processing for the malting, brewing and feed industries. The intensive livestock industry also benefits from using a hulled barley grain. The hull aids in holding crushed or pressed grains together. A thinner hull is desirable, as thicker hulls will result in higher levels of deleterious compounds, in particular lignin (Fox et al., 2006b), which have been shown to have a negative impact on feed performance in livestocks (Kaiser, 1999).

Kernel size and shape contain information relevant to the end use quality characteristics of cereals in general. The grain weight of barley, usually expressed as 1000 grain weight, is one of the most important yield components. It is influenced by both genetic and environmental factors (Fox et al., 2006a). Most two-row varieties have larger grain than six-row varieties (Fregeau-Reid et al., 2001). Grain weight is the latest yield component of barley that compensates for earlier stresses when favourable conditions prevail during the grain filling period (Evers and Millar, 2002).

Test weight is actually a measure of the density of weight per unit of volume of a grain. Test weight is important because of direct relationship this factor has between energy content and feeding value of grain. Grains of high test weight have a high percentage of large, plump grains. Plumper barley is generally higher in starch and with a lesser proportion of hull and concequently lower in fiber. The higher test weights had higher feeding value than lower test weight grains due to higher starch content in the grain (Chirstison and Bell, 1975). The seed coat of hulless barley is loosely attached and easily removed during harvesting, resulting in the feed grain with a test weight and physical appearance similar to wheat (Evers et al., 1999).

Barley varieties differ in traits related to grain texture (Beecher et al., 2002). Grain hardness is a product of the complex interaction between compositional and structural endosperm components, including starch, protein and β-glucan (Fox, 2003). Hardness may contribute significantly to barley quality. Malting barley varieties generally are classified as soft grain whereas non-malting or feed varieties were classified as hard grain (Alison et al., 1976). J. Bowman et al. (2001) demonstrated that the higher kernel hardness and slower dry matter digestibility is associated with higher feed quality. This research described that the grain hardness variation exists among barley genotypes. Therefore substantial advances in the selection for both malting and feed quality could partially depend on the grain textural differences inherent in the barley grain. According to B. Osborne et al. (2005) results the hardness index was shown to be influenced by genetic and environmental effect. Depending upon the method used differing techniques to measure of barley grain hardness. These methods are particle size method, milling energy and Single Kernel Characterisation System (SKCS) (Fox et al., 2003). SKCS was developed to determine wheat hardness. B. Osborne et al., (2005) demonstrated application of this method in the measurement of barley grain hardness. This instrument enables measurements of the mechanical properties of the botanical layers of grain (Osborne et al., 2007).

As the evaluation of barley quality is usually expensive and time consuming process the needs for screening methods in barley breeding in order to facilitate higher sample throughput. The rapid analytical methods for grain quality analysis also for feed grain analysis should reflect both the composition and nutritional value of the grain. Physical measurements can be advantageous commercially because they are usually more rapid and less expensive than chemical assays. Therefore the evaluation methods of the grain physical traits could be used as potential early screening tools in barley breeding also for characterisation of grain nutritional quality.

The objective of this study was to establish the variation of some grain physical traits (1000 grain weight, test weight, grain hardness, hull content) of different types of spring barley selected on the basis of their different characteristics – two-row and six-row, covered and hulless types. The correlation relationships between grain hardness and other grain quality traits will be found.

Materials and Methods

There were chosen 52 barley genotypes that represented a broad range of germplasm (two-row, six-row, covered, and hulless) of different origin (Table 1). Thirty-eight genotypes of covered spring barley, from which 27 with two-row and 10 with six-row ear types, and 15 hulless genotypes were used in this study. Only two-row hulless genotypes were included in this investigation.

Table 1

Spring barley genotypes used in the study

Barley type	n	Genotype, origin country
Two-row, covered	27	Ansis, Abava, Sencis, Kristaps, Rasa, Linga, Idumeja, Balga, Ruja, Gate, Malva, Klinta (Latvia); Hanka, Annabell, Danuta, Justina, Polygena (Germany); Austrian early, Landsorte Aus Tirol (Austria); Primus II (Sweden); Lysimax (Denmark); Hatvani 45/25 (Hungary); Cork, Century (Great Britain); Lechtaler (Portugal); Grimmet (Australia); 379 (Chile)
Six-row, covered	10	Druvis (Latvia); Colsess IV, July (Denmark); B90A, RNB-367 (Nepal); Zoapila, Puebla (Mexico); IV/192 (Macedonia); Valluno (Bolivia); Chosen (North Korea)
Two-row, hulless	15	L 302 (Latvia); KM 2084 (the Czech Republic); SW 1291 (Sweden); McGwire, Gainer, Candle (Canada); X-4 (Lithuania); 10250 (Russia); Orzo Nudo di Altamura (Italy); 2474, Clho 7799 (Guatemala); C.P.I. 22817 (Russia); Sumire Mochi (Japan), Merlin, Wanubet (USA)

The genotypes were grown at the State Stende Cereal Breeding Institute from 2004 to 2006. The soil at the site was sod-podzolic sandy loam, humus content – 12-15 mg kg^{-1}, soil pH – 6.0-6.7, precrop – potato, available for plants P – 88-94 mg kg^{-1}, and K – 103-122 mg kg^{-1}. Plot size was 2 m^2, 2 replicates, seed rate - 400 germinable seeds per m^2. The plots were fertilized with N60 P15 K40 kg ha^{-1}.

1000 grain weight (TGW) (LV ST ZM 43-95) and test weight (TW) (LVS ISO 7971-2) were analyzed. Crude protein (CP) content (N x 6.25) was determined by Kjeldahl method (LVS 277), starch content (ST) (ISO 10520). Content of β-glucans (BG) was analyzed enzymatically following the barley grains procedures of the commercial kits from *Megazyme* (Megazyme International Ireland Ltd.) (McCleary and Glennie-Holmes, 1985).

For hull content (HC) determination duplicate sample of 50 grains from each variety was weighted. The sample was diped into 10 ml of 3% solution of sodium hydroxide (NaOH) and kept at room temperature for 1 h and 15 min. Then the samples were washed in cold water and hulls removed by tweezers. The removed hulls were dried for

1 h at 130 °C. The dried hulls were then weighted and the difference in weight from initial and final weights was calculated taking into account that due to interraction with sodium hydroxide solution hulls lost 1/12 part of weight.

A Single Kernel Characterisation System (SKCS) 4100 (Perten instrument, USA) was used for assesment of barley single kernel hardness. Kernel hardness were recorded as the average of 300 grains. Since no apparent hardness standard has been established for barley, the hardness is reported as a relative hardness indekss (RHI). For this hardness method, the hardness range from soft to hard corresponds with low to high values. Samples with RHI<30 are characterized as soft, 30<RHI<60 as semi-soft, and samples with RHI>60 as hard (Nielsen, 2003).

ANOVA procedures were used for statistical data analysis. Significance level was determined at $p<0.05$ between groups of two-row and six-row, two-row covered and two-row hulless genotypes. The value of genotypic variability for traits was determined and expressed by coefficient of variation of traits. Pearson correlation coefficients between two year phenotypic means were calculated. Correlation coefficients for variables of different barley head types were labeled as follows - for covered - $r_{2\text{-row, C}}$, $r_{6\text{-row, C}}$, for hulless - $r_{2\text{-row, H}}$.

Results and Discussions

The genotypic variability of spring barley grain physical traits depends from both the barley type and evaluated trait. The coefficient of variation of traits was from 2.0 to 18.9% (Table 2).

1000 grain weight for two-row barley ranged from 39.6 g to 50.0 g with the mean value of 45.7 g. This value was significantly higher than for six-row barley (40.2 g). For six-row barley it ranged from 29.6 g to 44.1 g. The significant difference was not found between covered and hulless barley in average 1000 grain weight.

In this study there were found significant differences between all types of barley in average test weight. Test weight was significantly higher for two-row barley genotypes than for six-row head type barley genotypes. The mean value for two-row barley was 682.4 g l^{-1} (min value – 635.7 g l^{-1}, max value – 712.2 g l^{-1}), but for six-row 635.8 g l^{-1} (min value – 601.8 g l^{-1}, max value – 661.8 g l^{-1}). The significant difference was found also between covered and hulless barley in test weigh (mean values - 669.8 and 774.6 g l^{-1}, respectively). Average test weight ranged from 601.8 g l^{-1} to 712.2 g l^{-1} for covered genotypes, and from 738.0 to 798.3 g l^{-1} for hulless ones. For test weight the coefficient of variation was low (2.0 to 3.0%).

There was not significant difference in average relative hardness index between different types of barley. For all types of barley in this trait observed high genotypic variability. The coefficient of variation for this trait was stated as rather high for all types of barley. It ranged from 13.7% for six-row barley to 18.9% for hulless barley. The results indicate the potential exist to exploit this variation in grain relative hardness for the development of the improved barley varieties specifically designed for different end uses.

Table 2

Comparison of grain physical traits for two-rowed *vs* six-rowed, and covered *vs* hulless genotypes (mean of 2004-2006) [1]

Genotypes	Mean value [2]	Standard deviation	Minimum value	Maximum value	Coefficient of variation, %
1000 grain weight, g					
Two-row, covered	45.7a	2.99	39.6	50.0	6.5
Six-row, covered	40.2b	4.83	29.6	44.1	12.0
Two row, hulless	43.1ab	5.51	31.2	49.6	12.8
Test weight, g l^{-1}					
Two-row, covered	682.4a	20.4	635.7	712.2	2.9
Six-row, covered	635.8b	19.1	601.8	661.8	3.0
Two row, hulless	774.6c	15.7	738.0	798.3	2.0
Relative hardness index					
Two-row, covered	64.4a	9.48	43.5	80.8	14.7
Six-row, covered	67.1a	9.22	54.6	80.4	13.7
Two-row, hulless	64.8a	12.2	40.3	84.9	18.9
Hull content, %					
Two-row	8.6a	0.89	7.0	10.6	10.4
Six-row	10.4b	0.71	9.6	11.7	6.8

[1] mean of 2004-2005 for relative hardness index.

[2] means in each comparison between pairs of barley types followed by different letters are significantly different at the p</=0.05 level.

The greatest value of feed grain from barley improvement, besides increasing yield, is that of increasing the available energy content. For pigs there is a much clearer and distinct relationship between available energy and hull (fibre) content (Darroch et al., 1996). Lowering of the relatively indigestible hull content and/or lignin content of the hull in barley would increase available energy also for ruminants (Zinn et al., 1996). According to results of this study the higher hull content was for six-row barley type (10.4%) than for two-row (8.6%) ones that was confirmed also in other studies (Evers et al., 1999; Kong et al., 1995). Since two-row barley produces larger kernels with higher test weight and 1000 grain weight, and with lower hull content than six row barley, it is very likely that two row barley produces in general better quality feed than six-row barley.

Rather high genotypic variability was stated between genotypes also for 1000 grain weight of six-row (12.0%) and hulless barley types (12.8%) as well as in hull content for two-row barley (10.4%).

Figure 1 represents data of relative grain hardness index for 13 varieties bred in Latvia. There were found high variability between varieties in this grain quality indice. Hardness index ranged from 47.1 for two-row variety 'Sencis' to 80.4 for an only six-row variety 'Druvis'. According to results varieties 'Sencis' and 'Klinta' are defined as semi-soft varieties therefore they are more corresponding to malt barley requirements. Other barley varieties that characterized with hard endosperm could be more suitable for feed application as they should provide the slower dry matter digestibility.

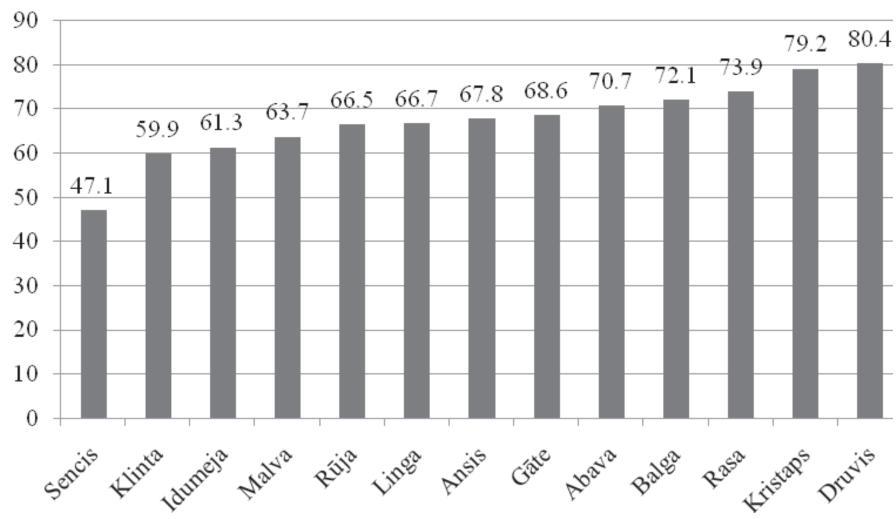

Figure 1. Characterisation of relative grain hardness index for varieties bred in Latvia (mean of 2004-2005).

Correlation relationships were calculated between relative grain hardness index and other grain physical traits including in the correlation matrice also the main chemical components of barley grain – starch, crude protein and β-glucan (Table 3).

Table 3

Phenotypic correlation coefficients between relative hardness index and other grain physical and chemical indices for covered and hulless spring barley

Grain quality indice	Two-row, covered $r_{25;\,0.05}$=0.396	Six-row, covered $r_{8;\,0.05}$=0.707	Two-row, hulless $r_{13;\,0.05}$=0.514
1000 grain weight	0.031	-0.432	0.212
Test weight	-0.027	0.289	-0.435
Crude protein	-0.255	-0.043	0.089
Starch content	0.177	-0.036	-0.213
β-glucans	0.418*	0.426	0.503

*significant at 95% probability level.

The significant positive correlation was detected between grain hardness and β-glucans for covered two-row head types of barley ($r_{2\text{-row, C}}$ =0.418> $r_{25;\ 0.05}$=0.396) (Table 3). Also for six-row head type and two-row hulless barley this relationship was positive ($r_{0.05/6\text{-row, C}}$=0.426; $r_{2\text{-row, H}}$ =0.503) even if unsignificant at 95% probability level. The similar result was obtained also in anothers studies (Henry and Cove, 1990; Chandra et al., 1999). As 70% of β-glucans are found in the endosperm cell walls their thickness might be able to contribute to grain hardness (Nielsen, 2003). Also the genetic mapping identified a number of common regions on chromosomes 4 that have been associated with barley grain hardness and content of β-glucans (Darlington et al., 2001). In the other studies differences were found regarding to correlation relationships between grain hardness and grain protein. There were studies where grain protein was positively correlated with hardness (Henry and Cove, 1990; Chandra et al., 1999). In this study no significant correlation was found between SKCS hardness and protein concentration that coincided also with B. Beecher et al. (2002) study. C. Brennan et al. (1996) found that strong starch-protein binding (high grain hardness) is related to poor malting barleys, and good malting barleys have a weak association between starch granules and protein matrix (low grain hardness). This association is independent of the nitrogen level in the grain. SKCS instrument showed potential as early screening tool in barley breeding for grain nutritional quality in breeding for different end uses.

Conclusions

1. The genotypic variability of spring barley grain physical traits was depending from both the barley type and evaluated trait. The coefficient of variation of traits was from 2.0 to 18.9%.
2. The mean value of 1000 grain weight and test weight for two-row barley was significantly higher than for six-row barley. Test weight for hulless barley was significantly higher than for covered ones. Higher genotypic variability was stated in 1000 grain weight for six-row (12.0%) and hulless barley types (12.8%).
3. The higher hull content was for six-row barley type than for two-row ones. Rather high genotypic variability was stated in hull content for two-row barley (10.4%).
4. There was not significant difference in relative hardness index between different types of barley. The genotypic variability for this trait was high for all types of barley. The coefficient of variation ranged from 13.7% for six-row barley to 18.7% for hulless barley.
5. The significant positive correlation was detected between grain hardness and β-glucans for covered two-row head types of barley. Also for six-row head type and two-row halless barley this relationship was positive, only unsignificant.
6. The potential exist to exploit the variation in grain relative hardness for the development of the improved barley germplasm specifically designed for different end uses. SKCS instrument showed potential as early screening tool in barley breeding for grain nutritional quality.

Acknowlegment

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CHARACTERISTIC OF GRAIN QUALITY FOR EARLY GENERATION LINES IN THE CROSSINGS BETWEEN COVERED AND HULLESS BARLEY

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Abstract

The objectives of the investigation were to determine effect of hulless gene on grain quality traits (crude protein, starch and β-glucans) and to evaluate the heritability of these traits in the F_4 and F_5 generations of six crosses between covered and hulless barley (*Hordeum vulgare* L.). The trial was carried out at the State Stende Cereal Breeding Institute during the years 2007 and 2008. Mean value, range and the coefficient of variation of traits for covered and hulless lines within each cross combination were calculated. Heritability of quality traits was estimated as intergeneration correlation (r) and linear regression coefficients (b). The highest intergeneration correlation values were observed for starch content within covered and hulless barley populations ($r_{F4:F5}$=0.609 and 0.635 respectively). Moderate intergeneration relationship was observed for crude protein content within covered barley population (r=0.582), and for β-glucans content within hulless barley population (r=0.593). The regression estimates of heritability were higher for starch content for both covered and hulless barleys (b=0.549 and 0.703 respectively). Due to effects of genotype and environment interactions the regression estimates of heritability for crude protein and β-glucans content for both covered and hulless barley were low (b varied from 0.347 to 0.373).

Key words: covered and hulless barley, crude protein, starch, β-glucan, variation, heritability.

Introduction

Genetic improvement of barley (*Hordeum vulgare* L.) quality has been made possible with considerable success, because many of breeding programmes are exclusively designed to improve both the malting and nutritive values (Edney, 1992; Eggum et al., 1995). It is worth considering that the improvement of the malting/food/feed quality is possible and desirable. The variation in grain quality traits among barley genotypes suggests that there is genetic variability in the species that can be manipulated by plant breeder. More knowledge of the inheritance of quantitative traits might promote selection for some of these in early generations too.

The breeders have to choose to perform the selection of desirable genotypes in early generation or delaying intense selection until advanced generations when progenies are nearly homozygous. It would be a great help to a plant breeder if he could select in an early segregating generation those plants or lines which contain the most desirable combination of genes (Bernardo, 2003). The analysis on self-pollinated crops confirmed that the introduction of early-generation quality testing leads to a faster rate of expected progress in quality, but a slower rate of progress in yield (O'Brien and Ronalds, 1986). Heritability of a trait is important in determining its response to selection because it indicates the total amount of variation that is under genetic control. Grain quality traits are mostly inherited quantitatively and their phenotypic performance is depending on both genetic factor and environmental conditions (O' Brien, 1999). Therefore, it is important for the plant breeder to continually consider the heritability of the trait under selection, the type of individuals selected, and the resources available to develop an effective selection strategy.

In breeding programmes for definite end use, a large number of lines have to be tested for their grain quality in a short time. Many of conventional methods are generally time consuming and expensive, as well as require large size grain samples. Therefore, plant breeders need better methods for segregation of breeding lines on the basis of grain quality, preferably at an early stage in the breeding process. The promise of near infrared spectroscopy (NIR) is that – it provides analysis of wide range of chemical attributes without destruction of grain sample (Wrigley, 1999). Whole grain analyzer Infratec offers to a breeder opportunity for automatic, fast and accurate enough analysis of small amount grain samples for some grain physical and chemical traits.

The effects of hulless (*nud*) gene are not yet fully realized in hulless barley. Determining the effect of hulless gene on different agronomic traits it was found that hullesness was associated with shorter plant height, lower seed weight, higher test weight and yield reduction, and was not associated with heading date, maturity, smut resistance, scald resistance and spike density (Choo et al., 2001). To evaluate the hulless gene influence on grain chemical composition is important estimation of barley lines derived from crosses made between covered and hulless varieties or outstanding lines.

The objectives of the investigation were to determine effect of hulless gene on some grain quality traits (crude protein, starch and β-glucans) and to evaluate the heritability of these traits in the F_4 and F_5 generations of crosses between covered and hulless barley varieties.

Materials and Methods

Thirty four covered lines and forty hulless F_4 and F_5 lines derived from F_2 covered and hulless populations from the six cross combinations along with their parents were grown at the barley breeding nurseries of State Stende Cereal Breeding institute during the years 2007 and 2008 (Table 1). In the cross combinations covered and hulless genotypes were used as parents.

Table 1

Cross Combinations and Number of Lines Used in the Study

Cross No	Parents (Origin)				Number of lines	
	Female parent	Type	Male parent	Type	Covered	Hulless
04-09	Justina (Germany)	covered	L 302 (Latvia)	hulless	5	8
04-10	Simba (Denmark)	covered	Wanubet (USA)	hulless	4	5
04-21	F_1 Austris/Danuta (Latvia/Germany)	covered	Freedom (Canada)	hulless	10	10
04-22	F_1 Austris/Danuta (Latvia/Germany)	covered	KM 2045 (the Czech Republic)	hulless	6	7
04-27	F_1 Linga/Kristaps (Latvia)	covered	SW 1291 (Sweden)	hulless	4	4
04-41	Gate (Latvia)	cocered	Freedom (Canada)	hulless	5	6
				In total:	34	40

The F_3 barley elite plants derived from F_2 bulk populations were divided in covered and hulless plants. The structural analysis of F_3 elite plants with the respect to a number of morphological and plant productivity traits were made and only desirable material was selected. In 2007, 50 grains from each F_3 covered and hulless elite plant and their parents were planted in one-meter row. During growing season phonological and immunological observations were carried out. In 2007, F_4 promising lines and their parents were harvested by hand. Grain quality traits for F_4 barley lines and their parents were determined. On the basis of superior agronomic performance in 2008, F_4 covered and hulless barley lines and their parents on plot size 1 m^2 were sowed. F_5 barley lines were harvested, and the grain quality traits were determined.

The soil at the site was sod-podzolic sandy loam, humus content – 12-15 mg kg^{-1}, soil pH – 6.0-6.7, precrop – potatoes, available for plants P – 88-94 mg kg^{-1} and K – 103-122 mg kg^{-1}. The plots were fertilized with N85 P43 K43 kg ha^{-1}.

The temperature and moisture conditions provided good barley field germination in 2007. In June the average temperature was 2.2 °C higher than long term average, the sum of precipitation was only 1.7 mm. July was cool and wet (average daily temperature 0.1 °C under norm, precipitation 120% from the norm). Mean temperature in August was 2.2 °C higher than the norm. April of 2008 was comparatively warm with mean daily temperature that was by 2.2 °C higher than the norm. The moisture deficit was observed in May (35.7% from the norm) and also in the first decade of June. In June and July the mean daily temperature was lower than the norm (by 0.2 °C and 0.4 °C respectively). The 2nd decades of July were rich with precipitation (58.4 mm). Very high precipitation was observed also in August (183.3% from the norm).

Grain quality traits - crude protein, starch, β-glucans in the grain in dry matter (DM) were determined by automatic grain analyzer Infratec. The barley samples were passed over a 2.1 mm sieve prior to analysis.

Mean value, range and the coefficient of variation of traits for covered and hulless lines within each cross combination were calculated. To compare the mean difference between covered and hulless lines in grain quality traits the significance level was determined at $p<0.05$ using t-test of two samples assuming unequal variance. Quality differences between F_4 and F_5 covered and hulless populations were compared using a paired t-test. Heritability of crude protein, starch and β-glucans for covered and hulless lines were estimated as the standard-unit heritability or intergeneration correlation (r) calculated by the Pearson's correlation between F_4 and F_5 (Frey and Horner, 1957) and linear regression coefficients (b) by regressing F_5 progeny means on F_4 progeny means (Smith and Kinman, 1965). Coefficient of determination (R^2 %) was obtained from regression analysis.

Results and Discussion

Crude protein of F_4 and F_5 barley lines and their parents in the different cross combinations between covered and hulless barley are showed in Table 2. Crude protein between parents differed in all cross combinations where for hulless parents crude protein content was consistently higher than for covered ones. According to the t-test predominantly there was no significant difference in crude protein for both covered and hulless F_4 and F_5 lines. Only in cross combinations 04-21 (Austris/Danuta//Freedom) in 2007, and 04-09 (Justina/L 302) and 04-41(Gate/Freedom) in 2008 there were significant differences in crude protein between covered and hulless lines. Q. Xue et al. (1997) found that in the cross between covered and hulless barley parents the total crude protein for hulless isogenic lines was higher by 59 g kg^{-1} in comparison with covered ones, but this difference was not significant. Most of lines in the different cross combinations correspond to mid parent value of crude protein. Range data for covered and hulless lines demonstrated that in both generations the variations exceeded the parents values in the cross combinations 04-21 (Austris/Danuta//Freedom), 04-27 (Linga/Kristaps//SW 1291), 04-41 (Gate/Freedom). Variation of crude protein for both covered and hulless barley lines varied among different cross combinations and generations. The highest variation in crude protein for both covered and hulless F_4 lines observed in cross combinations 04-09 (Justina/L 302) where coefficients of variation were 16.6 and 13.8% respectively and 04-21 (Danuta/Freedom) with coefficients of variation 11.8 and 10.4% respectively. Variation in crude protein between F_5 generation of covered and hulless lines was lower as for F_4 generation lines.

Table 2

Grain Crude Protein Content of F_4 and F_5 Barley Lines and Their Parents in Cross Combinations Between Covered and Hulless Barley, 2007-2008

Cross	Mean value, g kg^{-1} of DM				Range for lines, g kg^{-1} of DM		Coefficient of variation, %	
	Parents		Lines					
	♀ covered	♂ hulless	covered	hulless	covered	hulless	covered	hulless
F_4/2007								
04-09	109.0	180.0	132.8	152.1	113-160	129-195	16.6	13.8
04-10	117.0	153.0	146.0	159.0	139-167	149-163	9.3	3.5
04-21	115.0	155.0	138.6	154.9*	108-164	128-175	11.8	10.4
04-22	115.0	156.0	144.6	149.0	138-158	124-168	5.1	10.1
04-27	140.5	156.0	143.8	158.2	126-165	152-165	11.3	3.9
04-41	124.0	155.0	128.6	143.1	113-158	128-162	13.8	8.4
F_5/2008								
04-09	119.0	163.0	126.8	148.8*	118-139	136-161	6.0	7.1
04-10	115.0	136.0	133.2	135.8	129-138	121-148	2.8	7.4
04-21	132.0	138.0	132.6	138.4	114-151	114-156	7.7	10.3
04-22	132.0	148.0	134.1	138.4	126-145	123-147	6.7	6.6
04-27	142.5	149.0	142.0	141.5	127-150	130-151	7.3	6.4
04-41	125.0	138.0	121.4	134.8*	114-130	126-142	5.1	4.6

*mean difference between covered and hulless lines is significant ($p < 0.05$).

Hulless barley usually is characterized by higher starch content than covered barley (Bhatty, 1999). Also in this study the starch content for hulless parents in all crosses, except 04-09 (Justina/L 302), was higher than for covered parent (Table 3).

Table 3

Grain Starch Content of F_4 and F_5 Barley Lines and Their Parents in Cross Combinations Between Covered and Hulless Barley, 2007-2008

Cross	Mean value, g kg^{-1} of DM				Range for lines, g kg^{-1} of DM		Coefficient of variation, %	
	Parents		Lines					
	♀ covered	♂ hulless	covered	hulless	covered	hulless	covered	hulless
F_4/2007								
04-09	621.0	596.0	607.1	616.1	594-615	594-630	1.5	2.2
04-10	617.0	633.0	608.0	622.0*	605-611	612-638	0.4	1.7
04-21	610.0	620.0	608.1	619.6*	595-627	601-641	1.5	2.0
04-22	610.0	620.0	603.0	613.0*	596-610	605-628	0.9	1.2
04-27	598.5	614.0	601.7	612.2*	593-613	606-618	1.4	1.0
04-41	616.0	620.0	617.8	629.8*	602-629	614-644	1.6	1.7
F_5/2008								
04-09	632.0	627.0	625.0	632.5*	624-643	624-649	0.4	1.5
04-10	622.0	672.0	627.5	651.0*	620-635	642-664	1.0	1.2
04-21	619.0	644.0	618.5	645.1*	602-635	622-673	1.4	2.8
04-22	619.0	626.0	617.3	631.8*	605-625	624-645	1.4	1.3
04-27	607.5	622.0	616.2	630.7*	609-625	630-631	1.4	0.1
04-41	616.0	644.0	628.4	646.1*	621-635	638-659	0.8	1.2

*mean difference between covered and hulless lines is significant ($p < 0.05$).

Mean difference in starch content was significant ($p<0.05$) between obtained covered and hulless lines in all cross combinations. Higher variation in starch content was observed between hulless lines than in covered ones within all cross combinations in both generations except 04-27. Data range of starch in the different cross combinations demonstrated that for hulless lines in both generations variation of this trait exceeded the range between the parents. The heightened starch content in the dry matter is important criteria in the breeding of feed barley. Usually it is impossible to combine both high crude protein and starch in one genotype due to high negative correlation between these two important endosperm components (Bleidere, 2007). Nevertheless in the cross combinations 04-10 (Simba/Wanubet) and 04-41 (Gate/Freedom) there was possibility to find several not only hulless but also covered lines characterize by heightened crude protein and starch content that remains in both generations (data not shown).

β-glucans content of F_4 and F_5 barley lines and their parents in the different cross combinations between covered and hulless barley are showed in Table 4. β-glucans between parents differed in all cross combinations where for hulless parents β-glucan content was consistently higher than for covered ones. Mean difference in β-glucans content was significant ($p<0.05$) between covered and hulless lines in all cross combinations. Grain quality investigation of isogenic lines derived from cross between covered and hulless parents also showed that the content of total β-glucans was significantly higher for hulless barley lines than for covered lines (Xue et al., 1997). In the cross combinations between covered and hulless parents there is a possibility to obtain covered lines with increased β-glucans content and hulless lines with decreased β-glucans content. It ecially important for hulless barley if this type is offered for pig and poultry feeding where varieties with lower β-glucans content are more desirable (Miller et al., 1994), in its turn covered barley varieties with heightened content of β-glucans are more desirable if this type of barley is used as a food source (Klopfenstein, 1988). From this point of view the lines from cross combination 04-10 (Simba/Wanubet) showed comparatively higher variation in β-glucans within F_4 and F_5 covered and hulless barley lines as the coefficient of variation indicated. The variation of β-glucans content also (similarly to variation of crude protein and starch content) was higher within F_4 generation lines in year 2007 if compared with F_5 generation lines in year 2008.

Table 4

Content of β-glucans of F_4 and F_5 Barley Lines and Their Parents in Cross Combinations Between Covered and Hulless Barley, 2007-2008

Cross	Mean value, g kg^{-1}				Range for lines, g kg^{-1}		Coefficient of variation, %	
	Parents		Lines					
	♀ covered	♂ hulless	covered	hulless	covered	hulless	covered	hulless
F_4/2007								
04-09	31.0	54.0	32.8	45.7*	31-34	43-51	4.0	5.2
04-10	32.0	53.0	35.2	47.0*	32-40	43-51	9.6	7.5
04-21	31.5	53.0	34.0	44.0*	32-36	42-47	4.1	4.0
04-22	31.5	41.0	33.3	42.6*	31-36	38-45	5.2	5.7
04-27	32.0	46.0	34.2	42.5*	32-35	41-44	4.4	3.0
04-41	34.0	53.0	35.6	46.3*	33-38	44-51	5.1	5.6
F_5/2008								
04-09	34.0	52.0	41.6	52.5*	39-43	51-54	3.6	2.0
04-10	40.0	60.0	45.7	55.0*	43-48	52-59	4.5	4.6
04-21	34.0	52.0	42.2	52.5*	40-44	51-54	3.3	1.9
04-22	34.0	47.0	44.3	53.8*	40-45	51-54	4.6	4.1
04-27	42.5	56.0	43.7	51.7*	43-45	50-53	2.2	2.9
04-41	38.0	52.0	43.2	53.8*	41-46	51-57	4.5	4.3

*mean difference between covered and hulless lines is significant ($p < 0.05$).

As phenotypic values of traits are conditioned by both genetic and environmental factors, mean values of hybrids and lines may change depending on conditions in which the experiment has been performed. The presence of genotype and environment interaction may greatly influence the differences between studied generations, thus influencing values of estimates of genetic parameters as it was found also in this investigation (Schut and Dourleijn, 1999). According to the t-test the differences between means of grain quality traits of generation F_4 and those of generation F_5 were statistically significant (Table 5). The significantly higher starch content was observed in 2008 for both the covered and hulless lines when the meteorological conditions during grain filling period promoted more accumulation of starch. As the β-glucans are predominantly concentrated in the starchy endosperm cell walls (Shewry and Morell, 2001), it could be the reason of significantly higher amount of total β-glucans content also in the year of 2008 compared to 2007. Observed differences also indicate that phenotypic variability of grain quality - as it is typical for quantitatively inherited traits within a population - resulted from the combined effects of environment and genotype. If the variability in the phenotype is more strongly influenced by environmental effects on growth or development, then any attempt for selection progress is likely to fail.

Heritability of a trait expresses the reliability of the phenotypic value as a guide to the breeding value and the trait utility within the selection process (Bernardo, 2003). The correlation between F_4 lines values and the mean values of F_5 lines would provide an indication of the heritability of a quantitative trait. If the environment had no influence on the trait, the correlation would be high. In this study across generations (F_4 versus F_5), the relationship was statistically significant ($p<0.05$) for all of the investigated traits (Table 5).

Table 5

Means of Generations, Coefficient of Determination (R^2%) and Estimates of Heritability for Quality Traits in F_4 and F_5 Covered and Hulless Barley Lines by Intergeneration Correlations (r) and Linear Regression Coefficients (b)

Trait	Mean value, g kg^{-1}		$r_{F4:F5}$	R^2 %	sb
	F_4	F_5			
Covered					
Crude protein, g kg^{-1}	138.9a[1]	131.4b	0.582*	35.8	0.368
Starch, g kg^{-1}	607.7b	621.5a	0.609*	33.7	0.549
β-glucans, g kg^{-1}	34.1b	42.9a	0.336*	11.2	0.341
Hulless					
Crude protein, g kg^{-1}	152.4a	139.5b	0.458*	21.0	0.347
Starch, g kg^{-1}	618.9b	640.8a	0.635*	40.3	0.703
β-glucans, g kg^{-1}	44.7b	52.9a	0.593*	35.2	0.373

[1]means for the same trait in each comparison between progenies followed by different letters are significantly different at the p</=0.05 level.

* significant at 0.05 probability level ($r_{0.05/covered}$= 0.332, n=34; $r_{0.05/hulless}$= 0.310, n=40).

The highest intergeneration correlation values were observed for starch content within covered and hulless barley populations (r=0.609 and 0.635 respectively). The moderate intergeneration relationship was observed also for crude protein content within covered barley population (r=0.582), and for β-glucans content within hulless barley population (r=0.593). According to the results, comparatively higher coefficients of determination were found for starch content of hulless population (R^2%=40.3). The coefficient of determinations for other trait intergeneration relationships was only from 11.2 to 35.8% that indicated the influence of environmental effect. Heritability values, estimated as regression coefficients considering also environment effects, were higher for starch content for both covered and hulless barley (b=0.549 and 0.703 respectively). Reduced heritability values for crude protein and β-glucans content of both covered and hulless barley (regression coefficients b varied from 0.347 to 0.373) were noted due to effects of genotype and environment interaction. In M. Therien (2006) study the crude protein demonstrated a high average heritability (up to 70%), but it was less stable, indicative of a fairly strong environmental influence. R. Bernardo (2003) indicated that the heritability values tended to be higher at the later generations, where the degree of homozygosity was increased, and resulted in more reliable selection response. The results of this study indicate that selection in early generations for superior types is more feasible for starch content, but selection for crude protein and β-glucan due to lower heritability could impede selection progress. Thus, selection for these both traits needs to be based on observations in different environments.

Conclusions

Variation of crude protein for both covered and hulless barley lines varied among different cross combinations and generations. In both generations (F_4 and F_5) the variations exceeded the range between the parents in the cross combinations 04-21 (Austris/Danuta//Freedom), 04-27 (Linga/Kristaps//SW 1291), and 04-41 (Gate/Freedom).

Higher variation in starch content was observed among hulless lines than in covered ones in both generations. For hulless lines in both generations variation of starch exceeded the parent's values of trait.

In the cross combinations between covered and hulless parents there is possibility to obtain covered lines with increased β-glucan content and hulless lines with decreased β-glucan content.

The highest intergeneration correlation values that correspond to moderate relationships were observed for starch content within covered and hulless barley populations ($r_{F4:F5}$=0.609 and 0.635 respectively). The moderate intergeneration relationship was observed also for crude protein content within covered barley population (r=0.582), and for β-glucan content within hulless barley population (r=0.593).

The regression estimates of heritability were higher for starch content for both covered and hulless barley (b=0.549 and 0.703 respectively). Due to effects of genotype and environment interactions, the regression estimates of heritability for crude protein and β-glucan content for both covered and hulless barley varied from 0.347 to 0.373.

The results of this study indicate that selection in early generations for superior types is more feasible for starch content, but selection for crude protein and β-glucan needs to be based on observation in different environments.

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EFFECTS OF GROWING LOCATION AND VARIETY ON FREE TRYPTOPHAN AND MINERAL NUTRIENT CONTENT IN WHEAT

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Abstract

Tryptophan (Trp) is an essential amino acid for mammals since they cannot synthesise it. Wheat (*Triticum aestivum* L.) is a major source of dietary Trp, and wheat high in Trp would thus be very beneficial. This study investigated the impact of location and wheat variety on the content of free Trp and mineral nutrients in wheat grain.

Four wheat cultivars from national variety tests on wheat with varying protein contents were selected from seven different locations of Sweden representing different climatic zones and soil contents of trace elements. Grain was analysed for Trp content using reversed phase HPLC. Mineral nutrients were analysed using inductively coupled plasma emission spectrometry. Wheat yield and grain content of nutrients and Trp differed significantly between sites. High N content in grain was correlated with a high content of Cu, Fe and S, and also Ca and Mg. However, it was correlated with a low content of K and Na. Trp content was positively correlated with Na and Zn content and negatively correlated with K/Na and K/(Na+Zn) ratio. The varieties differed in Trp content and the two ratios, but there were no significant differences in yields between the varieties at any location. The results indicated salt stress induction of Trp synthesis, which may protect wheat against salt stress and yield losses.

Key words: amino acid, crop quality, HPLC, metabolites, salt stress.

Introduction

Wheat (*Triticum aestivum* L.) is an important agricultural crop worldwide. Due to its high content of starch and unique gluten proteins, wheat grain is used for many food and non-food applications. In addition, wheat is an important dietary source of vitamins and minerals. Wheat grain quality can be improved by manipulating environmental factors, agricultural practices and genetic factors to alter the chemical composition (Williams et al., 2008).

Tryptophan (Trp) is an amino acid synthesised by plants and microorganisms. It is essential in the diet of mammals, since they are unable to synthesise Trp and must obtain it from plants or microorganisms. Trp is either bound in the cell to proteins and peptides, or occurs freely. In plants, the shikimic acid pathway provides a route to the biosynthesis of Trp (Velíšek and Cejpek, 2006). The total level of Trp in grains is directly correlated with the input of N (Landry and Delhaye, 1993). Furthermore, minerals such as Zn affect the activity of the shikimic acid pathway and thus the synthesis of Trp (Herrmann, 1995; Knaggs, 1999). Trp is essential for protein synthesis, but is also an important precursor for many secondary metabolites critical for developmental processes and environmental responses (Radwanski and Last, 1995; Woodward and Bartel, 2005). Given the importance of wheat as a major food source and Trp as an essential amino acid, a wheat high in Trp would be of great benefit.

The aim of the present study was to investigate the impact of location and wheat variety on the content of free Trp and macro- and micronutrients in wheat grain. The effects of grain mineral nutrient contents on the accumulation of free Trp in grain were also assessed.

Materials and Methods

Plant material, site locations

Wheat grain samples were obtained from the Swedish national variety tests (Fältforsk, 2009). Four varieties of wheat ('Akteur', 'Olivin', 'Opus', 'Tulsa') representing different protein contents were selected from seven different locations in Sweden (Fransåker, Hedemora, Järpås, Laholm, Skänninge, Stenstugu, Vassmolösa) (Figure 1). The locations were chosen on the basis that they cover different climatic zones and varying concentrations of trace elements in soil. 'Akteur' and 'Olivin' are two bread grain varieties derived from Germany, while 'Opus' and 'Tulsa' are feed grain varieties and derive from Germany and the Netherlands, respectively. Achieved samples (2 kg) were stored at room temperature until analysis.

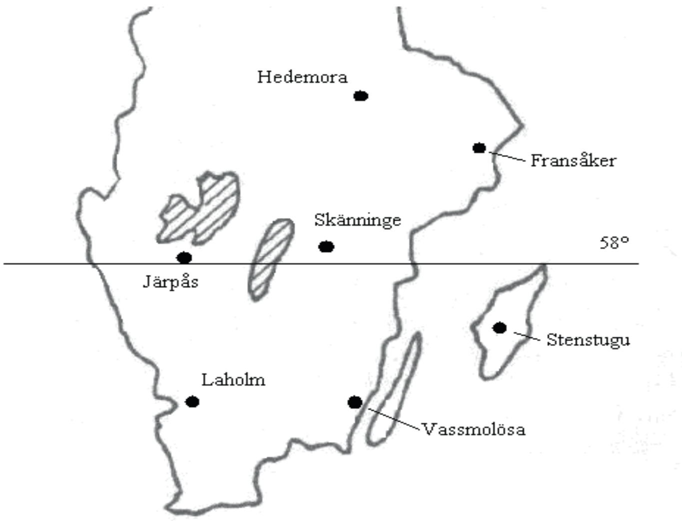

Figure 1. Map of southern Sweden showing the geographical position of the seven growing locations in Sweden.

Tryptophan analysis

Wheat grains (20 g of each sample) were milled in a ZM 1 ultracentrifugal mill with a 0.5-ring sieve (Retsch, Haan, Germany). The powder was mixed thoroughly, transferred to a plastic tube and flushed with argon to remove oxygen. All milled samples were stored at -20 °C until extraction; the storage time was no more than two weeks.

Each sample was extracted and analysed at least in duplicate. First, 5 mL of water-ethanol mixture (1:1, v/v) were added to 1.5 g of wheat powder. Extraction was performed by vortexing on a Multi Reax vortex machine (Heidolph Instruments, Germany) for 10 min at 2000 rpm, at room temperature. Samples were then centrifuged for 10 min at 3500 g and the supernatant was kept at 0 °C for 30 min, followed by another centrifugation for 10 min at 13000 g. The supernatant samples obtained were transferred to HPLC vials.

Extracts were analysed by reversed phase HPLC using an Agilent 1100 system equipped with a gradient quaternary pump, a thermostated autosampler, a thermostated column compartment, a diode array detector (DAD) and a fluorescence detector (FLD). Agilent ChemStation software was used to control the HPLC system and data processing. Samples were analysed using a ReproSil-Pur ODS-3 column (250×4.6 mm, 5 µm, Dr. Maisch GmbH, Germany) and a 1-mm Opti-Guard C18 guard column (Optimize Technologies Inc., Oregon City, USA). The column temperature was 20 °C, the autosampler temperature - 13 °C, and the injection volume - 5 µL. Water and acetonitrile, both containing 10 mM acetic acid, were used as mobile phase. The following gradient programme was used for separation: 3% acetonitrile from 0 to 5 min, 3-40% acetonitrile from 5 to 65 min, followed by column washing with 100% acetonitrile and then re-equilibration. The flow rate was 0.4 mL min^{-1}. DAD wavelength was set to 280. The excitation and emission wavelengths in the FLD detector were set to 290 nm and 360 nm, respectively. Retention time was used for peak identification.

Quantification of tryptophan was based on an external standard method performed by using multi-point calibration curve at concentrations 0.1, 0.3, and 1.0 mM. Standard solutions were prepared in aqueous 20% ethanol and analysed by the HPLC method described above. Tryptophan was quantified using peak areas recorded by FLD.

Acetonitrile was of HPLC grade; other chemicals were of analytical quality. Water was purified using a Milli-Q system (Millipore, USA). 2,2'-Azinobis-(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) and potassium persulphate were purchased from Fluka (Germany), acetic acid from VWR International (Darmstadt, Germany), and ethanol from Solveco AB (Rosersberg, Sweden). Tryptophan was obtained from Sigma-Aldrich (St. Louis, USA).

Analysis of mineral nutrient content

Analyses of mineral nutrient content were carried out using inductively coupled plasma emission spectrometry (ICP) after wet digestion with nitric acid (HNO_3). Ten mL concentrated HNO_3 were added to 1 g of dry ground sample in a 50 mL Kjeltec tube and kept at room temperature overnight. The sample was boiled for

6 hours (1 hr at 60 °C, 1 hr at 100 °C, and the final 4 h at 125 °C), 5 mL HNO_3 being added after 4 h of boiling. After hydrolysis, samples were diluted with distilled water to a total volume of 50 mL, filtered and analysed by ICP using a Perkin Elmer Optima 3000 DV. Nitrogen content and yield data were obtained from the Field Research Unit database at SLU (Fältforsk, 2009).

Statistics

A two-factorial analysis of variance was performed using a PROC GLM-model in SAS to determine the effect of location and variety on the content of mineral nutrients and free Trp. A multivariate analysis of variance (MANOVA) was performed to check for correlations between the parameters measured (SAS, 2009).

Results and Discussion

Wheat yield and grain content of mineral nutrients and free Trp differed significantly (p<0.0001) between the sites. Skänninge gave the highest yields of wheat, followed by Fransåker, Stenstugu and Vassmolösa (Table 1). Those sites were all located in eastern Sweden (Figure 1). The lowest yield was obtained at the most northerly site studied, Hedemora. The last two locations, Järpås and Laholm in western Sweden, had intermediate yields. There was no significant difference in yield between the varieties.

Nitrogen content reached the highest level in grain from Fransåker, Järpås and Skänninge. These sites were located away from the coast and to the south. The bread grain varieties 'Akteur' and 'Olivin' had a higher N content than the two feed grain varieties 'Opus' and 'Tulsa'. Grain from Fransåker, Järpås and Skänninge also had a high concentration of other nutrients, especially Cu, Fe and S. Consequently, high grain N content correlated with high content of Cu, Fe and S, but also Ca and Mg (Table 2). In contrast, high N content grain decreased the content of K and Na. These relationships appeared clearly in wheat grains from Laholm and Stenstugu, whereas it was only the negative correlation between N and K that was clear between the varieties (Table 1).

According to new data from an ongoing monitoring programme on the status of Swedish arable soils, the Cu content in wheat grain is positively correlated with the content of clay (r=0.51) and Cu (r=0.40) in the soil (Eriksson, 2008). As the soils at Fransåker, Järpås and Skänninge are rich in clay and Cu, this explains some of the variation in Cu content between grains from these locations and grains from the other locations. Furthermore, S is important for high wheat production (Randall and Wrigley, 1986). Like N, S is included in the amino acids that build up proteins, such as gluten in wheat. Hence, N and S metabolism are closely interrelated and an optimal N/S ratio of around 15 in grain has been shown to improve bread-making quality (Zhao et al., 1997, 1999). Consequently, an increased N uptake requires an increased uptake of S in order to maintain optimal production and quality, which explains the high correlation between N and S in the wheat samples studied here.

Table 1

Dry matter yield t ha^{-1}) and content of free tryptophan (Trp, mg kg^{-1} DW), macronutrients (g kg^{-1} DW), Na and micronutrients (mg kg^{-1} DW) in wheat grain of four varieties from seven different growing locations in Sweden

	Location							Variety			
	Fran	Hed	Järp	Lah	Skän	Sten	Vass	Akteur	Olivin	Opus	Tulsa
Yield	8.19 b	4.24 d	5.99 c	5.52 c	9.67 a	7.86 b	7.58 b	6.92 a	7.18 a	6.96 a	6.97 a
Trp	268 c	265 c	203 d	369 a	220 d	318 b	279 c	315 a	293 b	233 d	258 c
N	25.5 a	22.1 cd	25.6 a	21.2 d	25.3 a	22.4 bc	23.2 b	24.6 a	24.2 a	22.7 b	23.1 b
K	5.03 bc	4.90 c	5.06 b	5.51 a	4.96 bc	5.53 a	4.91 bc	5.02 b	4.88 c	5.30 a	5.31 a
Ca	0.33 b	0.32 b	0.43 a	0.28 c	0.42 a	0.32 b	0.41 a	0.35 b	0.32 c	0.35 b	0.42 a
Mg	1.11 c	1.10 c	1.29 a	1.17 b	1.29 a	1.28 a	1.18 b	1.22 b	1.26 a	1.16 c	1.16 c
P	3.08 c	2.78 d	3.43 b	3.54 b	3.85 a	3.78 a	3.45 b	3.59 a	3.40 b	3.32 b	3.35 b
S	1.53 a	1.37 c	1.45 b	1.19 d	1.45 b	1.37 c	1.38 c	1.45 a	1.41 b	1.38 b	1.31 c
Na	7.4 ef	4.5 f	8.1 de	56.3 a	12.4 c	20.8 b	11.3 cd	20.0 a	15.9 bc	18.2 ab	14.9 c
Fe	39.8 a	31.3 cd	37.8 a	29.3 d	34.6 b	34.7 b	32 9 bc	38.0 a	34.7 b	32.5 b	32.1 b
Cu	4.63 a	3.20 e	4.25 b	2.33 f	4.20 bc	3.83 d	4.07 c	3.82 b	3.99 a	3.74 b	3.76 b
Zn	29.3 b	34.5 a	14.9 f	27.1 c	21.6 d	22.6 d	20.1 e	26.4 a	23.9 b	22.5 c	24.4 b

(Fran=Fransåker, Hed=Hedemora, Järp=Järpås, Lah=Laholm, Skän=Skänninge, Sten=Stenstugu and Vass=Vassmolösa). Values within location or variety rows with different letters are significantly different (p<0.05)

DW = dry weight

Laholm and Stenstugu produced wheat grain with high free Trp content (Table 1). The free Trp concentration was at least 13% higher in grains from Laholm (369 mg kg^{-1} DW) and Stenstugu (318 mg kg^{-1} DW) than in grains from the other locations (<280 mg kg^{-1} DW). Grains from Laholm and Stenstugu were characterised by high content of Na and K and a low content of N, S, Ca and Cu. This gave a good positive correlation between content of free Trp and Na (r=0.592, p<0.0001) and a negative correlation between content of free Trp and N, S, Ca and Cu (Table 2). Besides Na, content of free Trp also showed a positive correlation with Zn (r=0.334, p=0.0003). Previous studies have shown that Zn can affect the synthesis of Trp (Mašev and Kutáček, 1966; Horák et al., 1976) and later studies have produced explanations for the Zn effect. For example, Zn can act by stabilizing cytosolic 80S ribosomes and by activating enzymes (Obata and Umebayashi, 1988; Knaggs, 1999; Lovkova et al., 2005). However, the content of free Trp was at the same level in grains from Hedemora, which contained the highest concentration of Zn, as in grains with low concentration of Zn from other areas. Therefore, Zn seems not to be the most important factor affecting the synthesis of Trp in wheat grown at different locations. Instead, the proximity of the growing location to the sea appeared to influence the synthesis of Trp more than the availability of Zn. Hence, wheat response to salt stress ought to be a significant factor for Trp synthesis.

Under conditions of soil salinity, there is a rapid reduction in germination and perturbed uptake and accumulation of essential nutrients (Iqbal and Ashraf, 2007). According to W.X.Wang et al. (2003), a number of nitrogen-containing compounds (NCC) can be accumulated. The most frequently accumulated NCC include amino acids, amides, imino acids, proteins, quaternary ammonium compounds and polyamines (Parida et al., 2004). Under salt stress, plants maintain a high concentration of K^+ and a low concentration of Na^+ in cytosols by regulating the expression and activity of K^+ and Na^+ transporters (Zhu, 2003). In general, Ca and K concentrations decrease in plants under saline conditions (Carter et al., 2005), but the content of P and Fe has also been shown to decrease with elevated salinity level (Shiyab et al., 2003). However, in the same situation the contents of Na, Zn and Mn in tissues can increase (Shiyab et al., 2003). Under salt stress conditions, the K/Na ratio decreases in salt-sensitive plants, whereas the ratio remains high in the tissues of salt-tolerant plants (Goudarzi and Pakniyat, 2008). In the present study, the correlation between [K]/[Na] ratio (concentrations expressed as mmol kg^{-1} wheat) and free Trp content in grains of the four wheat varieties from the seven locations was not very strong, especially for the varieties (Figure 2).

Table 2

Correlation between dry matter yield, free tryptophan (Trp) content and content of macro- and micronutrients in four wheat varieties from seven locations in Sweden, values >0.3 or <-0.3 are significant at p<0.001

	Yield	Trp	N	K	Na	Ca	Mg	P	S	Fe	Cu	Zn
Yield	-	-	0.363	-	-	-	-	0.463	0.338	-	0.486	-0.304
Trp	-	-	-0.301	-	0.592	-0.533	-	-	-0.325	-	-0.498	0.334
N	0.363	-0.301	-	-0.384	-0.469	0.385	0.411	-	0.725	0.601	0.679	-
K	-	-	-0.384	-	0.505	-	-	0.331	-0.323	-	-0.368	-
Na	-	0.592	-0.469	0.505	-	-0.402	-	0.308	-0.588	-0.325	-0.750	-
Ca	-	-0.533	0.385	-	-0.402	-	-	-	-	-	0.390	-0.474
Mg	-	-	0.411	-	-	-	-	0.709	0.317	-	-	-0.423
P	0.463	-	-	0.331	0.308	-	0.709	-	-	-	-	-0.419
S	0.338	-0.325	0.725	-0.323	-0.588	-	0.317	-	-	0.582	0.767	-
Fe	-	-	0.601	-	-0.325	-	-	-	0.582	-	0.487	-
Cu	0.486	-0.498	0.679	-0.368	-0.750	0.390	-	-	0.767	0.487	-	-
Zn	-0.304	0.334	-	-	-	-0.474	-0.423	-0.419	-	-	-	-

- no significant correlation

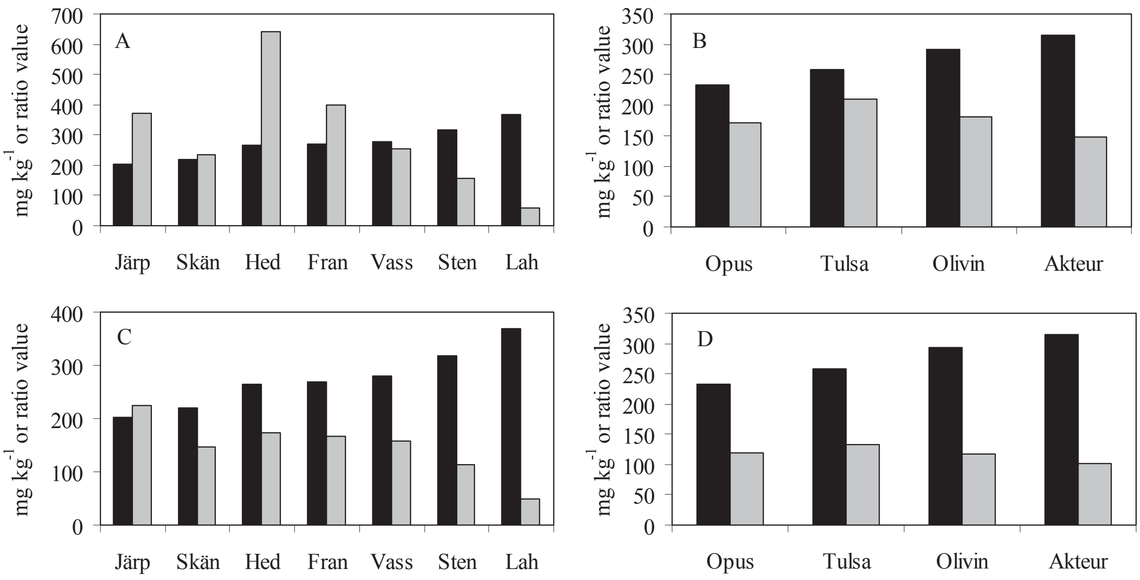

Figure 2. Relationship between [K]/[Na] ratio (upper diagrams, A and B, black bars=Trp, mg kg^{-1} DW, grey bars=ratio value) or [K]/([Na]+[Zn]) ratio (lower diagrams, C and D, black bars=Trp, mg kg^{-1} DW, grey bars=ratio value) and content of free tryptophan (Trp) in wheat grain of four varieties from seven growing locations. The ratios are calculated from the mean values in Table 1. Fran=Fransåker, Hed=Hedemora, Järp=Järpås, Lah=Laholm, Skän=Skänninge, Sten=Stenstugu and Vass=Vassmolösa.

However, as Zn can promote the synthesis of Trp, a high Zn concentration in the grain would increase the Trp content and therefore including Zn in the K/Na ratio may be of interest. As seen from Figure 2, the correlation between K/(Na+Zn) ratio and free Trp content was much better ($r=-0.601$, $p<0.0001$) than the correlation between K/Na ratio and free Trp content ($r=-0.193$, $p=0.0437$). This finding that an increase in free Trp content can protect wheat against elevated salt stress conditions was confirmed by the fact that there was no significant negative correlation between either free Trp content or K/(Na+Zn) ratio in the grain and wheat yield. This is consistent with literature data, where a high ratio, K/Na, is correlated with a high salt tolerance (Zhu 2003; Iqbal and Ashraf 2007; Goudarzi and Pakniyat, 2008).

In rice, as in several other crop species, the presence of NaCl in the regeneration medium can strongly reduce (Vajrabhaya et al., 1989) or even completely inhibit (Subhashini and Reddy, 1989) regeneration of plants. Several successful attempts to improve rice callus regeneration in the absence of stress are reported in the literature. Factors found to promote regeneration included an increase in osmotic pressure of the regeneration medium (Kavi Kishor, 1987), addition of amino acids such as proline and tryptophan (Datta et al., 1992; Chowdhry et al., 1993) or addition of specific growth regulators such as abscisic acid (ABA) (Peterson and Smith, 1991) or indoleacetic acid (IAA) (Kavi Kishor, 1987). Hence, accumulation of free Trp in wheat grain could be a way for wheat to increase the capacity of the grain to germinate under salt stress conditions, e.g. through the free Trp acting as a precursor for IAA.

Among the four varieties studied, Opus behaved differently from the other varieties. It had the lowest content of free Trp but not the highest ratio, which may indicate that Opus has a different response to salt stress than the other varieties. However, there was no interaction between location and variety for either yield ($p=0.581$) or the two ratios ($p=0.779$ and $p=0.495$), which showed that all varieties behaved similarly independent of growing location. 'Tulsa' generally had the highest ratio and 'Akteur' the lowest, while there were no significant differences between the yields for the varieties at the different locations.

Conclusions

Free Trp content of wheat was affected by the local conditions at the growing site. One important factor was the ratio between K and (Na + Zn). When this ratio decreased in grain, the free Trp content increased, probably as a protection against salt stress. However, neither free Trp content nor K/(Na+Zn) ratio in the grain was negatively correlated with wheat yield, indicating that this protection mechanism against salt stress seems to be sufficient in wheat in order to maintain good yield levels under Swedish conditions.

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FACTORS OF INFLUENCE ON WINTER RYE'S STARCH CONTENT

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Abstract

The EU "Directive on the promotion of the use of biofuels or other renewable fuels for transport" (COM 2003/30/EC) states that the proportion of biofuels in 2010 must make 5.75% of non-renewable fuels, but in 2020 – 10%. The only way for Latvia to fulfil the Directive 2003/30/EC is to use winter rye because it is one of the oldest cereals grown in Latvia, and Latvia has a long-lasting experience in growing it. A field trial of winter rye (*Secale cereale* L.) was arranged in the Agricultural Science Centre of Latgale from 2005 to 2007. The influence of four winter rye varieties and five fertilizer rates on grain yield and starch content was researched for three years. The year (factor A), the varieties (factor B), the fertilizer rates (factor C), and the interaction of factors AB, AC, BC, and ABC significantly influenced the yield of grain and the starch content with 95% probability. It is recommended to use good quality grain with a high starch content and a low protein content for bioethanol production. The varieties of winter rye 'Kaupo', 'Amilo', and 'Walet' are the most suitable for ethanol production in Latgale region.

Key words: bioethanol, yield, grain quality, winter rye.

Introduction

Biofuels (biodiesel, bioethanol, and biogas) are regarded as alternatives to oil fuels (Kalniņš, 2005; Bhattacharyya and Banerjee, 2007; Enerģētisko..., 2007). For bioethanol production, crops with a high content of starch or sugar must be grown (Enerģētisko..., 2007). Bioethanol is used as a mixture with petrol and is called "latol" in Latvia (Project …, 2007). Taking into account the amount of oxygen (34%) as well as octane number, the bioethanol-petrol mixture improves the quality of the fuel and ensures its afterburning, which in its turn reduces the exhaust and air pollution. One litre of bioethanol replaces about 0.66 l of pure petrol. At the same time, from one ha of cereal (provided the crop is 6 t per ha) about 2500 l of bioethanol can be produced. The quantity of biomass necessary for 1 litre of bioethanol production is as follows: wheat – 2.6 kg, rye – 2.2 kg, triticale – 2.5 kg, maize – 2.6 kg (Kivliņš, 2004; Kalniņš, 2005). The bioethanol used for fuel production consists of EtOH (ethanol) and cogeneration substance (≥99.6%; H_2O≤0.4%) (Enerģētisko…, 2007; Bhattacharyya and Banerjee, 2007). With lower non-fermentable levels the plant processes can be optimized for higher starch content and more efficient alcohol conversion. Energy consumption is lower in both the ethanol production process and particularly in non-fermentable processing and drying (Jakel, 2008).

In the EU "Directive on the promotion of the use of biofuels or other renewable fuels for transport", indicative targets for minimum proportions of biofuels in the fuel market are established (in 2010 must be 5.75%, but in 2020 – 10%) (Gulbis and Šmigins, 2006; Directive 2003/30/EC). The implementation of the Directive 2003/30/EC supports not only the Europe-wide market introduction of biofuels, but will create a new market for agricultural raw materials and contribute to additional emission reductions in the transport sector. From forecasts of the Latvia local market development, biofuel production requirement for 2010 will be 46 000 ha of rape to produce 45 000 t of biodiesel, and 26 000 ha of cereals to produce 32 000 t of bioethanol (Kalniņš, 2005).

In Latvia, there are more cereals produced than actually needed. At the same time, there are no natural energy resources such as gas, oil, or coal. So there is no other solution but to use renewable sources such as cereals for energy production, which would not affect human necessity for food in Latvia. Winter rye is one of the oldest cereals grown in Latvia. All industries of national economy are based on the use of energy, which increases annually. That is the reason why bioethanol production – a new form of cereal use in Latvia – should be developed. Rye is the best suitable culture for bioethanol production (Šķēle et al., 2001; Kalniņš, 2005; Enerģētisko ..., 2007).

The objective of the research is to study the influence of winter rye cultivation technology on the quality of grain and suitability of winter rye for bioethanol production in Latgale region.

Materials and Methods

Winter rye (*Secale cereale* L.) was cultivated in the Agricultural Science Centre of Latgale in 2005-2007. The used winter rye varieties were 'Kaupo' (Latvia), 'Amilo'

(Polland), 'Walett' (Poland), and 'Valdai' (Russia). The field trials were conducted on sod-podzolic sandy loam soils: organic matter content – 27 g kg^{-1} (Turin's method), pH 6.7, P – 67.64 mg $kg^{-1}$of soil, K – 76.37 mg kg^{-1} of soil (DL method). The soil parameters were fit for winter rye cultivation. The pre-crop was bare fallow.

The trial varieties of winter rye were sown on 18 September 2005, 12 September 2006, and 14 September 2007. The winter rye seeding rate was 450 germinate able seeds per m^2. The field experiment was carried out using a randomised block design. The area of trial plot was 20 m^2 (2 m × 10 m), and 4 replicates. N-fertiliser variants were N_{30}, N_{60}, N_{90}, N_{60+30}, and N_{90+30}. The herbicide Tooler d.g. (tritosulfaron, 714 g kg^{-1}), and the fungicide Flexity s.c. (metrafenon, 300 g l^{-1}) were used at the plant growth stage (GS) 26-32. The growth regulator Terpal d.c. (mepikvate hlorid, 305 g l^{-1}, and etefon, 155 g l^{-1}) was used at GS 32-49.

The climate of Latgale varies somewhere between maritime and continental and in general is favourable for cereal growing. The harvesting conditions were good in 2005-2007. As Figures 1 and 2 show, the best years were 2005 and 2007. There were no dramatic temperature deviations, and also precipitation was quite good for winter rye growing. In 2006, weather conditions were not so favourable which resulted in less yield and starch content.

The air temperature (Figure 1) was higher than the average temperature in the long-term average. In the period of winter rye vegetation during 2006, the air temperature was a little higher than the average year temperature; precipitation (Figure 2) in June and July made 43-56% of the average, but at the end of August increased to 217% of the average. During the winter rye vegetation in 2007, the air temperature at the end of June and July was lower than the average. In June of 2006 and 2007, agrometeorological conditions were similar at the flowering stage. The precipitation level was low in June, 2005-2007. The air temperature in 2005 was similar to the average. The precipitation in May and August of 2005 was 2-2.5 times higher than the long-term average.

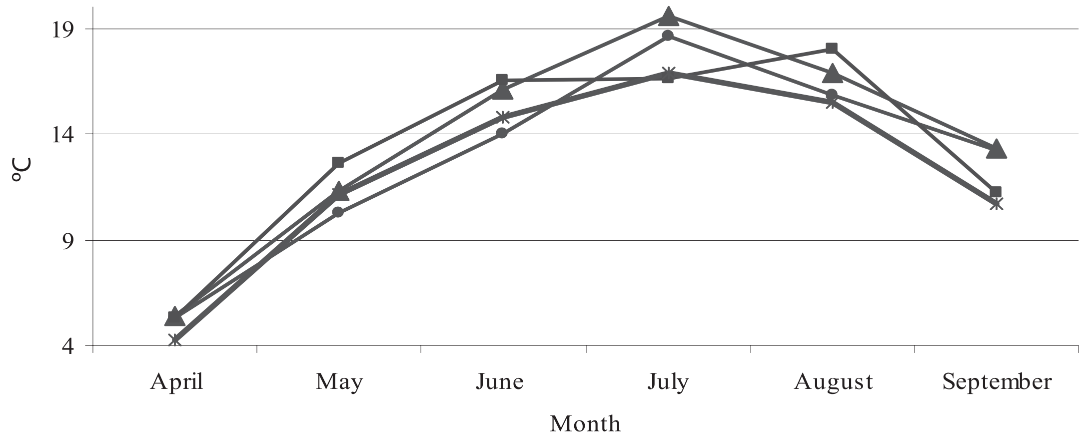

Figure 1. The air temperature for the vegetation period of winter rye in Agricultural Science Centre of Latgale in 2005-2007: ● – 2005,▲ – 2006, ■ – 2007, ✳– long-term average.

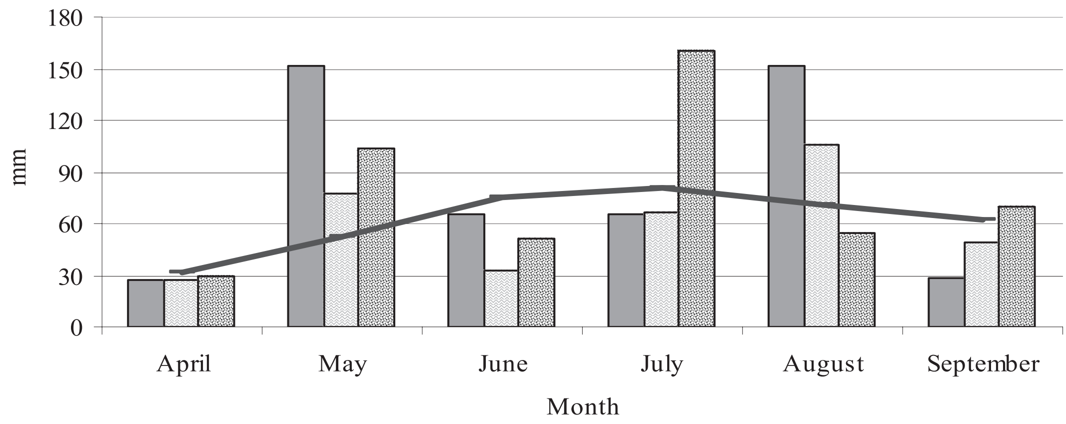

Figure 2. The precipitation during the vegetation period of winter rye in Agricultural Science Centre of Latgale in 2005-2007:
– 2005, – 2006, – 2007, — – long-term average.

The quality of grains of each variety was tested for three (2005-2007) years. Quality traits were detected at 100% purity and 14% moisture level (Linina and Ruza, 2005). The starch content, protein content, and volume weight of grain were determined by "Infratec 1241" in the stock company "Rēzeknes dzirnavnieks". The result of bioethanol was calculated (Lyons et al., 1995) using formula:

$$E = \frac{S \cdot K \cdot 41.15}{100 \cdot 180 \cdot 162 \cdot 100} \quad (1)$$

where E – ethanol, t ha^{-1};
S – grain yield (12% moisture level), t ha^{-1};
K – starch content, %;
180.00, 162.00, and 41.15 – coefficients.

The MS Excel program was used for data statistical processing. There were used the ANOVA method (factor A – years, factor B – winter rye varieties, and factor C – N fertiliser rates), and the correlation and regression analysis. The test of statistically significant differences ($LSD_{0.05}$) at Fisher criterion (F-test) and density of factors' influence (η^2, probality <0.05) were used for the analyses of means differences and correlation ratio (r) (Доспехов, 1985; Arhipova and Bāliņa, 2003).

Results and Discussion

The year (A), the variety (B), the fertilizer rates (C), and the interaction of factors AB, AC, BC, and ABC significantly influenced the yield of grain and the starch content with 95% probability. The seed yield and its formation process depend on genetic, environmental, and agronomic factors as well as on the interaction between them (Stramkale et al., 2008). In our experiment, the starch content, yield and the obtained bioethanol quantity changed and depended on the used variety, the growing year, and the fertilizer rate (Table 1). Also other authors (Maļecka and Strazdiņa, 2004; Šmatas and Gaurilčikiene, 2005) reported on the year's (factor A) influence on the yield and starch content of winter rye.

The highest average yield of the trial years was in 2007 – 7.73 t ha^{-1} (Table 1); for variety 'Walet' it was 6.66 t ha^{-1}. The average starch content for 'Amilo' was 613.8 g kg^{-1}. The ethanol outcome from 1.0 t of grain for 'Amilo' was 274.26 kg, and for 'Walet' – 273.94 kg. In the literature (Maļecka and Strazdiņa, 2004; Tupits, 2008), 'Kaupo' is considered as one of the best varieties (Figures 3 and 4).

Table 1

Effectiveness of winter rye growing technologies (average in 2005-2007) in Agricultural Science Centre of Latgale

Factors	Yield, t ha^{-1}	Starch, g kg^{-1}	Ethanol production, t ha^{-1}	Ethanol outcome from 1 t of grain, kg
Cultivation year – factor A				
2005	6.34	611.1	1.73	273.06
2006	5.37	606.6	1.46	271.07
2007	7.73	618.2	2.14	276.23
$LSD_{0.05}$	**0.02**	**1.1**	**0.10**	**0.47**
Winter rye varieties – factor B				
Kaupo	6.41	610.9	1.75	272.98
Amilo	6.33	613.8	1.74	274.26
Valdai	6.52	610.2	1.78	272.63
Walet	6.66	613.1	1.83	273.94
$LSD_{0.05}$	**0.02**	**1.2**	**0.10**	**0.55**
Fertilizer rate, kg ha^{-1} – factor C				
N30	5.86	612.9	1.60	273.86
N60	6.13	614.3	1.68	274.49
N90	6.48	611.0	1.77	273.01
N60+30	6.77	611.6	1.85	273.28
N90+30	7.17	610.2	1.95	272.66
$LSD_{0.05}$	**0.03**	**1.4**	**0.10**	**0.61**

The highest starch content (614.3 g kg^{-1}) and the highest ethanol outcome from 1.0 t of grain were observed at fertilizer rate N_{60} (Table 1). Table 1 shows that ethanol outcome in 2007 was better than in 2005 and 2006; however, the difference was only 3.17 kg and 5.16 kg, respectively. At the same time, bioethanol production differed significantly and made 0.41 t ha^{-1} between 2005 and 2007, and 0.68 t ha^{-1} between 2006 and 2007. The weather conditions in June 2007 were favourable for winter rye growing and harvesting.

Figure 3 demonstrates that meteorological conditions (factor A) have substantial influence on the varieties of grain for ethanol outcome. The best varieties in 2005 were 'Kaupo' and 'Valdai', but in 2006 and 2007 – 'Amilo' and 'Walet'.

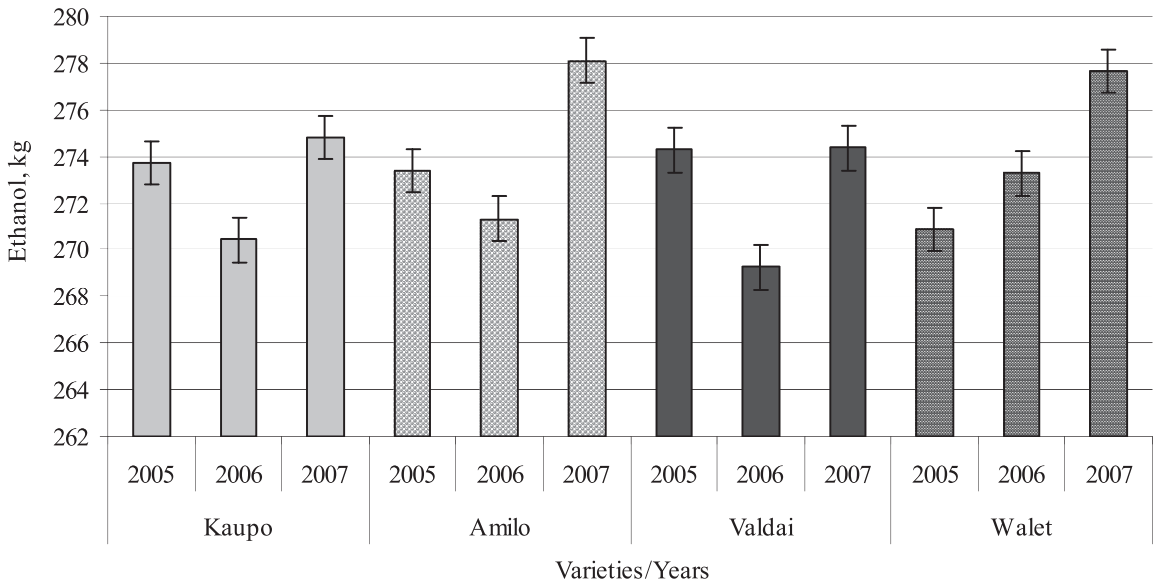

Figure 3. The interaction between the varieties and the year's influence on the average ethanol outcome from 1 t of grain (kg) in the Agricultural Science Centre of Latgale.

Fertilizer rates have influence on the variety and the ethanol outcome from 1.0 t of grain (Figure 4). Fertilizer rate N_{60} is favourable for growing the varieties 'Kaupo' and 'Walet'. The fertilizer rates N_{30} and N_{60} are less influenced from meteorological conditions (Figure 4 and 5). The fertilizer rates influence the ethanol outcome from 1.0. t of grain and the productivity of the variety. To reduce the nitrate content accumulation in crops which result in higher protein and lower starch content, the plant uses up its level of starch resources (Yanagisawa, 2004). The research showed that the higher the starch content, the higher the ethanol outcome from 1.0 t of grain. A comparatively high ethanol outcome from 1.0 t of grain was obtained from varieties 'Kaupo' and 'Walet' at low fertilizer rates (N_{30} and N_{60}).

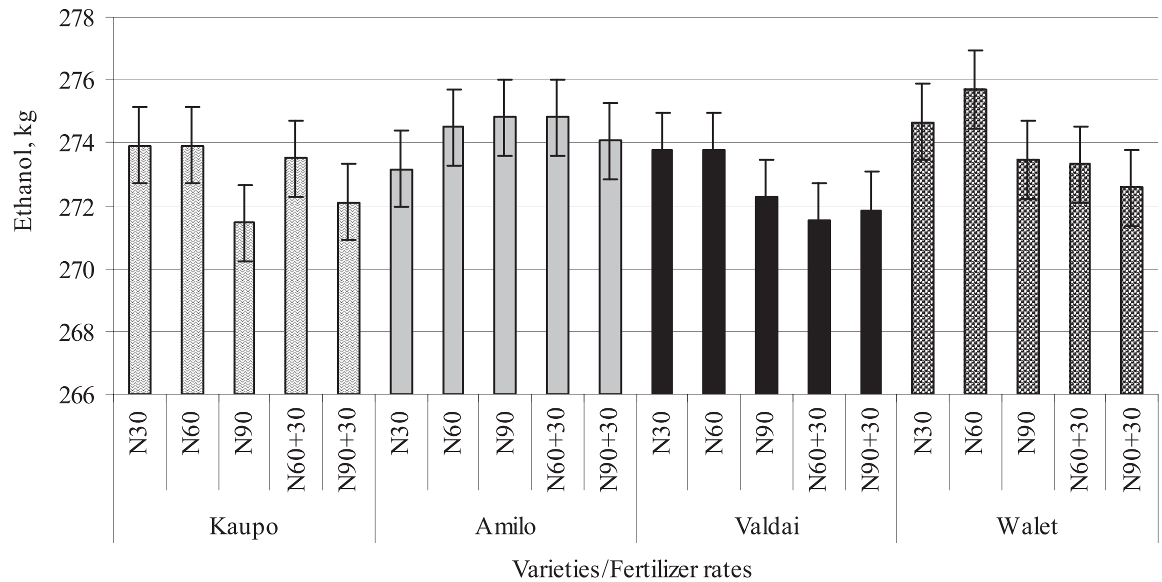

Figure 4. The interaction between the varieties and the fertilizer rates' influence on the average ethanol outcome from 1 t of grain (kg) in the Agricultural Science Centre of Latgale in 2005-2007.

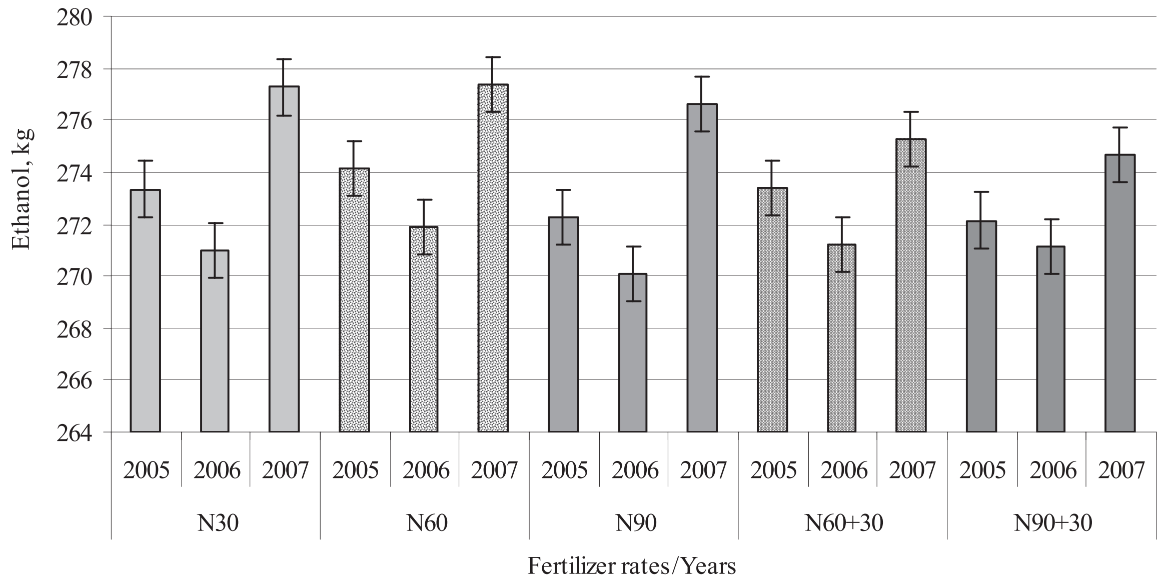

Figure 5. The interaction between the fertilizer rates and the year's influence on the average ethanol outcome from 1 t of grain (kg) in the Agricultural Science Centre of Latgale.

The influence of factors showed that the greatest difference in starch content was provided by the differences in meteorological conditions during the trials years, the interaction between AB factors, and the effect of unexplored factors. The variety had little (4.2%) influence on the starch content in grains (Table 2). The cultivation year, N fertiliser rate, and interaction between factors AB had the dominating influence on the grain yield. All the above factors had 95% probability.

Table 2

The influence of factors on winter rye grain yield and grain quality indices, η^2, %, in Agricultural Science Centre of Latgale (2005-2007)

Factor	Grain yield	Protein content	Starch content	Volume weight	1000 grain weight
Cultivation year – factor A	65.0*	85.4*	42.0*	67.3*	68.0*
Winter rye varieties – factor B	1.1	1.1	4.2*	13.4*	7.0*
N fertiliser rates – factor C	14.7*	2.8	3.9*	1.6	0.3
Interaction between factors AB	15.0*	5.5*	16.4*	3.9*	15.3*
Interaction between factors AC	1.8	0.6	2.5	0.7	2.6
Interaction between factors BC	1.3	1.0	4.3*	2.9*	3.3*
Interaction between factors ABC	0.9	1.3	8.7*	6.5*	3.0*
Effect of unexplored factors	0.2	2.3	15.7*	3.2	0.6

* $F>F_{0.05}$.

The analysis of paired regression between starch content and protein content (r=-0.65*; R^2=0.42; linear regression model y=-0.2257x + 63.69), and between starch content and 1000 grain weight (r=-0.56*; R^2=0.31; linear regression model y=-0.1085x + 64.806) revealed a negative correlation. A positive correlation was established between the starch content and the yield (r=0.58*; R^2=0.34; linear regression model y=0.3204x + 59.122), and between the starch content and the volume weight (r=0.48*; R^2=23; linear regression model y=0.016x + 49.434). The starch content and the yield were changing and depended on the variety, growing year, and fertilizer rate.

Conclusions

The highest starch content and ethanol of 1.0 t of winter rye grain was obtained at the fertilizer rate N_{60}. The difference between fertilizer N_{90+30} and N_{30} was 0.35 t ha^{-1}.

At 95% probability, factors A, C, and AB were most influential on the grain yield. As to the starch content, factors A, AB and the effect of unexplored factors were dominating.

The highest yield and starch content resulting in the highest ethanol production and outcome for 1.0 t of grain were in 2007, whereas the years 2005 and 2006 were less productive.

For bioethanol production it is recommended to use good quality grain with high starch content and high volume weight but with low protein content and 1000 grain weight. In order to successfully fulfil the Directive 2003/30/EC, winter rye varieties 'Kaupo', 'Amilo', and 'Walet' are recommended for bioethanol production.

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INFLUENCE OF AGROECOLOGICAL FACTORS ON WINTER OILSEED RAPE (*BRASSICA NAPUS* L.) AUTUMN GROWTH

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Abstract

Sowing area under oil-seed rape (*Brassica napus* L.) has increased during last decade in Latvia and has become more or less stable since 2007. Lack of research on impact of sowing date, sowing rate, fungicide as growth regulator application and other agroecological factor issues on rape autumn growth is observed. The aim of our research, started in autumn 2007 in Research and Study farm 'Vecauce', was to investigate the influence of applied agroecological factors (five sowing dates, four sowing rates and fungicide (as growth regulator in autumn) application on two type winter rape varieties development in autumn. Winter rape biometrical parameters, dry matter content and dry mass per m^2 of leaves were estimated. Sowing date affected height of growth point, root neck diameter, plant and root mass, main root length significantly ($p<0.05$). Sowing rate affected only some indices significantly in autumn 2007. Fungicide (juventus 90 s.c. - metconasol 90 g L^{-1}) application also affected rape plant biometric parameters during autumn depending on conditions of research year – height of growth point decreased only in year 2007, effect on number of leaves per plant was observed in both trial years, plant weight (2007) and root length (2008) were affected for hybrid variety. Sowing date showed effect on dry matter content in leaves as well as on dry matter mass of leaves per 1 m^2. Fungicide application increased dry mass of leaves per 1 m^2 in two earlier sowing dates. Results are important also for outline of further research directions evaluating significance of above mentioned factors for winter rape wintering in Latvia.

Key words: winter rape, sowing date and rate, growth regulator, plant biometric indices.

Introduction

Latvia, especially the central region, has suitable soil and meteorological conditions for winter rape cultivation. The area for growing rape (*Brassica napus* L.) is increasing in the world. Sowing area under oilseed rape has grown during last 10 years also in Latvia, but last two years have shown some stabilization of it: 99 600 ha in 2007 and 83 000 ha in 2008. Demand for rapeseed used for biofuel is increasing. On-going rapeseed prices were the main reason along with positive effect of rape in crop rotation for increasing area under oilseed rape in Latvia. There is still huge potential to increase rape production capacity to reach 5.75% of bio-fuel from the total amount of transport fuel existing in common national economy, which is the target for 2010 set by EU.

Winter rape growing techniques are quite similar across Europe, with the exception of sowing time, which ranges from 1st August to 10th September (Luthman and Dixon, 1987; Velicka, 2003). Previously investigated data in Lithuania and Latvia indicates that winter rapeseed overwintering depends on plant development stage and biological indicators at the end of the autumn vegetation period (Velicka et al., 2006; Balodis et al., 2007a, 2007b). Quantitative parameters of biological indicators such as number of leaves, height of terminal bud (growth point), diameter of root collar (neck), root length and root mass of rape characterize rape growing in autumn. Before the winter period, rapeseed plant should create a sufficient above ground and root mass, but on the other hand, it should not be overgrown (Becka et al., 2004). Different agroecological factors have an effect on rape autumn growth. The degree of rape development in autumn is described by the number of leaves per plant, diameter of the root collar, dry matter content in the plant, height of stem and other indicators (Luthman and Dixon, 1987; Velicka, 2003; Velicka et al., 2006; Becka et al., 2004; Balodis et al., 2007a, 2007b; Laaniste et al., 2007). Successful overwintering that depends mainly on good autumn growth of rape plants is observed after they develop sufficient amount (6-8) of leaves; therefore, the autumn development of oilseed rape leaves may affect not only their wintering and subsequent vegetative renewal in spring, but also the yield. Collar or root neck diameter has to be 8-10 mm, and distance between terminal bud and ground has to be not more than 3 cm (Diepenbrock, 2000; Velicka et al., 2006). Investigations of dry matter on different winter rape plant parts under field conditions have been carried out by C.G. Kjellstrom and H. Kirchmann (1994), D. Becka et al. (2004) and R. Velicka et al. (2005 and 2006).

The aim of currently described section of our research was to investigate the influence of agroecological factors (sowing date, sowing rate and fungicide (as growth regulator in autumn) application on two type winter rape varieties' development in autumn.

Materials and Methods

The investigations were carried out on winter oilseed rape (*Brassica napus* ssp. oleifera) plants. Three factor field trials with two type winter rape varieties (line 'Californium' and hybrid 'Excalibur') were carried out in the Research and Study farm 'Vecauce' of Latvia University of Agriculture starting with 2007/2008 and continuing in 2008/2009.

Factor A - sowing date: 1st – called 1st August (exactly 2nd August – 2007; 1st August – 2008), 2nd – called 10th August (exactly 10th August – 2007; 11th August – 2008), 3rd – called 20th August (exactly 20th August – 2007; 21st August – 2008), 4th – called 1st September (exactly 31st August – 2007; 30th August – 2008), 5th – called 10th September (exactly 10th September – 2007; 9th September – 2008).

Factor B – Fungicide application (B1 – control, without fungicide; B2 - fungicide applied as growth regulator). Fungicide application scheme: dose (0.5 L ha^{-1}) of fungicide juventus 90 s.c. (metconasol 90 g L^{-1}) was applied at the 4-6 leaf stage (for rape sown on 1st August – on 30th August 2007, 8th September in 2008; sown on 10th August – on 12th September 2007, 13th September in 2008, sown on 20th August – 27th September 2007, 8th October in 2008); rape sown on fourth and fifth sowing dates did not achieve necessary stage for fungicide application at the first ten-day period of October.

Factor C – sowing rate (120, 100, 80, 60 germinate able seeds per m^2 – 'Californium'; 80, 60, 40, 20 germinate able seeds per m^2 – 'Excalibur').

Soil in the trials' site was strongly altered by cultivation loam with pH_{KCl} = 7.2 to 7.4; content available for plants K was 169 to 194 mg kg^{-1} and P - 100 to 115 mg kg^{-1}; humus content 32 to 38 g kg^{-1}. Pre-crop was cereal mixture for silage in both years. Traditional soil tillage with mouldboard ploughing was used. Rototilling was used before sowing. Crop was fertilized with complex mineral fertilizer at the rate of N 12 to 28 kg ha^{-1}, P 18 to 30 kg ha^{-1}, and K 79 to 103 kg ha^{-1} before sowing depending on a year. Sowing was done according previously described design. Weeds were controlled using herbicide butisan star s.c. (metasachlor, 333 g L^{-1} + kvinmerac 83 g L^{-1}) 2.5 L ha^{-1} after rape was germinated in plots of first three sowing dates in 2007 and 2008. For plots of 4th and 5th sowing date herbicide was not used in autumn 2007, but in 2008 butisan star s.c. was used directly after sowing.

Rape plant density was established by counting plants in one constant 0.5 m^2 area of each plot in autumn.

At the end of autumn vegetation (2007 and 2008) 10-plant samples were taken randomly for each plot for biometrical analysis:

- First sowing date: 29 October 2007; 11 November 2008,
- Second sowing date: 30 October, 2007, fungicide treated in 31 October 2007; 12 November 2008,
- Third sowing date: 2 November, 2007; 13 November, 2008,
- Fourth sowing date: 5 November, 2007; 13 November, 2008,
- Fifth sowing date: 6 November, 2007; 19 November, 2008.

Number of leaves per plant (No), leave, plant, root weight (g), root length (cm), diameter of root neck (mm) and height of growth-point (mm), were measured in laboratory.

Ten-plant samples from plots of the first, the second and the third sowing date and all plants sown on 4th and 5th dates from 1.0 m^2 were taken for dry matter content analyses. Dry matter of leaves was determined by drying at temperature of 105 °C for 2 hours (ISO 6496: 1999). Rape leaves dry matter yield per m^2 was calculated according plant number per 1 m^2.

ANOVA procedures were used for processing the experimental data.

Mean air temperature in August and September 2007 (17.9 °C and 11.9 °C respectively) was higher than in 2008 (16.4 °C and 10.6 °C). Fall of 2007 was enough moist for successful seed germination. Different was autumn 2008, when first significant rain for seed germination was recorded only on 14 August that affected seed germination of rape sown on 1 August. Long rain was recorded from 20 August to 29 August (totally 59 mm) that made some difficulties for successful drilling on the 3rd sowing date. Weather on September 2008 was cool and dry (only 14 mm rainfall). Summarizing meteorological conditions of both autumns of research years, one could say that meteorological conditions were considerably different.

Results and Discussion

Rape seed field germination was influenced by soil moisture, especially germination in 2008 was affected by drought in the beginning of August when soil humidity was insufficient. Rainfall period in the third decade of August affected drilling quality in the 3rd (in 2008) and 4th (in 2007) sowing dates. Rape germination was influenced mainly by soil humidity and drilling quality in both trial years. Better average field germination was observed in the second – 10 August and the third – 20 August sowing time plots in both trial years. In plots sown on 1 September in 2007 and sown on 1 August 2008 field germination was considerably different from desirable plant density prescribed in the trial methodology.

From the two-year results (2007-2008), it is evident that winter rape biometrical indices were influenced by the sowing date, rate and fungicide application in autumn period, as well as by used cultivar.

Sowing Date Effect

Two year experiments showed that on average from both years (fungicide untreated) higher growth point was determin_ed for rape sown early (1 August; 28.41 mm for 'Californium', 43.2 mm for 'Excalibur'), lowest height of growth point was observed on the last sowing date (10 September; 4.3 mm for 'Californium', 4.8 mm for 'Excalibur'). Extremely high growth point was noted for both cultivars sown on 1 August 2007 (Fig. 1, 2).

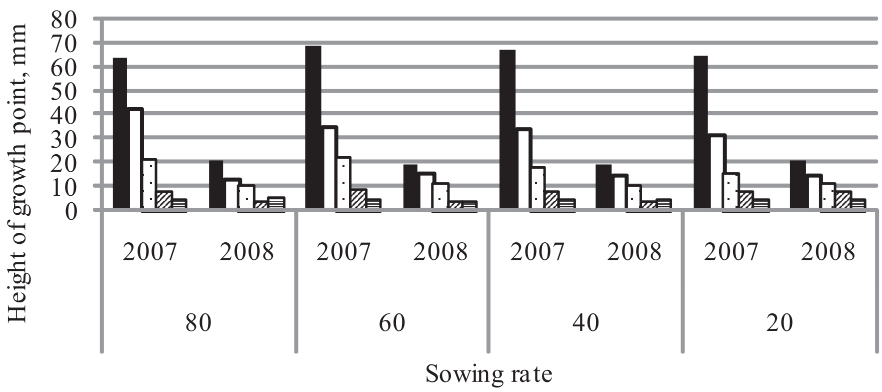

Figure 1. Sowing date and sowing rate influence on winter rape height of growth point of cultivar 'Excalibur' without fungicide application in autumn 2007 and 2008 (mm). Symbols of sowing date: ■ - 1 August; □ - 10 August; ⊡- 20 August; ◪-1 September; ⊟ - 10 September.

Sowing date affected height of growth point significantly (by 85% in 2007 and by 92% in 2008; $p<0.05$) in both trial years for variety 'Californium'. Two year experiments showed that sowing date affected height of growth point significantly (by 95% in 2007 and by 90% in 2008; $p<0.05$) also for variety 'Excalibur'. Optimal height of growth point in our region would not be higher than 30 mm according to results of researchers from Eastern Europe countries (Velicka, 2003; Velicka et al., 2006; Becka et al. 2004; Balodis et al., 2007a, 2007b). In autumn 2007 rape height of grow points were higher than in autumn 2008 that can be explained by different weather conditions, when average air temperature in 2007 was higher than in autumn 2008 during seedling development period. Still, there is a lack of new studies on sowing date effect on biometrical indices of winter rape, but quite lot of information has been found about air and soil temperature impact on winter rape growth during autumn. During August and September temperature decreases; according to Z.P. Kondra et al. (1983) decreased temperature reduces germination rate and as follows – plant density.

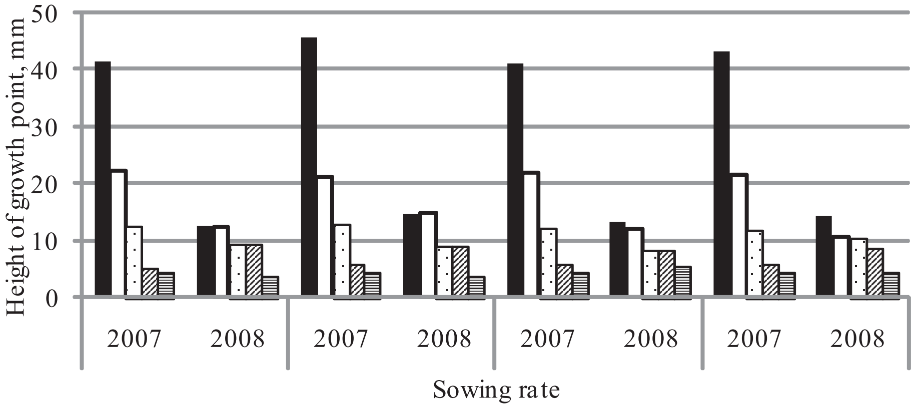

Figure 2. Sowing date and sowing rate influence on winter rape height of growth point of cultivar 'Californium' without fungicide application in autumn 2007 and 2008 (mm). Symbols of sowing date: ■ - 1 August; □ - 10 August; ⊡ - 20 August; ▨ - 1 September; ⊟ - 10 September.

W. Diepenbrock (2006) summarizes that plants should reach the 6-8 true leaves stage in autumn before wintering. The number of leaves per plant in both trial years according to this statement was optimal for good wintering of winter rape except plants sown on the last sowing date (10 September) when 5-6 leaves per plant were noted and leaf area (not measured, but observed visually in both years) was smaller (Table 1). Similar observations were noted by Miliuviene et al. (2004) in Lithuania.

Results of Estonian researchers (Laaniste et al., 2007) indicated that plants before wintering reached 9 - 11 leaves if sown at the beginning of August and 3- 4 leaves if sown at the end of August. Accordingly, it was found that the 7-8 leaf stage proved to be the most optimal for successful overwintering. In our study sowing date significantly affected (by 70% for 'Californium' and by 66% for 'Excalibur' in 2007; by 43% for 'Californium' and by 58% for 'Excalibur' in 2008, $p<0.05$) number of leaves per plant for both cultivars in both trial years. For rape plants sown later less number of leaves was noted at the end of vegetation period. It seems that results for plants sown in the first two sowing dates (1 August and 10 August) probably could be affected by sampling method. Some first fully developed true leaves were already dead at the very end of vegetation period, directly before wintering. Methodology of registration of leaves' number per plant has to be more developed in our next studies.

Table 1

Sowing date and sowing rate influence on winter rape number of leaves per plant on fungicide untreated cultivars 'Californium' and 'Excalibur' in autumn 2007 and 2008

Variety	Sowingrate	Year	Sowing date					Average
			01-Aug	10-Aug	20-Aug	01-Sep	10-Sep	
Californium	120	2007	7.0	7.0	6.0	6.0	4.0	6.0
		2008	7.0	7.0	6.0	7.0	5.0	6.4
	100	2007	7.0	6.0	6.0	6.0	4.0	5.8
		2008	8.0	6.0	6.0	7.0	6.0	6.6
	80	2007	7.0	7.0	7.0	6.0	5.0	6.4
		2008	8.0	7.0	5.0	7.0	5.0	6.4
	60	2007	7.0	7.0	7.0	6.0	4.0	6.2
		2008	8.0	6.0	6.0	6.0	5.0	6.2
		Average	7.4	6.6	6.1	6.4	4.8	x
Excalibur	80	2007	7.0	8.0	7.0	7.0	6.0	7.0
		2008	10.0	8.0	6.0	6.0	6.0	7.2
	60	2007	8.0	8.0	8.0	7.0	5.0	7.2
		2008	9.0	9.0	7.0	6.0	6.0	7.4
	40	2007	8.0	8.0	9.0	7.0	5.0	7.4
		2008	9.0	9.0	7.0	6.0	6.0	7.4
	20	2007	9.0	9.0	10.0	7.0	5.0	8.0
		2008	13.0	7.0	6.0	7.0	6.0	7.8
		Average	9.1	8.3	7.5	6.6	5.6	x

Sowing date affected root neck diameter significantly ($p<0.05$) for both varieties in both trial years. Root neck diameter decreased with later sowing date (on average from both cultivars 9.6 mm for plants sown on 1 August to 2.5 mm – 10 September in 2007; 8.9 mm for plants sown on 1 August to 2.8 mm – 10 September in 2008). Root neck diameter of plants sown on last two sowing dates was less than 5 mm. Researchers from Lithuania found that root neck with diameter less than 5 mm could be risky for good rape wintering (Velicka et al., 2006).

Average (from both cultivars) fresh winter rape plant weight was from 64 g (for rape sown on 1 August to 2 g (for rape plants sown on 10 September) in 2007 and from 49 g (for rape plants sown on1August) to 3.2 g (for rape plants sown on 10 September) sown in 2008. Average root length was higher in 2008 (24.5 cm – rape sown on 1 August; 12.2 cm – rape sown on 10 September) than in 2007 (21.4 cm – rape sown on 1 August to 8.6 cm – rape sown on 10 September). Average root weight was similar in both trial years (10.3 g – rape sown on 1 August to 0.2 g – rape sown on 10 September in 2007, and 10.0 g – rape sown on 1 August to 0.2 g – rape sown on 10 September in 2008).

Higher significant ($p<0.05$) influence of sowing date on winter rape plant weight, root length and root weight was noted for cultivar 'Excalibur' in 2008. Opposite was year 2007 when higher sowing date influence on winter rape plant weight, root length and root weight was noted for cultivar 'Californium' (Fig 3.).

Sowing Rate Effect

According to our two year results, height of growth point was not influenced significantly by sowing rate for both cultivars without fungicide treatment ('Californium': $p=0.921$, 2007; $p=0.247$, 2008; 'Excalibur' $p=0.197$, 2007, $p=0.085$, 2008) (Fig. 1, 2). These results are different from findings of other researchers were the lowest height of growth point was determined in the thinnest crop of rape. High crop density for plants can cause the possibility to spindle (Velicka, 2003; Velicka et al., 2006, Laaniste et al., 2007).

Strong correlation was found between the number of plant leaves and rape crop density in Experimental Station of LUA, 1998-2000 in Lithuania. According to these results more leaves per plant are found in stands with less plant density (Velicka, 2003). Our results shoved that number of leaves per plant was not influenced significantly ($p>0.05$) by sowing rate for cultivar 'Californium' in both years and for cultivar 'Excalibur' in year 2008. Sowing rate and dependant from that plant density significantly affected (by 11%, $p<0.05$) number of leaves per plant for 'Excalibur' in 2007. These results can be affected by method for counting leaves described above (in subsection *'Sowing Date Effect)*

Sowing rate affected root neck diameter, plant weight and root weight significantly ($p<0.05$) for 'Excalibur' in 2007. These parameters were not influenced significantly for another cultivar – 'Californium' by sowing rate.

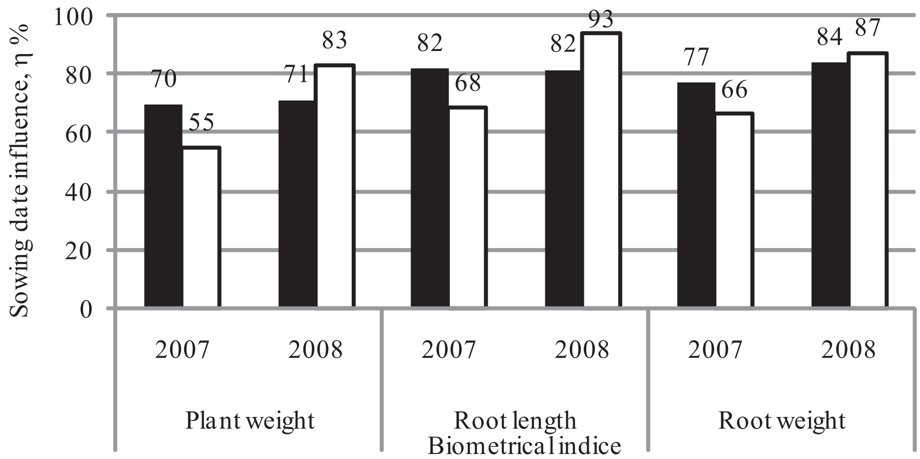

Figure 3. Proportion of sowing date influence on winter rape plant weight, root length and root weight on cultivars 'Californium' and 'Excalibur' in autumn 2007 and 2008, $p<0.05$ (■ - 'Californium'; □ - 'Excalibur').

Fungicide Application Effect

Fungicide (as growth regulator) application was used only for plots sown in the first three dates when rape plants achieved 4-6 true leaf stage. Plants of rape sown in 4th and 5th sowing dates were too small at the first ten-day period of October for fungicide application.

Fungicide application affected significantly (for 'Excalibur' by 16% in 2007, for 'Californium' by 5% in 2007, by 2% in 2008, $p<0.05$) height of growth point (height of growth point was decreased). This is in accordance with results of other studies (Gaveliene et al., 2002; Balodis et al., 2007a, 2007b). Growth point height decrease by fungicide application was noted for both cultivars sown in very early sowing dates (1 and 10 August), but fungicide application did not decrease this parameter for 'Excalibur' sown on 20 August (the 3rd sowing date) in 2008.

Fungicide application increased number of leaves per plant significantly ($p<0.05$) in both trial years. Also this is in accordance with results of other researchers and our previous investigations (Miliuviene et al., 2004; Gaveliene et al., 2005; Balodis et al., 2007a, 2007b) where more leaves were obtained using fungicide as growth regulator.

Researchers in Lithuania (Gaveliene et al., 1998, Miliuviene et al., 2004) found that use of growth regulators increased significantly the main root diameter and root mass in autumn. Our research showed that root neck diameter and plant weight were affected significantly by fungicide application for 'Excalibur' in 2007, but root length - in 2008.

Dry Matter Content and Dry Mass at the End of Autumn Vegetation Period

Other important indicators of rape vegetative growth in autumn and wintering are chemical composition of root column and crown bud, dry matter content of leaves and dry matter mass per 1 m^2. These parameters along with biometrical indices characterize plant development during autumn growth (Luthman et al., 1987).

Dry matter content in leaves of winter rape was defined in autumn 2008 when active vegetation stopped (11 – 19 November). In our research amount of dry matter was noted from 200 g kg^{-1} in leaves of 'Californium' sown on 1 August (sowing rate - 120 germinate able seeds per 1 m^2) to 80 g kg^{-1} in leaves of 'Californium' sown on 1 September (sowing rate - 80 germinate able seeds per 1 m^2) (Fig. 4). Higher dry matter content was observed in earlier sown winter rape plant leaves, and it decreases during later sown rape. Unexplainable for the present exception was only leaves of plants sown on the last sowing date (10 September) when higher dry matter content was noted (Fig. 4). Velicka et al. (2006) found dry matter content from 190 – 280 g kg^{-1} that is higher if compared with our results. Further investigations about dry matter content of rape plant including leaves should be done in Latvia's conditions.

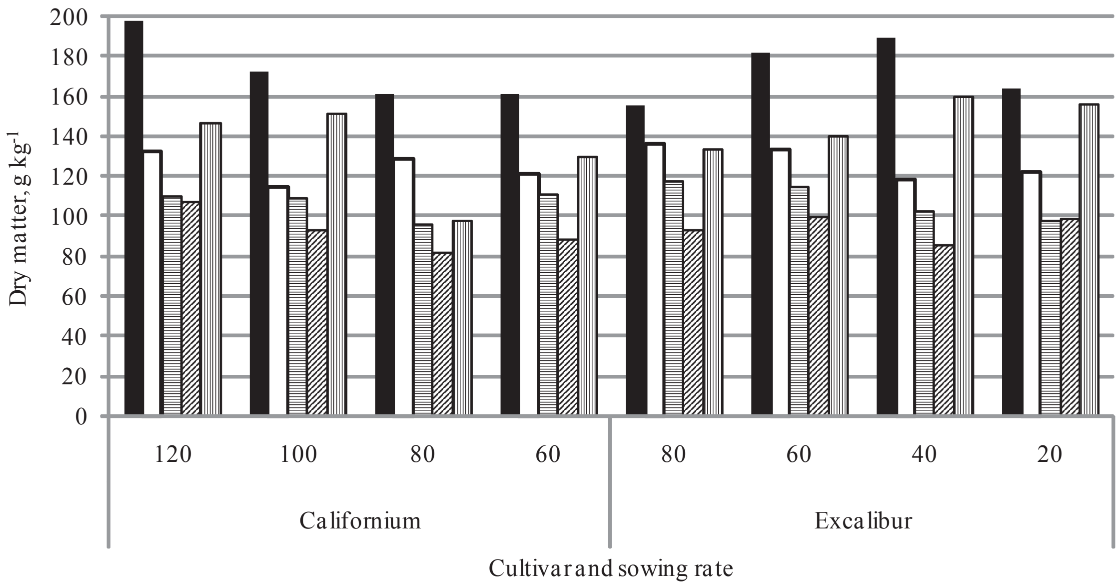

Figure 4. Sowing date and sowing rate influence on winter rape dry matter in leaves in autumn vegetative growth on cultivars 'Californium' and 'Excalibur' in autumn 2008
(■ - 1 August; □ - 10 August; ⊟ - 20 August; ▨ - 1 September; ◫ - 10 September).

Sowing date affected dry matter mass of leaves per 1 m^2 at the end of vegetation period significantly (by 74% - 'Californium' and by 58% - 'Excalibur', $p<0.05$). Also sowing rate affected dry matter mass of leaves per 1 m^2 significantly (by 6% - 'Californium' and by 11% - 'Excalibur', $p<0.05$). Amount of dry mass per 1 m^2 of leaves was noted from 164 g m^{-2} ('Excalibur' sown on 1 August at the rate 80 germinate able seeds per 1 m^2) to

1.5 g m^{-2} ('Californium' sown on 10 September at the rate 80 germinate able seeds per 1 m^2). Dry mass of leaves per 1 m^2 is not the only indice that could characterize winter rape autumn growth. Also dry mass of roots, dry mass of all above-ground biomass and dry mass of whole plant are important indicators (Kjellstrom 1994, Becka et al., 2004, Velicka et al., 2005).

Fungicide application increased dry matter mass of leaves per 1 m^2 significantly ($p<0.05$, $LSD_{0.05} = 8.37$) for cultivar 'Californium' sown on earliest dates (1 and 10 August). No significant impact of fungicide application was observed for rape sown on 20 August (the 3rd sowing date) (Fig. 5). Fungicide application effect on dry matter mass of leaves per 1 m^2 was not found for cultivar 'Excalibur' ($p>0.05$). More investigations should be performed on agro-ecological factors' impact on winter rape dry mass indices in different parts of plant.

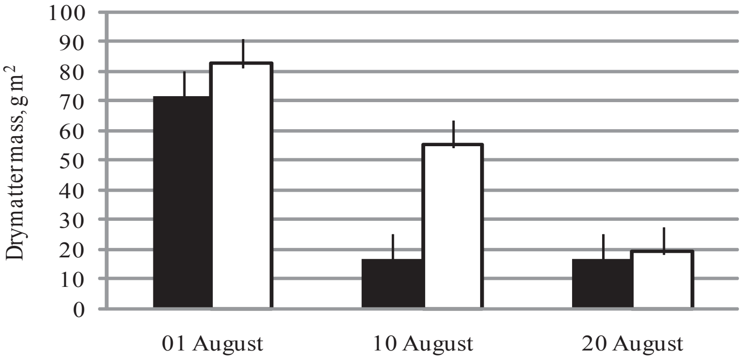

Figure 5. Fungicide application impact on rape dry matter mass per m^2 of leaves in autumn vegetative growth on cultivars 'Californium' in 2008 (■ - control without fungicide; □ - application of fungicide juventus 90).

Conclusions

1. Research results showed that sowing date was the main factor that had strong and significant impact on biometrical parameters of rape plants in autumn. Earlier sowing date increased height of growth point, root neck diameter, plant and root mass, main root length significantly for both cultivars.
2. Sowing rate affected number of leaves per plant, root neck diameter, plant weight and root weight significantly for hybrid cultivar in 2007. Height of growth point was not influenced significantly by sowing rate neither for 'Excalibur' nor 'Californium'.
3. Fungicide as growth regulator (juventus 90 s.c. - metconasol 90 g L^{-1}) application also affected rape plant biometric parameters significantly during autumn: significantly decreased height of growth point in 2007 for both cultivars and for 'Californium' in 2008, increased number of leaves per plant in both trial years, and increased plant weight (in 2007) and root length (2008) only for hybrid cultivar 'Excalibur'.
4. With later sowing date dry matter content in leaves decreased, unexplainable exception was the latest date (10 September) for both cultivars. Sowing date and rate affected dry matter mass of leaves per 1 m^2 significantly for both cultivars. Fungicide application increased dry mass of leaves per m^2 in the first two sowing dates (1 August; 10 August) for cultivar 'Californium', but not for 'Excalibur'.
5. As the winter rape winterhardiness is a risk factor of high significance, investigations on rape development during autumn and its affecting factors should be continued. Described results are important for outlining some further research directions in Latvia.

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INFLUENCE OF MAIZE HYBRID AND HARVEST TIME ON YIELD AND SUBSTRATE COMPOSITION FOR BIOGAS PRODUCTION

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Abstract

Maize is increasingly used for energy production in agricultural biogas plants. The first biogas production project in agriculture is realized in the Research and Study Farm (RSF) "Vecauce" of the Latvia University of Agriculture in 2008 and animal manure together with plant biomass are planned to be used as substrate. The paper aimed to evaluate ten maize hybrids possibly suitable for biomass production at three different harvesting times.

Field trial was carried out in Research and Study farm "Vecauce" of the Latvia University of Agriculture in 2008. Ten maize hybrids with different maturity rating according FAO numbers (FAO 180 – 270) were harvested at three different times beginning on 5 September at fourteen days intervals. Results showed that harvest time effect on maize yield was substantial ($p<0.05$), but hybrid influence on the average yield per all harvest dates was not substantial ($p>0.05$). The highest organic dry matter yield was obtained harvesting maize on October 3. The Total N, crude ash, protein, fiber, cellulose, lignin, neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentration decreased, but crude fat concentration increased during plant development. Relevance was not noticed between harvest dates and total carbon and hemi – cellulose content. The C : N ration rose from 34.76 at first, early harvest on 5 September to 37.97 at the last harvest on 3 October.

Key words: maize hybrid, harvesting time, biogas, chemical composition.

Introduction

From an ecological and economical perspective, biogas is an important source of energy. The fossil resources are limited. With the technological progress made in recent years, high energy efficiency and low-maintenance operation have made investment into biogas facilities more attractive. In the last ten to twenty years, biogas plants have become a major point in the effort to use renewable sources of energy to generate electricity in Western Europe. It is essential to develop sustainable energy supply systems that aim to cover the energy demand from renewable sources. Mitigation of greenhouse gas emissions through renewable energy production is of rising importance. Biogas production is of major importance for the sustainable use of biomass from agriculture as renewable energy source (Amon et al., 2007a). Production of methane rich biogas through anaerobic digestion of organic materials provides a clean and versatile form of energy. Biogas can be used for heat and power generation.

Biogas production from energy crops is of growing importance. Biogas production has higher demands for arable land, assets and work than other forms of renewable energy production. Therefore, economic efficiency must be given particular attention. Economic biogas production requires high biogas yields (Ress et al., 1998).

Three biogas plants that use organic waste are operated now in Latvia. The biogas produced is used for electricity co-generation. Nowadays, only 1% of electricity produced from renewable energy resources is produced using biogas. But the Ministry of Environment of Latvia has developed a programme for biogas production and utilization in the period 2007-2011. The greatest potential of biogas production is related to agricultural sector: from 13 million m^3 of the biogas produced in 2011, ~64% should be produced using substrates from agriculture. In Latvia according to drastically increasing prices for energy during the recent years, the interest about energy from alternative energy resources and especially for biogas increases (Adamovics et al., 2008). The first biogas production project in agriculture is realized in the Research and Study Farm (RSF) "Vecauce" of the Latvia University of Agriculture in 2008 and animal manure together with plant biomass are used as substrate.

Maize has recently been established as an energy-rich and technically advantageous substrate for the production of electricity from renewable sources of energy in biogas plants. Maize is yet the most dominating crop for biogas production in Europe. Maize is considered to have the highest biomass yield potential of all field crops grown in Central Europe (Amon et al., 2007a). In Germany the acreage of maize for co-digestion with slurry or mono-digestion has been expanded which is mainly due to its high methane yields per hectare and the storability of maize silage (Herrmann et al., 2006). The increasing use of maize as a biogas substrate raises questions concerning the morphology and chemical composition of the ideal maize (Schittenhelm, 2008).

Key factors for a maximum biogas yield from maize are hybrid, time of harvesting, mode of conservation and pretreatment of the biomass prior to the digestion process, but also the nutrient composition of the energy crop. Guidelines on optimum maize production, optimum harvesting time, optimum nutrient composition, optimum conservation and pre-treatment technology must be developed. Requirements on the biomass quality are different when crops are anaerobically digested in biogas plants compared to being fed to cattle. The digester at the biogas plant offers more time to degrade the organic substance than the rumen does. In addition it is likely to assume that the micro-organism population in the digester is different from that in the rumen. Biogas plants can degrade cellulose to an extent of about 80% (Ress et al., 1998) whereas in the rumen and total digestive tract of ruminants cellulose will be broken down to a degree of approximately 40% and 59%, respectively. T. Amon (2002) found that maize silage gave a 21% higher specific methane yield than fresh maize. Lactic acid formation during silage delivers precursors that are important for methane formation during anaerobic digestion. Ninety five percent of maximum possible methane yield was achieved after 40 – 45 days of anaerobic digestion with all experiments.

With biogas production, the key factor to be optimized the methane yield per hectare. This may result in different harvesting strategies when growing energy crops for anaerobic digestion compared to growing them as a forage source for ruminants. Specific harvest and processing technologies and specific genotypes are required when crops are used as a renewable energy source (Amon et al., 2007b). Many problems that are still unresolved are pointed out in the fields of harvest time optimization, assessment of energy maize production with respect to C and N flows at system level (Herrmann et al., 2006).

The paper aimed to evaluate ten maize hybrids possibly suitable for biomass production at three different harvesting times.

Materials and Methods

Two-factor field trial was carried out in 2008 in Research and Study farm "Vecauce" (latitude: N 56° 28´, longtitude: E 22° 53´) of the Latvia University of Agriculture. Trials were arranged in four replication randomized blocks with plot size 16.8 m^2. Row width was 0.7 m. Planted population density 82000 plants per ha. Original seed of ten maize hybrids (Factor A) with different maturity rating defined by FAO number (Tango (standard, FAO 210), Target (FAO 180), Estelle (FAO 200), Salgado (FAO 200), Silas (FAO 210), Turini (FAO 220), Ceklad (FAO 235), Celio (FAO 250), Cemet (FAO 260), Celido (FAO 270)) were used. Soil at the site was strongly altered by cultivation sand loam with pH_{KCl} – 6.7, available for plants content of P – 112 mg kg^{-1}; K – 99 mg kg^{-1}, humus content – 19 g kg^{-1}. Maize was sown on May 6. Traditional soil tillage was used: mould-board ploughing in previous fall, cultivation and rototilling before sowing in spring. The following fertilizers were given : 34 kg ha^{-1} P, 75 kg ha^{-1} K, 148 kg ha^{-1} N (18+70+60). Planting was carried out by hand handled planter at 3-4 cm depth. Weeds were controlled by spraying herbicides (arrat d.g. 200 g ha^{-1} (triosulfuron 250 g kg^{-1}; dicamba 500 g kg^{-1}) and titus 25 d.g. 50 g ha^{-1} (rimsulfuron 250 g kg^{-1}) together with surfactant) on June 6, and mechanically on July 7. Harvesting was done at three different times (factor B), beginning with September 5 (120 days after sowing). The second harvest time was done on September 19 (134 days after sowing) and the third on October 3 (148 days after sowing). Yield was accounted from 0.7 m^2 on 5 and September 19 and from 8.4 m^2 on October 3. The following observations were carried out during the season: field germination, flowering, plant density before harvest, plants per ha (data are not presented), green, dry matter (DM) and organic dry matter (ODM) yield, t ha^{-1}. The following parameters were determined for all hybrids using standard methods: dry matter (DM) (samples were dried up to constant weight at 105 °C) and organic dry matter (ODM) (calculated from DM and ach content) content of fresh yield, crude protein, g kg^{-1} of DM (ISO 5983), crude fiber, g kg^{-1} of DM (ISO 5498:1981), cellulose, g kg^{-1} of DM (calculated from NDF and ADF), hemicellulose, g kg^{-1} of DM (calculated from NDF and ADF), lignin, g kg^{-1} of DM (calculated from ADF), crude fat, g kg^{-1} of DM (ISO 6492:1999) total N, (by Kjeldahl method), neutral detergent fibre (NDF), g kg^{-1} of DM (LVS EN ISO 16472:2006), acid detergent fibre (ADF), g kg^{-1} of DM (Forage analyses, USA, method 4.1:1993) and ash (XA), g kg^{-1} of DM (ISO 5984), total carbon (C), g kg^{-1} of DM (CS – 500 method)). Results were statistically analyzed using analysis of variance. Average day and night temperature from April 25 to October 3 was 14.3 °C. Sum of precipitation during the same period was 230 mm. Average soil temperature during maize germination from May 6 till May 21 was 10.8 °C. Season was cool and dry if compared with long term average data.

Results and Discussion

Plant management and the stage of vegetation when maize is harvested must be optimally chosen to maximize the methane yield (Amon et al., 2007a). Maize was harvested at three different times in course of the vegetation period. ODM yield substantially ($p<0.05$) depended on harvest time. Average ODM yield increased from September 5 till October 3 by 2.35 t ha^{-1} (Table 1). Maize hybrid influence on average ODM yield was not substantial ($p=0.148$). Range of average DM content of maize hybrids per all three harvest dates was wide (from 216.7 g kg^{-1} (Celio) to 266.4 g kg^{-1} (Target)) (Table 2), but average per all three harvest dates ODM yield for maize hybrids ranged from 11.28 t ha^{-1} (Silas) to 12.78 t ha^{-1} (Turini). Maize hybrid influence on ODM at first two harvest times (September 5 and September 19) was not substantial ($p=0.41$ and $p=39$, respectively), but maize hybrid influence at last harvest time (3 October) was substantial ($p=0.02$). Average ODM yield was 95.2% from the total DM yield. T. Amon et al., (2007a) found the similar average ODM yield (95.8%) from the total DM yield.

T. Amon et al., (2004) reported that methane yield per hectare is markedly influenced by hybrid and time of harvesting. Late ripening maize hybrids (FAO 600) make better use of their potential to produce biomass than medium (FAO 300 – 600) or early ripening (FAO 240 – 300) hybrids in Austria. With early to medium ripening hybrids, the optimum harvesting time is at the „end of wax ripeness". Late ripening hybrids may be harvested later, towards „full ripeness". Z. Gaile (2008b) found that in conditions of Latvia wax ripeness could be reached only by using hybrids characterised by FAO numbers up to 220 and even so not always. It means that according to previous results hybrids, mentioned as "early ripening" in Austria are too late for Latvia (Gaile, 2008a).

Table 1

Organic Dry Matter Yield of Maize Depending on Hybrid and Harvesting Time, t ha^{-1}

Hybrid – factor A	FAO	Maize harvesting time – factor B			Average for A
		5.09.2008.	19.09.2008.	3.10.2009.	$p=0.148$
Tango - st.	210	11.63	12.42	11.77	11.94
Ceklad	235	10.23	11.75	12.15	11.38
Celio	250	11.17	12.49	13.19	12.28
Cemet	260	10.47	12.34	14.52	12.44
Celido	270	10.85	11.55	13.80	12.07
Estelle	200	10.79	11.37	14.01	12.06
Target	180	11.32	12.76	12.68	12.25
Turini	220	11.56	13.38	13.40	12.78
Salgado	200	10.96	12.38	13.21	12.18
Silas	210	9.70	10.71	13.44	11.28
Average for B $LSD_{0.05}=0.56$	x	10.87	12.12	13.22	x
$LSD_{0.05}$ or p – value for hybrid at specific harvest time	x	$p=0.41$	$p=0.39$	$p=0.02$ $LSD_{0.05}=1.87$	x

T. Amon et al., (2007a) found that the latest harvest at full ripeness resulted in a loss in net total biomass yield. The reduction in biomass yield from late harvesting of early ripening maize hybrids may be due to respiration and/or breakage losses. The optimum harvesting time for maize is reached at a dry matter content of 30 – 35%. Maize can then easily be ensilaged and gives maximum biomass yields. A. Lemmer et al., (2003) found that the maize hybrids showed a clear dependence of dry matter yield per area unit on the time of harvest and maturity group. Scientists recommend using maize for biogas production that matures only slightly later (maximal 50 FAO units) than the forage maize typically grown at a given location (Schittenhelm, 2008).

DM content depended on harvest time. Average per all three harvest dates DM content for maize hybrids ranged from 216.7 g kg^{-1} (Celio) to 266.4 g kg^{-1} (Target) (Table 2). Another hybrid which showed high average DM content per all three harvest dates was Turini (259.7 g kg^{-1}). The highest average DM content was reached when maize was harvested on October 3. Highest DM content was reached by two hybrids (Target 307.40 g kg^{-1}, Silas

305.80 g kg^{-1}) on 3 October (Table 2). From September 5 to October 3 DM content increased by 67.6 g kg^{-1}.

Average dry matter content 294.9 g kg^{-1} was reached by early ripening (FAO 180-220) maize hybrids at last (October 3) harvest time, but for medium ripening maize hybrids (FAO 235 – 270) average DM content at the same harvest date was 247.8 g kg^{-1}. T. Amon et al., (2004) found that with late ripening maize hybrids, the optimum methane yield per hectare is achieved if maize is harvested at >430 g kg^{-1} (43%) dry matter. Methane yield from late ripening hybrids reached a maximum at full ripeness. Possibility in our conditions to reach so late development stage and so high DM content of yield is doubtful even using early maturity hybrids.

Table 2

Dry Matter Content of Maize Depending on Hybrid and Harvesting Time, g kg^{-1}

Hybrid – factor A	FAO	Maize harvesting time – factor B			Average for A
		5.09.2008.	19.09.2008.	3.10.2009.	
Tango - st.	210	221.20	250.90	280.40	250.80
Ceklad	235	191.60	234.70	246.90	224.40
Celio	250	188.80	217.60	243.70	216.70
Cemet	260	195.00	213.80	258.40	222.40
Celido	270	184.70	206.20	242.00	211.00
Estelle	200	219.00	254.80	289.90	254.50
Target	180	234.10	257.70	307.40	266.70
Turini	220	223.40	262.20	293.60	259.70
Salgado	200	218.90	247.20	292.10	252.70
Silas	210	207.90	259.40	305.80	257.70
Average for B	x	208.46	240.44	276.02	x

The total N, crude ash, protein and fiber, cellulose, lignin, NDF and ADF concentration decreased during plant development (Table 3). The highest ash content 41.2 g kg^{-1} was noted on 5 September. The highest average crude protein was also noted on 5 September (77.9 g kg^{-1}) and lowest on 3 October (69.1 g kg^{-1} %). Average Crude protein content between hybrids ranged from 67.8 g kg^{-1} (Tango) to 76.6 g kg^{-1} (Celido).

Methane production from organic substrates mainly depends on their content of substances that can be degraded to CH_4 and CO_2. Composition and biodegradability are key factors for methane yield from energy crops. Crude protein, crude fat, crude fiber, cellulose, hemi – cellulose, starch and sugar markedly influence methane formation (Amon et al., 2007a).

Table 3 gives average chemical content of maize hybrids at different harvesting times. The C : N ration rose from 34.76 at first, early harvest on 5 September to 37.97 at the last harvest on 3 October.

The raw fiber content has a decisive influence on the degradability of the organic dry substance and thus negatively affects the methane yield. C : N ration of the substrates also exerts a significant influence on the methane yield (Lemmer et al., 2003). When the C : N ration is too wide, carbon can not optimally be converted to CH_4 and the CH_4 production potential is not fully used. A. Lemmer et al., (2003) found that if C : N ration is only approximately (15 : 1) the organic mass cannot be completely converted even at low fiber contents. Substrates having a C : N ratio of (37 to 45 : 1), like silo maize, allow a significantly higher percentage of the organically bound energy to be converted. The crude fiber content decreased from first to the last harvesting date.

According to findings of T. Amon et al., (2004) crude protein, crude fiber and cellulose content declined in the course of the vegetation period. Hemi – cellulose and starch content increased.

Table 3

Average Content of Chemical Components of Ten Maize Hybrids, g kg^{-1}

Chemical components	g kg^{-1} in dry matter		
	5.09.2008.	19.09.2008.	3.10.2009.
Crude ash	41.2	38.5	34.8
Total N	12.5	11.8	11.1
Crude protein	77.9	73.8	69.1
Total carbon	433.5	410.7	419.3
Crude fiber	232.3	208.8	202.7
Crude fat	15.9	19.7	22.3
Cellulose	240.4	234.6	225.3
Hemi – cellulose	224.5	191.9	197.3
Lignin	10.3	8.9	8.9
Neutral detergent fibre	461.2	435.4	431.5
Acid detergent fibre	250.7	243.5	233.2
C : N ration	34.76	34.76	37.94

Strong harvest date effect was noticed of NDF and ADF content. Table 3 shows that from September 5 to September 19 average NDF content decreased by 25.8 g kg^{-1} and from September 19 to October 3 by another 3.9 g kg^{-1}.

Crude fat concentration increased during plant development. Average crude fat content for maize hybrids ranged from 15 g kg^{-1} (Celio) to 23 g kg^{-1} (Target). Marked relevance was not noticed between harvest dates and total carbon and hemi-cellulose content.

Hybrids with a high protein, fat cellulose, hemi – cellulose, and starch content and with a high potential for biomass production were especially suitable for anaerobic digestion. Crude fiber did not give much methane (Amon et al., 2004). T. Amon (2002) reported that specific methane yield did not depend on the maturity group, but on the nutrient composition that varied between hybrids.

Conclusions

Maize is optimally harvested when organic dry matter yield per hectare reaches a maximum. Our results showed strong harvest time effect on maize ODM yield. Highest ODM yield was obtained harvesting maize on October 3. The maize hybrid influence was not substantial on average ODM yield per three harvest dates. The data presented in this paper demonstrated that ODM yield increase from the first to the last harvesting date.

Delayed harvest of maize in Latvia resulted mainly in crude ash, total N, crude protein, crude fiber, cellulose, lignin, neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentration decrease but crude fat concentration increase. Marked relevance was not noticed between harvest dates and total carbon and hemi – cellulose content.

This paper demonstrated that the C : N ration rose from 34.76 at first, early harvest on 5 September to 37.97 at the last harvest on 3 October.

Acknowledgments

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THE IMPACT OF SOIL PENETRATION RESISTANCE ON WINTER WHEAT YIELD AND DEVELOPMENT

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Abstract

Formation of yield in crop cultivation is affected by influence of many factors. Simple summation of individual factors is quite rare occasion. Interaction among factors is a dynamic value. The effect of interactions varies depending on the crop development stages as well as by graduation of factors. The study aimed to evaluate the soil penetration resistance effect on winter wheat grain yield and development. It allows to specify recommendations for soil treatment difference criteria for use in site-specific soil tillage. Field trials were carried out at the Research and Study farm Vecauce of Latvia University of Agriculture during the years 2005-2007 to investigate factors influencing formation of winter wheat grain yield. Forty seven points (distributed as grid 50x50 m) were selected in the winter wheat *Triticum aestivum* L. field. All points were attached to their geographic coordinates. Data shows significant effect of soil resistance to grain yield - increase of soil penetration resistance by 100 kPa cm^{-2} reduced yield of winter wheat by 0.37 to 0.48 t ha^{-1}. By contrast in 2007 a significant linear regression relationship between soil penetration resistance and the yield was not detected. Differences of fresh weight of winter wheat plants in tillering stage and the beginning of stem elongation were insignificant compared to different groups of soil penetration resistance at soil layers 0.10-0.30 m in both experimental years. Higher impact of soil penetration resistance on flag leaf area difference had soil resistance at the layer of 0.20-0.30 m and differences were significant in both trial years.

Key words: precision field management, winter wheat, soil resistance, yield, cereal development.

Introduction

Precision crop cultivation is a form of modern field management using new technologies, machinery and equipment, including GPS (Global Positioning System). GPS allows detect, analyze and respectively respond to unevenness of cultivable area. It is closely associated with the new information technologies - GIS (Global Information System) and GPS – and includes development and use of structural planning of production processes and management of modelling of optimal solutions. Precision crop cultivation operational functionality requires computerized management of this process (Vilde et al., 2005; Vilde et al., 2008; Lapins et al., 2007; Lapins et al., 2008).

Formation of yield in crop cultivation is affected by influence of many factors. Simple summation of individual factors is quite rare occasion. Interaction among factors is a dynamic value. The effect of interactions varies depending on the crop development stages as well as by graduation of factors. Rising of value of a single factor resulted in a rise of value of interactions effect (Lapins et al., 2003).

Investigations in precision agriculture were initiated in 2004 at Latvia University of Agriculture. The results are already partly reflected in Latvia and foreign editions. This study is aimed to evaluate effect of soil penetration resistance on development and yield of winter wheat. It allows to specify recommendations for soil treatment difference criteria for use in site-specific soil tillage.

Materials and Methods

Investigations were carried out in 2005–2007 in Kurpnieki field at Research and Study Farm Vecauce of Latvia University of Agriculture. Winter wheat variety 'Tarso' was grown in 2006 and 2007. Forecrop of wheat was winter rape *Brassica napus* ssp. *oleifera*. The agrotechnology used in wheat cultivation was equal in the whole field and in both trial years. 47 points (distributed as grid 50x50 m) for sampling were selected in the winter wheat *Triticum aestivum* L. field. All points were attached to their geographic coordinates. The coordinates of observation points were defined by GPS receiver Garmin IQ 3600 using AGROCOM software AgroMAP Professional that allows to find the coordinates by accuracy of ±3 m, as well as to determine the field boundaries. Information from Garmin IQ 3600 was transferred into a computer and processed by the program AgroMAP Professional.

Soil penetration resistance, kPa cm^{-2} was determined in soil layers from 0.00 to 0.50 m with Eijkelkamp soil penetrometer in 4 replications twice in vegetation period – in autumn at crop one-two leaf stage (BBCH 11-12) and in spring at wheat tillering growth stage (BBCH 21-29).

Number of crop plants per m², fresh weight of plant and coefficient of tillering were determined at the same time. Flag leaf area was determined at wheat dough development stage (BBCH 80-83) by using a specialized computer program WinFOLIA. The yield was harvested by combine CLASS LEXION 420 GPS.

Data analysis was performed using a mathematical descriptive statistics and correlation analysis.

Meteorological condition differs between trial years. Observed average air temperatures were above long term in both trial years, especially in the second part of the year 2006 (Figure 1).

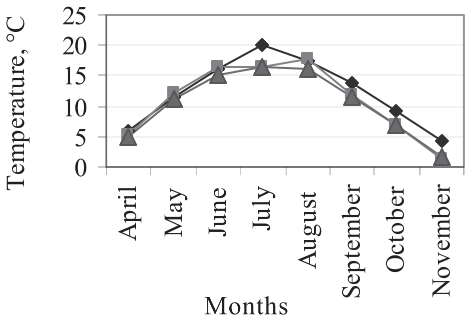

Figure 1. Average day and night air temperatures in years 2006 and 2007, °C (according to Vecauce Metpole and long term to Dobele HMS): ◇2006; □2007; △long term.

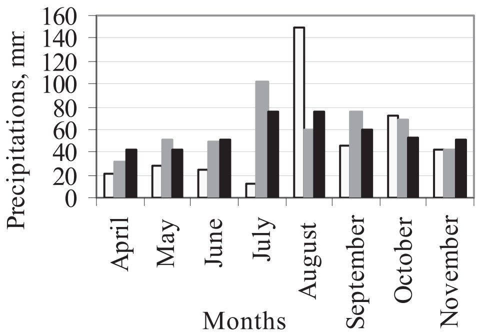

Figure 2. Average amount of precipitations in years 2006 and 2007, mm (according to Vecauce Metpole and long term to Dobele HMS): □ 2006; ■ 2007; ■ long term.

Average temperature of July 2006 was by 3.5 °C higher than long term observed. Alongside with insufficient amount of precipitations it causes rapid ripening and early harvesting of winter wheat compared with long-time observed harvesting time. The sum of precipitations was low in both trial years, but during the period April–August it was lower in year 2007 compared to 2006 despite of high amount of precipitation in August 2006 (Figure 2).

Results and Discussion

Coefficients of linear correlation shows a significant $p<0.05$ ($r_{crit.}=0.288$) positive effect of flag leaf area and a significant negative effect of soil penetration resistance in subsoil on winter wheat grain yield in 2006 (Figure 3).

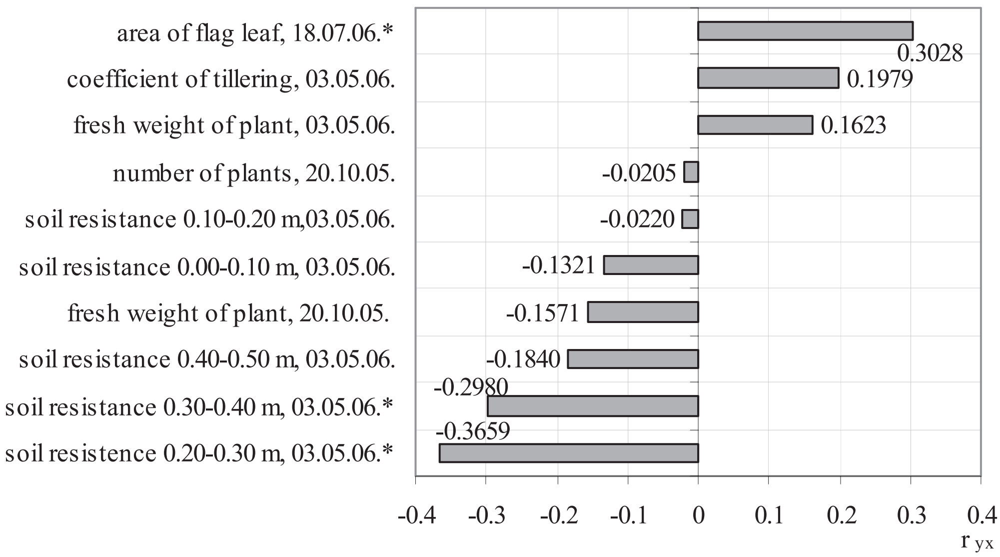

Figure 3. Coefficients of linear correlation, r_{yx}, among winter wheat yield (y) and factorial indices (x), in year 2006; *p<0.05.

Area of flag leaf had significant $p<0.05$ effect to winter wheat grain yield also in 2007. Significant positive effect to yield showed also fresh weight of plant ($p<0.05$), but negative effect – soil penetration resistance at depth of 0.20-0.30 m ($p<0.05$) and at depth of 0.00-0.10 m ($p<0.1$; $r_{crit.}=0.243$) (Figure 4). Significant correlation among other factorial indices was not found.

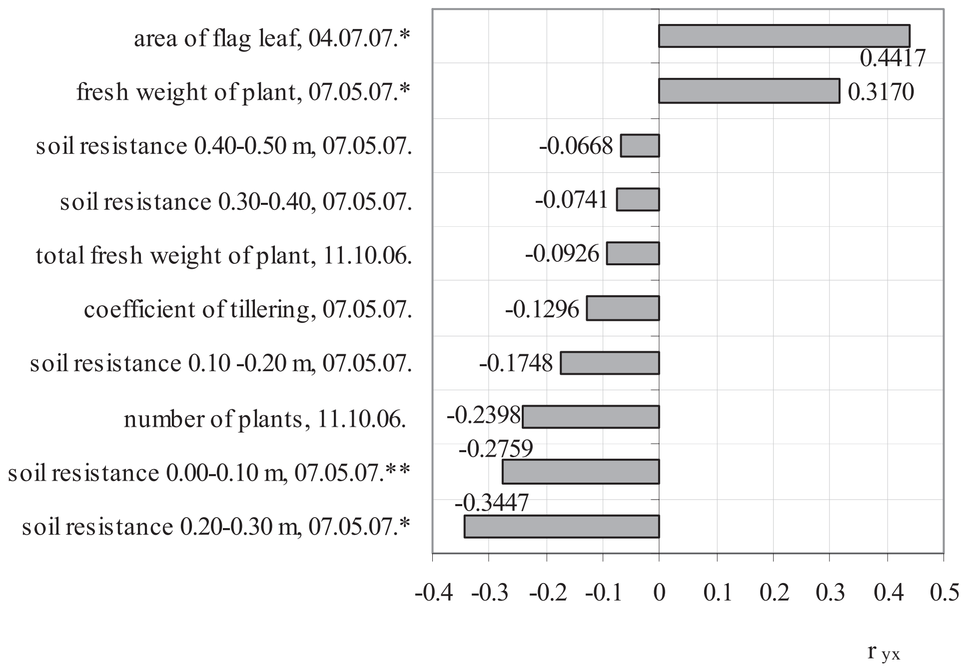

Figure 4. Coefficients of linear correlation, r_{yx}, among winter wheat yield (y) and factorial indices (x), in year 2007; *$p<0.05$; **$p<0.1$.

Overall soil penetration resistance was higher in 2006 compared to 2007. Data analysis shows that higher soil penetration resistance at depth of 0.20-0.30 and 0.40-0.50 m resulted in significant lower yields of winter wheat in both trial years whereas there were no significant differences in grain yield between soil penetrations resistance groups at depth of 0.30-0.40 m (Figure 5).

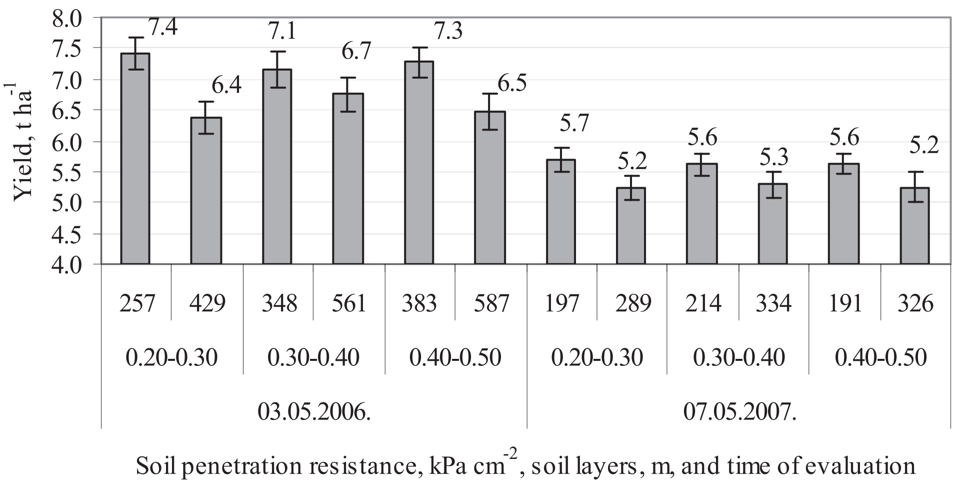

Figure 5. Winter wheat yield and soil penetration resistance in years 2006 and 2007.

Values of linear regression coefficients and their probability levels indicated that the differences in soil penetration resistance at depth of 0.20-0.30 m and 0.30-0.40 m and winter wheat grain yield had significant negative linear functional relationship in 2006 (Figure 6). It was established that increase of soil penetration resistance in subsoil by 100 kPa cm^{-2} reduces winter wheat grain yield by 0.37 to 0.48 t ha^{-1}.

On the contrary, significant linear regression relationship between soil penetration resistance and the yield was detected only for subsoil layer at the depth of 0.20-0.30 m in 2007. Also a significant negative effect $p<0.1$ to winter wheat grain yield showed soil resistance in topsoil layer at depth 0.00-0.10 m (Figure 6).

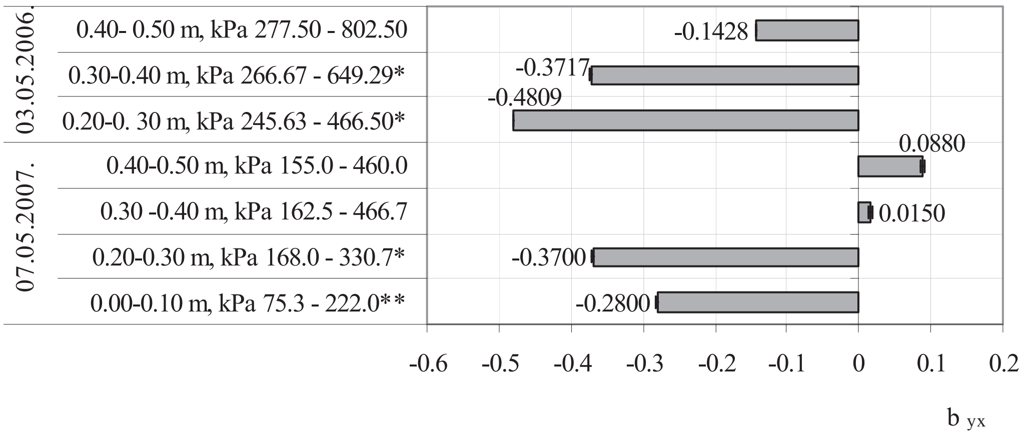

Figure 6. Effect of soil penetration resistance increase by 100 kPa cm^{-2} to winter wheat yield; *p<0.05, **p<0.1.

Differences in coefficient of tillering in connection with determined soil penetration resistance (Figure 7) demonstrated that increased soil penetration resistance resulted in smaller coefficient of tillering of winter wheat in 2006 although differences were insignificant between soil layers 0.00-0.10 and 0.10-0.20 m. Soil penetration resistance was overall smaller in year 2007, but higher coefficient of tillering was observed in places with higher soil penetration resistance and differences are significant in both soil layers from 0.00-0.10 and 0.10-0.20 m.

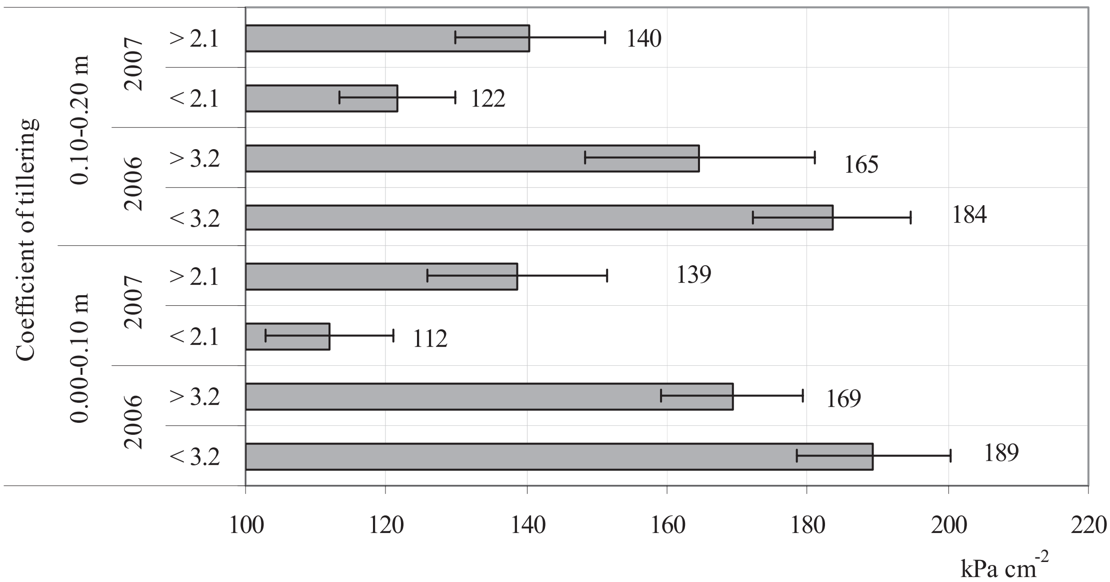

Figure 7. Dependence of coefficient of tillering on soil penetration resistance in years 2006 and 2007.

Differences of fresh weight of winter wheat plants in tillering stage and the beginning of shooting stage was insignificant compared by different groups of soil penetration resistance at soil layers 0.10-0.30 m in both experimental years (Figure 8). Significant effect to winter wheat plant fresh weight caused by the soil penetration resistance was observed only in 2007 in the soil layer 0.00-0.10 m.

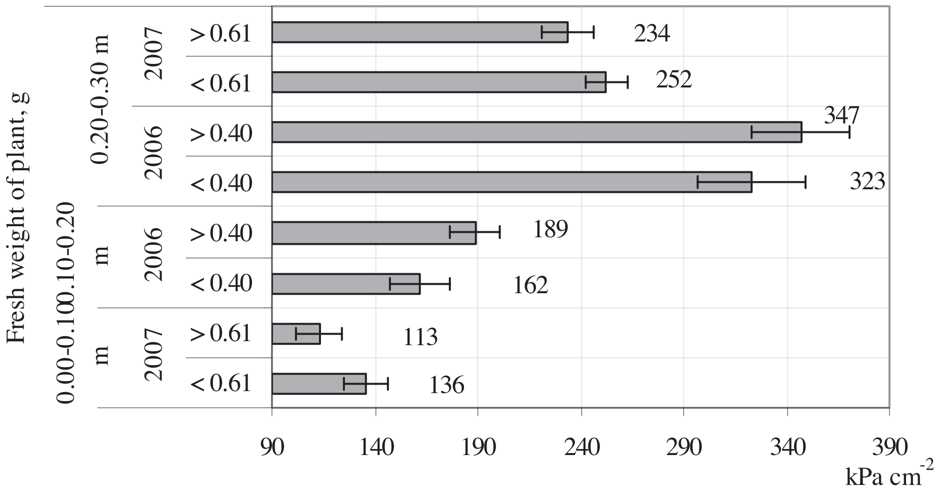

Figure 8. Fresh weight of plant and soil penetration resistance in years 2006 and 2007.

Soil penetration resistance at depth of 0.20-0.30 m gave a significant negative effect to the area of winter wheat flag leaf (Figure 9). Results from other soil layers showed no significant impact on the area of the flag leaf.

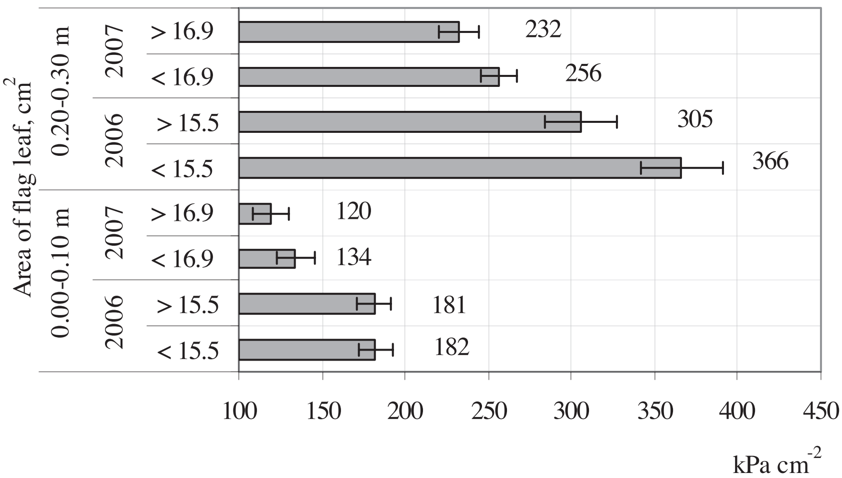

Figure 9. Flag leaf area and soil penetration resistance in years 2006 and 2007.

Winter wheat grain yield ranged from 2.0-9.5 t ha^{-1} in Kurpnieki field in 2007 with an average yield of 5.53 t ha^{-1} (Figure 10). In comparison with the year 2006, the winter wheat grain yield ranged from 4.5-9.2 t ha^{-1} with average yield of 6.75 t ha^{-1}.

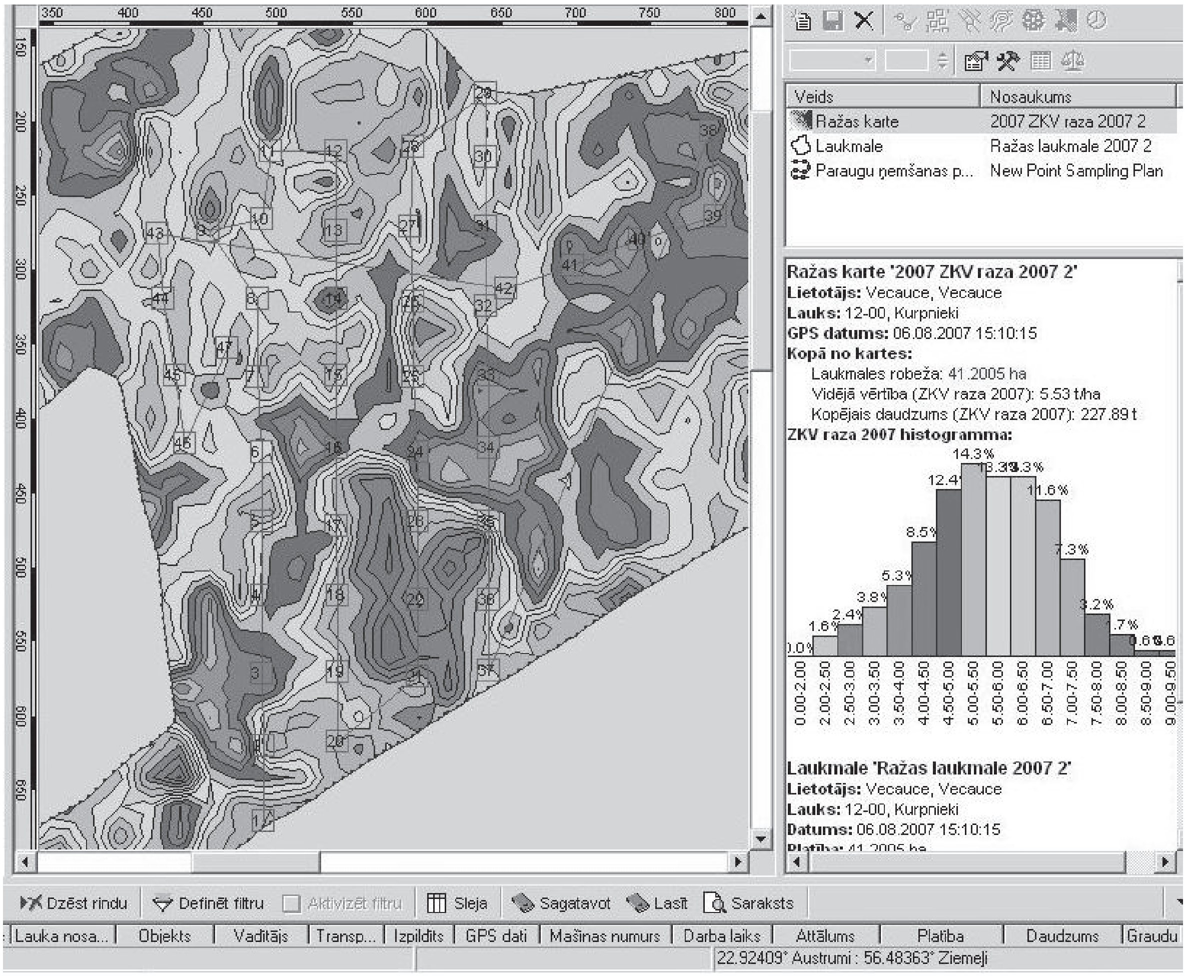

Figure 10. Cartogram of the winter wheat grain yield in Kurpnieki field in 2007.

Conclusions

1. Coefficients of linear correlation shows a significant $p<0.05$ positive effect of the flag leaf area and a significant negative effect of the soil penetration resistance in subsoil on the winter wheat grain yield in 2006.
2. Area of flag leaf had significant $p<0.05$ effect to the winter wheat grain yield also in 2007. Significant positive effect to the yield showed also fresh weight of a plant ($p<0.05$), but negative effect – soil penetration resistance at depth of 0.20-0.30 m ($p<0.05$) and at depth of 0.00-0.10 m ($p<0.1$).
3. Linear regression coefficient values show that higher soil penetration resistance at the depth of 0.20-0.30 and 0.40-0.50 m resulted in significant lower yields of the winter wheat in both trial years.
4. Increase of soil penetration resistance in arable layer by 100 kPa cm^{-2} reduces the winter wheat grain yield by 0.37 to 0.48 t ha^{-1}.
5. Increased soil penetration resistance in 2006 resulted in smaller coefficient of tillering of the winter wheat although differences were insignificant between soil layers 0.00-0.10 and 0.10-0.20 m, but in 2007, when the overall soil penetration resistance was smaller, higher coefficient of tillering was observed in places with higher soil penetration resistance and differences were significant in both soil layers: from 0.00-0.10 and 0.10-0.20 m.
6. Differences of fresh weight of winter wheat plants in tillering stage and the beginning of shooting stage was insignificant compared by different groups of soil penetration resistance at soil layers 0.10-0.30 m in both experimental years.
7. Soil penetration resistance at depth of 0.20-0.30 m gave significant negative effect to the area of the winter wheat flag leaf.

Acknowledgments

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REMOVAL OF NITROGEN, PHOSPHORUS AND POTASSIUM WITH SUMMER PRUNING OF APPLE TREES

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Abstract

The objective of the research was to study the removal of nitrogen, phosphorus and potassium with summer–pruned branches of apple–trees grown on dwarfing rootstocks under the influence of applied moisture regulation methods. The investigation was done at the Latvia State Institute of Fruit-Growing in Dobele, on the basis of an existing field experiment planted in 1997 with cultivar 'Melba' (rootstock B9) at 1.5 × 4 m trees spacing distances. Three different treatments of soil moisture management was compared: control (without moisture regime regulation), sawdust mulch and fertigation. Inter–row strips were covered by grass vegetation (*Lolium perenne* L. and *Poa pratensis* L., in proportion 1:3). Pruning of apple–trees was done in mid–July. The results of the research showed that the applied soil water regulation treatments (mulch and fertigation) had significant influence ($p<0.05$) on the apple–tree biomass (leaves, one–year and older wood) removed by summer pruning, as well as on the content of dry matter in biomass. The contents of N and K were influenced both by the treatment and age of tree vegetative parts, but the content of P did not differ significantly among treatments or tree parts ($p>0.05$). Removal of N with summer–pruned leaves and branches was 30 kg ha^{-1} N in the mulch treatment and 16 – 17 kg ha^{-1} in control and fertigation treatments ($p<0.05$). Removal of K in the control treatment was 19 kg ha^{-1}, in the mulch treatment 40 kg ha^{-1}, but in the fertigation treatment 27 kg ha^{-1} ($p<0.05$). Removal of P varied from 5.04 to 9.84 kg ha^{-1}, no significant differences were found among treatments ($p>0.05$).

Key words: fertigation, mulch, nutrient removal.

Introduction

Since the end of the 20th century with the rapid development of commercial fruit growing in Latvia, the farmers are introducing more advanced growing technologies for apple (*Malus domestica*. Borh.) production. One of the relatively new method is summer pruning of apple–trees (summer pruning of branches) at the end of June, July, also August. Summer pruning is mostly done for improvement of light conditions inside the tree canopy (Autio and Greene, 1990; Wagenmakers and Callesen, 1995). Low light access decreases the amount of soluble solids and starch in fruits, therefore fruits are smaller, ofted deformed, with too low flesh firmness. Lack of sunlight also has a negative effect on fruit colour, such fruits cannot be sold as dessert quality products. Summer pruning also reduces tree size, as well as the development of harmful organisms (insects, diseases). By pruning of branches the density of the canopy is reduced, so the air humidity inside the canopy decreases. High humidity in combination with high temperature makes optimal environment for the development of pests and diseases (Lakso et al., 2003).

There are additional aspects related to the pruning. Plant nutrients, like nitrogen, phosphorus and potassium, are irreversibly removed from the orchard with the cut–off branches if they are taken off from the area. The above mentioned nutrients, also called main macroelements, because plants need them are in comparatively high amounts, and they are very important for tree development and yield formation. Nitrogen is necessary for many life functions of the tree, such as growth of shooots, setting of buds and fruits, and fruit growth. Nitrogen deficiency for apple–tres results in several negative consequences: the shoots grow weak, leaves become light green or yellowish, which in turn negatively influence the intensity of photosynthesis (Fallahi et al., 2001; Cmelik et al., 2006). Phosphorus requirement for apple–trees are less compared with field crops (Neilsen et al., 2006), but it is essential for the provision of the transfer of plant genetic information. Phosphorus takes part in the plant metabolism, respiration, photosynthesis, facilitates fertilization of the flowers. Lack of phosphorus has negative effect on the growth and development of the plant reproductive organs (seeds), as well as vegetative parts (trunk, leaves). Potassium, on the other side, facilitates the water supply in cells, the accumulation of carbohidrates. The amount of potassium influences also fruit colour, tree winter–hardiness and disease resistance. If there is not enough potassium, brown necrotic spots appear on leaf margins, older leaves can even die, and plants become susceptible to fungal diseases (Nosal et al., 1990).

Novelty of discussed experiement is that introduction of summer tree pruning is a new method for Latvian commercial farms. This method has been introduced based on experience of other countries. There is a lack of information about the loss of nitrogen (N), phosphorus (P) and potassium (K) through removed wood and leaves. Also data about distribution of plant nutrients in differt parts of apple–trees are quite old and go back to the 1960–ties – 1970–ties (Dimza and Gross, 1994). These data are applicabile for trees on vigorous seedling rootstocks with traditional late winter pruning. Researchers in other countries (Bünemann and Struklec, 1980) have come to a conclusion that during the growth season vegetative parts of apple–trees (branches, leaves) contain nutrients in a significantly higher concentration than during dormancy. Therefore lost of nitrogen, phosphorus and potassium might be higher for summer–pruned branches and leaves compared with traditional technology when crown formation was done in early spring. Additionally, more and more of commercial growers are introducing different soil water management methods. In average amount of precipitations in Latvia is adequate for plant water supply, but some periods in summer when water requirement is high there could be some deficit which has negative influence on apple yield and yield quality. Therefore soil moisture regulation technologies: mulching of tree strips, as well as establishing of various irrigation systems, become more popular. Water management may affect not only the nutrient turnover, uptake, fertiliser use efficiency, but also their loss from the rooting zone. The applied soil moisture regulation methods and the removal of nutrients with apple–trees are the basic factors when fertilization planning is performed. Therefore the objective of this study was to assess the amount of nitrogen, phosphorus and potassium removed with plant parts trimmed by summer pruning, in relation withe aplied soil moisture regulation methods – sawdust mulch or fetigation.

Materials and Methods

The investigation was carried out at the Latvia State Institute of Fruit–Growing, Dobele, in 2008. Field trial in three replications was set up on the basis of an orchard planted in 1997, for cultivar 'Melba' on rootstock B9 (planting pattern 1.5 × 4 m). Three kinds of soil water treatments in tree strips were compared: (1) control – no any regulation methods; (2) sawdust mulch and (3) fertigation, e.g., drip irrigation with fertilizer. In the mulching treatment soil surface was covered with 10 – 20 cm layer of sawdust renewed every three years. In the irrigation treatment 'Den' type pipelines with built–in drippers spaced 0.38 cm apart were used. The irrigation provided effective moistening of a 1 m wide zone in sandy loam soil or about 25% of orchard area.

For the lawn sown in the inter–row strips *Lolium perenne* L. and *Poa pratensis* L. in proportion 1:3 were used. The tree strip in the control and drip irrigation treatments were 1 m wide and during the growing season it was maintained free from grasses. The inter–row strips were 3 m wide. The grass during the experiment was mown regularly (5 – 6 times per season). The apple–trees were performed as slender spindle. The average yield was 20 t ha^{-1}. Branches of apple–trees were pruned in mid–July. In July, 2008 the precipitations was below the normal (only 60 mm), but the mean air temperature was close to the average, +18 °C.

Soil of experimental plot was Haplic Luvisol (Hypereutric), sandy loam, interspaced with Cutanic Luvisol, sandy loam. These are typical automorphic soils with relatively good water storage and water supply capacity. Organic matter content in soil – 25 g kg^{-1} (according Tyurin method, wet combustion), soil reaction pH – 6.5 (in 1*M* KCl suspension, potentiometrically). Plant available P was 130.9 mg kg^{-1}, K – 157.7 mg kg^{-1}, and Mg – 102.2 mg kg^{-1} (according Egner – Rheem or DL method).

During the summer pruning (July 12) all the cut branches and leaves were collected and grouped into one–year, two–year or older wood and leaves, weighed, air–dried and chopped. Chemical analyses were done for the above–mentioned vegetative tree parts, determining the total nitrogen (Kjeldahl method, wet digestion), phosphorus – P (colorimetrically) and potassium – K (flame photometerically) concentration in plant material. The removal of nutrients were calculated as kilograms per hectare area (kg ha^{-1}) (Kārkliņš, 1988).

The results of the investigation were analyzed using analysis of variance *ANOVA* test, as well as descriptive statistics *(Descriptic statistic)*. To compare the data from two sample groups Fisher criteriom was used.

Results and Discussion

The applied methods of soil moisture regulation – mulch and fertigation – had significant ($p<0.05$) influence on the content of dry matter in apple–tree vegetative parts removed by summer pruning (Table 1). The lowest content of dry matter was in the fertigation treatment, the highest – in control treatment.

The highest content of dry matter was found for older wood in control and mulch treatments, it was 30 – 40% higher than in one–year wood, and the difference was statistically significant ($p<0.05$). It may be explained by different moisture supply in the above mentioned treatments. Other researchers (Nagy et al., 2006) point out that apple–trees which have higher available soil moisture supply contain less dry matter in biomass. That may indicate that apple–trees grown with fertigation have more favourabale moisture conditions. Yet in that study the total biomass of summer–pruned vegetative parts was significantly higher ($p<0.05$) not in the fertigation, but in the mulch treatment. The biomass from mulched apple–trees amounted up to 3.13 kg, in the fertigation treatment 2.2 kg, but for control plot – only 1.95 kg per tree. Investigations done in Latvia (Rubauskis, 2005) also showed that the increase of biomass is positively influenced by mulching. Leaves on one–year wood contained significantly less dry matter in the fertigation treatment as compared with control, while the mulch treatment did not significantly differ from control. Leaves on two–year wood contained similar amounts of dry matter in all treatments ($p>0.05$).

Table 1

Content of Dry Matter in Apple–tree Vegetative Parts (g kg^{-1})

Tree vegetative parts	Control (n = 9)	Mulch (n = 9)	Fertigation (n = 9)
Leaves on one–year wood	57.3 ± 4.7^{b}	53.2 ± 1.6^{ab}	49.7 ± 2.2^{a}
One–year wood	45.2 ± 6.4^{d}	47.2 ± 2.9^{c}	44.5 ± 2.8^{bc}
Leaves on two–year wood	53.5 ± 5.2^{ab}	52.6 ± 1.5^{ab}	49.8 ± 2.3^{ab}
Two–year wood	69.5 ± 1.5^{g}	66.5 ± 1.8^{f}	63.3 ± 1.3^{e}
Older wood	76.6 ± 1.8^{i}	72.6 ± 1.6^{h}	69.4 ± 1.7^{g}
Average	60.44	58.42	55.3

a, b, c, d, e, f, g, h – significantly different ($p<0.05$).

Dry matter content in the control treatment had comparatively high dispersion of data, especially in leaves of one–year wood ($S_x = 4.7$) and in leaves of two–year wood ($S_x = 5.2$), as well as in one–year wood ($S_x = 6.4$). In the mulch and fertigation treatments data dispersion was 2 times lower. Variation of data possibly is an evidence of different growth conditions of apple–trees. Mulch and fertigation ensured optimal moisture supply to plants, so the moisture content in plants also was more even, while in the control treatment moisture supply tends to be irregular and trees often has lack of water (Evans et al., 1985; Rubauskis, 2005). For the content of dry matter in older wood, differences in data dispersion among treatments were insignificant.

Apple–tree leaves contained 2 times more nitrogen (N) per one dry matter unit than wood (Figure 1), and the difference was significant ($p<0.05$). In the control treatment the leaves contained signifcantly less nitrogen than in mulch and fertigation treatments ($p<0.05$). In one–year, two–year and older wood the content of nitrogen per dry matter unit did not differ significantly among treatments ($p>0.05$).

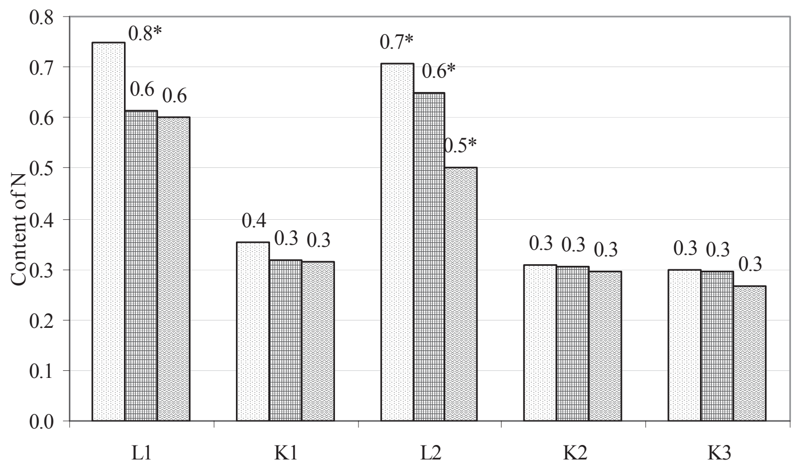

Figure 1. Content of nitrogen (N) in apple–tree parts per unit of dry matter.

– control – mulch – fertigation

* – significantly different ($p < 0.05$)

L1 – leaves on one–year wood; K1 – one–year wood; L2 – leaves on two–year wood;
K2 – two–year wood; K3 – older wood.

The results of this experiment do not fully comply with findings of other researchers (Burke and Morris, 1993; Gland, 2006) that in younger plant parts the content of N usualy is higher. Content of N in vegetative parts of apple–trees is the highest during the active growth – in May, June, but in July vegetative growth starts to decrease (Nurzinski et al., 1990). Summer pruning of apple trees was done in July that possibly explains why there were no significant differences between one–year, two–year and older wood. Probably nitrogen in plants has high reutilisation capacity. Depending on plant vegetative part age N uitilization rate cauld be 70 – 80% from total assimilated in leaves (Adamec, 2002). It is possible that in the control treatment (as a result of periodical moisture deficit) the changes of N concentration and the reutilisation process were slower. Nitrogen in plants is found either in the form of NO_3^- (mobile) or NH_4^+ (immobile) ions (Dong et al., 2005). In this study only total N was determined in plant parts. Therefore there is not enough data to explain variation of nitrogen content in apple leaves expecially in relation to it high value in control treatment.

Although results of the study showed tendencies for the content of P in apple–tree wood (Figure 2) to decrease depending on the age of wood, still the differences among treatments, as well as types of vegetative parts were not significant (p>0.05). In the fertigation treatment the amount of P found in apple leaves was 3 times higher compared with one–year wood, but difference statistically was not significant due to the high data variability. The content of P in apple–tree vegetative parts starts to decrease already after flowering (Nurzinski et al., 1990). It is possible that during summer pruning when the content of phosphorus in apple tree parts was decreasing rapidly, the turnover of P was influenced also by its reutilisation, which in comparison with other studied elements is lower, 51 – 82% (Adamec, 2002), and this can also explain the insignificance of differences and the high data variation.

Other researchers (Burke and Morris, 1993) also had pointed out that the age of apple–tree vegetative parts does not influence P content in it.

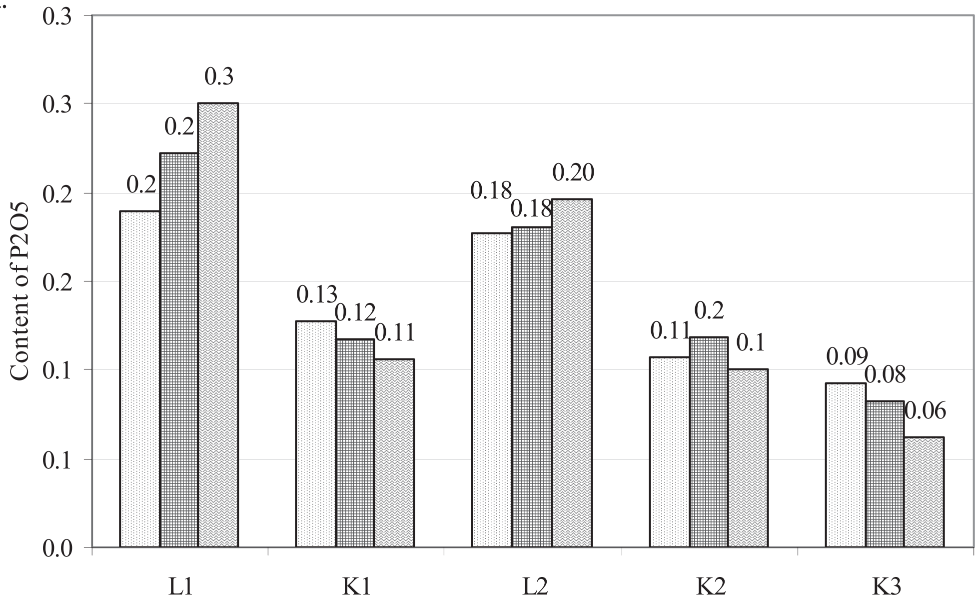

Figure 2. Content of P in apple–tree parts per unit of dry matter.

– control – mulch – fertigation

L1 – leaves on one–year wood; K1 – one–year wood; L2 – leaves on two–year wood

K2 – two–year wood; K3 – older wood.

The K content in dry matter was significantly influenced both by the age of apple–tree vegetative parts and the method of applied soil moisture regulation in tree strips: mulch or fertigation (Figure 3). Leaves of apple–trees contained even 3 – 4 times higher potassium than wood, and one–year wood 2 times higher potassium than two–year and older wood. Our results agree with conclusions made by researchers in other countries that the content of potassium in younger leaves is higher (Burke and Morris, 1993; Aichner, 2002), compared with old leaves and other parts of plant. Although the content of K, similarly as for N, was significantly higher in apple–tree leaves (p<0.05), especially leaves of one–year wood, yet the data obtained in our study showed different tendencies compared with nitrogen content (Figure 1). Significantly higher content of K in leaves of one–year wood was found in the fertigation treatment, and a similar tendency was also found for the content of K in other vegetative parts, only the differences among treatments were not statistically significant (p>0.05).

The content of potassium in the vegetative parts of apple–trees increases since the beginning of growth season, reaches its maximum at the beginning of June, then for 10 weeks it remains stable and afterwards begins to decrease (Nurzinski et al., 1990; Aichner, 2002). This may explain the relatively low variation of the results in our experiment. From all the elements analyzed in this experiment, potassium is supposed to be the most mobile, and also with very high reutilization capacity – up to 95 – 99% (Adamec, 2002). Mobility of potassium in soil is facilitated by the amount of water. The more water is available for plants, the faster potassium moves in cells (Malaguti et al., 2006). This may explain the significantly higher content of K in the fertigation treatment.

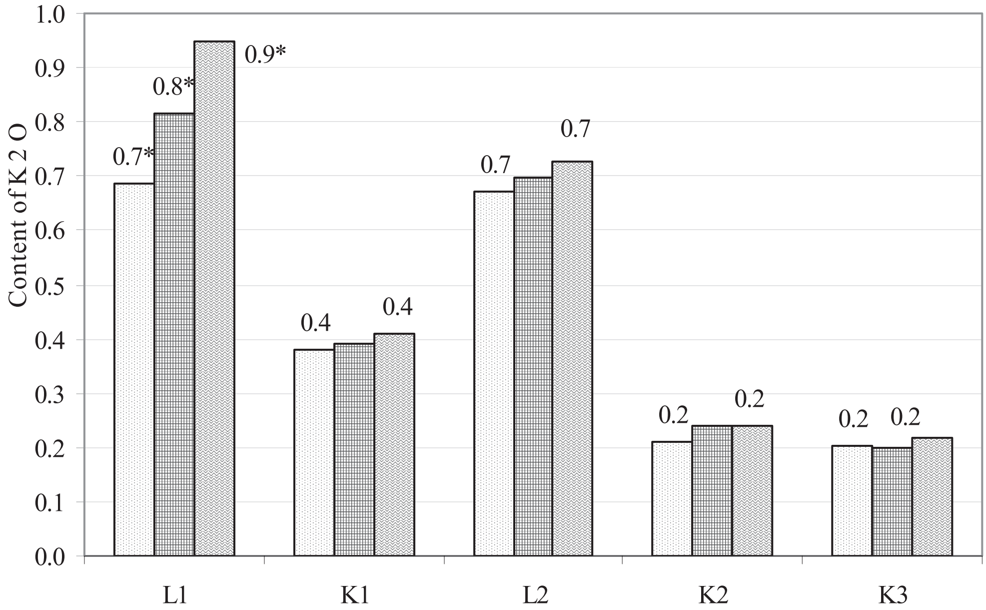

Figure 3. Content of K in apple–tree parts per unit of dry matter.

– control – mulch – fertigation

* – significantly different (p < 0.05)

L1 – leaves on one–year wood; K1 – one–year wood; L2 – leaves on two–year wood

K2 – two–year wood; K3 – older wood

The method of soil moisture regulation significantly influenced (p<0.05) removal of nutrients by summer–pruned vegetative parts (Table 2). In the mulch treatment removal of N was 2 times higher than in fertigation and control plots, removal of potassium was also 2 times higher in the mulch treatment than in the control, while removal of phosphorus did not differ significantly among the treatments (p>0.05). Removal of nitrogen and potassium did not differ significantly in the control and mulch treatments, while removal of phosphorus in these treatments was 3 times lower. In the fertigation treatment removal amounts of all three nutrients differed significantly (p<0.05), the biggest part was potassium (50% from total nutrient removal).

One–year old wood together with leaves composed the biggest part of total nutrient removal. One–year wood and its leaves in the control treatment made up to 63% from the total N removal per ha, but in the mulch and fertigation treatments even 75% from the total N removal. Removal of P and K with the above mentioned tree parts was 67% (control) and 78 – 82% (mulch and fertigation) from the total phosphorus and potassium removal. Sometimes fruit production orchards are used also for obtaining the propagation material. Taking into account that only one–year shoots are cut as graftwood (cutting of grafts is done at the same time as summer pruning), in this case substantial amount of nutrients is removed from the orchard.

Data obtained in our experiment cannot be directly compared with the results obtained by I. Dimza and A. Gross in 1960 – 1970–ties (Dimza and Gross, 1994), as these researchers investigated nutrient removal by tree pruning in the end of winter and most of the trials corresponded with the late-season cultivar `Antonovka`. In the current study the early apple cultivar `Melba` was used, and, according to conclusions of Polish researchers (Zydlik and Pacholak, 2006), nutrient removal from early cultivars is significantly higher. Although the results are not directly comparable, similar tendencies were observed – the largest part from the total nutrient removal was made up by K, removal of N was about 1.5 times lower, but the lowest removal was for P (Dimza and Gross, 1994). The result of our experiment agrees with conclusions of Latvian (Dimza and Gross, 1994) and other researchers (Neilsen et al., 2006) that phosphorus uptake by apple–trees, unlike for other cultivated plants, is lower compared with nitrogen and potassium.

Table 2

Removal of Nutrients through Summer–pruned Branches and Leaves

Nutrients	Treatment	One–year wood leaves	One–year wood	Two–year wood leaves	Two–year wood	Older wood	Total	Nutrient removal, kg ha^{-1} (1666 tree per 1 ha)
	per tree, g							
N	Control	4.61	1.69	2.98	0.44	0.26	9.99	16.64*
	Mulch	10.57	3.07	3.27	0.88	0.52	18.30	30.49*
	Fertigation	5.81	2.25	1.81	0.55	0.18	10.60	17.66*
P	Control	0.64	0.24	0.30	0.10	0.04	1.32	2.20
	Mulch	1.55	0.50	0.33	0.15	0.05	2.60	4.30
	Fertigation	1.22	0.37	0.33	0.11	0.02	2.04	3.40
K	Control	4.96	1.55	2.45	0.36	0.20	9.56	15.92*
	Mulch	12.97	3.20	3.71	0.58	0.22	19.70	32.81*
	Fertigation	8.61	2.49	1.88	0.46	0.11	13.55	22.57*

* – significantly different ($p < 0.05$)

Research results found in publications about the influence of soil water treatments on the content of nutrients in apple–tree vegetative parts are controversial. Some researchers (Evans and Proebsting, 1985; Malaguti et al., 2006) demonstrated that the amount of nutrients in apple leaves increases along with the increase of their moisture content, but researchers from Warsaw University (Pietranek and Jadczuk, 2005) came to the opposite conclusion that fertigation has no influence on the mineral composition of leaves. It is possible that the changes of nutrient content in apple–tree vegetative parts were influenced by weather conditions of the growth season along with THE soil water capacity. This is supported by other study in Poland (Zydlik and Pacholak, 2006), where close correlation was found between air temperature, precipitation and apple leaf mineral composition. Therefore the amount of nutrients in vegetative parts depends also on weather conditions in the specific growth season.

Conclusions

The applied soil moisture regulation methods (mulch and fertigation) had significant influence on the content of dry matter in the vegetative parts of apple–trees ($p<0.05$). The highest content of dry matter (g kg^{-1}) was found in the control plot, but the highest amount of biomass removed by pruning – in the mulch treatment.

The content of N per one unit of dry matter (g kg^{-1}) was influenced by the applied soil moisture treatment. Significantly higher content of N was found in the control plot. Both in one–year and older wood the content of N was lower than in apple leaves ($p<0.05$). The content of P did not depend of the treatment or the age of tree vegetative parts. In the mulch and fertigation treatments tendencies for higher P content in leaves were observed, but the differences were not significant ($p>0.05$). The content of K was influenced both by the soil water regulation method and the age of apple–tree vegetative parts. In the younger tree parts the content of K was even several times higher than in older wood ($p<0.05$).

Removal of nitrogen with summer–pruned branches and leaves was 30.49 kg ha^{-1} in the mulch treatment and 16.64 – 17.66 kg ha^{-1} in control and fertigation treatments ($p<0.05$). Removal of potassium in the control treatment was 15.92 kg ha^{-1}, in the mulch treatment 32.81 kg ha^{-1}, but in the fertigation treatment 22.57 kg ha^{-1} ($p<0.05$). Removal of phosphorus varied from 2.20 to 4.30kg ha^{-1}, no significant differences were found among treatments ($p>0.05$).

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EFFECTS OF IRRIGATION AND WOODCHIP MULCH ON GROWTH AND HABIT OF SOUR CHERRIES

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Abstract

Sour cherries becomes more popular due to their food value. Therefore sour cherries could be a profitable crop for fruit growers in Latvia. Information about sour cherry response to soil moisture adjustment is needed, because based on previous studies it is not possible to predict the influence of irrigation and mulch on sour cherry growing.

The trial was carried out at the Latvia State Institute of Fruit Growing in 2007 to determine the effect of soil moisture adjustment on the growth of different sour cherry cultivars. Woodchip mulch and drip irrigation were used as main factors, cultivars 'Bulatnikovskaya', 'Desertnaya Morozovoi', 'Latvijas Zemais', 'Orlica', 'Shokoladnica', 'Tamaris', 'Zentenes' were used as a secondary factor. Vegetative growth, branching angles of lateral shoots, proportions of pruned shoots, spurs and twigs were determined to characterize the response of cultivars to mulching and irrigation. In general use of drip irrigation increased vegetative growth of sour cherries, but the use of woodchip mulch decreased this growth. Branching angles were wider in variant with woodchip mulch. Cultivar 'Zentenes' most positively responded to use of woodchip mulch and drip irrigation.

Key words: drip irrigation, woodhip mulch, lateral shoots, spurs, twigs.

Introduction

Sour cherries (*Prunus cerasus* L.) are common fruit plants in all Latvia. There are many opportunities for the use of cherry fruits.The greatest part of sour cherry yield is used for processing in different ways although sour cherries are also consumed as fresh fruit. A special value of sour cherries is phenolic compounds in their composition, which has attached much attention to this species in recent years. Phenolics have antineurodegenerative activity (Kim et al., 2005) and can be used as chemotherapeutics for numerous diseases including cancer (De-Xing Hou et al., 2004). These findings enable using of sour cherries in processing of functional food. Sour cherries could be a profitable crop for fruit growers in Latvia but information about the most appropriate growing technologie is needed.

Water is one of the main factors in plant growing. Although the total amount of precipitation is sufficient for cherry growing in Latvia, long-drawn drought periods during season of vegetation can happen and decrease growth and yield. Positive effect of irrigation on plants was observed in numerous studies carried out in Latvia, Lithuania and Poland. So irrigation advanced growth and yielding of raspberries (Buskiene and Petronis, 2000) as well as growth of some of apple rootstocks (Treder et al., 2005) and apple trees (Skrivele et al., 1998).

However, apple rootstocks responded differently to irrigation. Some rootstocks grew without significant differences in full-irrigation and moderate drought conditions (Treder et al., 2005), but in some cases moderate drought advanced growing of apple rootstocks (Sakalauskaite et al., 2006).

Significant positive relationship between irrigation rate and yield of sour cherries 'Łutówka' was found also in a research conducted in central Poland (Rzekanowski and Rolbiecki, 2000). However response of various cherry cultivars to drought stress could be different. So cultivar 'Meteor' was more tolerant to drought stress than 'Colt' (Ranney et al. 1991).

Increased shoot growth of fertigated sour cherries was observed in research carried out in Denmark (Dencker and Hansen, 1994). In this case additional supply both of water and nutrients had positive influence.

Woodchip mulch is widely used in ornamental gardening, but there is little information about the influence of this mulch on the growth and yield of agriculture crops. It is proven that using of woodchip mulch encouraged growth of pecan (*Carya illioinensis* (Wangenh.) K. Koch) seedlings (Smith et al., 2000) and yielding of fall collards (*Brassica oleraceae* L.) (Guertal and Edwards, 1996).

Woodchip mulch has similar pecularities with sawdust mulch. There were some investigations about using of sawdust mulch at the Latvia State Institute of Fruit-Growing. Using of sawdust mulch in black currant growing had no signifficant effect in years with sufficient amount of precipitations and even distribution of them. Mulch had negative influence on black currant growing in the season with long dry period (Strautina and Kampuss, 2000). Yet sawdust mulch can slightly improve growth of apple trees (Skrivele et al., 1998) or cause significant increase of apple tree growth (Rubauskis, 2005).

There is a lack of information about sour cherry response to soil moisture adjustment to Latvian conditions. Based on previous studies it is not possible to predict the influence of irrigation and mulch on sour cherries grown in Latvia. Therefore an investigation was established at the Latvia State Institute of Fruit - Growing. The aim of the research was to determine the effect of woodchip mulch and drip irrigation on the growth of different sour cherry cultivars. In this contribution the results of the first two growing years are shown. They characterise the vegetative growth and formation of canopy as precondition for yielding. Response of seven sour cherry cultivars which are common in Latvia is described.

Materials and Methods

In spring of 2007 sour cherries were planted at the Latvia State Institute of Fruit – Growing at Dobele, they are observed during 2007 and 2008. Effect of two factors was determinated in this trial. The treatments were arranged in a split plot design: the method of soil moisture adjustment – on the main plots, the cultivars – on the split plots. The main factor –method of soil moisture adjustment had three variants:

- using of woodchip mulch in the tree strips, thickness of woodchip layer was 10 cm,
- drip irrigation in the tree strips providing soil moisture as 70% of the field water capacity in an approximately 1 m wide strip,
- control – neither mulch nor irrigation in the tree strips.

There were three replications both per mulch and control variants and four replications per the irrigation variant. Seven sour cherry plants (one of each cultivar) were planted in every replication.

The second factor – cultivar of sour cherries had the following variants:

- cultivar with week vigour - 'Tamaris' ,
- cultivars with medium vigour - 'Bulatnikovskaya', 'Desertnaja Morozovoi', 'Latvijas Zemais', 'Orlica', 'Shokoladnica',
- cultivar with strong vigour - 'Zentenes'.

The trial was carried out on clayic Podzoluvisol soil, it was slightly acid – pH 6.5. The content of P was 50 mg kg^{-1}, content of K was 119 mg kg^{-1}.

Planting distances were 4 x 4 m. The fertilizers were given yearly as 12 g m^{-2} of N, 5.2 g m^{-2} of P and 10 g m^{-2} of K in the tree stripes.

Weeds were restricted by both removing them and spraying in 1 m wide strips along the trees. Perennial grasses were sown in the space between strips. Trees were slightly pruned in autumn of 2008.

At Dobele the total amount of precipitation during the period of active vegetation (when the mean diurnal temperature reached at least 10 °C) was 373 mm in 2007 and 191 mm in 2008 (these indices are based on data of Latvian Agency of Enviroment, Geology and Meteorology). In 2007 sour cherries were irrigated 9 times and the total amount of water was 162 l per tree. In 2008 irrigation 12 times was done and total amount of water 249 l per tree was used to provide the preferable soil moisture.

The length and function of shoots were determined in autumn after the vegetation period. The vegetative growth was characterized by a sum of shoot length. Pruned shoots were counted as well. The shoots were subdivided as the trunk, upright shoots, lateral shoots, spurs and twigs. Proportions of cutted shoots, twigs and spurs were calculated and the angles of lateral shoots were determined to characterize the habit of trees. Differences of trees of different cultivars and soil moisture adjustments were studied.

The data were statistically processed using analysis of variance and Duncan's test or Dunett T3 test for post hoc analysis (in cases with equal variances or not equal variances – respectively). Mann – Whitney U test was used in cases when data distribution differed from normality. Following indices were used for characterization of means: the arithmetical mean was used in cases with data normality, but median was used in cases when the data distribution differed from normality (in analysis of branching angles and in some cases of analysis of proportions of shoots and vegetative growth).

Results and Discussion

Analysis of sour cherry vegetative growth

In 2007 the vegetative growth was influenced by both soil moisture adjustment ($p<0.05$) and cultivar features ($p<0.01$).

Differences in growth caused by cultivars were observed already in time of planting – before the use of soil moisture adjustments. Plants of cultivars 'Orlica', 'Shokoladnica', 'Bulatnikovskaya', 'Desertnaya Morozovoi' were significantly shorter than plants of cultivar 'Zentenes'. There were no significant differences of the plant height of cultivars 'Tamaris', 'Latvijas Zemais' with other cultivars. After the first growing year mean vegetative growth of the cultivar 'Latvijas Zemais' (670 cm) was bigger than the growth of other cultivars. Comparatively big mean growth was observed also for cultivars 'Bulatnikovskaya' and 'Zentenes': 460 cm and 450 cm respectively ($p<0.05$) (Table 1).

Influence of cultivar features on the vegetative growth was highly significant ($p<0.01$) also in 2008. Cultivars 'Latvijas Zemais', 'Desertnaya Morozovoi' and 'Zentenes' had comperatively bigger growth: 4321 cm, 3186 cm and 2698 cm respectively. Cultivar 'Tamaris' had significantly ($p<0.05$) smallest growth both in 2007 and 2008.

Table 1

Mean Lenght of Plants and Mean Total Vegetative Growth of Sour Cherry Cultivars in 2007 and 2008

Cultivars	Mean length of plants at planting time (cm)	Mean total vegetative growth in 2007 (cm)	Mean total vegetative growth in 2008 (cm)
'Tamaris'	81^{ab}	215^{a}	795^{a}
'Shokoladnica'	67^{a}	235^{ab}	1908^{b}
'Orlica'	65^{a}	311^{ab}	2050^{b}
'Bulatnikovskaya'	70^{a}	460^{c}	2144^{b}
'Zentenes'	103^{b}	450^{bc}	2698^{bc}
'Desertnaya Morozovoi'	75^{a}	383^{ab}	3186^{bc}
'Latvijas Zemais'	88^{ab}	670^{d}	4321^{c}

Means in the column marked with the same letter did not differ significantly at $p<0.05$.

In general the mean total vegetative growth in year 2007 was 287 cm in the variant with mulch, 301 cm in the control variant and 448 in the variant with drip irrigation. The differences between vegetative growth in variants with mulch and drip irrigation treatments were significant ($p<0.05$). Vegetative growth in the control variant did not differ with high probability ($p=0.3$) from other variants.

In 2008 the difference of vegetative growth between variants with mulch and drip irrigation usE was less significant than in 2007 - $p=0.1$. The difference of vegetative growth between control variant and drip irrigation variant had the same level of significance as in 2007 ($p=0.3$). There was no diference between the variants of control and mulch ($p=0.9$). The mean total vegetative growth in 2008 year was 2040 cm in the variant with mulch, 2341 cm in the control variant and 2750 cm in the variant with drip irrigation.

In general the growth increase caused by drip irrigation of sour cherries in 2007 was similar to the drip irrigation effect determined for apples in 1997 in Latvia. Growth of apple trees increased by 44% due to the drip irrigation (Skrivele et al., 1998). In our research vegetative growth of sour cherries in the variant with drip irrigation increased by 49% if compared to the control in 2007. Regardless of similar effects of irrigation, there were different moisture conditions in these investigations. The period with insufficient amount of precipitation continued from July to the beginning of September in 1997. Apples were watered 16 times, the total amont of water – 277 l per tree (Skrivele et al., 1998). Precipitations were relatively evenly distributed in 2007. Sour cherries were watered less (9 times, total amount – 162 l per tree). A shared feature is the age of trees – drip irrigation caused similar effect on trees during the first growing year in both trials.

Effect of irrigation used for sour cherries in 2008 was similar to the effect of drip irrigation determinated on raspberries in Lithuania in 1999. Drip irrigation caused 18% increase of raspberry growth comparing with control (Buskiene and Petronis, 2000). Vegetative growth of sour cherries in drip irrigation variant increased for 17% comparing to control variant in 2008 in our investigation. There were some droughty months in both investigations. Raspberries were watered less than sour cherries but there was striking difference between soil in trials – raspberries grew in peat soil.

The comparison of drip irrigation effects on sour cherries in years 2007 and 2008 confirms the relevance of the tree age. Irrigation caused bigger growth increase in the first growing year despite the fact that the second growing year was drier. It can be explained by a more developed root system in the second growing year.

Influence of sawdust or woodchip mulch on vegetative growth varied depending on the plant genus, cultivar and background conditions in trial. Response of apples to the use of sawdust mulch was converse to sour cherries in our research. Sawdust mulch increased growth of apples for 15% in the first growing year (1997) (Skrivele et al., 1998). Bigger increase of vegetative growth was observed in the first four growing years, on average - 30% increase for apple trees and 43% increase for sweet cherry trees. However, in that investigation additional 20% of nitrogen fertilizers was given to trees in mulch variants to compensate immobilization caused by bacterium (Rubauskis, 2005). So it was not possible to assess influence of mulch and additional nitrogen seperately. On the contrary sawdust mulch did not influence the growth of black currants in a year with sufficient moisture despite the additionally given 30 % of nitrogen fertilizers (Strautina and Kampuss, 2000). In general mulch decreased the growth of sour cherries for 5% in 2007 and for 15% in 2008 in our investigation. Doses of nitrogen were equal in the mulch and control variants. Growth decrease could be related to insufficient amount of precipitation in 2008 or losses of nitrogen due to the activity of microorganisms.

However, effects of mulch and drip irrigation were not equal for all observed sour cherry cultivars. In 2007 the vegetative growth of cultivar 'Orlica' and 'Desertnaya Morozovoi' did not differ significantly (p=0.3...0.4) between the control variant and soil moisture adjustment variants, but there were significant differences (p<0.05) between variants with mulch and drip irrigation (Figure 1). The biggest growth was observed in the variant with drip irrigation, the smallest – in the variant with woodchip mulch for both cultivars.

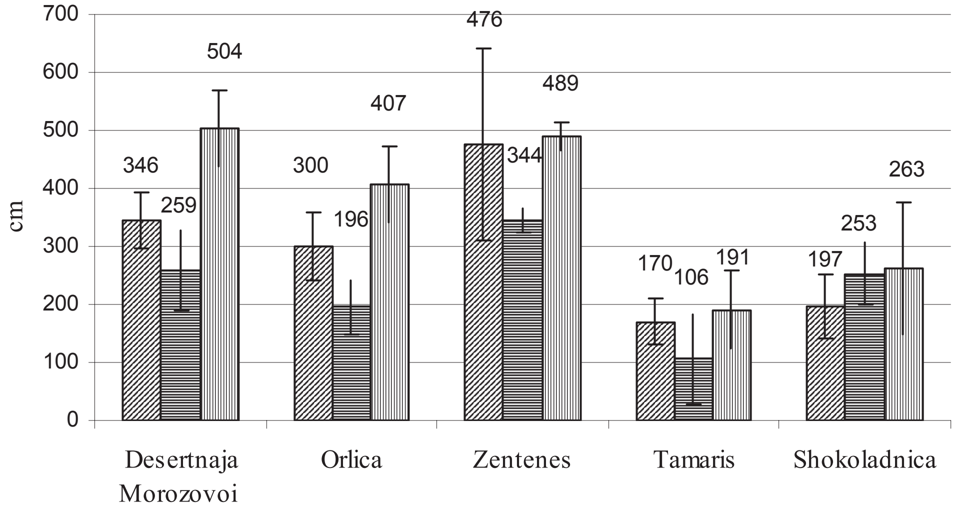

Figure 1. Vegetative growth (cm) of several sour cherry cultivars influenced by woodchip mulch or drip irrigation use in 2007 (columns with diagonal strokes mark the growth in control variant, columns with horizontal strokes – the growth in woodchip mulch variant, columns with vertical strokes – the growth in drip irrigation variant).

Soil moisture adjustments did not cause significant differences (p<0.05) to the growth of cultivars 'Tamaris', 'Shokoladnica', 'Bulatnikovskaya', 'Latvijas Zemais' and 'Zentenes' in 2007.

In 2008 most of cultivars had the biggest growth in the variant with drip irrigation but differences with the growth in other variants were not significant by p≤0.05. This tendency was most pronounced in growing of the cultivar 'Zentenes'. The mean vegetative growth of the cultivar 'Zentenes' in the drip irrigation variant was 3148 cm, in the mulch variant - 3074 cm, in the control variant – 1814 cm (p= 0.1...0.2).

Still the growth of cultivar 'Shokoladnica' was bigger in the variant with mulch than in control variant in both years, and growth of cultivar 'Bulatnikovskaja' was the biggest in the control variant in both years. But these diferences were not significant by p ≤ 0.05 either.

Analysis of sour cherry branching angles

The branching angles of lateral shoots were characterized, because they are different. Branching angles of spurs and twigs usually are wide whereas branching angles of upright shoots are narrow. Wide angles are preferable for lateral shoots. They provide better light distribution in canopy and better yielding. It must be pointed out that these terms - wide and narrow angles - differ in fruit growing and geometry. Wide angles are wider then 45˚ but narrow angles are narrower than 45˚ as categorized in fruit growing.

In general the mean branching angles of lateral shoots did not differ significantly in 2007 (50˚ in all variants) depending on soil moisture adjustment. Only one sour cherry cultivar – 'Shokoladnica' had significant (p<0.05) differences between branching angles in the control variant (mean angle 46˚) and the variant with mulch (mean angle 65˚) or the variant with drip irrigation (mean angle 57˚). Differences between mulch and drip irrigation variants were not significant.

Using of woodchip mulch significantly (p=0.05) influenced the branching angles of lateral shoots in 2008 –the mean branching angle was 70˚ in this variant. The mean branching angle of lateral shoots in the control did not differ significantly from the mean branching angle in the variant with drip irrigation (60˚ and 55˚ respectively).

Differences between the mulch variant and other variants were also significant in the summarized estimation of both years.

Differences between branching angles depending on sour cherry cultivar features were in general significant ($p<0.01$) in both years. Lateral shoots of cultivar 'Zentenes' had the widest angles – the mean angle was 80˚. Cultivars 'Shokoladnica' and 'Orlica' had wider angles of branches (mean angles 75˚ and 58˚ respectively) than the other cultivars ($p<0.05$).

The same cultivars – 'Zentenes', 'Shokoladnica', 'Orlica', as well as cultivars 'Bulatnikovskaya' and 'Desertnaya Morozovoi' significantly ($p<0.05$) responded to the using of woodchip mulch by developing wider branching angles than in the control variant in 2008. Most of cultivars had no significant differences between the irrigation variant and the control variant this year. However, branchig angles of cultivars 'Zentenes' and 'Desertnaja Morozovoi' were significantly wider in the variant with drip irrigation than in the control variant.

Branching angles of cultivars 'Latvijas Zemais' and 'Tamaris' did not respond significantly to soil moisture adjustments both in 2008 and in 2007.

There is a lack of information about the influence of the soil moisture adjustment on the branching angles of horticultural crops. Many factors and their interaction can be involved. One of them phototropism - is a well known property of plants, the ability to slope towards light (Briggs, 1960). The light reflected by woodchip mulch could partially influence this tendency.

Analysis of various shoot type proportions

Advanced growth caused by the drip irrigation was proven in several investigations. However, some questions have risen:

-if the additional pruning is needed due to the increased growth,

-if the amount of intensively yielding shoots – twigs and spurs changes proportionally with the total vegetative growth.

Proportions of pruned branches did not differ significantly ($p=0.2$) either between the soil moisture adjustment variants or various cultivars. On the average proportion of pruned branches was 19% in the control variant, 20% in the variant with drip irrigation and 23% in the variant with woodchip mulch. The proportion of pruned branches in the drip irrigation variant was only for 1% bigger than in the control but growth increase in the drip irrigation variant differed from 17% to 49%. So the growth at drip irrigation caused no significant additional pruning. There was a tendency of a more dense canopy and additional pruning caused by the mulch variant.

Differences of twig proportions were not significant either between soil moisture adjustment variants or cultivars. The mean twig proportion was 4 % on average, it differed from 2% (control variant) to 4% (drip irrigation variant) depending on the soil moisture adjustment, and from 2% ('Latvijas Zemais', 'Zentenes') to 5% ('Tamaris') depending on the cultivar.

In general the proportions of spurs were not significantly different depending on the soil moisture adjustments. These proportions varied from 0.8% (mulch variant) to 1.4% (control variant). There were significant differences between spur proportions depending on the sour cherry cultivar ($p<0.05$). Cultivars 'Tamaris', 'Zentenes', 'Orlica' had significantly higher proportions of spurs than the other cultivars: 3.4%, 2.6% and 1.6% respectively (Figure 2). Cultivar 'Latvijas Zemais' had the lowest proportion of spurs – 0.3%.

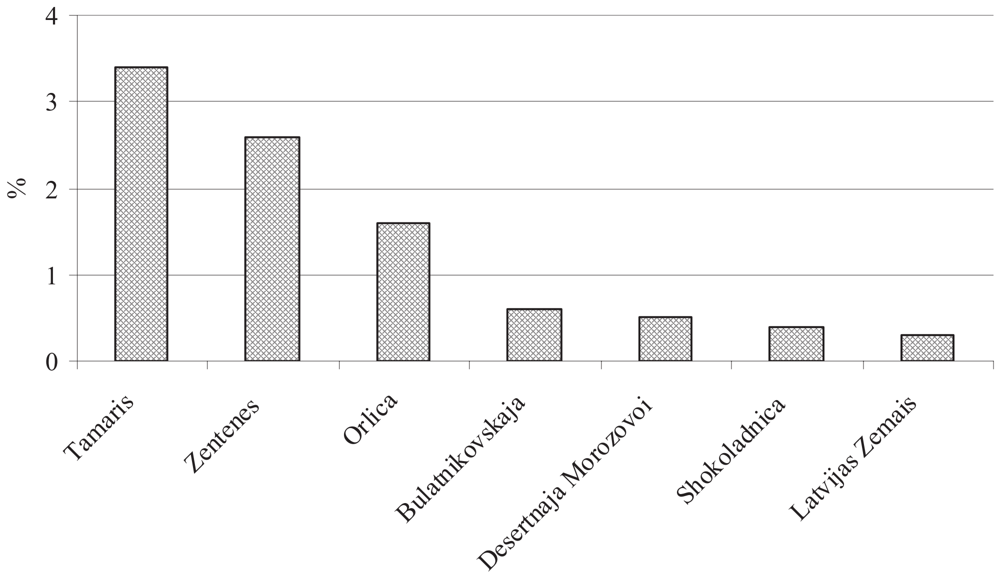

Figure 2. Mean spur proportions (%) of cherry cultivars.

Soil moisture adjustment did not cause significant differences of spur proportions in most of separately observed cultivars too. Only one cultivar – 'Orlica' had significant differences ($p<0.05$) of the spur proportion between the variant with woodchip mulch (0.8%) and the variant with drip irrigation (2.0%) or the control variant (3.8%). Similar results obtained I. Dencker and P. Hansen with the sour cherry cultivar 'Stevnsbaer' (Dencker and Hansen, 1994). In their investigation, there was a higher proportion of spurs in the control variant than in the variant with fertigation.

The investigation carried out by E. Rubauskis with apple trees confirms the significance of the cultivar to the spur formation – the spur proportions differed depending on apple cultivars (Rubauskis, 2005).

Conclusions

1. The cultivars 'Zentenes', 'Desertnaja Morozovoi', 'Latvijas Zemais', 'Orļica', 'Tamaris' had a tendency to increase the vegetative growth in the variant with the drip irrigation.
2. The rate of branching angles of sour cherries was significantly influenced by the use of the woodchip mulch in the second growing year – branching angles were wider ($p<0.05$).
3. The cultivar 'Orlica' had significantly higher spur proportion in the control variant ($p<0.05$).
4. Vegetative growth, branching angles and proportion of spurs were significantly influenced by the cultivar of sour cherries ($p<0.05$).

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THE EVALUATION OF *RHIZOBIUM LEGUMINOSARUM* STRAINS EFFECTIVENESS IN FIELD BEANS (*VICIA FABA* L.) AT DIFFERENT SOIL MICROBIOLOGICAL ACTIVITY

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Abstract

The inoculation of the legume seed material with active nitrogen fixing bacteria strains before sowing has a significant role for the increase of the legume yield. Inoculation can improve crop yields in cases where appropriate rhizobia are not present in the soil or the soil contains a significant proportion of non-nodulating or ineffective nitrogen-fixing strains. The aim of the investigation was to detect the effectiveness of *Rhizobium leguminosarum* strains in field beans at different soil microbiological activity. The experiment was conducted at the Institute of Soil and Plant Sciences of the Faculty of Agriculture of the Latvian University of Agriculture from the 5th of June till the 17th of October 2008.

The field bean (*Vicia faba*. L) cultivars 'Ada', 'Lielplatones', *Rhizobium leguminosarum* bv. *vicia* strains No. 110; 408; 501 and 2 types of soils (with different microbiological activity) were used in vegetation pot experiment. The highest shoot dry matter was observed in cultivars cultivated in soil with higher microbiological activity. The highest pod dry matter was observed in cultivars cultivated in soil with higher microbiological activity. The highest total nitrogen amount was in field beans cultivated in soil with lower microbiological activity. *Rh. leguminosarum* strain resistance to streptomycin decreases with the plants age, from anthesis forward in both soil types and both cultivars. The fingerprinting showed significant difference between *Rh. leguminosarum* strains.

Key words: field beans, *Rhizobium leguminosarum*, inoculation.

Introduction

Wide cultivation and spread of field beans (*Vicia faba* L.) in the temperate and the subtropical regions have ranked it the fourth most important legume crop in the world, next to dry beans, dry peas and soya. The crop contributes to human and productive domestic animal nutrition as a result of its high protein content and other essential nutrients. Although field beans are less consumed as human food in western countries, it is considered as one of the main sources of cheap protein and energy in Africa, parts of Asia and Latin America, were most people cannot afford meat sources of protein (Haciseferogullari et al., 2003).

The nutritional value of field beans has always been traditionally attributed to its high protein content, which ranges from 27 – 34% depending on genotypes. Most of these proteins comprise globulins (79%), albumins (7%), and glutelins (6%) (Haciseferogullari et al., 2003). Legume seeds contain several comparatively minor proteins, including trypsin inhibitors, lectins, lipoxygenase and urease, which are relevant to the nutritional quality of the seed (Alghamdi, 2009).

One of the major aims of agricultural policy is increasing crop production, which could be achieved by various ways; one of the methods is increasing the efficiency of biological nitrogen fixation.

Rhizobium is a genus of soil bacteria whose members are best known for their ability to establish symbiotic relationships with legumes of agricultural and environmental importance in a process of biological nitrogen fixation (Moschetti et al., 2005).

Symbiotic nitrogen fixation results from the complex interaction between the host plant and the microorganisms. The host plant provides the microorganisms with a source of energy for growth and function, and with a specialized ecological niche. The microorganism fixes atmospheric N_2 and provides the plant with a source of reduced nitrogen, in the form of NH_4 (Hirsch, 1992).

The inoculation of cultivated leguminous plants with selected rhizobial strains is recommended in order to maximize the contribution of biological nitrogen fixation to the nitrogen status of the host plant (Oliveira et al., 1999).

The success of inoculants requires that the inoculant strains are both highly effective in nitrogen fixation and highly competitive with the indigenous soil strains in nodule formation (Gwyn et al., 1989). The presence of indigenous rhizobia in soil may represent a barrier to efficient inoculation with *Rhizobium leguminosarum* strains because indigenous strains are often better adapted to the prevailing soil and climate condition

(Oliveira et al., 1999). The various environmental and biotic factors which directly or indirectly affect competition for nodulation of the host legumes, including soil characteristics, pH, salinity, water potential, temperature, microbial antagonism, predation and parasitism (Bottomley, 1992).

The aim of the investigation was to detect the effectiveness of *Rhizobium leguminosarum* strains in field beans in soils with different microbiological activity.

Materials and Methods

The experiment was conducted at the Institute of Soil and Plant Sciences of the Faculty of Agriculture of the Latvian University of Agriculture from the 5th of June till the 17th of October 2008.

The field bean (*Vicia faba*. L.) cultivars 'Ada' and 'Lielplatones' were used in vegetation pot experiment.

Before seeding, the surface of field bean seeds was sterilized (with ethanol, 98%), rinsed three times in sterile water. *Rhizobium* seed inoculation was done by using *Rhizobium leguminosarum* bv. *vicia* strains No. 110; 408; 501 which were obtained from the *Rhizobium* collection of the Latvia University of Agriculture of Institute of Soil and Plant Science. The *Rh. leguminosarum* strains No. 110 are included in IBP World catalogue of Rhizobium leguminosarum Collections (Allen and Hamatova, 1973). The inoculants were mixed with moistened seeds. Control seeds weren't inoculated with *Rh. leguminosarum* strains.

The vegetation pots (5 L) were sterilized (with phenol, 5%) and after sterilization filled with soils. In each pot were seeded five sterile field bean seeds. In the vegetation pot experiment were used 2 types of soils from the Latvia University of Agriculture agency Research Institute of Agriculture. The first type (A): organic matter 2.7%; pH_{KCl} 6.8; P 60.66 mg kg^{-1}; K 86.33 mg kg^{-1} and the second type (B): organic matter 5.2 %; pH_{KCl} 6.9; P 71.13 mg kg^{-1}; K 82.18 mg kg^{-1}. The soil microbiological activity was detected by catalysis. Results show: the soil A catalysis activity was 0.76 but the soil B catalysis activity was 1.08 mL O_2 in 10 g soil per 1 min (Sinha et al., 2009). The experiment was performed in 4 replicas.

After seeding all pots were placed outdoor and watered.

Plants were analyzed at five plant development stages: three leaves; butonisation; anthesis; pod development and pod maturing. In each plant development stages, in each soils and in cultivars were analysed 16 vegetation pots. The analysed parameters of plants were shoots: fresh mass (g per plants), dry matter (all samples were desiccated at 60 °C, not higher, for further nitrogen analysis (g kg^{-1})) and total nitrogen amount (by Kjeldal (g kg^{-1})).

Nodules resistance to the antibiotic streptomycin was analysed at butonisation, anthesis and pod development stages. At least 20 nodules from each inoculated sampling at each plant development stage and a total of 3200 nodules were processed for strain identification. Nodules were washed and surface sterilized by sublimate ($HgCl_2$, concentration 0.1%) for 5 minutes. The nodules were then washed in three changes of sterile distilled water, crushed and streaked on maximum sustainable yield agar containing streptomycin (100 µg mL^{-1}) and incubated at 27 °C. For the control maximum sustainable yield agar weren't added streptomycin. Establishment of the inoculums strain was estimated as the percentage of isolates (from 20 streaked on agar) which were resistant to streptomycin.

Total genomic DNAs from *Rh. leguminosarum* strains were extracted by using Fast DNA® Kit (MP Biomedicals), according to manufacturer's instruction. The concentration and the purity of DNA were estimated spectrophotometrically at 260 and 280 nm (Nano Drop ND – 1000). Chromosomal portion of the *Rhizobium leguminosarum* genome was characterized using the automated ribosomal intergenic spacer analysis (ARISA). ARISA distinguishes microbial populations based on the length heterogeneity in the ribosomal intergenic spacer region (Jones et al., 2007). The conditions for ARISA polymerase chain reaction (PCR) using the 1406f/23Sr primer set. Primer set 106f/23 Sr consist of 5' – TGYACACACCGCCCGT – 3' (forward primer sequence) and 5'- GGGTTBCCCCATTCRG – 3' (reverse primer sequence) methods described by Angela D. Kent (personal communication). A molecular size marker 100 bp + 500 bp DNA Ladder (Fermentas) was run in gels (1%). The restriction patterns were visualized under UV illumination (Cleaver Scientific, DI – HD).

Results and Discussion

The obtained results on resistance to the antibiotic showed that at the butonisation, anthesis and pod development stages all *Rh. leguminosarum* strains were active and formed nodules. Results are significant for understanding Rhizobium leguminosarum strain activity on legumes root infection and competitiveness with native rhizobia. For the cultivar 'Lielplatone' at the butonisation and anthesis stages (Fig. 1.) in both soil types the highest resistance to streptomycin was showed by strain No. 110, but at the pod formation stage by strain No. 408. In both soil types at the butonisation and anthesis stage the lowest resistance to streptomycin was showed by strain No. 501, but at the pod formation stage by strain No. 110. For the cultivar 'Ada' at the butonisation, anthesis and pod development stages in both soil types the highest resistance to streptomycin was showed by strain No. 408. In both soil types at the butonisation, anthesis and pod development stages the lowest resistance to streptomycin was showed by strain No. 501. The obtained results in cultivar 'Ada' and 'Lielplatone' showed that resistance of the used *Rh. leguminosarum* strains to streptomycin decreases in both soil types from the anthesis stage forward. This is related to decreased activity of *Rh. leguminosarum* strains and nodules agedness.

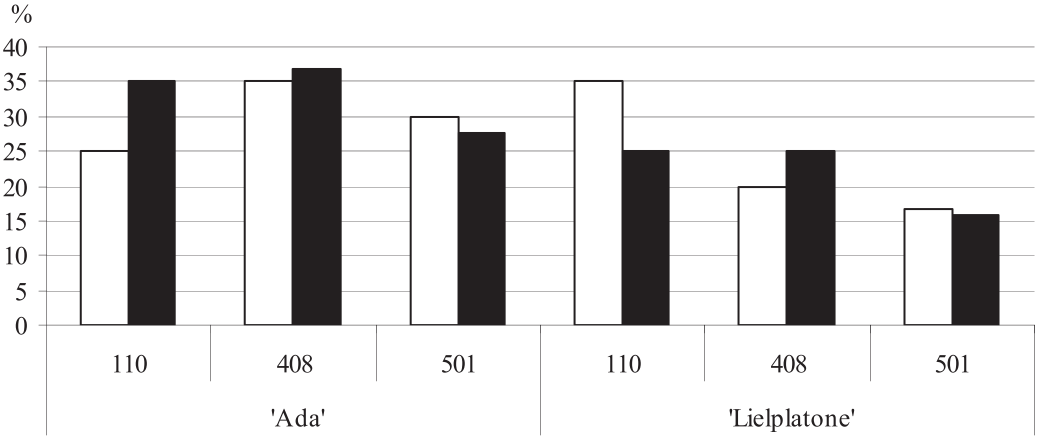

Figure 1. Rh. *leguminosarum* strains resistance to strempomycin at anthesis phase, %: ❑ Soil A ■ Soil B.

The field bean cultivar 'Ada' shoot fresh mass was significantly influenced by soil type (F_{fact} 112 > F_{crit} 3.05), *Rh. leguminosarum* strains (F_{fact} 3.88 > F_{crit} 2.66) and plant development stages (F_{fact} 92.986 > F_{crit} 2.42) (Fig. 2.). The highest fresh mass was detected at pod development stage, and the highest increase of fresh mass was detected from anthesis till pod formation stage. A significant influence of soil type (F_{fact} 110.879 > F_{crit} 3.05) and plant development stages (F_{fact} 109.695 > F_{crit} 2.42) on shoot fresh mass of the cultivar 'Lielplatones' was observed. The impact of *Rh. leguminosarum* strains was not observed. The highest fresh mass was detected at pod development stage, and the highest increase of fresh mass was found from anthesis till pod formation stage. The observed results showed the highest fresh mass for cultivars 'Ada' and 'Lielplatone' cultivated in soil B. The significant impact of cultivar was observed on field bean fresh weight at the pod formation stage (F_{fact} 8.24 > F_{crit} 3.98).

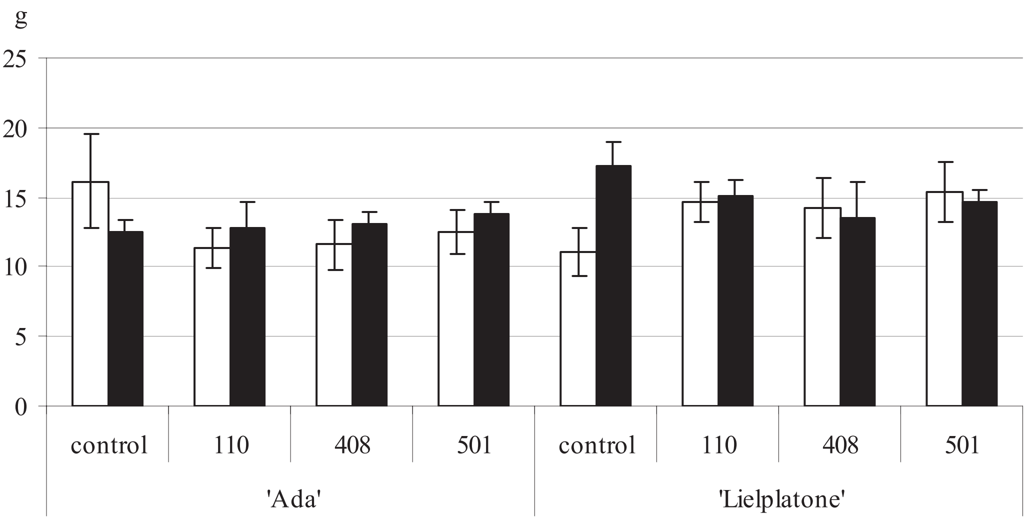

Figure 2. The field bean shoot fresh mass at the anthesis phase, g per plants: ❑ Soil A ■ Soil B.

Shoot dry matter of field bean cultivar 'Ada' was significantly affected by soil type (F_{fact} 5.015 > F_{crit} 3.05), and plant development stages (F_{fact} 81.418 > F_{crit} 2.42) (Fig. 3.). At the end of vegetation period the highest dry matter was observed in field beans cultivated in soil A with inoculums No. 501 and cultivated in soil B with inoculums No. 110. A significant impact of cultivar was observed only at the pod development stage. A significant impact of soil type (F_{fact} 14.565 > F_{crit} 3.05), and plant development stages (F_{fact} 20.492 > F_{crit} 2.42) on field bean cultivar 'Lielplatone' shoot dry matter was observed. At maturity stage the highest dry matter was in the field beans cultivated in soil A with inoculums No. 110 and cultivated in soil B with inoculums No. 408. Results show that dry matter in cultivars 'Ada' and 'Lielplatone' significantly increased from the pod development stage till maturity stage.

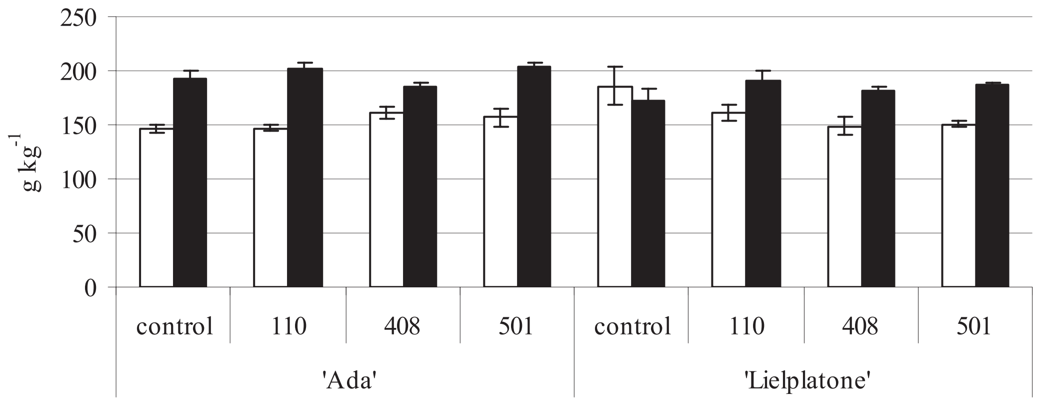

Figure 3. The shoot dry matter at the anthesis phase, g kg^{-1}: ❑ Soil A ■ Soil B.

No significant impact of the *Rh. leguminosarum* strains on total nitrogen amount at the anthesis stage was detected (Fig. 4.). For cultivar 'Ada' cultivated in both soil types the highest total nitrogen amount at anthesis stage was observed in field beans without inoculants. Whereas for cultivar 'Lielplatone' cultivated in soil A the highest total nitrogen amount at anthesis stage was detected in field beans inoculated with strain No. 501 and in soil B in field beans inoculated with strain No. 408. The observed results showed that the highest total nitrogen amount was in the field beans cultivated in soil A. This is explained by soil A containing less organic matter, organic and inorganic nitrogen, and lower microbiological activity as compared to soil B. Less organic matter, organic and inorganic nitrogen induce *Rh. leguminosarum* strain and indigene nitrogen fixing bacteria to fix N_2 from the atmosphere more actively. Lower microbiological activity causes less competition with other soil microorganisms, although this question demands more research.

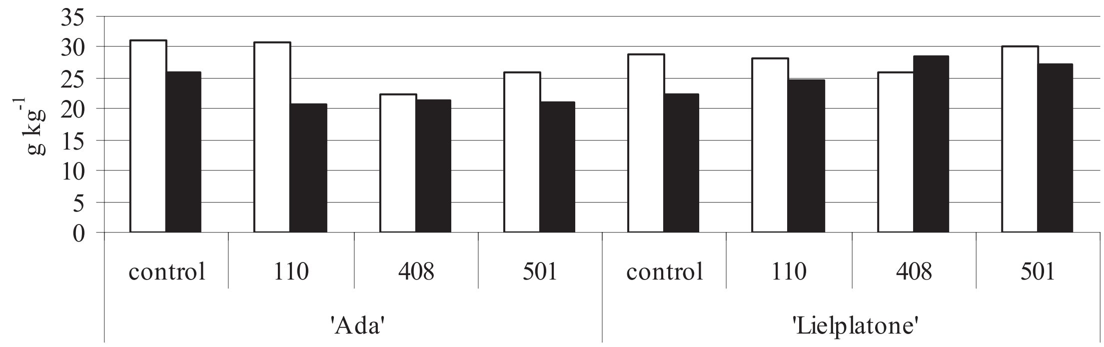

Figure 4. The total nitrogen amount at the anthesis stage, g kg^{-1}: ❑ Soil A ■ Soil B.

The fingerprintings show differences between *Rh. leguminosarum* strains. The characterizing DNS fragments used primers 106f and 23 Sr the *Rh. leguminosarum* the base pairs (bp) range from 1500 – 3500 bp.

Conclusions

1. A significant impact of soil type, inoculant and plant development stage on fresh weight of plants was observed.

2. The highest fresh weight, shoot dry matter and pod dry matter was detected in cultivars cultivated in soil with higher microbiological activity. The highest total nitrogen amount was in field beans cultivated in soil with lower soil microbiological activity.

3. *Rh. leguminosarum* strain resistance to streptomycin decreases with the plants development stages from anthesis forward in both soil types and both cultivars. For the cultivar 'Lielplatone' the highest resistance on streptomycin was showed by strain No. 110, but for cultivar 'Ada' by strain No. 408.

4. For understanding the role and significance of indigenous nitrogen fixing bacteria in competition with *Rh. leguminosarum* strain, future studies are needed.

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EVALUATION OF WINTER HARDINESS AND PRODUCTIVITY OF FIVE HIGHBUSH BLUEBERRIES CULTIVARS IN LATVIA

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Abstract

Winter hardiness is very important for introducing and commercial cultivation of blueberries in North Europe. Winter survival in the field is influenced by multiple factors that are influenced by uncontrollable environmental parameters. In the years 2006-2008, in eight farms were surveyed in different fruit-growing areas of Latvia, which produce highbush blueberries. We were interested in the plants physiological conditions (winter hardiness) after the winter, yields and the growth conditions. All study sites were evaluated by 6-year-old plant of highbush blueberry cultivars 'Polaris', 'Chippewa', 'Patriot', 'Northblue' and 'Duke'. After the year 2006/2007, the highest winter hardiness was observed for 'Polaris', 'Chippewa', 'Northblue' and 'Patriot'. The lowest winter hardiness was observed in 'Duke'. December 2007, January and February 2008 changing weather conditions did not do significant damage in plantations. 'Patriot' and 'Chippewa' had the highest average yield (kg per bush) throughout the production period, cultivar 'Northblue' had the lowest yield. On the other hand, 'Northblue' had the highest 100 berry weight. Cultivar 'Patriot' had the largest berry size - most of the berries had a diameter of 15 - 16 mm.

Key words: *Vaccinium corymbosum* L., weather condition, yield, berry weight.

Introduction

Blueberry is one of the richest sources of polyphenolic antioxidant compounds that have important role in human health. In the last few years, consumer demand for components that protect health and delay the onset of disabilities associated with chronic and degenerative diseases has given producers a significant opportunity to obtain higher prices for blueberries than they could get if blueberries were sold merely as food (Giongo et al., 2006).

In commercial agriculture the major blueberry-producing species are lowbush and highbush blueberries. Highbush blueberries (*Vaccinium corymbosum* L.) are native to North America (latitudes 40 to 45 °N, Latvia is located in latitudes 55 to 58 °N), upright, 2 m tall, crown-forming shrub. Fruit ranging 3 – 20 mm are blue-black berries with many seeds. More than 50 cultivars of highbush blueberry have been developed in North America, primarily based on selections for commercially valuable fruit characteristics and seasonality. Lowbush blueberry (*Vaccinium angustifolium* Ait.) is native to eastern and central Canada and the north-eastern United States.

Highbush blueberry cold hardiness varies tremendously among types and cultivars. Highbush and lowbush blueberries generally are hardy to at least - 2 °C, although some cultivars are tenderer. Winter injury usually is not a problem in western Oregon and Washington (USA). However, if a severe cold spell occurs early, before plants are fully dormant, winter injury may occur (Hancock et al., 1987). Winter hardiness of blueberry species and cultivars is very important for introducing and commercial cultivation in North Europe (Haffner and Vestrheim, 1994). Winter survival in the field is influenced by multiple factors that are influenced by uncontrollable environmental parameters (Hummel et al., 1982). For example such as fall-timing of growth cessation, freezing tolerance at the cold acclimation state, the tolerance to fluctuation of temperature in late winter and early spring, chilling requirement, wind desiccation, snow cover etc. and thus may exhibit annual variation (Fowler and Gusta, 1979; Fear et al., 1985).

Depending on which tissues have been injured and the degree of injury, symptoms of "delayed winter injury" may not appear until late spring or early summer. Shoots may bloom, leaf out, and even begin setting fruit before suddenly collapsing and dying over one or two-day period. Sudden collapse usually is related to the onset of hot weather, which increases the demand for water by the developing shoots and fruit. Injured vascular tissues are unable to supply the needed water and nutrients, and the shoot collapses (Biermann et al., 1979).

Cultivars of northern highbush blueberries require the greatest number of winter chilling hours, and therefore most suitable for areas with long cold winters (Trehane, 2004). Highbush blueberry plants damage usually occurs when temperatures fall to around - 29 °C, well-acclimated canes can withstand an extreme of - 40 °C.

Half-highbush blueberries (*Vaccinium×covilleanum)* 'Northblue' survive -30 °C, 'Nortcountry' -35 °C and they need 800 chilling hours (Gough, 1994). Dangerous time for blueberry plants is spring with the flowers receiving the frost damage (Hicklenton et al., 2002).

Critical temperatures and spring frost damage of blueberry have been well studied in the world; however, there are few studies about influence of temperature fluctuations on blueberry growth, development and productivity. Distance to the Atlantic Ocean, Baltic Sea and Gulf of Riga and the large-scale terrain are major factors that determine regional differences in climate in Latvia. Away from the Atlantic Ocean and the Baltic Sea, marine climate features decline and the growing conditions have signs of continentality. Frequent cyclones from west influence the winter character in Latvia and arisen a high air temperature fluctuation (daily from + 5 °C to -10 °C or more).

The aim of the study was to define the five highbush blueberry cultivars winter hardiness and productivity in Latvia.

Materials and Methods

In the years 2006-2008 was evaluated the situation in eight farms of different fruit-growing areas of Latvia that produce highbush blueberries. We were interested the plants physiological conditions (winter hardiness) after the winter, fruit productivity and quality.

Studies for plant physiological conditions, productivity and yield quality characteristics taken in the LUA, Faculty of Agriculture Institute of Agrobiotechnology teaching-research base in Jelgava, as well as part of the studies carried out in the farms from western (region of Jelgava and Tukums), eastern (region of Aluksne and Preili), central (region of Valmiera) part in Latvia and district of Riga six-year-old plants of highbush blueberry cultivars 'Polaris', 'Chippewa', 'Patriot', 'Northblue' and 'Duke' were evaluated in all study sites.

Short characteristics of cultivars:

'Chippewa'- midseason, berry: medium size, very light blue color, medium firm, good flavour;

'Duke' – early season, berry: large size, medium blue color, firm, good flavour;

'Northblue' – early midseason, berry: medium size, dark blue color, medium firm, fair acid flavour;

'Patriot' – early season, berry: large size, medium blue color, firm, excellent flavour;

'Polaris' - early season, berry: medium size, light blue color, firm, excellent flavour (Hancock and Hanson, 2001).

In spring (from the beginning of May to the end of June), winter hardiness was estimated using a ten-point scale (0 point – a plant is dead, 1 point – very low winter hardiness, all branches damaged up to the soil level, 9 point – very high winter hardiness, branches not damaged).

The air temperature was determinate by using State agency Latvian Environment, geology and meteorology agency's data in different areas of Latvia.

Taking into account the climatic conditions of the years 2006/2007 it was impossible to correctly register the blueberry yields in 2007. The highbush blueberry fruit ripen gradually, so the yield was picked five times from the end of July 2008 to the end of August 2008. The yield was harvested by hand and at the same time was established 100 fruit weight (g) and fruit was grouped by size group (< 12, 12-14, 15-16, 17-18, < 19 mm). We observed 3 individual plants of every cultivar in every fruit-growing area.

All measurements were made in three replications. The calculation of standard division was used in same objective.

Results and Discussion

The first seven months in 2006 passed with insufficient precipitation for blueberries. There was a particularly scarce amount of precipitation in July, only 24% of the norm for Latvia. The insufficient amount of precipitation caused losses in all agriculture in Latvia (Table 1).

Table 1

Temperature and Precipitation Values Compared with the Long Term Average in 2006-2007*

Month	Average daily air temperature, °C			Precipitation, mm		
	2006	2007	Long term average	2006	2007	Long term average
January	- 5.2	0.3	- 4.8	15	99	40
February	- 5.9	- 8.2	- 5.2	23	27	30
March	- 3.0	4.4	- 1.0	30	27	31
April	4.8	5.1	4.5	29	28	41
May	12.0	12.6	13.0	40	57	48
June	17.0	18.3	15.0	37	60	62
July	20.0	16.6	17.0	19	111	80
August	17.0	18.0	15.5	89	79	80
September	14.0	11.9	11.0	43	81	72
October	8.0	7.1	6.0	75	91	62
November	4.0	1.2	2.0	73	78	61
December	4.3	1.7	- 2.5	68	41	50

*Source: Latvian Agency of the Environment, Geology and Meteorology.

The fluctuation of temperature in November and December, 2006 and January and February, 2007 (Table 2) influenced the frost resistance of highbush blueberry.

Table 2

The Air Temperature in Different Fruit Growing Areas of Latvia (from November 2006 to April 2008, °C)*

Monthh	Western Part		District of Riga		Central Part		Eastern Part	
	min	max	min	max	min	max	min	max
Nov.06	-12.9	11.1	-6.4	10.0	-11.8	8.8	-10.6	7.6
Dec.06	-6.4	11.6	-2.7	11.0	-10.2	8.8	-8.1	9.7
Jan.07	-20.3	10.7	-13.3	10.2	-18.8	4.0	-18.7	8.8
Feb.07	-29.7	4.2	-21.4	3.4	-25.9	0.9	-27.1	0.6
Mar.07	-5.2	18.0	-1.9	16.5	-3.6	16.9	-3.9	16.8
Apr.07	-5.0	23.9	-2.3	21.7	-4.1	21.3	-7.7	22.1
Mai.07	-3.6	29.4	-0.3	28.3	-4.3	22.1	-5.2	29.0
Jun.07	2.8	27.5	8.8	26.1	8.1	25.4	5.9	26.2
Jul.07	6.0	28.1	9.2	25.7	9.1	25.2	7.4	25.4
Aug.07	2.1	30.1	4.9	27.5	5.0	30.1	4.4	30.1
Sep.07	0.6	22.5	4.8	20.0	1.5	22.5	1.2	21.9
Okt.07	-5.5	18.1	-1.9	15.7	-3.0	17.2	-3.1	16.6
Nov.07	-6.6	11.4	-3.9	10.0	-8.5	9.2	-9.9	8.9
Dec.07	-9.1	8.6	-5.6	6.8	-8.7	6.2	-9.3	5.6
Jan.08	-14.3	7.3	-15.2	5.5	-18.8	4.7	-18.4	4.2
Feb.08	-12.4	9.4	-6.6	9.8	-12.0	6.7	-14.0	5.9
Mar.08	-9.4	15.5	-6.3	15.2	-11.0	11.2	-10.0	11.6
Apr.08	-3.3	22.8	-0.6	22.7	-1.4	22.0	-3.1	21.6

*Source: Latvian Agency of the Environment, Geology and Meteorology.

Likewise, the minimum air temperature for December of the year 2006 was unusually high (+11.6 °C in western part). During the warmest days of the month it reached even 8 to 10 °C in some locations which is typical for September. As a result, the plants did not have the deep rest period and flower buds of the high-bush blueberries were swollen to the degree which is usually observed at the start of May (the flower buds of the high-bush blueberries are usually swollen when the average temperature of the air is above 10 °C, but the vegetation period starts when the average temperature of the air is above 4.7 °C (Gough, 1994). In turn, the minimum temperature January 2007 in western part fall till - 20.3 °C, and February 2007 - 29.7 °C (respectively in eastern part - 18.7 and - 27.1 °C, central part - 18.8 and - 25.9 °C but district of Riga – 13.3 and – 21.4 °C). Winter of 2007/2008 was more suitable for growing highbush blueberries and more typical for Latvia.

All surveyed plantations of highbush blueberries were affected by frost in the winter 2006/2007 (Table 3). The new plantations, planted in 2006, were particularly affected in the eastern part of Latvia and many plants died. In six farms, plantations were renewed, but other two enterprises have decided not to replant cultivars 'Duke'. After the winter of 2006/2007, the highest winter hardiness was observed for 'Polaris' in farm by district of Riga (8 points), but lowest winter hardiness was in central part only 4 points. In all of parts 'Chippewa' was observed even result (4.2 points in district of Riga to 5.5 points western and central parts of Latvia). 'Northblue' the highest winter hardiness was in central part (6.5 points). The 'Patriot' highest winter hardiness was in district of Riga 5.5 points, but in all other part 'Patriot' winter hardiness was lowest (from 3.2 in eastern part to 4.2 points in central part). The lowest winter hardiness was observed for 'Duke' in eastern part 0.5 points to 1.8 points in district of Riga.

Only single highbush blueberry branches were damaged by frost (cultivars 'Chippewa' in western part and district of Riga, and cultivars 'Duke' in eastern part), performed in 2008 (Table 3). Highbush blueberries crops damage from spring frost in western and eastern part, when the temperature dropped.

Table 3

Winter-hardiness of the High-bush Blueberry Plantations in the Fruit Growing Areas of Latvia 2007 – 2008

Variety	Western Part		District of Riga		Central Part		Eastern Part	
	2007	2008	2007	2008	2007	2008	2007	2008
'Polaris'	4.5	8.7	8.0	9.0	4.0	9.0	5.5	8.5
'Chippewa'	5.5	7.5	4.2	8.0	5.5	8.7	5.0	8.0
'Patriot'	3.5	8.5	5.5	8.3	4.2	9.0	3.2	8.3
'Northblue'	4.0	8.3	4.0	9.0	4.0	9.0	6.5	8.0
'Duke'	1.5	8.7	1.8	9.0	1.2	8.6	0.5	7.7
Standard deviation	1.48	0.5	2.27	0.48	1.57	0.19	2.36	0.31

The highest winter hardiness of all fruit-growing areas was observed in plantations of farms in district of Riga. Different cultivars of the highbush blueberries are grown in the different fruit-growing areas of Latvia. The highest cultivar diversity was observed in the western and central parts of Latvia and in the District of Riga. The selection of cultivars was more limited in the eastern part.

Only at the end of June 2007 it was possible to determine highbush blueberry plants for winter damage. In all the surveyed farms from the adverse weather highbush blueberries were damaged very minimally, some plantations were seen frost injury (suffered fruit slips), this was due to low air temperatures in June (in western part minimum temperature was + 2.8 °C) and July (in western part minimum temperature was + 6.0 °C).

In 2008 blueberries began to bloom in the 1st decade at the end of May - June, while production started in July 2nd and 3rd decade beginning in Latvia. In all areas of most fruit varieties grown are 'Patriot', 'Polaris', 'Chippewa', 'Northblue' and 'Duke'. There is no unity among growers about the best cultivars - each grower considered another cultivars as the best one, because each growers has different goals. In Latvia, unlike blueberry cultivars, grown in the United States, where the crop is ripening more or less simultaneously, highbush blueberry berries harvest is a very laborious process, since berries develop gradually, they must be collected on average of 3-4 times a season, but, for example, the cultivars 'Chippewa' is to be collected up to 6 times (Gough, 1994). We harvested all cultivars five times in a season ('Patriot', 'Polaris', 'Northblue'), except 'Chippewa'. 'Chippewa', which were six times a season.

Taking into account the climatic conditions of the years 2006 and 2007 and winter damage of the highbush blueberries, it was impossible to correctly register the yield in 2007, especially for 'Duke'.

In 2008, assessing the average yield per cultivars in the production period, the highest yield (kg per bush) cultivars showed 'Patriot' - with a yield 4.08 (standard deviation ± 0.47) kg per bush and 'Chippewa'- 3.68 kg per bush, while the lowest yield was cultivars 'Northblue' 1.44 kg per bush (Table 4). The average yield was 2.68 kg per bush.

Table 4

Average Yield and 100 Berries Weight of the Highbush Blueberry Cultivars

Cultivars	Average yield (kg per bush)	100 berries weight, kg
Patriot	4.08±0.47	0.21±0.023
Polaris	2.44±0.85	0.22±0.026
Northblue	1.44±0.36	0.20±0.032
Chippewa	3.68±0.56	0.19±0.01

The 100 berries weight ranged from 0.19 to 0.22 kg (Table 4). During the harvest and its quality performance record, the heaviest 100 berries were from the cultivar 'Northblue' 0.22 kg.

The evaluation of the berry size, most of the berries had a diameter of 15 - 16 mm cultivar 'Patriot'; it is 52%. Cultivar 'Northblue' 34% of the berry had a diameter of 17 - 18 mm and 31% of 15 – 16 mm. Cultivars 'Chippewa' most of berries had a diameter of 12 - 14 mm (Fig.1.).

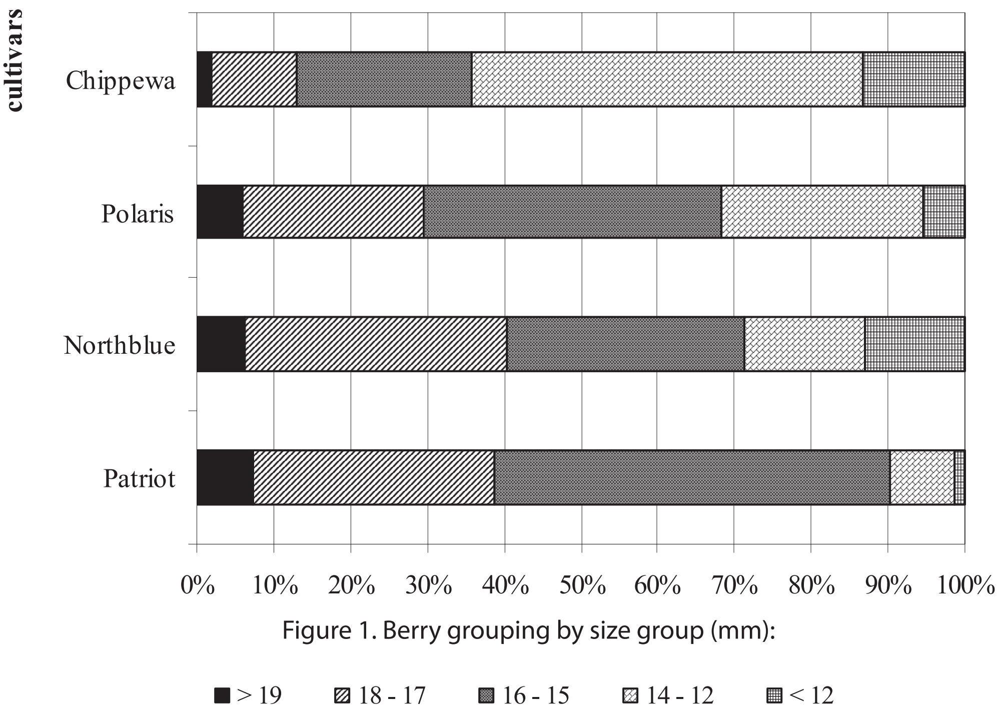

Figure 1. Berry grouping by size group (mm):

Observations, made on blueberry cultivars winter hardiness and yield production, showed that temperature has a major impact on blueberry growth, development and yield formation. In Latvia's climatic conditions blueberries were harvested several times (3 - 6 times, depending on variety).

Although research indicates that the maximum cold hardiness is associated with drought stress in some woody species, blueberry plants should not be allowed to become drought stressed, either during the growing season or after the plants are dormant, in regions with low annual rainfall, irrigate deeply before the soil freezes to provide enough moisture to supply the blueberries during the winter (Byres and More, 1987).

Conclusions

After the year 2006/2007, the highest winter hardiness was observed for 'Polaris' (4 to 8), 'Chippewa' (4.2 to 5.5), 'Northblue' (4 to 6.5) and 'Patriot' (3.2 to 5.5 points). The lowest winter hardiness was observed in 'Duke' (0.5 to 1.8 points).

'Patriot' and 'Chippewa' had the highest average yield (kg per bush) throughout the production period - 4.08 and 3.68 kg per bush, respectively, and cultivar 'Northblue' had the lowest yield.

Cultivar 'Northblue' had the highest 100 berry weight – 0.22 kg and cultivar 'Patriot' had the largest berry size - most of the berries had a diameter of 15 - 16 mm.

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STABILITY OF MORPHOLOGICAL TRAITS IN LATGALE'S MELON LINES

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Abstract

The investigation was carried out from 2006 to 2008 with the aim of observing the stability of morphological traits in Latgale's melon (*Cucumis melo* L.) lines in the Tukums region of Latvia. Four lines of Latgale's melons ('8', '14', '5(2)', and '4(3)') were grown in high plastic tunnels: five plants from each line. The following parameters were measured to determine stability of morphological traits in melons: fruit petiole and flower scar diameters (cm), length and wide of melon fruit (cm), and thickness of flesh (cm). Results showed that there was a significant difference in fruit petiole scar diameter between the years 2006 and 2007 for all lines. The melon line '14' was stable in all parameters from 2006 till 2008 except fruit flower scar diameter. The melon line '4(3)' was less stable in all parameters between all melon lines in all years of investigation.

Key words: *Cucumis melo*, local genotypes, flower scar, petiole scar, fruit length and width, flesh thickness.

Introduction

Melons *Cucumis melo* L. are widely cultivated plants in Central and Southern Europe originated from South Asia and central part of Africa. From these regions (mostly from South Asia) melons have spread around the world (Белик, 1998; Salunkhe, 1998; Лебедева, 2000). Many melon varieties were selected by humans in the entire world since the beginning of melon cultivation (IPGRI, 2003). The melons require high air and substrate temperatures. The recommended sum of effective temperatures (temperature ≥ +10 °C) for melon growth is 3000-5000 °C (Taranovs, 1968). Climatic conditions in Latvia are not suitable for melon growing in open field every season, but it is possible to grow them in plastic tunnels or greenhouses.

In the middle of the past century in Daugavpils region a well-known grape breeder - Pauls Sukatnieks bred several melon cultivars. He worked in Dviete, Latgale's region, and bred such varieties as 'Dvietes Oranžā' and 'Dvietes Banānu'. P. Sukatnieks also developed the growing systems for melons in Latvia (Sukatnieks, 1954). The varieties bred by him were suitable for Latvia's agroclimatic conditions. These varieties were of very short vegetation period, and yielded also in rainy summers (Sukatnieks, 1954).

During several decades these genotypes were destroyed by cross-pollination of different varieties. This unique genetic material was maintained by the gardener Ēvalds Piļka, and scientists Uģis Dēķens and Inese Drudze. Since 2003, a renewal of Latgale's melons was started in Pūre Horticultural Research Centre. Since 2003, inbreeding and sibling was carried out.

The objective of the study was to determine stability of morphological traits in Latgale's melon lines. The main aim of the investigation is to homogenize the genetic material of Latgale's melons.

Materials and Methods

The research was carried out in Pūre Horticultural Research Centre of Tukums region in 2006, 2007 and 2008. Four lines of Latgale's melons ('8', '14', '5(2)', and '4(3)') were used. Five plants were planted from each line.

The melons were sown at the end of April in plastic pots of 8 cm in diameter, in peat substrate with pH_{CaCl2} 5.5±0.5, N – 100-140 mg kg^{-1}, P – 48-74 mg kg^{-1}, and K – 158-241 mg kg^{-1}. The seedlings were grown in pots in a high plastic tunnel till the end of May. Plants were planted in a high plastic tunnel in peat substrate at 0.8 m distance. During the investigations melons were regularly watered and fertilized with $Ca(NO_3)_2$ (1200 g m^{-3} of water) and 'Kemira' 10:10:20 (1750 g m^{-3} of water) every second week.

Harvesting was done when melons were easily separated from the fruit petiole. Measuring of melon parameters was done immediately after harvesting.

The following parameters were measured to determine stability of morphological traits in Latgale's melons: length and width of melon fruit (cm), petiole scar and flower scar diameter (cm) and thickness of flesh (cm).

The vegetation period of 2006 was warmer than one in 2007 and 2008, and the temperature in the high plastic tunnel was high, only the 2nd and 3rd decade of May and the 1st decade of June were cooler in comparison with 2007. The highest temperature was observed in the 1st decade of July in 2006, and the lowest temperature was observed in the 1st decade of May in 2007. The vegetation period of 2008 was cooler in average than one in 2006 and 2007 (Figure 1).

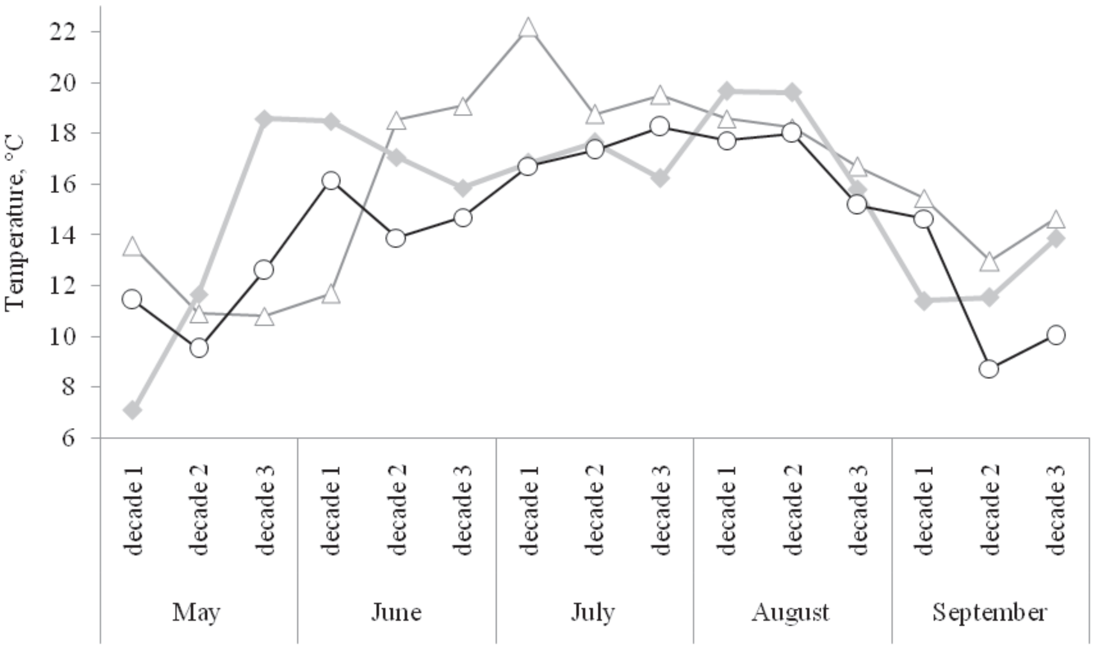

Figure 1. Average outdoor air temperature data of 2006 - 2008

As melons were grown in the high plastic tunnel, the air temperature there was higher and promoted the growth and development of melons. Temperature data were taken from the meteorological station of Pūre Horticultural Research Centre.

Differences between measurements of melon lines were evaluated according to ANOVA. ANOVA two-factor variance with replications was used. P-value was used for stability evaluation.

Results and Discussion

In 2006, 2007 and 2008 the climatic conditions were favorable for the melon growth in high plastic tunnel. The melon growth was depressed only at the beginning of the vegetation period as a result of low air temperatures.

The sum of effective air temperatures in the high plastic tunnel was 2700-2900 °C in average. It should be noted that melons require the sum of effective temperatures between 2800–3200 °C (Фурса et al., 1985; Борисова et al., 1984).

The storage of fruits depends on a fruit petiole scar and flower scar diameter. The scar is a possible focal point of fruit infection by different fungal diseases. (Борисова et al., 1984). The melon lines included in the research are not suitable for a long storage.

The bigger petiole scar diameter was observed for melon lines '5(2)' (1.77 cm), '14' (1.8 cm) in 2006 (Figure 2). The bigger flower scar diameter was observed for melon lines '5(2)' (2.78cm), '14' (2.78 cm) in 2006 and for a melon line 4(3) (2.7 cm) in 2008. It is possible to deny null hypothesis, and the mathematical analyses of the data showed that there was a significant difference between the years according to the fruit petiole scar diameter (P_{max}=0.99). Significant differences were stated for the fruit petiole scar diameter between 2006 and 2007 for all lines, and between 2007 and 2008 for '4(3)', and between 2006 and 2008 for '8', '14', '5(2)'.

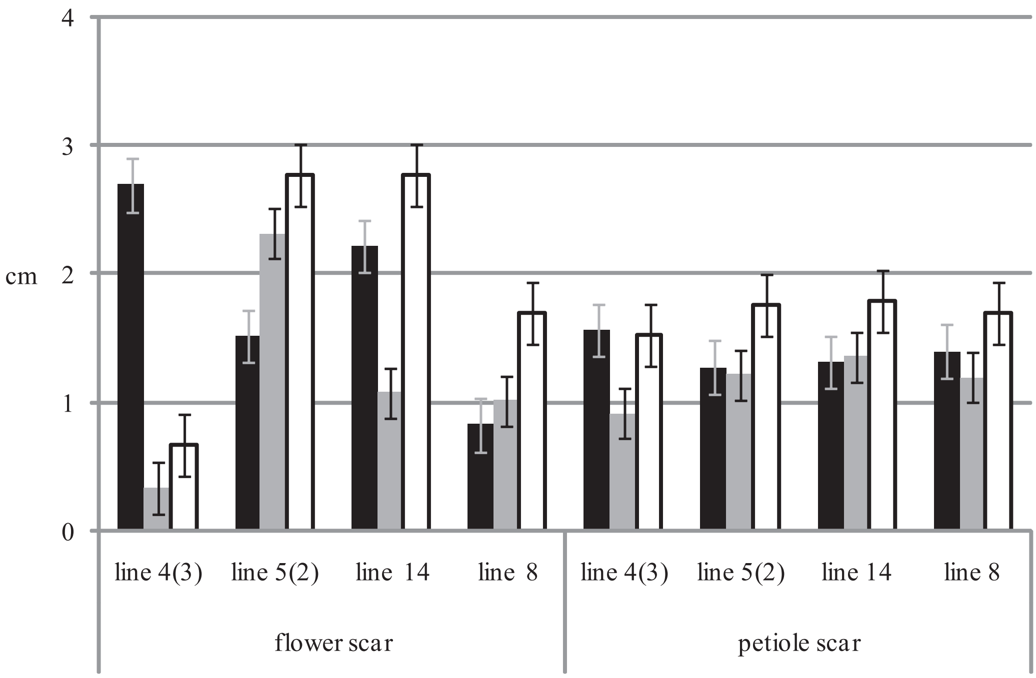

Figure 2. Fruit flower and petiole scar diameters.

■ 2008 ■ 2007 □ 2006

Insignificant interconnections were found between years for the fruit flower scar diameter. With probability P=95% it is not possible to deny null hypothesis – the fruit flower scar diameter is not dependent upon the year. Maximum probability for significant influence for the fruit flower scar diameter parameter between years is P_{max}=0.5566.

The average fruit length and width were higher for melon lines '5(2)' and '4(3)' (Figure 3).

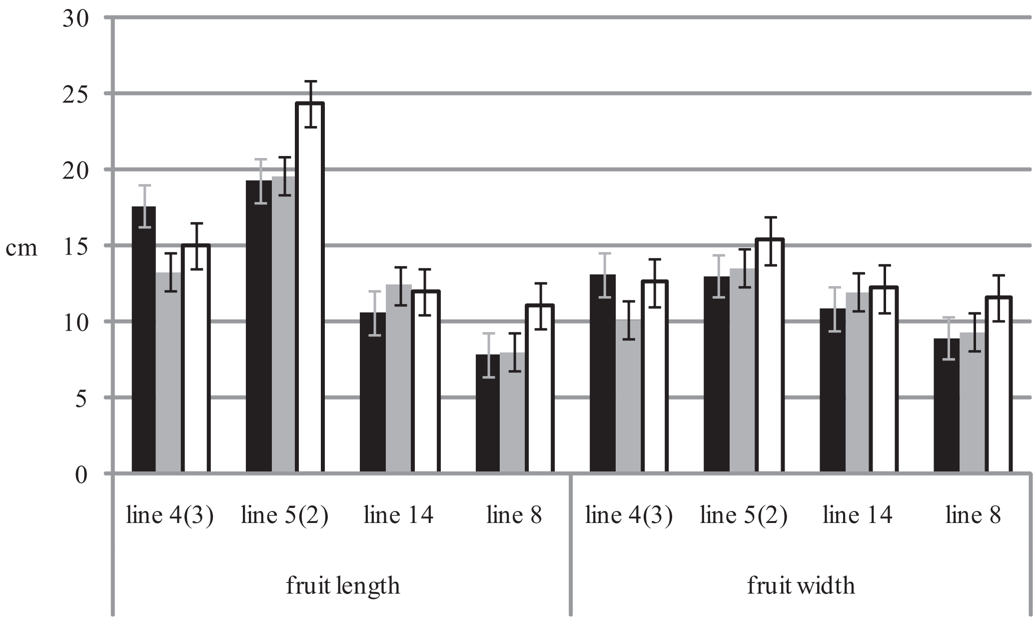

Figure 3. Fruit lenght and width diameters.

■ 2008 ■ 2007 □ 2006

Insignificant interconnection was found between years for the fruit length parameter. With probability P=95% there is not possible to deny null hypothesis – the fruit length and width parameters are not dependent upon the year. Maximum probability for significant influence for the fruit length parameter between years is P_{max}=0.1683, and for the width parameter - P_{max}=0.58.

The thickness of fruit flesh is important morphological parameter. If the cavity of seeds is smaller, the weight of fruit will be higher. Thicker flesh was observed for the melon line '5(2)' (4.4 cm) in 2006 (Figure 4). Fruit thickness of flesh depends from genotype.

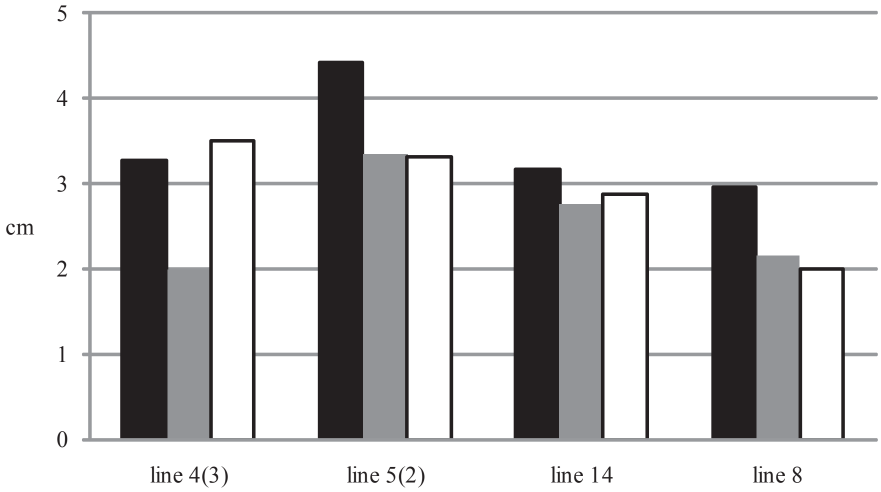

Figure 4. Fruit flesh thickness.

■2006 ■2007 □2008

Insignificant interconnection was found between the years for the fruit thickness. With probability P=95% there is not possible to deny null hypothesis – the fruit thickness is not dependent upon the year. Maximum probability for significant influence for the fruit thickness parameter between the years is P_{max}=0.7963.

To assess parameters which were included in research, the highest stability was observed at the melon line '14'. There was found insignificant interconnections between parameters. The melon line '4(3)' was less stable in all parameters. There was found significant interconnections between parameters. P-value was used for stability evaluation. The parameter is stable if its value year to year does not change with probability 95%.

Conclusions

1. The mathematical analyses of the data showed that there was a significant difference for the fruit petiole scar diameter between 2006 and 2007 for all lines.
2. The line '14' was stable in all parameters from 2006 till 2008 except the fruit flower scar diameter.
3. The line '4(3)' was less stable in all parameters between all melon lines in all years of investigations.

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INFLUENCE OF BIOLOGICAL PRODUCTS - TRIHODERMIN AND BIOMIKSS ON THE YIELD OF LETTUCE AND STRAWBERRIES

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Abstract

Under open environmental conditions, Trihodermin and BioMikss were used for trial purposes to study lettuce (*Lactuca sativa* L.) and strawberry (*Fragaria x ananassa* Duch) yields in 2008. Experiments were carried out in the Region of Riga at the farm 'Pukulejas'. The lettuce cultivar 'May King' and the strawberry cultivar 'Senga Sengana' were both used in the trial. The purpose of the trial was to evaluate the use of biological products when applied on the above mentioned trial plants. In the field trial, both Trihodermin and BioMikss in dry powder form in peat mixture were applied for soil treatment 10 kg ha^{-1}. Trihodermin contains cells of microscopic fungus *Trihoderma harzianum 8-21* and *Trihoderma viride 1-5*. BioMikss is a mixture of microorganisms, containing cells of seven various bacteria (*Azotobacter chroococcum 23, Polyangium cellulosum 5-t, Polyangium 56, Pseudomonas putida 48-t, Rhizobium meliloti 15, Streptomyces griseoviridis P-t* and *Streptomyces cellulosae D*) and cells of two various fungus (*Trihoderma harzianum 7-t* and *Trihoderma viride A-L*). Three times during the growing period Trihodermin and BioMikss water solution 100 g kg^{-1} was applied on the trial plants. When compared to non-treated plants, significantly increased yield was observed on BioMikss-treated lettuce. A significantly increased yield was also observed on BioMikss-treated strawberries. The results of the experiments showed that in open environment, both strawberry and lettuce plants treated with BioMikss showed resistance to the grey mould, caused by a parasitic fungus *Botrytis cinerea*. The results prove that biological products, by environmentally friendly means, revitalize soils, protect plants, enhance growth, immunity and productive potential.

Key words: *Lactuca sativa, Fragaria x ananassa,* grey mould, open environment.

Introduction

In Latvia, cultivation of horticultural crops takes place in open environment; therefore, climatic conditions are crucial during the growing season. Within small distances, the environment is subject to considerable variations – from heavy precipitation and limited sunshine to moderate, dry and warm weather. With drastic consequences throughout the growing season, damp and cold conditions promote the spreading of grey mould, caused by a parasitic fungus *Botrytis cinerea*. Intensive growing technologies heavily depend on pesticides – generally environmentally unfriendly; therefore, it is important to find other ways for avoiding influence of pathogens or suppressing them. One of the possibilities to reduce environmental pollution from horticultural production will enhance using of biological products.

The ability of microscopic fungus *Trichoderma* spp. – to suppress activity of several plant pathogens – makes it possible to use it in biological control. *Trichoderma* produces metabolites that demonstrate antibiotic and mycoparasitic activity against a wide range of phyto pathogens (moulds, root rots, black scab, grey rot, white rot, powdery mildew, wilt, fruit rot etc.). The use of *Trichoderma* for biological control of plant pathogens has been observed in studies by several researchers. *Trichoderma* has shown positive effect on biological control of vegetable diseases (Inbar et al., 1994). Few results show, in some cases, *Trichoderma viride* inhibited development of cucumber, tomato and pepper seedlings (Menzies, 1993). The species *Trichoderma harzianum* has also been described as a biocontrol agent to control several fungi such as *Sclerotinia minor* and *S. sclerotiorum* (Sanchi et al., 2005). It is found that research in biological control has mostly concentrated on *Gliocladium* and *Trichoderma,* mycoparastitic *Pythium,* non-pathogenic *Fusarium,* binucleate *Rhizoctonia*, as well as antagonistic bacteria belonging to the genus *Bacillus*, fluorescent *Pseudomonas* and *Streptomyces* (Vanacci and Gullino, 2000).

Trichoderma, as a genus, is widely distributed all over the world, and fungi, belonging to this genus, are easily isolated from soil (Mako and Alimova, 2006; Vanacci and Gullino, 2000). The Microbial Strain Collection of Latvia was established in 1993 and holds over 700 cultures of micro organisms. In cooperation with the company BIOEFEKTS the microorganisms of agricultural significance are being studied. The BIOEFEKTS - a Latvian owned company – has high experience in producing biological products from 1993. These products contain live micro organisms, able to destroy the causative agents of plant diseases - fungi (Trihodermin) and several bacteria, also a complex product (BioMikss) and several products against noxious insects (Verticilin et al.). Biological products are free from active chemicals and can be applied in ecologically clean agriculture. The biological preparations protect the plants, renew the soil and are beneficial for the health. The harvesting may take place immediately after the application of biological preparations. Trihodermin may be purchased into three preparative forms: Dry powder, Wet preparation with 70% of moisture and Soluble concentrate).

BioMikss is a mixture of microorganisms, containing cells of seven various bacteria and cells of two various fungus. *Azotobacter* sp. fixes the air nitrogen, accelerates the growing process of plants and inhibits pathogens. *Polyangium* spp. produces auxins and vitamins to increase the immunity of plants. *Streptomyces* spp. produces antibiotic compounds, litical ferments, heteroauxins and amino acids. *Streptomyces* spp. are antagonists to range pathogens as well as *Trichoderma* spp. All microorganisms, added in preparation BioMikss are fighting against pathogens and promoting fertility of the soil. BioMikss may be purchased into two preparative forms: Dry powder and Wet preparation.

The goal of this research was to find out the possible influence of Trihodermin and BioMikss on lettuce and strawberry yields under open environmental conditions.

Materials and Methods

In 2008, a field trial was established in the farm 'Pukulejas' in the Region of Riga. The lettuce cultivar 'May King' and the strawberry cultivar 'Senga Sengana' were both used in this trial. Both Trihodermin and BioMikss were provided by the company BIOEFEKTS.

Trihodermin is a fungicide that contains cells of microscopic fungus *Trihoderma harzianum 8-21* and *Trihoderma viride 1-5. T. harzianum* is intensive antagonist for wide range of pathogen microorganisms (snow mold, moulds,roots rots, potato light blight, black scab, grey rot, white rot, powdery mildew, wilt, fruit rot, downy mildew etc.) - it stands in the competition with pathogens after nutritive, acts as parasite in the cells of pathogen fungus produces antibiotic compounds (glioxine, viridine, trichodermine), in this way inhibit pathogen. The biological product stimulates germination of seeds, growth of the plants as well as their wintering, decreases diseases of various plants. Excellent preventive effect can be obtained with usage of Trihodermin. In this trial Trihodermin Dry powder form was applied.

BioMikss is a mixture of microorganisms, containing cells of seven various bacteria (*Azotobacter chroococcum 23, Polyangium cellulosum 5-t, Polyangium 56, Pseudomonas putida 48-t, Rhizobium meliloti 15, Streptomyces griseoviridis P-t* and *Streptomyces cellulosae D*) and cells of two various fungus (*Trihoderma harzianum 7-t* and *Trihoderma viride A-L*). They all decrease development of pathogens; promote growth, blooming and harvesting of plants. *Azotobacter* sp. fixes the air nitrogen, accelerates the growing process of plants and inhibits pathogens. *Polyangium* spp. produces auxins and vitamins to increase the immunity of plants. *Streptomyces* spp. produces antibiotic compounds, litical ferments, heteroauxins and amino acids. *Streptomyces* spp. are antagonists to range pathogens as well as *Trichoderma* spp. All microorganisms, added in preparation BioMikss are fighting against pathogens and promoting fertility of the soil. Microorganisms are in interaction with each other in this process. Roots are colonised, biological active compounds are produced, and direct liquidation of pathogens are prefaced as a result of using BioMikss preparation. In the case of miscellaneous infection BioMikss is recommended and it gives an excellent preventive effect. If all agro technical demands are accomplished, crop capacity increases for 50 % with the usage BioMikss. In this trial BioMikss Dry powder form was used.

The soil of the trial was podzolic sandy, well prepared and reached a pH_{KCl} 5.8, content of N = 356 mg kg^{-1}; P = 272 mg kg^{-1}; K = 257 mg kg^{-1}; Mg = 617 mg kg^{-1}, and the humus content 46 g kg^{-1}. The pH of soil was suitable for growing lettuce and strawberries and also for the development of the *Trichoderma*.

Trials were carried out in three variants – 1) lettuce treated with Trihodermin; 2) with BioMikss and 3) non treated and three replications. Planting scheme of lettuce seed in plots were 1m x 0.5 m, and 0.5 m between plots. In each plot 20 lettuce seeds of 'May King' were sown. Trihodermin and BioMikss treatements were applied during the sowing of seeds 10 kg ha^{-1} Three times during the growing period plants were treated with moisture of Trihodermin and BioMikss 20 L ha^{-1}. Trihodermin and BioMikss water solution 100 g kg^{-1} was applied on the lettuce plants.

Control plants were not treated with biological products. Plots were covered with white textile covering. After 20 days, lettuce plants were thinned out (10 plants to each plot). Lettuce was harvested at 41 day after planting. Ten (10) lettuce-heads from each plot were weighed and compared.

Plantings of strawberries were established in two 1 m wide and 10 m long beds; 0.3 m apart, and 0.5 m between beds. Trials were carried out in three variants 1) strawberries treated with Trihodermin; 2) with BioMikss and 3) non treated and three replications. There were 30 plants per replicate. Before planting, 1 gram of each - Trihodermin and BioMikss peat preparation were added to all planting holes of one bed to ensure microorganism activity in the growing area. Three times during growing period, strawberry plants were treated with moisture of Trihodermin and BioMikss: 1) before flowering; 2) before formation of berries and 3) to begin to form berries (20 l ha^{-1}). Control plants in second beds were not treated with biological products. Under standard conditions, no fungicides were used during the season.

Strawberries were harvested from 19th of June till 15th of July, 2008, two or three times per week – depending on ripening rate. The weight of berries per plot was recorded on each harvest date. Strawberry yield data were analyzed by analysis of variance (ANOVA) at significance level of P<0.05.

Meteorological conditions

The trial year of 2008 in the farm 'Pukulejas' in the Region of Riga was mild with heavy precipitation. Strawberries were attacked by grey mould. May was warm and dry. The amount of precipitation was 40% below the average. The average monthly temperature in May was 10 °C – slightly below the average. The spring frosts were in the first and third decade in May – with night temperature two to three degrees below zero and continued in the first decade in June. The average monthly temperature in June was 15 °C – one degree below the average temperature. The first decade of June was without precipitation. Heavy rains started in the second decade; therefore, the weather was unfavourable for the strawberry yield. The parasitic fungus *Botrytis cinerea* caused heavy damage.

The average monthly temperature in July was 18 °C – 0.4 °C higher than the average temperature had been for many years. Precipitation during the first and second decades of July was heavy – resulting in early lettuce harvesting.

Results and Discussion

Experiments were carried out to study influence of both biological products - Trihodermin and BioMikss, on the yield of both lettuce and strawberries under open environmental conditions. Average yield of all replications 1) treated with Trihodermin; 2) with BioMikss and 3) non treated is shown in Figure 1.

Lettuce

There was no statistical difference (P>0.05) between two biological products used in experiments in 2008.

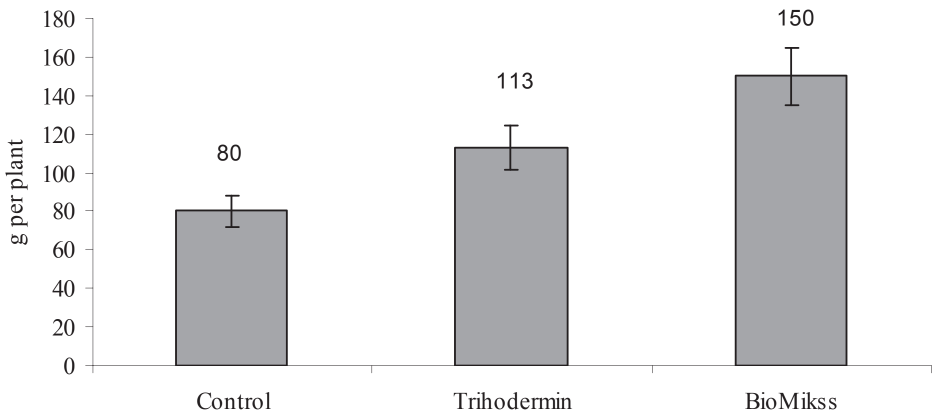

Figure 1. The average yield of lettuce treated with Trihodermin and BioMikss.

The average yield of the control variant was 80.0 g per plant; the yield of Trihodermin-treated plants – 113.0 g per plants; the yield of BioMikss-treated plants – 150.0 g per plant (represents significance level of P<0.05). BioMikss-treated lettuce plants show higher yield potential than Trihodermin-treated plants, or the control variant; actually BioMikss-treated plants gave significantly higher yield when compared to the yield of control plants.

Strawberries

Yields were influenced by a late-May frost that killed or severely damaged flowers and young berries. Because of the late frost, only the fruit harvested after 19th June were evaluated.

Table 1

Influence of Both Trihodermin and BioMikss to the Yield of the Strawberry Cultivar 'Senga Sengana' (on average)

Variants	Yield, kg m^{-2}	Increase of the yield		Infected berries, proportion, %
		kg m^{-2}	%	
1. Control	2.5	-	-	16
2. Trihodermin	2.9*	0.4	16.0	8
3. BioMikss	3.1*	0.6	24.0	-

* significant (P<0.05) differences from the control

Table 1 showed that the yield averaged 2.9 kg m^{-2} if the plants had been treated with Trihodermin and it was 16.0% higher if untreated, and the difference was statistically significant (P<0.05). BioMikss treated strawberry plants showed 3.1 kg m^{-2} and it was 24% higher yield average than untreated plants, and the difference was significant (P<0.05). When compared to the control variant, infection with *Botrytis cinerea* was reduced by 50% if the plants had been treated with Trihodermin. No infected berries were found of treatment with BioMikss. The trial resulted that both biological products Trihodermin and BioMikss increased the yield of strawberries and decreased the infection of the grey mould.

Most strawberries produced in Latvia are used fresh. The cultivar 'Senga Sengana' is popular. It is highly productive, winter hardy and content with growing conditions in Latvia, but is susceptible to the grey mould (Rīderers, 2007). It was found, spraying of fungal suspension *Trichoderma viride* and *T.harzianum*-based products, significantly decreased the severity of *Botrytis cinerea* (Sternshis, 2005). Our results concur with the literature findigs that *T.harzianum* and other spp. are the antagonists against *Botrytis cinerea* (Vanacci and Gullino, 2000).

Conclusions

Horticultural crops grown in Latvia require ecologically-safe disease control which includes application of biological products – particularly, to avoid chemical residues on vegetables and fruits.

Treatment with BioMikss shows increased yield in lettuce and strawberries when compared with untreated plants. Infection with *Botrytis cinerea* was reduced by 50% if the plants had been treated with Trihodermin. No infected berries were found of treatment with BioMikss.

Acknowledgements

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DEVELOPMENT AND SITUATION OF TROUT CULTURE IN TURKEY

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Abstract

The production of rainbow trout (*Oncorhynchus mykiss*) is developing and it is most cultured finfish species in Turkey. It was first introduced in Turkey in the mid 1970s from Italy. In the following years, culture studies of native trout strains, mainly Black Sea trout; *Salmo trutta labrax* and Abant Lake trout*, Salmo trutta abanticus* started in late 1990. Market size trout production was performed in two main categories, inland areas (mainly concrete ponds by flow through fresh water and cages) and in sea (off-shore cages). Total tout production was 61.173 tons in 2007.

Key words: Aquaculture, rainbow trout, *Oncorhynchus mykiss,* fish farming, Turkey.

Introduction

Aquaculture in Turkey is very new when compared with European countries. The first fish farm was established as a rainbow trout farm in mid 1970s. The following years, new fish farms have been established year by year. When it comes to 1980s, cultured fish species were varied such as carp (*Cyprinus carpio* L.), trout, sea bream (*Sparus aurata*), and sea bass (*Dicentrarchus labrax*). Nowadays, although main aquatic production consist of mainly three carnivore species (trout, sea bass and gilthead sea bream), culture of new species are also performing such as Black Sea turbot (*Psetta maxima*), Black Sea trout (*Salmo trutta* Labrax), bluefin tuna (*Thunnus thynnus*), Mediterranean mussel (*Mytilus galloprovincialis*) and Shrimp (*Penaeidae* spp).

The rainbow trout is the most farmed fish species. The rainbow trout is one of the oldest fish in culture. Gall and Crandell (1992) report that Mr. S. Green transferred eyed eggs in 1874 from the McCloud River in northern California to his private hatchery at Caledonia, New York. The First successful shipment of rainbow trout outside of North America was realised in 1877. The European rainbow trout farming began in Denmark in 1890 (Laird and Needham, 1988; Gall and Crandell, 1992). Trout farming is widely exercised in the world because of some characteristics of rainbow trout. It is highly adaptable to its environment, can tolerate water temperature from 0 to 26 °C, can be cultured in sea water after reaching a minimum size.

The European trout faming industry has grown in the 1980s. Small quantity of trout production, developed rapidly due to development of feed industry in Turkey in last three decades. In early years of trout culture history, trout production was less than 1000 tons per year. In following years, trout production increased and production amount reached up to 61.170 tons in 2007 (Figure 1).

According to Ministry of Turkish Agricultural and Rural Affairs (MARA), the trout farms number that is active recently has reached to 1.170 in 2007. Majority of those trout farms are small scale family owned farms. Some of them have great production capacity. Although trout farms were allocated mainly in the west of the country called Aegean Region of Turkey, they are distributed in all over of Turkey. On the other hand, investment of 732 trout farms is going on by the year 2007.

In this paper, trout production, current situation and its potential for future expansion in Turkey were reviewed.

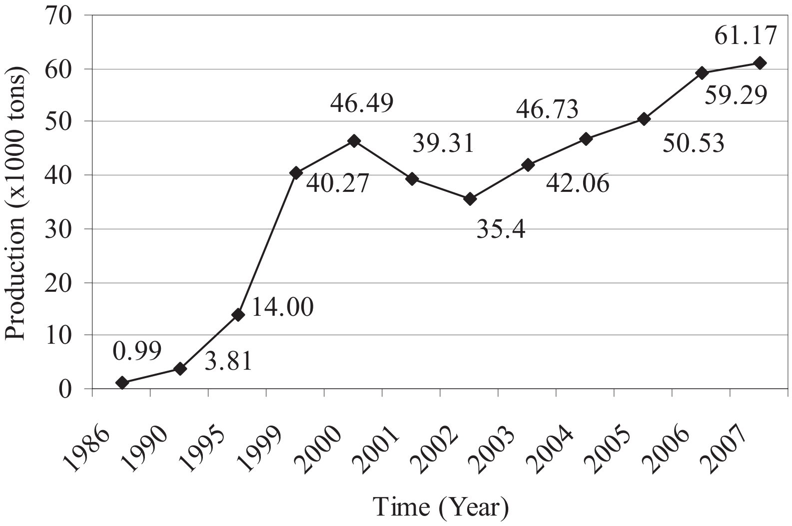

Figure 1. Total trout production in Turkey in years 1986-2007 (Turkish Statistical Institute, 2007).

Trout Farming: Methods, Production Strategies

Trout farming has begun at the beginning by concrete ponds in 1970s (Canyurt, 1977 and 1978). In later stages, cage-culture has developed in lakes and dam lakes which are suitable for trout culture in 1990s. Trout farming started also in Black Sea early 1990s by cages (Sahin et al., 1999). Trout culture can be discussed as hatchery production, inland culture and marine culture. The majority of trout farms are pond farms inland area. The marine production is possessed in off-shore cage farms activated in Black Sea and Aegean Sea.

Hatchery

The hatcheries for fry production of trout and other native trout strains in Turkey, their size, capacity and the type depend on the quality and the quantity of water and demand for fry to produce the market size fish. On the other hand, according to Turkish Ministry of Agriculture and Rural Affairs (2007), 18 trout hatcheries have produced only fry and their production capacity is 76,760.000 fry per year (Table 1).

Also, The General Directory of Nature Conservation and National Parks of the Turkish Ministry of Environment and Forest produce native trout stains' fry in three government hatcheries. In these hatcheries, 15 different native trout strains' fry are produced and restocked in streams and rivers.

The spawning time of brood rainbow trout is varying between November and April in Turkey. The production of high quality and disease-free eggs is a specialized activity requiring a high degree of skill and management. Most of the eggs used in commercial trout production in the Turkey are produced in the western part of the country. Trout eggs are usually stripped using conventional methods and are incubated in vertical and horizontal incubators. Swim-up yolk-sac fry are transferred to larvae tanks for first feeding. These equipments are made from generally fibreglass material. In general fry are kept during 10 to 12 weeks in the hatchery under controlled conditions with careful feeding and protection against infections and diseases.

Trout Culture in Inland Waters

Inland trout farms consist of pond farms and cage farms. Pond production was performed mainly concrete ponds. The ponds used for trout farming are generally 1m to1.4 m depth, 2 m to 4 m width and 15 m to 50m length. Stock density varies between 10 and 40 kg m^{-3}. The fingerlings reach to market size (200-250g) in 8-12 months. Total 25.350 tons rainbow trout produced in 999 pond farms in 2006 (Table 1). Large amount of production (30.695 tons) comes from 171 pieces of cage farms. Fingerlings are stocked in September-October generally, and production season is ended up to July when the lake water gets warmer. The cages are made by wooden or High Density Polyetylene (HDPE) and cage shape is square (5x5 m). But nowadays fish farmers prefer circular HDPE cages. Trout grows faster in cages than concrete ponds. The food conversion ratio vary between 0.8 and 1.1 is also lower than concrete ponds. Cage net depth varies between 5 and 8 meters. Stock density varies between 10 and 25 kg m^{-3}.

Table 1

Number of inland trout farms (Turkish Ministry of Agriculture and Rural Affairs, 2006)

	Number	Capacity (tons/year)
Cage farm†	171	25.350
Pond farm	999	30.695
Hatchery	18	76,760.000*
Total	1.188	57.170
*fry number, †generally those trout farms produce their own fry		

Extruded fish feed is used to feed the trouts. Due to the growth in production of trout aquaculture, aqua feed market has significantly grown parallel to these increases. There has been a substantial improvement in feed efficiency. The average FCR for trout was estimated to be 2 in 1980s, but nowadays it is about 0.8 - 1.1 in cages (Gullu and Guzel, 2006) and 1.1-1.2 in ponds (Harmantepe and Büyükhatipoğlu, 2007).

Trout Culture in Marine Water

The rainbow trout has been cultured in Black Sea coast of Turkey since 1990s (Akbulut et al., 2002). In recent years, increasing numbers of trout farmers establish off-shore cage farms in Black Sea shore. This method consists to transfer 100-250 g rainbow trouts from the fresh water ponds to sea-cages in autumn and harvest them until June. This production strategy reduces rearing time when comparing pond production in fresh water condition. In Turkish fish market, Black sea reared rainbow trout was won approval by consumers. As a result of this, the cage farms number has raised in the course of recent years. At the beginning, early 1990s, cage farms were established only in winds and waves sheltered Black Sea bays and farmers have used kames type wooden cages. After off-shore cages technology has been developed, new farms were established and some of them have been in investment stage (Table 2). Annual trout production was occurred as 300 tons in 1990 and reached 1961 tons in the year 2000 (Figure 2).

Table 2

Actively trout producing and investment stage cage farms number and their capacity (Turkish Ministry of Agriculture and Rural Affairs, 2006)

Status of cage farms	Farm numbers	Capacity (tons / years)
Active cage farms	12	4,810.00
Investment stage farms	8	2,779.00
Total	20	7,589.00

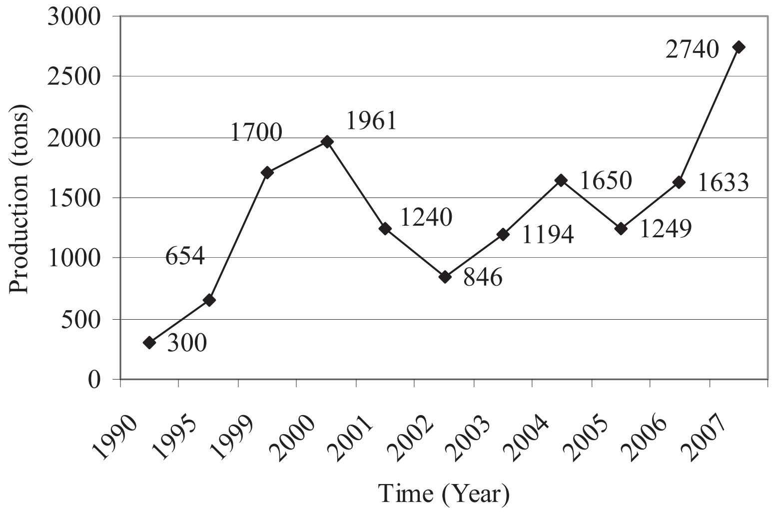

Figure 2. Annual trout production in marin farms (Turkish Statistical Institute, 2007).

Start weight were offered by B. Akbulut et al. (2002) for cage culture of rainbow trout in Black sea condition as 150-200 g. In this research results indicated that 150-200 g rainbow trout had reached up to 900-1000 g final weight for 7 months. This is consumer preferred market size of sea reared rainbow trout. Although the researchers also reported that feed conversion rate (FCR) was realized as between 1.4 and 1.7. T. Sahin et al. (1999) reported that 200 g rainbow trout were grow up to 1036-1226 g in six months and feed conversion rate was recorded as between 1.5 and 2.2.

Stock density varies between 10-20 kg m^{-3} in routine culture process. Cages in use are circular (10-20 m diameter) and made by HDPE material. Net depth of cages varies between 8-18 m.

Trout Harvesting and Marketing

The rainbow trout is widely consumed in Turkey. Harvesting size of rainbow trout ranges from 200 g to 250 g for pond cultured fish and >1000g for sea reared one. The 200-250 g fish weight are the more suitable fish size for harvesting in ponds because higher feed efficiency. On the other hand, harvesting size are >1000g in sea cages. In generally, market size rainbow trout served as fresh and frozen. Some restaurants and consumers prefer live trout and some markets serve them freshly. Old broods and sea reared trout are filleted. Therefore harvested trout should be package and transport to Turkey wide by cold chain. Generally harvested trout from medium size and some of large trout farm was transported to great cities, wholesalers. Major of great trout farms and fish processing firms produce smoked trout and export to Europe.

Economics of Trout Farming

The costs of establishing and creating a fish farm are generally higher. Investment cost for a pond farm is much higher in comparison with cage farm projects. This is due to more expensive facilities needed, such as concrete cemented ponds.

The key to increasing trout production profits lies in understanding and controlling production costs. A majority of trout producers throughout the Turkey, production costs probably break out as in Table 3.

Trout is very much appreciated by the consumers in Turkey. It is consumed fresh or frozen especially. According to the data obtained from Turkish Statistical Institute (Turkish Statistical Institute, 2007) important quantities of salmonidae like Rainbow trout, Pacific salmon, Atlantic salmon and Danube salmon are imported as fillets, frozen and smoked from the North European countries. The amount of salmonidae importation was 170.910 kg and the value of this importation is about $1,755.322. The amount of trout exportation and other salmonidae species from Turkey to European Countries was 5 197 468 kg and the value of this exportation is $29,155.968 (Table 4 and Table 5).

Table 3

Estimated cost break-out for trout production in ponds and net-cages

Category	% of Costs	
	In pond farms	In cages farm
Feed	44%	61%
Fry[a] or Start fish[b]	20%	18
Labour & Salaries	30%	12%
Mortality	2%	4%
Others (chemicals, analysis, laboratories materials, etc.)	4%	4%

[a] 0.10 € is for 10 g fry and [b] 200 g trout is for cage culture,
1 € per kg is price of feed and 2.3 € per kg of market size fish price in ponds
2.6 € per kg of market size net cage reared market size fish accepted for calculation

Table 4

Importation of Salmonid fishes of Turkey (Turkish Statistical Institute, 2007)

Fish Products	Quantity (kg)	Value ($)
Rainbow trout, fillets-fresh	10 135	70 917
Pacific Salmon, fillets	30 323	276 683
Rainbow trout, frozen	32 682	189 856
Pacific, Atlantic and Danube salmon, smoked	44 122	490 479
Rainbow trout, smoked	53 658	727 387
TOTAL	170 590	1 755 322

Table 5

Exportation of Salmonid fishes of Turkey (Turkish Statistical Institute, 2007)

Fish Products	Quantity (kg)	Value ($)
Pacific, Atlantic and Danube salmon, fresh	1 899	11 701
Salmonidae, frozen	2 929 935	9 921 491
Rainbow trout, fillets- frozen	408 061	3 013 903
Rainbow trout, smoked	1 857 574	16 208 873
TOTAL	5 197 468	29 155 968

Conclusions and Recommendations

Aquaculture development, especially trout farming in inland waters and sea bass and sea bream in marine waters in Turkey is growing rapidly. Turkey has the third fastest growing aquaculture sector in the world (Deniz, 2007). Marine and inland water resources provide an important source of protein for human nutrition. In addition to this appreciation, aquaculture has some advantages over capture fisheries in term of marketing the products. One of these advantages is that aquaculture creates jobs. More than 25 000 persons are working in the sector of aquaculture in Turkey (Deniz, 2007). But some ecological and socio-economical interactions should be discussed for a sustainable aquaculture (Canyurt, 2005; Deniz, 2007). That is why it is necessary to support the development of sustainable aquaculture.

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DEVELOPMENT OF DRIVING CYCLES FOR DYNAMOMETER CONTROL SOFTWARE CORRESPONDING TO PECULIARITIES OF LATVIA

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Abstract

Performing biofuel use studies, a large number of parameters that characterize engine operation under different conditions and with different fuel mixtures have to be identified. The real driving conditions are usually simulated by driving cycles on a laboratory chassis dynamometer. There are two major categories of driving cycles: legislative and non-legislative. From the viewpoint of cycle formation there are also two ways. One is composed of various driving modes of constant acceleration, deceleration and speed, and is referred to as modal or polygonal. The other type is derived from actual driving data and is called as 'real world' cycle. There is a strong agreement among researchers that driving characteristics of each city are unique because of different vehicle fleet composition, driving behaviour and road network topography. It is therefore better to develop own driving cycles than using driving cycles developed elsewhere. The aim of this investigation is to develop driving cycles or models for dynamometer control software corresponding to peculiarities of Latvia. The procedure for cycle development and fuel consumption and exhaust emissions measurement was worked out. Using real driving data on the Jelgava streets, models simulating driving in different urban areas were constructed. The model quality was determined using vehicle driving parameters and fuel consumption measurement results from both the road and laboratory tests. Since the obtained data coincidence of all the parameters exceeded 98%, the elaborated cycles can be used for the biofuel use efficiency determination.

Key words: driving cycles, laboratory chassis dynamometer, exhaust emissions, fuel consumption.

Introduction

During the pilot studies on the biofuel use level, it is necessary to identify a large number of parameters that characterize engine operation under different conditions, with different fuel mixtures, etc. If the methods of power, torque, acceleration, etc. detection are particularly developed, the fuel consumption and exhaust gas composition determination is often a problem. Potential users of biofuel are less satisfied with the results found in the analytical experiments, for example, by running the engine on the test bench. The more relevant is to know the parameters that would be expected in real operating conditions, therefore it is very important to work out the methodology of the synthetic experiments to draw them nearer to the real urban traffic, driving outside the city or the combined mode.

The typical driving profile consists of a complicated series of accelerations, decelerations and frequent stops and it is simulated by driving cycles on a laboratory chassis dynamometer, for example, MD-1750 (Figure 1).

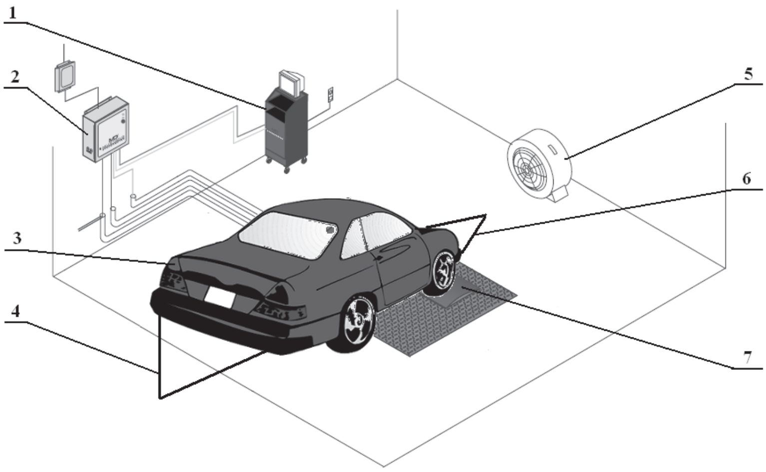

Figure 1. Laboratory chassis dynamometer MD-1750: 1, 2 – control units; 3 – car;
4, 6 – safety belts; 5 – fan; 7 – dynamometer.

There are two major categories of driving cycles: legislative and non-legislative. According to legislative driving cycles, Exhaust Emission Specifications are imposed by governments for the car Emission Certification. Such cycles are the FTP-75 used in the USA, the NEDC used in Europe, and the 10-15 Mode Cycle used in Japan (Emission Test Cycles, 2008). Non-legislative cycles, such as the Edinburgh cycle (Esteves-Booth et al., 2001), the Hong Kong driving cycle (Hung et al., 2007), the Athens driving cycle (Tzirakis et al., 2006), the California driving cycle (Lin and Niemeier, 2002), etc. find broad application in research for fuel consumption and pollution evaluation.

The directive 80/1268/EEC relating to the carbon dioxide emissions and the fuel consumption of motor vehicles, describes the procedure that all new types of vehicles have to follow. The driving cycle used by the EU countries for the certification of passenger cars and light trucks, consists of four segments of ECE-15 (also known as Urban Driving Cycle) and the Extra Urban Driving Cycle (EUDC). The procedure is called New European Driving Cycle (NEDC). Urban Driving Cycle is representative of city driving conditions in a typical European city (for example, Paris and Rome). Extra Urban Driving Cycle simulates high speed driving and is applied directly after the fourth segment of ECE-15 (Figure 2) (Emission Test Cycles, 2008).

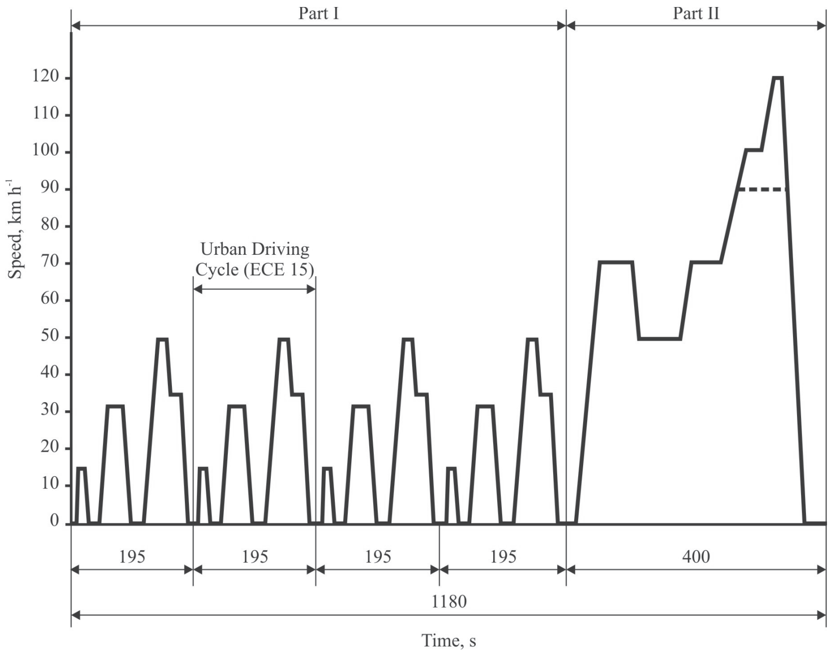

Figure 2. New European Driving Cycle.

There are two ways of developing a driving cycle. One is composed of various driving modes of constant acceleration, deceleration and speed, for example, NEDC, and is referred to as modal or polygonal. The other type is derived from actual driving data and is referred to as 'real world' cycle. Such cycle examples are the FTP-75 and the Athens driving cycle. The 'real world' cycles are more dynamic, reflecting the more rapid acceleration and deceleration patterns experienced during on road conditions. It results in higher emissions compared to those under the modal test cycles (Tzirakis et al., 2006).

There is a strong agreement among researchers that driving characteristics of each city are unique because of different vehicle fleet composition, driving behaviour and road network topography (Andre et al., 2006). It is therefore better for environmental protection administrations to congregate all the distinct information to develop their own driving cycles than using driving cycles developed elsewhere. A practical driving cycle construction method comprises three major components – namely data collection methodology, test route selection methodology, and the cycle construction methodology.

Many driving cycles have been developed worldwide. The FTP-72 and FTP-75 cycles were developed by choosing the whole test run data with the most representative speed-time profile based on the idle time, average speed, maximum speed, and number of stops per trip. One of the earliest European driving cycles was the Improved Driving Cycle (IMC) developed by using ten assessment parameters, including the average speed, average running speed, average acceleration and deceleration, mean length of micro-trips, average number of acceleration-deceleration changes within one micro-trip, and proportions of idling, acceleration, cruising and deceleration (Kuhler and Karsten, 1978). The UK fuel consumption cycle was developed by random simulation of the speed against time as the function of the distributions of the operational modes. The Edinburgh cycle was developed by the TRAFIX method, which generated specific codes for each driving segment (Esteves-Booth et al., 2001). The German motorway driving cycle was derived using the Monte Carlo statistical method, simulating acceleration from speed-time profile as a function of the cumulative speed acceleration distribution.

The laboratory chassis dynamometer MD-1750 used in the experiments at the Scientific Laboratory of Biofuels (Latvia University of Agriculture) includes Mustang's MD-7000 software package. Supported tests are the IM-240, FTP, 505 MT, BAR 31 Int., ECE 1504 A/M, and Japanese 10/11.

Performing tests under the real road conditions of Latvia and comparing the obtained results with the available cycle parameters (cycle duration, average micro-trip length, average micro-trip duration, stops per kilometre, proportion of acceleration and deceleration, average and maximum running speed, etc.), they were very different, especially driving in urban areas. Consequently, the need to develop the driving cycles, which would be applied directly to Latvia, arose. Development of the urban cycles have to be done first, because the different incidental factors (for example, traffic intensity and traffic light setting changes, unexpected barriers on the streets, etc.) more often occur in the city driving.

Summarizing literature studies, the following tasks were set for this investigation:

- identification of approximate number of different necessary urban cycles for Latvia;
- selection of the specific city driving routes;
- development of the real driving imitation (model) for the laboratory chassis dynamometer;
- performing the model quality verification;
- setting up the targets for further investigations.

Materials and Methods

Based on the Eurostat document 'Nomenclature of Territorial Statistical Units' (NUTS) (European Regional and Urban Statistics, 2007) and analyzing the urban population, the street network, the existence of traffic lights, etc. parameters in the cities of Latvia, it was assumed that in the cycle creation cities can be divided into three categories: the capital of Latvia – Riga, the large cities (for example, Daugavpils, Jelgava, Liepaja), and the small cities (for example, Aluksne, Gulbene, Smiltene). In addition, separate research is needed for the cities centre or core (intensive driving with the traffic lights), for the widened centre (with and without the traffic lights), and for the more widened urban area with segments where driving speed more than 50 km h^{-1} is allowed. The 'real world' cycle development method was chosen. The flow chart of the procedure for the cycle development and the emission and fuel consumption measurement is shown in Figure 3.

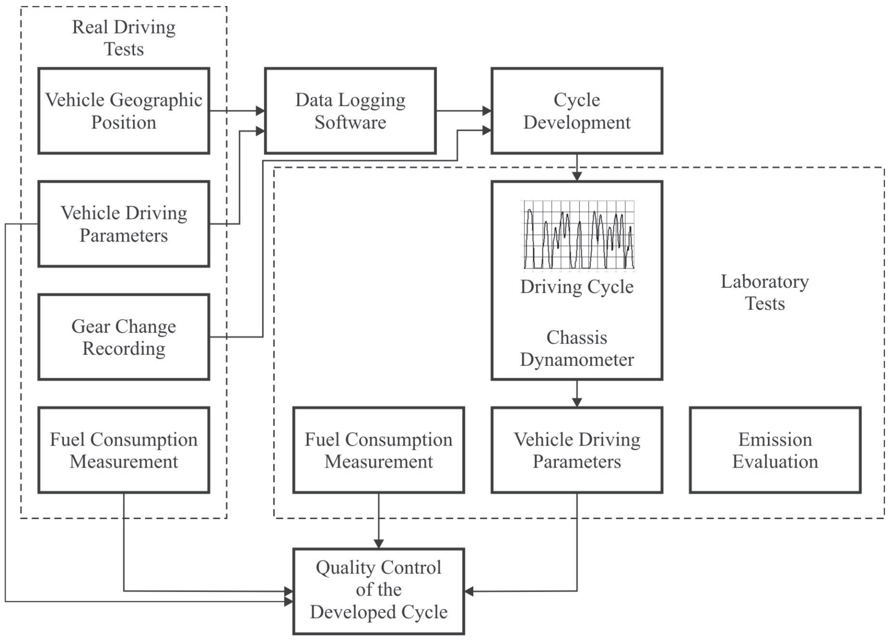

Figure 3. Flow chart of the procedure for cycle development and measurement.

A VW Golf 1.9TD was employed as the chase instrumented vehicle in this study. It was installed with the following equipment:

- data logger CANYON CNS-GPS2 for determination of the GPS (Global Positioning System) coordinates and driving speed;
- camcorder DCR-SR30E for fixing the route and gear switching time;
- fuel consumption meter AVL KMA Mobile;
- laptop for recording GPS and fuel consumption signals.

As the first city for experiments Jelgava was chosen. A total of 10 h of data were collected with the car chasing technique along three selected representative routes (Figure 4) during the peak hours (8:00–9:30 and 11:30–13:30). Driving tests were conducted only during normal working days, excluding the public holidays.

Figure 4. Driving routes in Jelgava.

Processing of the data collected from the data logger and the fuel consumption meter proved to be very time-consuming due to the variable field separation format and a lot of unnecessary information between data records, especially considering the large number of repetitions for each test series. As an example the fuel consumption meter data format is shown in Figure 5.

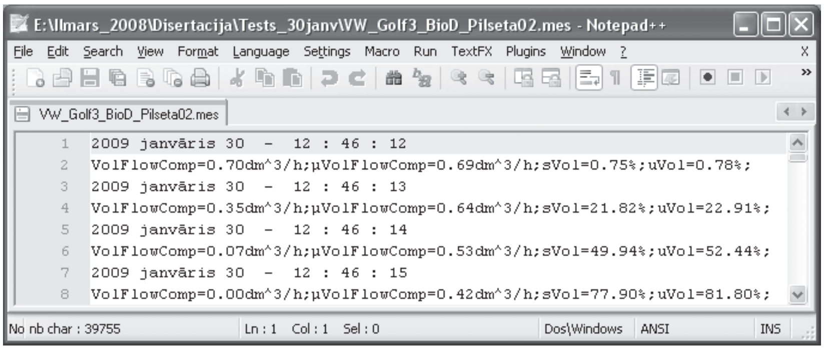

Figure 5. Obtained data format from AVL KMA Mobile.

Solving this problem several macroses were programmed by using of Visual Basic for Applications that allows quickly to import data into the spreadsheet application.

In the first route, 15 drive repetitions were made. Three trips with the highest speed curves correlations were selected for model building (Figure 6, Table 1).

For each trip second, an average speed was calculated. Extreme phases were removed such as very high top speed phases, and minor adjustments to speed curves displacement were made. As the result a theoretical velocity curve for 360 second cycle was built. Gear switching moments were determined by video cameras records (Figure 7).

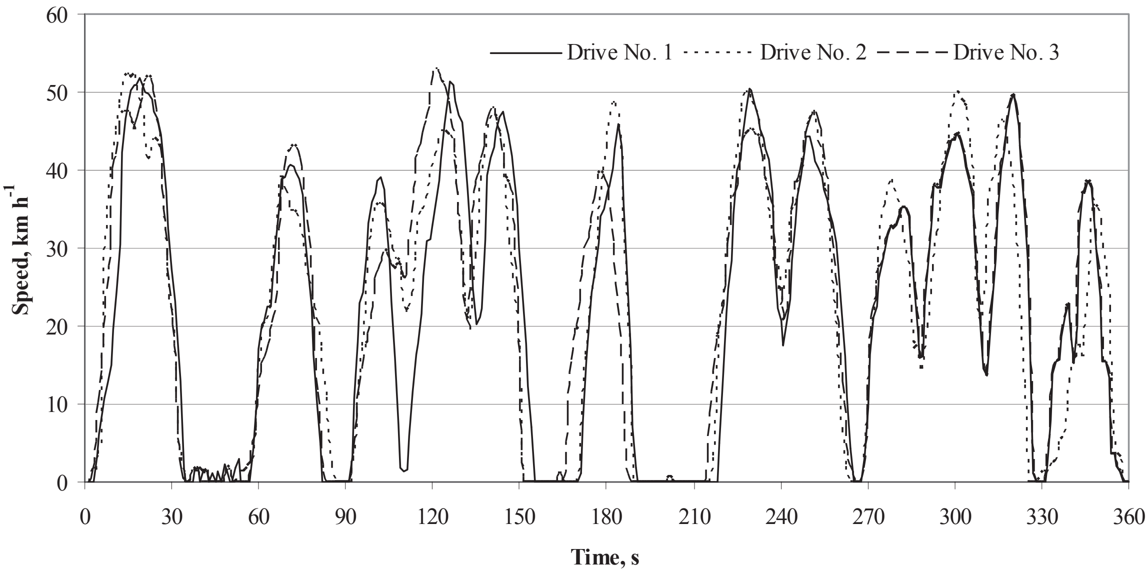

Figure 6. Velocity curves of test drives.

Table 1

Analysis of test drives

Drive No.	Time, s	Distance, km	Average speed, km h^{-1}	Correlation of velocity curves		
				1	2	3
1	366	2.322	22.839	N/A	0.892	0.891
2	364	2.374	23.481	0.892	N/A	0.913
3	361	2.348	23.158	0.891	0.913	N/A

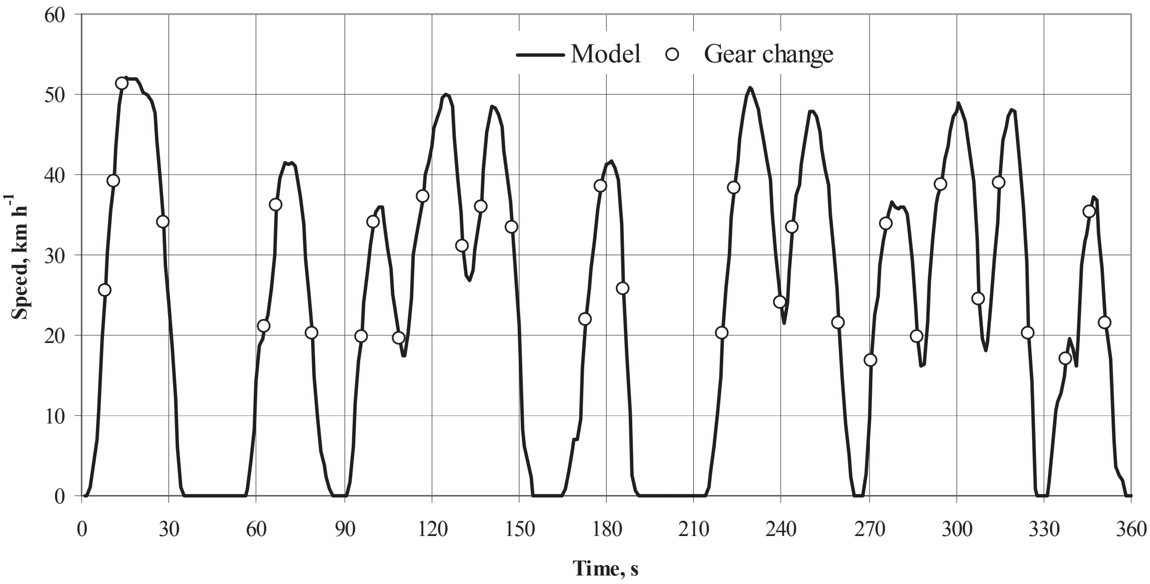

Figure 7. The model velocity curves and gear changing points.

The characteristics of the cycle match the overall summary characteristics of the data up to 97%.

Since the Mustang Software interface and menu does not provide a new driving cycle adding, then the system software core was investigated, variables were identified, and the current cycle parameter files were analyzed, but self-made cycle was programmed. Its fragments are given in Table 2, but the appearance of the developed cycle in the test mode is shown in Figure 8.

Table 2

Program code fragments

Cycle general information	Speed points	Gear switching points
[General]	[SpeedPoints]	[ShiftPoint1]
Name=Jelgava	Point1 = 0	TimeIntoTest=8
RunningTime=360	Point2 = 0	FromGear=1
MaxSpeedToShow=60	Point3 = 0.7	ToGear=2
SpeedErrorLimit=2	Point4 = 2.5	[ShiftPoint2]
SpeedErrorTimeRange=1	Point5 = 4.4	TimeIntoTest=11
WarningToViolationTime=2	Point6 = 6.6	FromGear=2
MaxDistanceError=0.05	Point7 = 12.2	ToGear=3
HPIntegrationWindow1Start=55	Point8 = 15.8	[ShiftPoint3]
HPIntegrationWindow1End=81	Point9 = 18.8	TimeIntoTest=14
HPIntegrationWindow1Tolerance=0.5	Point10 = 22.1	FromGear=3
HPIntegrationWindow2Start=189	Point11 = 24.3	ToGear=4
HPIntegrationWindow2End=201	…	…
HPIntegrationWindow2Tolerance=0.5	…	…
LR_MinSE=0	…	…
LR_MaxSE=2	Point352 = 12.6	…
LR_Minm=0.96	Point353 = 10.6	[ShiftPoint31]
LR_Maxm=1.01	Point354 = 4.4	TimeIntoTest=346
LR_MinR2=0.97	Point355 = 2.3	FromGear=2
LR_MaxR2=1	Point356 = 1.6	ToGear=3
LR_Minb=-2	Point357 = 1.2	[ShiftPoint32]
LR_Maxb=2	Point358 = 0	TimeIntoTest=351
MaxISEPercent=1	Point359 = 0	FromGear=0
MinPurgeFlow=1	Point360 = 0	ToGear=0

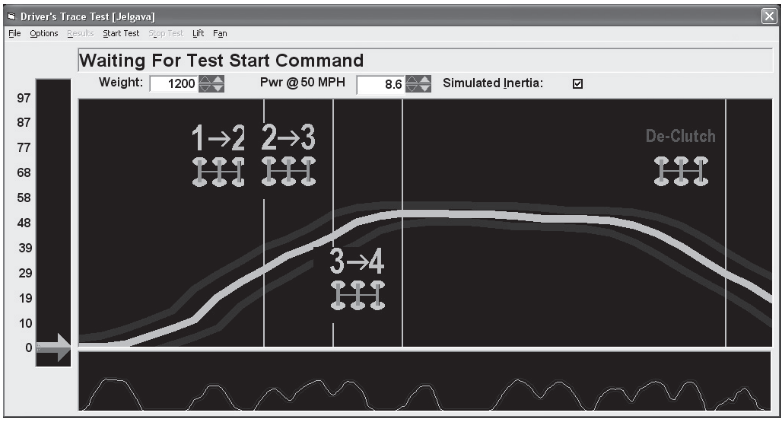

Figure 8. The appearance of the developed cycle in the test mode.

Results and Discussion

To determine whether a model (developed cycle) corresponds to the actual city driving, six test repetitions were made on the chassis dynamometer. The results are summarized in Table 3.

Table 3

Model quality verification results (using biodiesel)

Parameters	Real driving tests	Laboratory tests	Difference, %
Distance, km	2.348	2.321	1.15
Average speed, km h^{-1}	23.159	23.278	0.51
Average fuel consumption per 100 km, l	10.653	10.589	0.60

These results qualify as a high rating. To verify the fuel type influence on the model, the test series using the same car, but different fuel were performed. The measurement and calculation results are given in Table 4.

Table 4

Model quality verification results (using fossil diesel)

Parameters	Real driving tests	Laboratory tests	Difference, %
Distance, km	2.362	2.331	1.31
Average speed, km h^{-1}	23.356	23.332	0.10
Average fuel consumption per 100 km, l	9.666	9.584	0.85

Also in this case, the coincidence is very high. By analogy determining the quality of the cycle was also carried out with two other cars – Chrysler Voyager 2.5 CDI and Audi A4 (1.8 l gasoline engine), as it was necessary to be sure that the use of larger capacity diesel or petrol car does not influence the results. In all experiments, average fuel consumption differences between the real and bench driving did not exceed 1%.

By analogy with the methods described above, cycles for the second and third route, given in Figure 4, were developed. The length of the second route was 6.32 km, average speed – 29.67 km h^{-1}. For the third these parameters were correspondingly 17.47 km and 38.27 km h^{-1}.

Performing several repetitions of these routes, it was found that the larger is the distance the greater is also the probability of various random factors (such as traffic light changes, pedestrian crossings, etc.). In these routes there was greater displacement of individual trip speed curves, but, thanks to the large route length, casual factor impact on the travelling time, average speed and fuel consumption was insignificant. Comparing the results of the real and bench driving, the differences were even smaller than in the urban core. Unfortunately, a direct imitation of such a long route on the bench relates with the high time consumption and the car 'torture'. That is why further research will be carried out analysing phases of different trips (not just in Jelgava, but also in other cities). The trip data will be summarized by the following criteria: average speed of the entire driving cycle; average running speed; average acceleration; average deceleration; average micro-trip duration; time proportions of driving modes for idling, acceleration and deceleration; and average number of acceleration-deceleration changes.

Summarizing the distribution of the various real-world driving routes parameters in different cities, the cycles for Riga, large and small cities will be created.

Conclusions

1. Development of the particular city urban driving cycles allows obtaining much more accurate and relevant data on the car's fuel consumption and harmful exhaust emissions than the use of standard cycles elaborated for vehicles certification.
2. In order to objectively simulate driving in the cities of Latvia, at least three different cycles have to be worked out, which would reflect the average traffic conditions of the city categories defined by the citizen population, street networks, and the existence of traffic lights.
3. Creating the capital and the largest city driving cycles, the road network has to be divided into three regions – the centre or core, and the two expanded areas. For each of these areas it is necessary to create independent cycles. For the particular city core analysis, best fits direct imitation of the real driving route, but for the expanded areas – modal or polygonal cycles.
4. Analyzing the software data modules of chassis dynamometer, it is possible to program own cycles that correspond to the particular circumstances of the city.
5. For the first cycle developed for Jelgava, the model quality was determined using vehicle driving parameters and fuel consumption measurement results from both the road and laboratory tests. Since the obtained data coincidence of all the parameters exceeded 98%, the elaborated cycles can be used for the biofuel efficiency determination in car tests.
6. Performing further studies, other cities data and traffic conditions have to be collected and analysed. Based on these analyses, uniform driving cycles can be developed reflecting overall real driving routes of Latvia.

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DIVERSITY OF NON-STARTER LACTIC ACID BACTERIA IN LATVIAN SEMI-HARD CHEESES

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Abstract

The most non-starter lactic acid bacteria (NSLAB) isolated from semi-hard cheeses are heterofermentative and handled as one of the reasons of cheese off-flavours and yield defect but at the same time majority of researches argued positive effect of NSLAB on cheese flavour formation and diversification due to rendered compounds of chemical reactions. The amount of NSLAB in cheese varies from 10 at the beginning of ripening to 10^5 cfu ml^{-1} within 6-8 weeks.

The aims of this paper were to establish diversity of NSLAB in commercial samples of Krievijas and Holandes cheeses, and to evaluate the effect of ripening temperatures on NSLAB in the trials of Krievijas cheese.

A total of 12 commercial cheese samples from seven different Latvian manufacturers and trials from one cheese manufacturer were examined. The trials were ripened for 60 days at different temperatures – 6 °C and 12 °C. Serial dilutions of each cheese sample (1:1000 and 1:10 000) in saline were made. NSLAB were cultivated using MRS media. Strain identification was performed by the API 50 CHL system (BioMerieux, Marey l'Etoile, France).

In commercial samples of Krievijas cheese dominance of *L. curvatus* was observed, simultaneously *L.plantarum* and *L.paracasei subsp. paracasei* were isolated. Whereas in Holandes cheese samples dominance of *L.paracasei subsp. paracasei* was noted and *L.plantarum, L.curvatus, L.rhamnosus* and *L.acidophilus* were isolated. In the trials ripened at different temperatures prevalence of *L.curvatus* was noted. Concentration of *Lactobacillus spp.* varied from 10^4 cfu ml^{-1} on the first day of ripening and reached the highest concentration (10^6 cfu ml^{-1}) after 6 weeks of ripening.

Key words: API, ripening temperatures, Krievijas cheese, Holandes cheese.

Introduction

The contribution of non-starter lactic acid bacteria (NSLAB) to cheese ripening and quality is a vexed question' remains topical. Their effects are strain-specific, strongly affected by the technological issues and probably by the interactions with other microorganisms in cheese.

NSLAB affect cheese quality and contribute to the intensity of flavour, although sometimes they may cause off-flavours in cheese (Fox et al., 1998). The most NSLAB isolated from semi-hard cheeses are heterofermentative lactobacilli. Heterofermentative lactobacilli are regarded as an adventitious flora in cheese, and they originate in raw milk and factory environment. This flora can reach 10^8 cfu ml^{-1} in most, if not all, ripened cheeses (Beresford et al., 2001; Cogan et al., 2007; Fox, 1999). Many factors influence cfu of *Lactobacillus spp.* and variety of derived products. One of them is ripening temperature, which can intensify or slowdown the ripening process and influence sensory properties of cheese (Kujawski et al., 2003; White, 2000).

Differences in aroma, taste, consistence and holes of Holandes and Krievijas cheeses even from one manufacturer have showed necessity to examine the main factors influencing the quality parameters of above-mentioned cheese brands. Therefore the aims of this paper were to establish diversity of NSLAB in commercial samples of Krievijas and Holandes cheeses, and to evaluate the effect of ripening temperatures on NSLAB in the trials of Krievijas cheese.

Materials and Methods

Twelve cheese samples from seven different Latvian cheese manufacturers were selected for examination and identification of NSLAB (see Table 1). 10 g of analysed cheese samples were diluted in 90 ml of saline solution, and samples were homogenized in Bag Mixer 400 MI. Serial dilutions of each cheese sample (1:1 000, 1: 10 000) in saline were made, then plated onto MRS agar and incubated for 48 hours at 37 °C. Calculation of colony forming units (cfu) was performed by ACOLYTE colony counter. Grown cultures were examined microscopically and seeded onto MRS agar at the same conditions as previous for multiplication. Grown *Lactobacillus spp.* colonies were identified on the basis of carbohydrate fermentation patterns with API 50 CHL system (BioMerieux, Marey l'Etoile, France) as recommended by the manufacturer. The APILAB Plus version 4.0 program (bioMerieux) was used to analyze the fermentation profiles obtained with the identification strips.

Table 1

The characteristic of analysed cheese samples

Manufacturer	Cheese brand name	Protein content, %	Fat content, %	Fat content in dry matter, %	Salt content, %
JSC 'Smiltenes piens'	Krievijas	17	28.2	50	1.5-2.5
	Holandes	17	26.0	45	1.5-3.0
JSC 'Rīgas piena kombināts'	Edamjuusto (Holandes)	37	19	40	1.5-3.0
	Old Farmer (Krievijas)	23	29	50	1.3-1.8
	Limbažu (Krievijas)	23	29	50	1.3-1.8
JSC 'Trikātas piens'	Krievijas	23	29	50	1.3-1.8
	Holandes	26	26.8	45	1.5-3.0
LTD 'Mālpils piensaimnieks'	Holandes	25	25.2	45	1.5-3.0
JSC 'Cesvaines piens'	Holandes	26	26.8	45	1.5-3.0
JSC 'Valmieras piens'	Holandes	26	26.8	45	1.5-3.0
JSC 'Rankas piens'	Holandes	25	25.2	45	1.5-3.0
	Krievijas	23	28.5	50	1.3-1.8

The trials of Krievijas cheese were selected from JSC 'Rīgas piena kombināts' with fat content of 50% in dry matter. All trials were divided into two groups. Cheese samples of the first group were ripened at 6 °C but of the second group - at 12 °C for 60 days. The ripening temperature of cheese samples at 6 °C was selected according to ordinary practice of Latvian cheese producers. The ripening temperature of cheese samples at 12 °C was selected according to Dutch type cheese maturation parameters to achieve classical sensory properties. Analyses of NSLAB in trials were made at first day and after 15, 30, 45 and 60 days of ripening. The scheme of NSLAB identification was the same as for analyses of the commercial samples described above.

Results and Discussion

In commercial samples of Latvian cheeses dominance of *L.curvatus* (28.6%) and *L.paracasei subsp. paracasei* (38%) was detected, moreover *L. plantarum* (14.3%), *L. rhamnosus* (14.3%), *L. acidophilus* (4.8 %) were isolated (Tables 2 and 3).

Table 2

***Lactobacillus spp.* in Krievijas cheese samples**

Manufacturer	Cheese brand	*Lactobacillus spp.*
JSC 'Smiltenes piens'	Krievijas	*L.curvatus, L.plantarum 2*
JSC 'Rīgas piena kombināts'	Old Farmer (Krievijas)	*L.curvatus*
	Limbažu Krievijas	*L.curvatus, L.plantarum 2*
JSC 'Trikātas piens'	Krievijas	*L.curvatus*
JSC 'Rankas piens'	Krievijas	*L.curvatus, L.acidophilus 3*

Table 3

***Lactobacillus spp*. in Holandes cheese samples**

Manufacturer	Cheese brand	*Lactobacillus spp.*
JSC 'Smiltenes piens'	Holandes	*L. paracasei subsp.paracasei 1, L. paracasei subsp.paracasei 2*
JSC 'Rīgas piena kombināts'	Edamjuusto (Holandes)	*L.paracasei subsp.paracasei 1, L.rhamnosus*
JSC 'Trikātas piens'	Holandes	*L.paracasei subsp.paracasei 1, L.rhamnosus*

Table 3 continued

Manufacturer	Cheese brand	*Lactobacillus spp.*
LTD 'Mālpils piensaimnieks'	Holandes	*L. paracasei subsp.paracasei 1, L. paracasei subsp.paracasei 2, L.rhamnosus*
JSC 'Rankas piens'	Holandes	*L. paracasei subsp.paracasei 1, L. paracasei subsp.paracasei 2*
JSC 'Valmieras Piens'	Holandes	*L. curvatus, L. plantarum 2*

It is generally recognised that *L. paracasei subsp. paracasei, L. rhamnosus, L. plantarum* and *L. curvatus* are the main species of facultative heterofermentative lactobacilli in cheese (Cogan et al., 2007).

Colony forming units of *Lactobacillus spp.* in analysed commercial cheeses are presented in Figures 1 and 2.

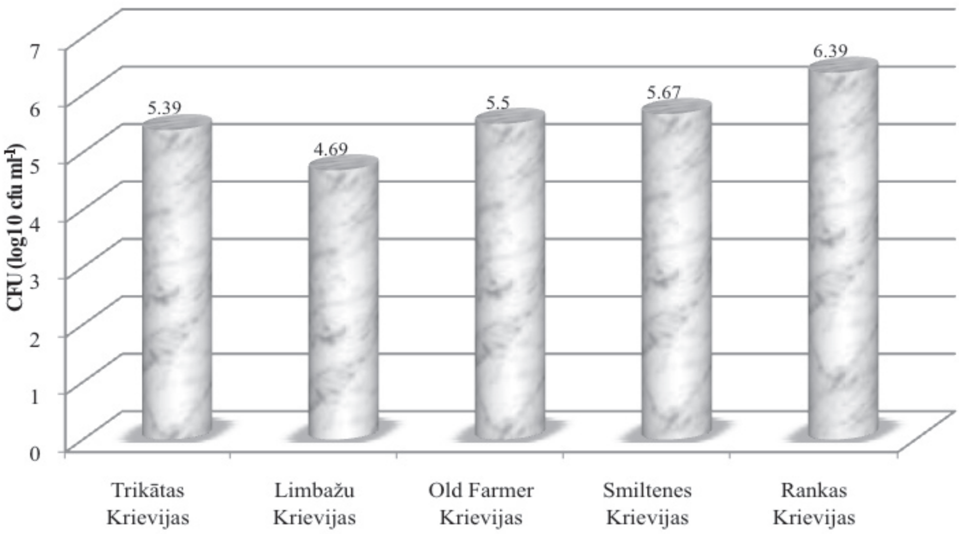

Figure 1. Colony forming units of *Lactobacillus spp.* in Krievijas cheese samples.

The obtained results showed that the lowest number of colony forming units was detected in the sample of Krievijas cheese with brand name 'Limbažu' in comparison with other sample from this manufacturer 'Old Farmer'. The highest value of colony forming units was noted in the sample from JSC 'Rankas Piens'. Among samples of Holandes cheese the lowest number of cfu was detected in the sample from JSC 'Valmieras Piens' while almost the same was the sample from JSC 'Cesvaines Piens' where count of colony forming units was only by 7% higher than in the first sample. The highest value of cfu was observed in sample from JSC 'Rankas Piens', difference between two extreme values was 17.6%. The same result for this manufacturer was etablished in the sample of Krievijas cheese, where difference between lowest and highest value was 26.6%.

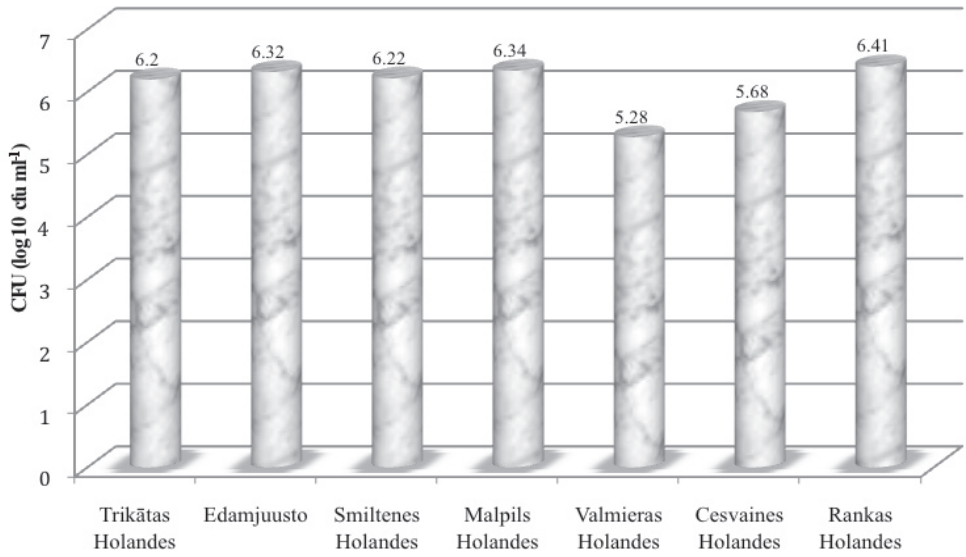

Figure 2. Colony forming units of *Lactobacillus spp.* in Holandes cheese samples.

Average colony forming units in all samples of Krievijas and Holandes cheese was 5.53 and 6.06 log10 cfu ml^{-1} respectively, which implies varying manufacturing conditions of these two cheeses. The lowest number of colony forming units in Krievijas cheese infers lower pH and higher lactic acid concentration than in Holandes cheese; however Table 1 shows that salt content in Holandes cheese varies from 1.5 to 3 and upper threshold is twice higher than in Krievijas cheese, which could be one of explanations for differences in the total bacterial count of examined samples (Upreti et al., 2006).

The growth of NSLAB in the trials during different temperatures of cheese maturation is presented in Figure 3.

The prevalence of *L. curvatus* in analysed samples was noted. Concentration of cultures varied from 4.14 log10 cfu ml^{-1} on the first day of ripening to 6.53 log10 cfu ml^{-1} after 4 weeks of ripening.

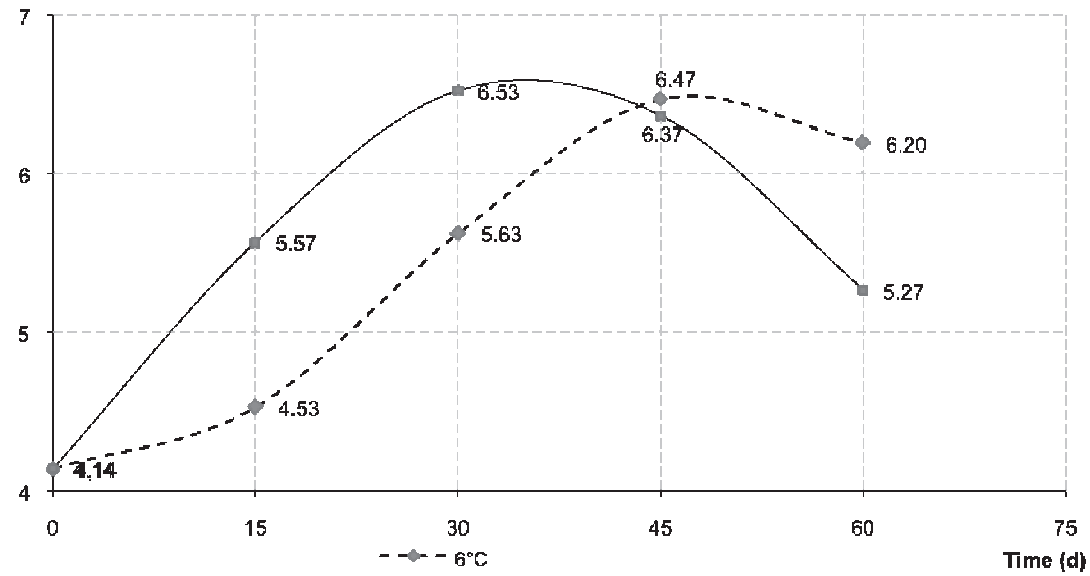

Figure 3. The dynamics of NSLAB in cheese during ripening.

The differences in cfu were observed from the 15th day of ripening. The count of colony forming units increased up to 9.42% and 34.54% for cheeses ripened at 6 °C and 12 °C respectively. Further changes were more obvious: on the 30th day of cheese aging the growth of colony forming units was 35.87% and 57.61% (6.53 log10 cfu ml^{-1}) in comparison with the initial numbers, reaching the peak value for cheese ripened at 12 °C. The decrease in cfu for cheese ripened at 12 °C was noted after 30 days, whereas for cheese matured at 6 °C the cfu increased steadily, and reached its peak value (6.5 log10 cfu ml^{-1}) after 45 days of ripening.

Non-starter lactobacilli have a generation time of approximatley 8.5 days in cheese ripened at 6 °C (Jordan et al., 1993). Ripening at low temperatures reduces their growth rates. Shakel-Ur-Rehman et al. (2000) found that in cheese ripened at 1 °C, the non-starter lactobacilli population was 3 log lower than in a cheese ripened at 8 °C. NSLAB concentration in cheese is lower than maximum numbers of starter (10^9-10^{10} cfu ml^{-1}). Different concentrations of *Lactobacillus spp.* in cheese ripened at 6 °C and 12 °C of temperature at the end of maturation could be explained by a higher metabolism of *Lactobacillus spp.* at a higher temperature. High metabolic rate results in an early approach of the stationary phase and autolysis during ripening (White, 2000).

The role of heterofermentative lactobacilli in flavour formation in cheese is still unclear compared to the homofermentative starter lactobacilli. Hence the next stage of investigation should be the establishement of the sensory properties of cheese and the evaluation of the level of proteolyses and fat degradation during ripening of cheese at different temperatures.

Conclusions

The main representative of NSLAB in Krievijas cheese is *Lactobacillus curvatus* and in Holandes cheese – *Lactobacillus paracasei subsp. paracasei*.

Ripening of cheese at the temperature of 6 °C reduces NSLAB growth rates due to lower metabolism of *Lactobacillus spp.*

A higher metabolism of *Lactobacillus spp.* at 12 °C results in an early approach of the stationary phase and death phase of microorganisms during cheese ripening.

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CHANGES IN QUALITY OF PARENTS STOCK HENS MEAT DURING CHILLED STORAGE

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Abstract

The aim was to study changes of chemical composition (fat content, protein content), pH and colour of poultry meat during chilled storage.

Various criteria are used for evaluation of bird and carcass quality, while the combination of several indices determines the quality of poultry meat, which has an important role in the following meat processing and quality of end product. Chilled poultry meat is offered in retail and it is used in processing plants for various meat products production. Chemical composition (fat content, protein content), pH and colour are important quality determinants. Hens' meat is cheaper compared to broiler meat, therefore its use in processing is profitable.

Parents stock hens of the cross Ross 308 were used for the study. Parents stock hens were fed compound feed. After chilling a hen fillet *[musculus pectoralis]*, hen thighs *[musculus biceps]* and hen drumsticks *[musculus gastrocnemius; musculus fibularis longus]* were separated from carcasses. The obtained products were refrigerated at temperature +1±0.5 °C. The analyses were performed 1 day after slaughter and on the 5th day of storage. The following parameters were analysed: pH value (3510pH Meter – JENWAY); total protein content (LVS ISO 937:1978); fat content (LVS ISO 1443:1973); colour changes (Color Tec-PCM; software ColorSoft QCW for colour data analysis).

The analysed parameters significantly differ in 'white' and 'red' poultry meat, and in various cuts of 'red' meat.

Key words: poultry, pH, meat composition, colour, texture.

Introduction

Poultry meat muscles differ by colour ('white' and 'red') and quality. 'White' meat in hens mainly is located in breast part, while the rest is considered 'red' meat. The differences in colour give the presence of protein myoglobin, which gives red colour to muscles. 'White' muscle tissue contains a little higher amount of essential amino acids, less fat, cholesterol, and phosphatides (Мысик, Белов, 1986).

Although the consumer may choose meat primarily for its aesthetic appeal, or through habit, it is important not to overlook its nutritional value. The composition of lean meat is relatively constant over a wide range of animals. Variation is most marked in the lipid contend, which may be evident as different degrees of 'marbling' (Varnam and Sutherland, 1995).

Water is quantitatively the most important component of meat comprising up to 75% of weight. Water in meat is associated with muscle tissue, and proteins have a central role in the mechanism of water binding (Varnam and Sutherland, 1995).

Poultry meat is a wholesome food, which contains valuable proteins, all essential amino acids, lipids, macro- and microelements, vitamins. Cholesterol content in poultry is relatively low. The content of carbohydrates is low as well (Мысик, Белов, 1986).

Almost all water soluble vitamins are found in poultry muscle tissue. Poultry is a good source of group B vitamins (Мысик, Белов, 1986).

Meat is justifiably considered a high protein food. Of the total nitrogen content of muscle, 95% is protein and 5% smaller peptides, amino acids, and other compounds. The quality of the protein is very high, the types and ratios of amino acids being similar to those required for maintenance and growth of human tissue. Of the essential amino acids, meat supplies substantial quantities of lysine and threonine and adequate quantities of methionine and tryptophan, although the content of these amino acids in meat is relatively low.

Meat has relatively high lipid content. This is of dietary significance in provision of energy, especially for persons engaged in heavy labour, or where overall dietary intake is limited (Varnam and Sutherland, 1995).

Post mortem lipid oxidation (rancidity) is one of the causes of deterioration of the meat product quality, affecting the flavour, colour, nutritive value, and safety (Dawson et al., 1987).

Water content compared to other compounds in poultry is higher. Water present in meat provides its digestibility and sensory properties. Water serves as media where metabolism processes take place, which means that water participates in digestion process (Warkup et al., 1991).

Materials and Methods

Parents stock hens of the cross Ross 308 were used for the study. The average age of slaughtered parents' stock hens was 46 weeks; an average carcass weight of a bird was 2.6 kg.

The slaughter and primary treatment was performed at a meat processing plant (line Stork PMT). Laying hens were stunned, then killed with a knife, bleeded for 3.37 minutes and scalded in a steam bath at 60.2±0.2 °C for 3.47 minutes, defeathered, eviscered and chilled for 100 minutes at +1±0.5 °C. Three carcasses were randomly selected for separating a fillet *[musculus pectoralis]*, thighs *[musculus biceps]*, and drumsticks *[musculus gastrocnemius; musculus fibularis longus]* (Brūveris, 2007). The obtained products were refrigerated at the temperature of +1±0.5 °C. The analyses were performed 1 day after slaughter and on the 5th day of storage.

The following parameters were analysed at the Faculty of Food Technology (Latvia University of Agriculture), and the National Diagnostic Centre of Food and Veterinary Service:

- pH value using 3510pH Meter – JENWAY;
- total protein content by the method of LVS ISO 937:1978;
- fat content by the method of LVS ISO 1443:1973;
- colour changes were evaluated using Color Tec-PCM and software ColorSoft QCW was used for colour data analysis.

The Hunter *L, a, b* system was used for food colour evaluation. The Hunter tristimulus data, *L* (value), *a* (redness or greenness), and *b* (yellowness or blueness) can be converted to a single colour function called colour difference (*ΔE*) by using the following equation:

$$\Delta E^* = (\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2$$

$\Delta L^* = L^*_{sample} - L^*_{standard}$ $+\Delta L^*$ means sample is lighter than Standard
$-\Delta L^*$ means sample is darker than Standard

$\Delta a^* = a^*_{sample} - a^*_{standard}$ $+\Delta a^*$ means sample is redder than Standard
$-\Delta a^*$ means sample is greener than Standard

$\Delta b^* = b^*_{sample} - b^*_{Standard}$ $+\Delta b^*$ means sample is yellower than Standard
$-\Delta b^*$ means sample is bluer than Standard

The colour difference is a measure of the distance in colour space between two colours. It does not indicate the direction in which the colours differ (DeMan, 1999).

Analysis of pH, protein, and fat content were done in triplicate for each parameter. In colour evaluation, 10 replications were used.

Results and Discussion

Chemical composition of poultry meat depends on bird type, variety, age, fatness, and other factors (Мысик, Белов, 1986). Changes in fat content in the cuts - hen fillet *[musculus pectoralis]*, hen thighs *[musculus biceps]*, and hen drumsticks *[musculus gastrocnemius; musculus fibularis longus]* - were observed during refrigerated storage (see Fig. 1).

Figure 1. Changes in fat content in various poultry meat cuts during refrigerated storage.

During refrigerated storage, an increase in fat content was observed in a hen fillet which had by 14.68% higher fat content on the 5th day of storage compared to the fat content detected on the 1st day after slaughter. Fat content was by 20.22% higher in drumsticks, but it was approximately at the same level in hen thighs after 5 days of storage.

The increase in fat content in fat tissues and muscle tissues is closely related to water content reduction. Warris (2000) found that tendency of negative correlation exists between fat and water content, although strong linear correlation was not found.

The total lipid content of white meat is approximately half of dark meat, and skin contains the highest proportion of lipid (Ratnayake et al., 1989). The total fat content in light muscle with skin has been quoted as approximately 10 times higher (11.1 g 100 g^{-1} muscle) than in muscle without skin (Decker and Cantor, 1992).

Lipids in meat are of three discrete types: subcutaneous, intermuscular, and intramuscular. The amount that accumulates in an animal depends on a number of factors including genetic predisposition, age, gender and sex status, level of nutrition, and exercise.

Chicken contains approximately 7% of fat (DeMan, 1999).

There can also be marked variation according to the location of the fat in the body. Internal body fats are significantly harder than those near the skin. This is thought to reflect the fact that the lower temperatures at the outside of the body mean the fat must have a lower melting point to permit mobilization. Conversely internal fats must have some structural rigidity and thus have a higher melting point (Varnam and Sutherland, 1995).

In poultry, fat is synthesized in the liver primarily and is transported to the adipose tissue in the form of very low density lipoproteins (VLDL). High deposition of adipose tissue is associated with high circulating levels of VLDL and high rates of hepatic lipogenesis. Significant correlations exist between body fat, hepatic activities of the lipogenic enzymes such as ATP-citrate lypase or malate dehydrogenase, and plasma VLDL concentration (Nahm, 1999).

The changes in protein content in a hen fillet *[musculus pectoralis]*, hen thighs *[musculus biceps]*, and hen drumsticks *[musculus gastrocnemius; musculus fibularis longus]* are demonstrated in Fig. 2.

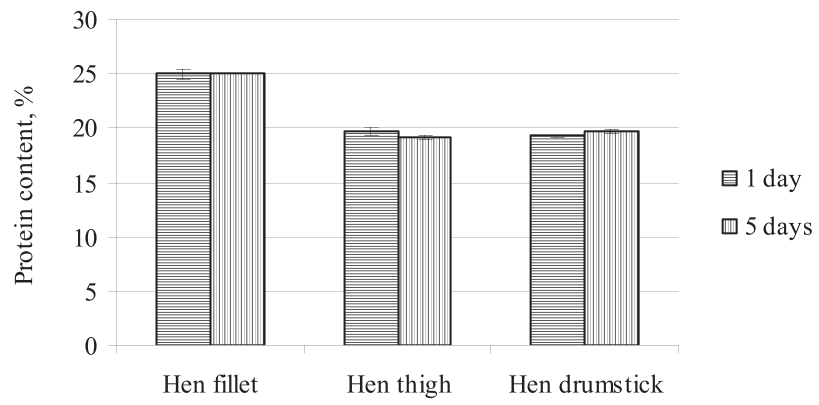

Figure 2. Changes in protein content in various poultry meat cuts during refrigerated storage.

During the storage, content of protein in chilled hen fillet was practically constant - changes of protein content in thighs and drumsticks were small, i.e., protein content in thighs decreased by 2.5%, while in drumsticks increased by 2.2%.

Muscle may be classified in a number of ways. The simplest is 'red' or 'white', colour reflecting the different myoglobin content. 'Red' muscles are characterized by high myoglobin content, a highly developed vascular system, and copious supplies of oxygen. They are consequently adapted to oxidative metabolism and are thought to be involved in sustained, repetitive activity. As a further consequence, 'red' muscles have limited glycolytic activity and a relatively high content of mitochondria. 'White' muscles have lower myoglobin content, relatively few mitochondria, and a less well developed vascular system than the 'red' ones. They have greater glycolytic capacity and are thought to be involved in short bursts of violent activity, during which metabolism becomes anaerobic. The simple differentiation between 'red' and 'white' is of value in meat science since there is a broad correlation with post-mortem behaviour and functional properties in meat products (Varnam and Sutherland, 1995).

Research studies have shown that increasing the levels of energy as well as protein results in improved growth rates and feed conversion. Increasing the levels of energy increases the carcass fat content, while increasing protein levels decrease the carcass fat content (Nahm, 1999).

Changes in pH during chilled storage in hen fillet *[musculus pectoralis]*, thighs *[musculus biceps],* and drumsticks *[musculus gastrocnemius; musculus fibularis longus]* are shown in Fig. 3.

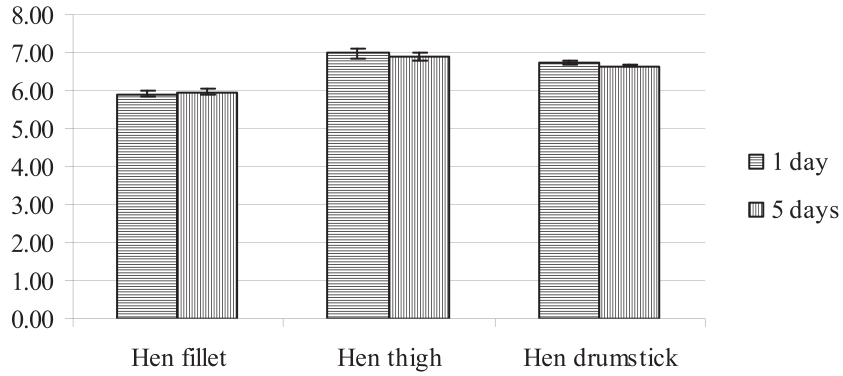

Figure 3. pH changes in various poultry meat cuts during refrigerated storage.

Experiments proved that the pH value changes during chilled storage of poultry meat are negligible due to low storage temperature (+1±0.5 °C). 'White' meat (hen fillet) pH is considerably lower than that of 'red' meat, i.e., hen thighs and hen drumsticks, which correlates with earlier findings that the lighter muscle (fillet) has lower pH values (Fletcher, 1999).

The pH values of the lighter-than normal, normal, and darker-than normal groups were 5.81, 5.96, and 6.23 respectively. (Qiao et al., 2001). Glycogen content in meat - 0.10% (DeMan, 1999).

The ultimate pH value of 'red' muscles tends to be higher than that of 'white'. This is a consequence of the biochemical specialization of the two types of muscle, 'red' muscles having relatively low glycogen reserves and being of relatively limited glycolytic enzyme activity. Differences in the ultimate pH value of different muscles may be explained by the differing ratios of 'red' and 'white' fibres present.

The fact that poultry meat colour changes during storage is well established (Petracci and Fletcher, 2002).

The colour changes during chilled storage for hen fillet inner side and hen inner fillet are presented in Table 1.

Table 1

Colour changes in hen fillet during chilled storage

L*a*b* parameters		Hen fillet (inner side), 1st day	Hen fillet (inner side), 5th day	Hen inner fillet, 1st day	Hen inner fillet, 5th day
L* parameter	Average	48.53	46.47	43.83	43.66
	STD	±3.11	±1.41	±1.81	±1.20
a* parameter	Average	-3.52	-2.23	-2.01	-1.39
	STD	±1.51	±0.90	±1.42	±1.98
b* parameter	Average	10.63	12.91	10.68	9.84
	STD	±2.09	±2.01	±1.84	±2.96

Calculations and results for colour changes in hen fillet inner side:

$\Delta L^*_{hens\ fillet\ (inner\ side)} = 46.47 - 48.53 = - 2.06$

$\Delta a^*_{hens\ fillet\ (inner\ side)} = -2.23 - (-3.52) = + 1.29$

$\Delta b^*_{hens\ fillet\ (inner\ side)} = 12.91 - 10.63 = + 2.28$

$\Delta E^* = (-2.06)^2 + (1.29)^2 + (2.28)^2 = 11.09$

The calculations show that hen fillet inner side becomes darker during its storage, *Δa** gives evidence that it becomes more red, but *Δb** in its turn proves the change towards more yellow colour compared to the colour observed at the beginning of the storage.

Calculations and results for colour changes in hen inner fillet:

$\Delta L^*_{hens\ inner\ fillet} = 43.66 - 43.83 = - 0.17$

$\Delta a^*_{hens\ inner\ fillet} = -1.39 - (-2.01) = + 0.62$

$\Delta b^*_{hens\ inner\ fillet} = 9.84 - 10.68 = - 0.84$

$\Delta E^* = (-0.17)^2 + (0.62)^2 + (-0.84)^2 = 1.11$

The calculations show that according to change in *ΔL**, hen inner fillet becomes darker during the storage, factor *Δa** shows tendency to become more red, but parameter *Δb** shows that increase in blueness is observed during the storage.

The hen meat colour changes in thighs and drumsticks during chilled storage are summarized in Table 2.

Table 2

Colour changes in hen thighs during chilled storage

L*a*b* parameters		Hen thigh, 1st day	Hen thigh, 5th day	Hen drumstick, 1st day	Hen drumstick, 5th day
L* parameter	Average	72.33	69.64	72.25	71.28
	STD	±1.25	±2.20	±1.78	±2.53
a* parameter	Average	-2.50	-2.75	-2.27	-3.19
	STD	±0.85	±0.77	±0.76	±0.72
b* parameter	Average	13.15	13.80	12.37	9.86
	STD	±1.49	±2.11	±1.72	±1.96

Calculations and results for colour changes in hens' thighs with skin:

$\Delta L^*_{hens\ thigh} = 69.64 - 72.33 = - 2.69$

$\Delta a^*_{hens\ thigh} = -2.75 - (-2.5) = - 0.25$

$\Delta b^*_{hens\ thigh} = 13.8 - 13.15 = + 0.65$

$\Delta E^* = (-2.69)^2 + (-0.25)^2 + (0.65)^2 = 7.71$

A conclusion can be drawn that hen thigh colour after five days storage becomes darker according to parameter *ΔL**, more green – according to *Δa**, and more yellow – according to parameter *Δb**, if compared to the meat on the first day after slaughter.

Calculations and results for colour changes in hens' drumsticks with skin:

$\Delta L^*_{hens\ drumstick} = 71.28 - 72.25 = - 0.97$

$\Delta a^*_{hens\ drumstick} = - 3.19 - (-2.27) = -0.92$

$\Delta b^*_{hens\ drumstick} = 9.86 - 12.37 = - 2.51$

$\Delta E^* = (-0.97)^2 + (-0.92)^2 + (-2.51)^2 = 8.08$

It means that hen drumstick colour after five days storage becomes darker according to parameter *ΔL**, more green – according to *Δa**, and more blue – according to parameter *Δb**, if compared to the meat on the first day after slaughter.

Colour is the most important factor with respect to initial selection. In red meats a bright red colour associated with a high content of oxymyoglobin is a positive determinant of quality, while metmyoglobin content is a negative determinant.

Two specific defects – pale, soft, exudative meat (PSE) and dark, firm, dry meat (dark cutting; DFD), both of which are due to abnormal post-mortem pH values – are also recognized.

Poultry meat skin colour is thus a factor influencing perceptions of quality. Strain of bird and diet, as well as processing conditions (scalding), are often manipulated to produce a range of skin colours to suit particular markets.

The importance of colour as a quality determinant should be seen in the context of overall appearance. Perception of quality related to colour can be modified by other visual factors. The most important of these, in red meats, is the extent of marbling the adipose tissue located between muscle fibre bundles in the perimysial connective tissue. Marbling is positively associated with good eating quality and can be an important factor influencing consumer choice. At the same time, the amount of fat surrounding major muscles influences the appearance or 'finish' of the meat. Excessive fat has always been associated with poor quality, although a certain quantity is expected on some cuts (Varnam and Sutherland, 1995).

Skin and meat colour changes that occur during storage are variable and depend on processing or holding conditions (Petracci and Fletcher, 2002).

The characteristic colour of meat is a function of two factors: the meat pigments and the light-scattering properties. The basic pigment of fresh meat is myoglobin. Haemoglobin, which is very similar in chemistry, is also present in small quantities, especially if bleeding has been inefficient. Myoglobin levels vary according to breed and age, concentration increasing with age. Leg muscles contain more myoglobin and are of darker colour. Meat from male animals also usually contains more myoglobin than that from females.

Pale, soft, exudative meat, which is of low myofibrillar volume, has a high light-scattering ability. Light is unable to penetrate a significant distance into the meat without being scattered. This means that there is relatively little absorption by myoglobin and the meat appears pale. Dark, firm, dry meat has only very limited light-scattering ability, permitting incident light to penetrate for a considerable distance. Considerable absorption by myoglobin occurs and the meat appears dark (Varnam and Sutherland, 1995).

Conclusions

Fat content in meat fat tissues is increased by decrease of water content. Fat content in 'white' meat is lower compared to 'red' meat. Analysis of 'red' meat proved higher fat content in hen thighs than in drumsticks.

Protein content in all tested cuts was relatively high, although the highest protein content was established in hen fillet. 'White' meat contained by 20% more proteins compared to 'red' meat. No significant changes in fat content were observed during five - day chilled storage.

'White' meat (hen fillet) had significantly lower pH than 'red' meat (hen thigh, hen drumstick). The pH changes during storage were negligible possibly due to low storage temperature (+1±0.5 °C).

The most pronounced colour changes were observed in hen fillet inner side. Colour changes in 'red' meat cuts (thighs and drumsticks) were similar. The parameter *ΔL** proved that all analysed meat samples became darker during five - day chilled storage.

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METHODOLOGY OF DIETARY FIBRE DETERMINATION IN GRAIN PRODUCTS

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Abstract

The dietary fibre is edible parts of plants' carbohydrates that are resistant to digestion in human small intestine. Diets naturally rich in dietary fibre support to prevent constipation, improve gastrointestinal health, glucose tolerance and the insulin response, and reduce the risk of colon cancer, hyperlipidemia, hypertension and other coronary heart disease risk factors. About 45% of the dietary fibre intake comes from grains and grain mixtures. In Latvia, there are neither data, nor investigations of the dietary fibre content in grain products during processing and in the end products in which manufacturers and consumers are interested. The aim of this paper was an approval of dietary fibre determination methodology by using analytical equipment the Full option science system (FOSS) Analytical Fibertec E 1023. The dietary fibre determination experiments were carried out in the Research Laboratory of the Department of Food Technology at the Latvia University of Agriculture in 2009. The Total Dietary Fibre (TDF) content was analyzed in the samples of rye whole grain flour, rye whole grain bread, and wheat biscuit. Experiments showed that the fibre content in rye whole grain flour is 13.8 g 100 g^{-1}, in rye whole grain bread –11.6 g 100 g^{-1}, and in the wheat biscuit –1.9 g 100 g^{-1}. Reached data are comparable with results of other researchers` data.

Key words: dietary fibre, grain products.

Introduction

It is generally believed that E.H. Hipsley in 1953 was the first to use 'dietary fiber' as a term for the nondigestible constituents that make up the plant cell wall. These constituents were known to include cellulose, hemicellulose, and lignin (DeVries et al., 1999).

By 1976, the dietary fibre definition had been broadened to include all indigestible polysaccharides such as gums, modified celluloses, mucilages, oligosaccharides, and pectins (Trowell et al., 1976). It remained primarily a physiological definition, identifying dietary fibre on the basis of edibility and resistance to digestion. The definition was broadened to reflect chemical research findings obtained in the interim years. In alter years scientists began to seek consensus on a dietary fibre definition with the aim to quantify it in foods for nutrition improvement and labeling purposes. By the 1981 workshop of the Association of Official Analytical Chemists (AOAC) in Canada, general consensus had been achieved on methodology that would quantify dietary fibre, as defined by H. C. Trowell in 1976, and adopted in collaborative study by 43 laboratories in 29 countries (Prosky, 1990). The method was adopted by AOAC as the first Official Enzymatic-Gravimetric Method of Analysis for total dietary fibre, in foods-AOAC Official Method 985.29 (Andrews, 1998). After that American Association of Cereal Chemists (AACC) adopted the method as AACC Approved Method 32-05. Also adopted as official methods were: AOAC 992.16, Total Dietary Fiber, Enzymatic Method and AOAC 994.13, Total Dietary Fiber (Determined as Neutral Sugar Residues, Uronic Acid Residues, and Klason Lignin)–Gas Chromatographic–Colometric–Gravimetric Method (Uppsala Method), (Andrews, 1998).

At the end of 90th last century before scientists had realized the International survey of 147 scientists for dietary fibre methodology (DeVries et al., 1999), 65% of the scientists supported the physiological definition; while an additional 5% favored using it in combination with the chemical definition. Fifty nine per cents supported the inclusion of digestion-resistant oligosaccharides in that definition. Workshop participants acknowledged that AOAC 985.29/AACC 32-05 did not quantify non-digestible oligosaccharides. After that, methods were developed to specifically measure oligosaccharides – methods 997.08, 999.03, 2001.02, 2000.11, 2001.03, 2002.02, and (IFST, 2007). Codex Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU) and International Life Sciences Institute (ILSI) took part in dietary fibre methodology development (ILSI, 2007). The Issue of a definition for dietary fibre has been discussed and debated in the scientific community for many years (ILSI, 2007). A consensus has been developed basing on clear scientific evidence that the definition of dietary fibre should be based on the physiological properties of food constituents, not merely on their physiochemical characteristics. This consensus is reflected in the original definition developed in CCNFSDU, AACC and numerous other definitions, including US National Academy of Institute of Medicine and Health Council of the Netherlands. Each of these definitions is based on the physiological property of non-digestion and non-absorption in the small intestine, with one or more desirable health effects (ILSI, 2007).

Dietary fibre definition adopted at the 28th Session of CCNFSDU in November 2006 is as follows: 'Dietary fibre means carbohydrate polymers with a degree of polymerization (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerization not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consists of one or more:

- edible carbohydrate polymers naturally occurring in the food as consumed;
- carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means;
- synthetic carbohydrate polymers' (AACC, 2007).

Grain foods provide complex carbohydrates important not only as a source of energy, but also a source of fibre in human diet and therefore a benefit to human health (Poutanen, 2006). Consumers are interested in higher content of dietary fibre in grain products, which improves health because dietary fibres are an extremely beneficial component. There is strong and expanding epidemiological evidence linking high intake of cereal fibre to reduced risk of chronic and cardiovascular disease (Poutanen, 2006). A diet naturally high in fibre helps prevent constipation, reduce the risk of colon cancer, improves gastrointestinal health, effect of satiety, and impacts weight loss by reducing food intake at meals (Leeds, 1982). Such dietary fibre component as β-glucan lowers cholesterol level in blood and effected diabetes disease (Shinnick et al., 1991), but the World Health Organization has recommended that total fibre intake be 25 g day^{-1} (Viscione, 2007).

The aim of this study is to approve the total dietary fibre determination methodology in grain products produced in Latvia according to AOAC standard No. 985.29 using FOSS Analytical Fibertec E 1023 system. At present this method is the most commonly accepted choices for nutrition labeling of fibre content.

Materials and Methods

The experiments were carried out in the Research Laboratory of the Department of Food Technology, Latvia University of Agriculture in 2009. The samples used in experiments were obtained from:

- rye whole grain flour (stock company 'Jelgavas Dzirnavas', Type 1740);
- rye whole grain bread (baked from whole meal grain flour with scalding and sourdough at the Department of Food Technology);
- wheat biscuit (baked from wheat flour Type 405 at the Department of Food Technology).

The total dietary fibre in these samples was determined according to the AOAC approved method No. 985.29 by FOSS Analytical Fibertec E 1023 system (Fig. 1).

Figure 1. FOSS Analytical Fibertec E 1023 System.

The samples of every type were used in duplicates. The samples were defatted and dried with a particle size less than 0.5 mm. After weighing, each sample was enzymatically digested with α amylase and incubated at 100 °C, and then the samples were digested with protease and amyloglucosidase and were incubated at 60 °C. The determination procedure of TDF is shown in Figure 2. After digestion, the total fibre content was precipitated by adding 95% ethanol. Then the solution was filtered and fibre was collected, dried and weighed. The protein and ash content were determined to correct any of these substances which might remain in the fibre. For calculations, basic equation was applied: Content of fibre=residue weight–weight of (protein+ash) (Prosky, 1990).

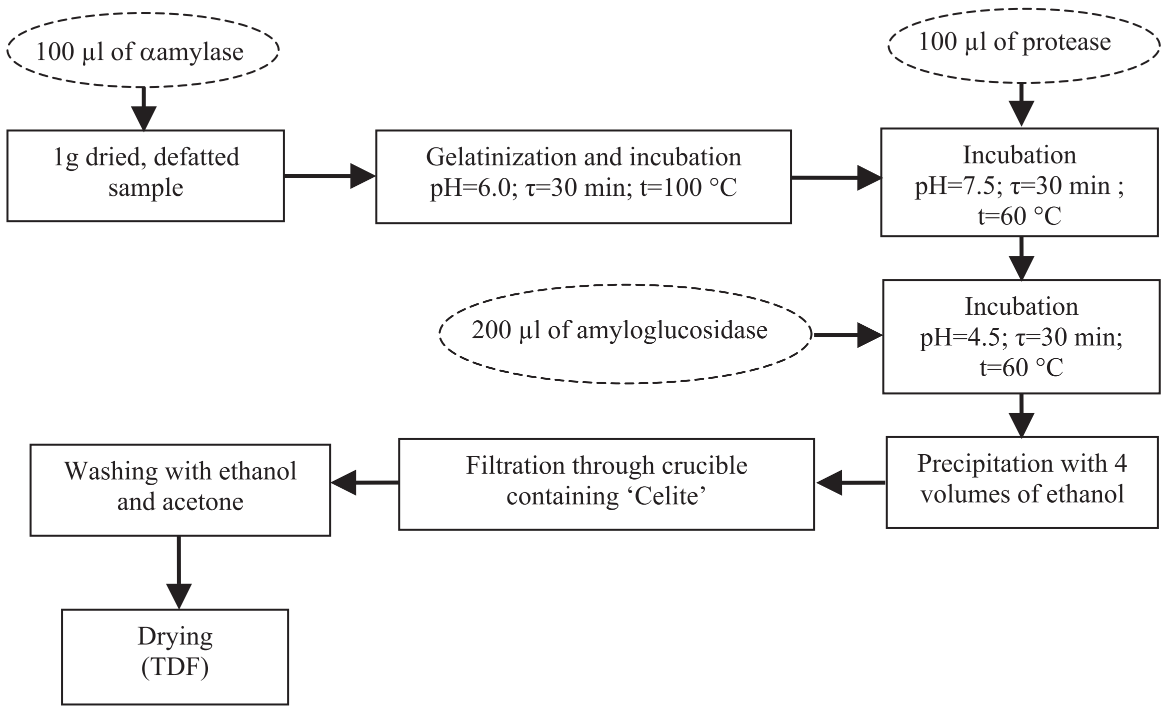

Figure 2. TDF determination procedure.

The experiments were carried out by using enzymatic processing with incubation in a thermostatic shaking water bath. The TDF residues were filtrated by using the Filtration Module. The protein content was determined by using Kjeldahl (AACC, 1995) nitrogen equipment. Each determination process took 2 days.

Results and Discussion

The authors evaluated practice and experience of investigations and found out that factors most impacting determination of dietary fibre are weighing, sample preparing, and residue transfer and practice (Figure 3).

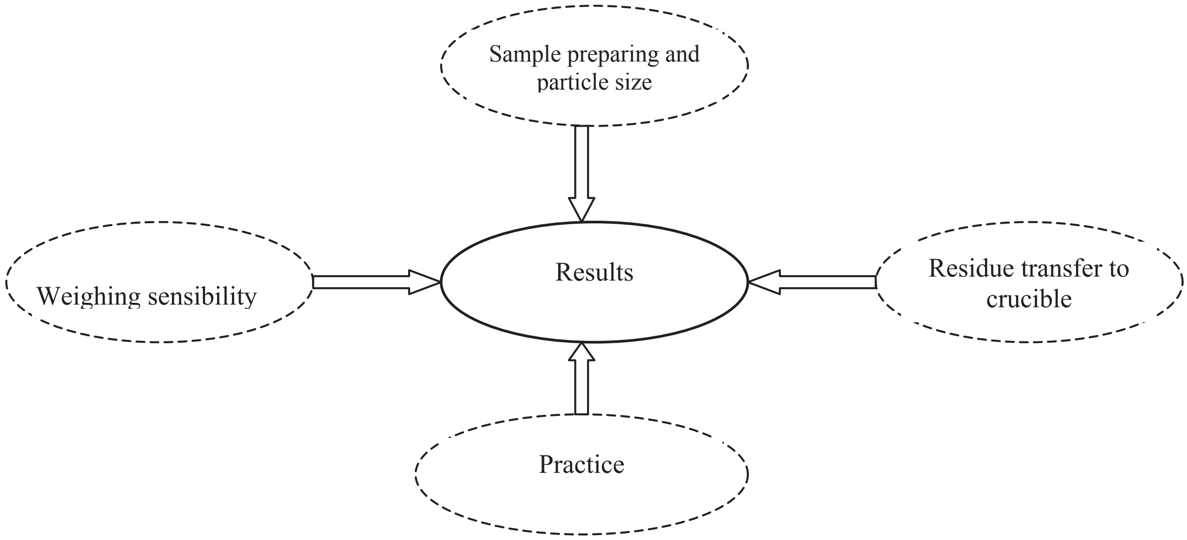

Figure 3. Factors impacting results of dietary fibre content.

In the determination procedure more attention should be devoted to sample preparation and particles transferring degree from precipitate sample to crucible. From our experience, the most attention should be addressed to weighing procedure if gravimetrical methods are applied. To reach comparable analytical results, quality of reagents and enzymes is important, as well as practical arrangements like qualification of involved personnel and major analytical equipment at the same location. It is envisaged to continue the studies of grain and other food products total dietary fiber content determination.

The content of total dietary fibre was determined in rye whole grain flour, rye whole grain bread, and wheat biscuit. The results of total dietary fibre were obtained in three independent repetitions by using FOSS Analytical Fibertec E 1023 system (see Table 1).

Table 1

Results of experiments compared to the literature data

Sample	Experimental data of TDF, g 100 g^{-1}	Literature data of TDF, g 100 g^{-1}		
		Kujala, 1999	Lindhauer, 2005	Fineli, 2008
Rye whole grain flour	13.8±0.7	13.6	–	13.9
Rye whole grain bread	11.6±0.6	9.9	9.0	11.0
Wheat biscuit	1.9±0.1	–	–	1.3

Fibre content in grain depends on corn sort and climatic, growing and harvesting conditions. In the milling process, the kernel can be ground and fractionated into different types of flour. Whole grain rye flour contains all parts of the grain. In the literature it was found that the average dietary fibre content usually is between 12% and 15% of dry matter (Kujala, 1999). This research showed that the amount of total dietary fibre in whole grain rye flour is 13.8±0.7 g 100 g^{-1}.

The fibre content in rye bread is about three times higher (about 8.5 –10 g 100 g^{-1}) than in wheat bread. The latest research data demonstrate that in the rye whole grain bread total dietary fibre content is 11.6±0.6 g 100 g^{-1}. This amount is higher than that in the literature and should be taken into account corn sort, and that bread was baked from whole grain flour.

Wheat biscuit baked from wheat flour 550. Type contains very limited amount of fibre-according Fineli Food Composition Database – 1.3 g 100 g^{-1}. New experimental data 1.9±0.1 g 100 g^{-1} (Table 1) and the literature data demonstrate high comparability.

Conclusions

1. The experiments of total dietary fibre determination show that using Full option science system Analytical Fibertec E 1023 is acceptable and workable to analyze grain products according to standard method AOAC 985.29 for investigations in future.
2. Experimental data demonstrate that fibre content in rye whole grain flour is 13.8±0.7 g 100 g^{-1}, in rye whole grain bread –11.6±0.6 g 100 g^{-1}, and in wheat biscuit –1.9±0.1 g 100 g^{-1}.
3. Reached data are comparable with results of other researchers` data.

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CHROMATOGRAPHIC PROFILING OF HYDROPHILIC METABOLITES FROM TUBERS OF DIFFERENT POTATO CULTIVARS

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Abstract

Potato is an important source of nutrients and bioactive compounds with profitable effect for health, such as antioxidants, vitamins and essential amino acids. The knowledge about metabolite composition of various potato cultivars is necessary to facilitate development of new cultivars with desirable properties. In the present study, the hydrophilic metabolite composition of six potato cultivars with different resistance against potato late blight disease was analyzed. For this, an HPLC-based method was developed and used for the analysis of water-ethanol extracts of freeze-dried potato tubers. Significant differences in concentrations of adenosine, chlorogenic acid, and rutin were revealed. Some other metabolites were found to be cultivar-specific.

Key words: potato, cultivar, hydrophilic metabolite, HPLC, LC-MS.

Introduction

Potato (*Solanum tuberosum*) is globally one of the most important crops. According to FAOSTAT it is the fifth largest food crop in the world. There is an ongoing geographic shift of the global potato production away from developed countries towards lower-income areas of the world. Europe has the highest per capita production and consumption of potato in the world, but during the last decades there has been a large expansion of its production in Asia. Nowadays, the largest potato producer in the world is China, which together with India produces almost a third of the world's potatoes (FAOSTAT, 2007).

The importance of potato as a major food crop is determined by its high content of various nutrients and bioactive compounds with profitable health effects. It is, therefore, of great interest to develop new potato cultivars with improved nutritional composition and higher concentrations of health-promoting compounds. Furthermore, the efforts should be taken to enhance the resistance of the potato crop to different pests and pathogens as well as adaptability to adverse climatic conditions to maintain sustainability in its production. The knowledge about various metabolites and their levels in existing potato cultivars is important when new cultivars are developing by breeding technologies. In this context, methodologies that allow rapid and effective screening of certain metabolites would be very valuable.

A broad range of metabolites including organic acids, sugars, sugar alcohols, amino acids, phenylpropanoids and numerous phenolic compounds have been found in potato tubers (Defernez et al., 2004; Dobson et al., 2008; Yang and Bernards, 2007). Analysis of polar metabolite profiles in a study on 29 cultivars and land races by Dobson et al. (2008) revealed separation of two cultivars from the other cultivars and land races. This separation was largely due to higher levels of sugars. Comparatively the data from non-polar metabolite profiles revealed only partial separation of two land race lines. This separation seemed to be on the basis of some minor fatty acids.

The phenolic compounds are important antioxidants of whole potato tubers (Lugasi et al., 1999). The oxidation products of phenolic compounds appear to be involved in the defense of plants against invading pathogens (Friedman et al., 1997). Chlorogenic acid is one of the phenolic constituents of plants including potato. It constitutes about 90% of the total phenolic content of potato tubers. The interest in chlorogenic acid is largely due to its role in blackening and resistance mechanisms to diseases in potato (Malmberg and Theander, 1985; Friedman et al., 1997). Chlorogenic acid containing extract of potato can also act as primary and secondary antioxidant in prevention of oxidative stress (Lugasi et al., 1999).

Flavonoids, primarily rutin and other quercetin glycosides, have also significant importance as food antioxidants; quercetin and its derivatives demonstrate one of the highest radical-scavenging activity levels in vitro (Cao et al., 1997). Rutin is the most abundant of them in potato tubers, while others are present only in trace amounts (Shakya and Navarre, 2006).

The objective of this study was to compare the chromatographic profiles of hydrophilic metabolites in tubers from selected potato cultivars and land races with different degree of resistance against potato late blight disease.

Materials and Methods

Plant material and sample preparation

Tubers from six different potato cultivars and land races were used in this study: King Edward, Bintje, Fakse, Sarpo Mira, Swedish land race and Mongolian land race. These cultivars are known to have different levels of resistance against potato late blight disease caused by *Phytophthora infestans*. King Edward and Bintje are susceptible to the late blight disease, Fakse is moderately susceptible (DANESPO, 2009) and Sarpo Mira is highly resistant (The European Cultivated Potato Database, 2009). The resistance of the two land races (Swedish and Mongolian) against potato late blight was studied previously according to Yuen and Forbes (2009). These two land races were found to be highly resistant (Alström and Andersson, unpublished data).

All cultivars were planted on 21 May 2008 in a field north of Ultuna, Uppsala, Sweden (59°50′ north latitude, 17°39′ east longitude). Chemical and physical characteristic of the field soil at planting were: P-AL - 10.3, K-AL - 17.5, Mg-A - 9.8, Ca-A - 135 mg $100g^{-1}$, organic content - 3.7%, clay content - 13.5%, silt content - 24.5%, sand content - 58.3% and pH - 6.4. The crop was fertilized before planting with 1800 kg ha^{-1} of Binadan (NKP 5:2:4). Defoliation was conducted on 2 September 2008 and the tubers were harvested on 15 September 2008. Tubers were then stored for four months at 6-8 °C in the darkness until analyzed.

Eight uniformly sized tubers (50-80 g of mass) of each cultivar were washed thoroughly and dried. Each tuber was quartered by clean stainless knife. The quarters were peeled, pooled (one quarter from each tuber) and sliced into 2-3 mm thick slices by using a food processor. Slices were immediately frozen at -20 °C for 2-3 hours and freeze-dried using Hetosicc lyophilizer (Heto, Birkerod, Denmark). To calculate the ratio between dry and fresh potato mass, the slices were weighted just before and after freeze-drying. Dried slices were then powdered using a coffee miller for 7 sec; the powder was flushed with argon to remove oxygen and stored in the dark at -20 °C until analysis.

Chemicals

Standards of L-phenylalanine, L-tyrosine, L-tryptophan, adenosine, chlorogenic acid and rutin hydrate were purchased from Sigma Aldrich (St. Louis, Missouri, USA). Amino acids were of reagent grade, >98% (TLC) purity, adenosine was >99% (HPLC), chlorogenic acid and rutin hydrate were >95% (HPLC). Acetonitrile (HPLC grade) and acetic acid were from Merck (Darmstadt, Germany), and ethanol from Solveco AB (Rosersberg, Sweden). Water was purified using a Milli-Q system (Millipore, USA).

Extraction of metabolites from freeze-dried powder

Each cultivar was analyzed in duplicate. Five ml of water-ethanol mixture (1:1 v/v) was added to 0.5 g of each sample in a plastic tube, vortexed for 5 min at 22 °C, and centrifuged for first 10 min at 4000 g, then for 10 min at 13000 g. The supernatants were stored at 0 °C for 30 min, filtered through 0.45μm cartridges to remove the compounds insoluble at low temperatures and then subjected to analysis within 12 h.

HPLC and LC-MS analysis

The supernatants were analyzed by RP-HPLC using an Agilent 1100 system equipped with a gradient quaternary pump, a thermostated autosampler, a thermostated column compartment, a diode array detector (DAD) and a fluorescence detector (FLD). DAD wavelengths were set to 260, 280, and 320 nm. The excitation wavelength in the FLD detector was 280 nm, the emission wavelengths were 320 and 350 nm. Agilent ChemStation software was used to control the HPLC system and data processing.

LC-MS analysis was performed using an Agilent 1100 HPLC system equipped by variable UV detector and a single quadrupole mass analyzer (G1946D). UV wavelength was set to 280 nm. Electrospray ionization was operated both in positive and negative ion mode. Mass spectra were collected in scan mode in the range m/z 100-1000 at fragmentor voltage 100 V.

Metabolites in each sample were separated on a Zorbax SB-Aq column (150 × 4.6 mm, 5 μm, Agilent Technologies Inc., USA) protected by an 1-mm Opti-Guard C18 guard column (Optimize Technologies Inc., Oregon City, USA). The column temperature was kept at 20 °C, the autosampler temperature at 10 ºC, and the injection volume used was 5 μl. Water and acetonitrile (MeCN), both containing 10 mM of acetic acid, were used as mobile phase. The gradient program used was: 0-10% MeCN from 0 to 20 min, 10-15% MeCN from 20 to 35 min, 15-30% MeCN from 35 to 60 min, followed by column washing with 100% MeCH for 5 min before re-equilibration. Duration of total run time was 100 min. The flow rate was 0.4 ml min^{-1}.

Six major potato metabolites (phenylalanine, tyrosine, tryptophan, adenosine, chlorogenic acid, and rutin) were identified by comparison with standards based on the retention times and peak area ratios between peaks of different wavelengths registered by DAD and FLD. The LC-MS was used for additional verification of peaks by m/z values (mass/ion charge ratio). Quantification of their concentration in potato extracts was based on an external standard method. It was performed by using one-point calibration at 0.1 mM of each compound.

Standard solutions of these compounds were prepared in aqueous 10% acetonitrile.

Characterization of the cultivar-specific metabolites whose structures had not yet been defined was attempted by their MS spectra (in both positive and negative ion mode if possible) and retention times. The compound was regarded as being present in a certain cultivar if signal-to-noise (S/N) ratio of its peak was >10 and the corresponding peak had also been verified by LC-MS analysis.

Results and Discussion

Determination of six major potato metabolites

The chromatograms of potato tuber extracts were registered using multi-wavelength DAD at 260 nm and 320 nm, as well as by FLD at excitation wavelengths 280 nm and two emission wavelengths, 320 and 350 nm. Six major hydrophilic metabolites were chosen for quantitative analysis in six potato cultivars: aromatic amino acids (phenylalanine, tyrosine, and tryptophan), rutin (the most abundant flavonoid), chlorogenic acid (the most abundant phenolic acid), and adenosine. All of them were highly abundant in water-ethanol (1:1) tubers extracts. Tyrosine and tryptophan showed high fluorescence at the excitation wavelength 280 nm. Maximum intensity was at the emission wavelength near 320 nm for tyrosine and near 350 nm for tryptophan. To achieve the best response, chromatograms were registered by FLD at both emission wavelengths, 320 and 350 nm. Chlorogenic acid showed an intensive absorbance near 320 nm, which made it possible to observe its peak by DAD at this wavelength. Three isomers of chlorogenic acid were present in potato tubers (chlorogenic, cryptochlorogenic, and neochlorogenic acid), which differ by the position of ester bond between caffeic and quinic acid residues (Andre et al., 2007). The peaks of these isomers were not perfectly separated using the present method, and only the total contents of all three isomers could be quantified. Phenylalanine, adenosine and rutin could be quantified using DAD at 260 nm as no interference with other peaks was observed. Chromatographic profile of the extract of Fakse potato cultivar is shown as an example in Figure 1. The peaks of all selected metabolites have been identified on the chromatograms.

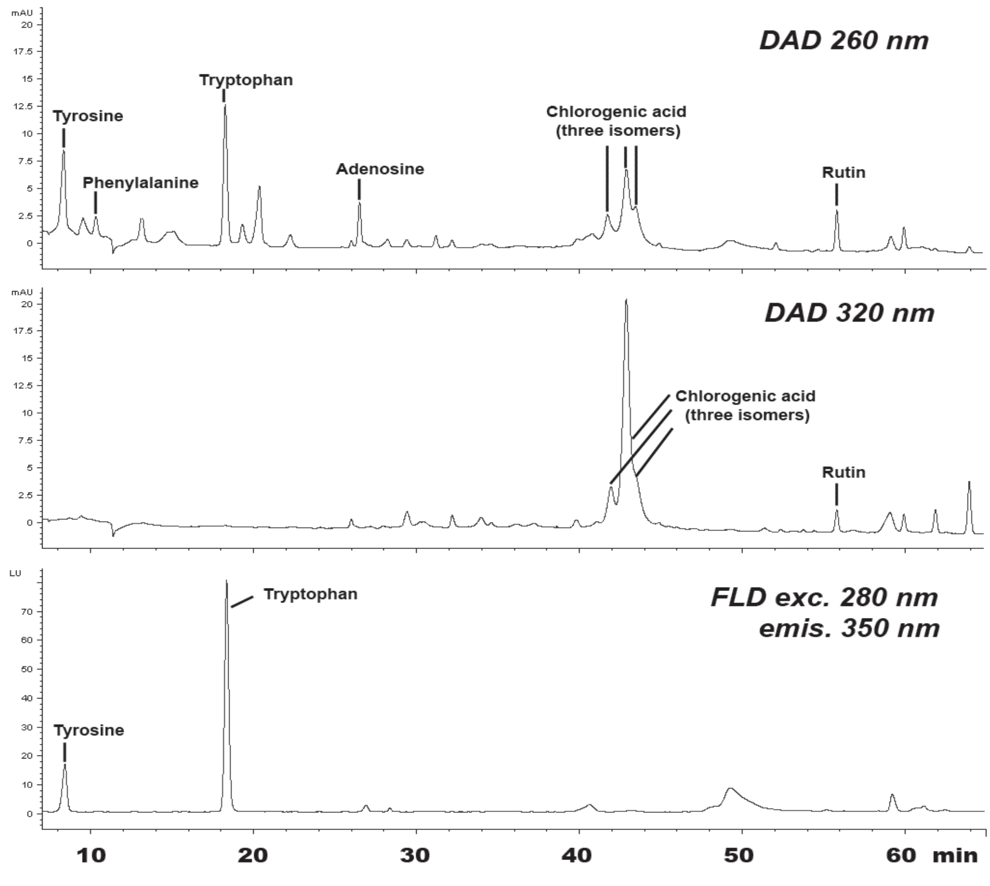

Figure 1. Chromatographic profiles of hydrophilic metabolites in tubers of Fakse cultivar. Chromatograms are registered by DAD at 260 and 320 nm and by FLD with excitation and emission wavelengths at 280 and 350 nm. The peaks of six selected metabolites are indicated.

Table 1

Retention times and concentrations of six metabolites in tubers of six tested potato cultivars

Compound	Retention time, min	Concentration*, mg g^{-1} of potato dry mass					
		King Edward	Bintje	Fakse	Sarpo Mira	Swedish land race	Mongolian land race
Tyrosine	8.4	0.60	0.44	0.64	0.22	0.32	0.47
Phenylalanine	10.3	0.56	0.47	0.45	0.25	0.22	0.32
Tryptophan	18.3	0.17	0.13	0.16	0.13	0.11	0.19
Adenosine	26.5	0.024	0.004	0.015	0.002	0.016	0.017
Chlorogenic acid	42.9	0.27	0.11	0.20	0.11	0.16	0.06
Rutin	55.8	0.0091	0.0040	0.0206	0.0033	0.0051	0
Dry/fresh mass ratio (%)		22.6	22.8	18.1	23.5	23.9	23.9

* The values are presented as means of duplicates; the difference between two separate values of a duplicate was less than 5% for all samples

The concentrations of metabolites quantified in this study are compiled in Table 1. Cultivars are ordered by increasing of resistance against potato late blight disease (from left to right); Swedish and Mongolian land races show similar resistance. Some differences were revealed between aromatic amino acid concentrations in different cultivars. These differences were minor in the case of tryptophan (0.11 – 0.19 mg kg^{-1}), but they were more pronounced for tyrosine and phenylalanine (0.22 – 0.56 and 0.22 – 0.64 mg kg^{-1}, respectively). The lowest concentrations of all three amino acids were revealed in Sarpo Mira and Swedish land race cultivars.

Three other metabolites (adenosine, rutin, and chlorogenic acid) showed much greater concentration differences between the cultivars. For instance, adenosine concentration in King Edward cultivar was more than 10 times higher than in Sarpo Mira. According to W.L.Morris et al. (2007), 5'-nucleotides, including adenosine monophosphate, are among the major determinants of flavour and taste of potato. Rutin had not been detected in Mongolian land race, whereas its content varied from 0.0033 to 0.0206 mg kg^{-1} in other cultivars. The concentration of chlorogenic acid was highest in King Edward cultivar and lowest in the Mongolian land race.

The concentrations of all six compounds in the cultivar Sarpo Mira, which demonstrates high resistance to the late blight disease, were generally lower than in other cultivars. Alternatively, Fakse and King Edward tubers contained higher concentrations of these metabolites than others. This may be due to more intense metabolic processes and/or different starch content in these latter cultivars. However, no correlation was found between concentrations of these six compounds and resistance to the late blight disease.

Cultivar-specific metabolites

The comparison of chromatograms of extracts revealed peaks of some compounds which were present in quantifiable concentrations only in certain cultivars. They were either absent or present under the detection limit in other cultivars even if the injection volume was increased 5-fold (data not shown). The peak areas of all these compounds were significantly lower than the peak areas of six major metabolites described above. The molecular weights of these compounds were defined using LC-MS analysis. The fragment of chromatograms presented in Figure 2 clearly indicates the difference between the profiles of six potato cultivars. Table 2 summarizes the information about retention times, LC-MS peaks, and presence or absence of these compounds in different cultivars. However, further investigations are necessary to elucidate the structures of these compounds.

Four compounds with retention times 22.5, 48.0, 53.1, and 59.9 min (Table 2), were tentatively identified by LC-MS as caffeoyl putrescine (mol. weight 250), quercetin-3-O-glucosyl-rutinoside (mol. weight 772), caffeoyl methyl quinate (mol. weight 368), and kaempferol-3-O-rutinoside (mol weight 594), respectively. They were previously shown to be present in potato tubers (Shakya and Navarre, 2006). Five compounds, which are shown on

Fig. 2, have retention times and molecular masses close to those of glycoalkaloids, such as solanine and chaconine, but do not match them exactly (the masses of solanine and chaconine are 867 and 851, respectively).

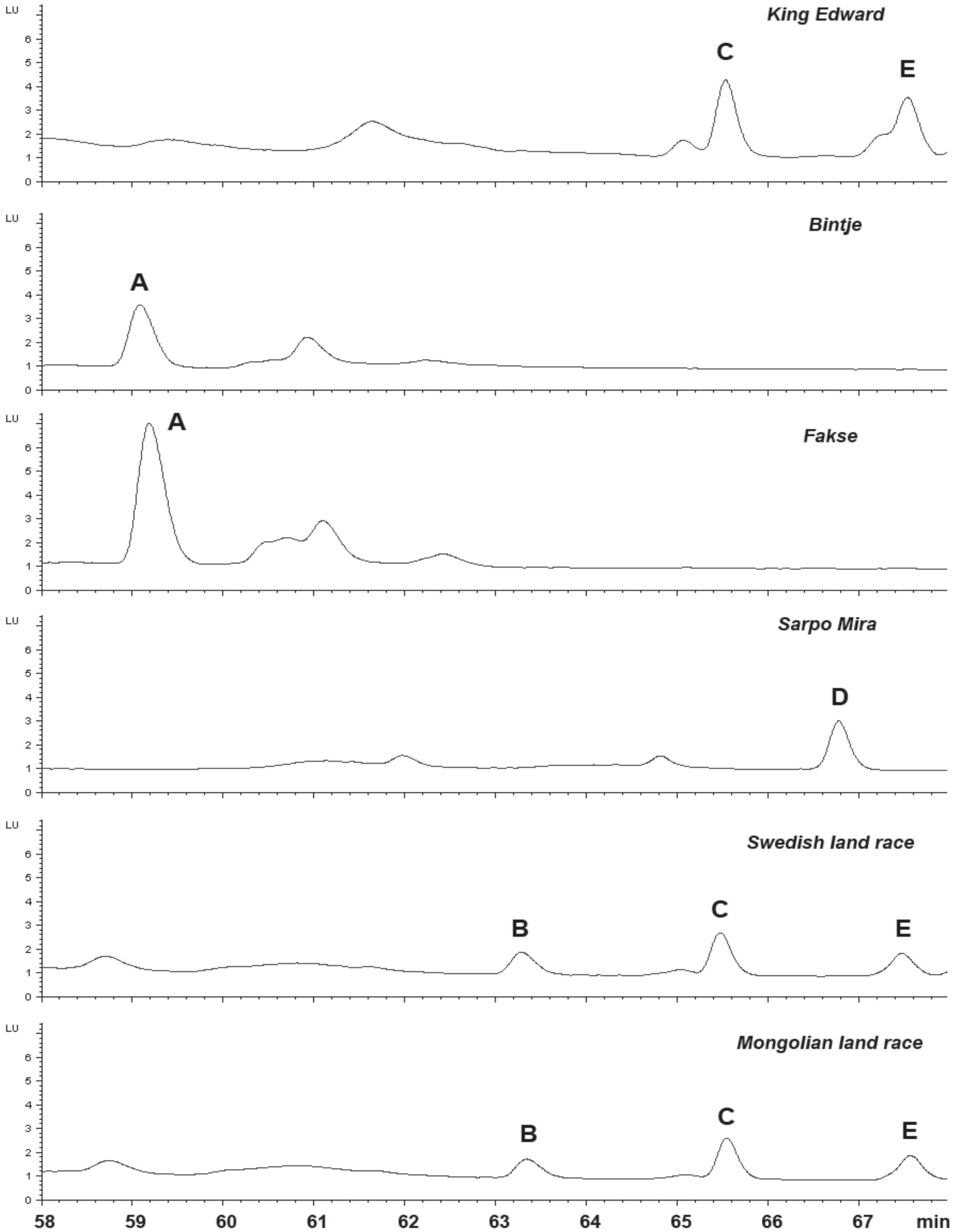

Figure 2. Fragments of chromatograms of extracts of six potato cultivars registered by FLD (280/350 nm) between 58 and 68 min. The letters indicate peaks of different cultivar-specific compounds in those cultivars where they were detectable. For A, B, C, D, and E please see table 2.

Table 2

Occurrence of metabolites with non-defined structures in potato cultivars with different levels of resistance to potato late blight disease. The letters in the left column correspond to the metabolites shown in Fig. 2.

	Retention time of metabolites	m/z^+ (positive mode)	m/z^- (negative mode)	Presence (+) or absence (–) in the extracts from cultivars					
				King Edward	Bintje	Fakse	Sarpo Mira	Swedish land race	Mongol. land race
	22.5	251	249	+	+	–	–	+	+
	32.2	448	no peak	–	–	+	–	–	–
	36.9	323	321	–	–	–	+	+	+
	48.0	no peak	771	+	–	–	+	–	–
	53.1	no peak	367	+	–	–	–	+	+
A	59.2	856	no peak	–	+	+	–	–	–
	59.9	no peak	593	–	+	+	+	–	–
	61.8	no peak	429	–	+	+	+	+	+
B	63.4	874	no peak	–	–	–	–	+	+
C	65.6	833	no peak	+	–	–	–	+	+
D	66.7	826	no peak	–	–	–	+	–	–
E	67.7	807	no peak	+	–	–	–	+	+

Conclusions

Chromatographic profiling of hydrophilic metabolites in six potato cultivars revealed the differences in concentrations of aromatic amino acids, adenosine, rutin and chlorogenic acid between the cultivars. However, the correlations between concentrations of these metabolites and cultivar resistance against late blight disease had not been observed. Some metabolites were found to be cultivar-specific, which indicates the potential to use these compounds as biomarkers in potato breeding.

Acknowledgements

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INHIBITION OF MICROBIAL GROWTH OF A SALAD WITH MEAT IN MAYONNAISE BY DIFFERENT PACKAGING TECHNOLOGIES

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Abstract

The objective of the research was the shelf life extension of a salad with meat in mayonnaise. The microbial stability of the salad with meat in mayonnaise packaged under vacuum, in modified atmosphere, and using *'Sous vide'* technology was examined and compared with conventionally packaged (in ambient air) salad. The salads were packaged in polyamide/polyethylene pouches with barrier properties as well as in pouches made from biodegradable plasticized poly-β-hydroxybutyrate or polylactic acid film. Control samples without preservatives were packed in traditional polypropylene containers covered with non-hermetic lids. PURASAL Powder Opti Form (sodium lactate) in the amount 5 g kg^{-1}, 10 g kg^{-1}, and 15 g kg^{-1}, and ethyl alcohol in the amount of 2 ml were used as single preservatives for separate samples. The studies of the samples were carried out after 1, 3, 7, 10, 15, 18, 25, 29, 42, and 52 storage days at the temperature of +4±0.5 °C. Experimentally the quality of the salad with meat in mayonnaise was characterized by measuring the total plate count of microorganisms. The obtained results indicate that different packaging technologies and addition of preservatives show significantly different influence on the microbial growth in different samples. *'Sous vide'* packaging technology was effective for the shelf life extending and guarantee of safety of the salads with meat in mayonnaise.

Key words: shelf life, packaging, total count of microorganisms, meat salad.

Introduction

Food preservation has been a long time desire of human beings. The day when prehistoric humans discovered fire, it started significant developments in food preservation. The humans used indigenous methods of food preservation such us pickling, oiling, and salting of different food types, whether raw or processed. Some of the earlier techniques are still in use and are available in several commercial formats. The major developments and needs in food processing and preservation started during the wars, when extended shelf life of foods became a necessity. As a matter of fact, several food processing techniques such us ready-to-eat food in pouches, aseptic packaging of milk and liquid foods with particiles, and ohmic electric resistance heating of foods were developed to achieve extended shelf life of foods for soldiers in wars. A transfer of technology occurred when consumers started demanding a food product with fresh-like characteristics, along with extended shelf life. The food market increased and consumers became more and more educated about adding food preservatives and their adverse effects on long-term health (Geeraerd et al., 2000; Juneja, 2006).

Nowadays food industries need to become more efficient while simultaneously satisfying the consumer's growing demand for yet higher quality in food. Considering all the small units producing these products, it is essential to ensure that the products are safe for the consumers (Nissen et al., 2002).

The market for salads with meat in mayonnaise has become popular in the recent years in Latvia. In the 1980s such kind of salads was popular only in coffee-bars. In the 1990s it was possible to find only some kinds of no packed salads on the market, but in 1996 the first salads in packaging boxes came appeared at the market showcases. The packaging boxes were polyethylene (PE) or polypropylene (PP) trays with non hermetical lids. The safety of those products was limited (Levkane et al., 2008).

Food safety and security are significant issues in the food industry today. Companies which ones are producing salads with mayonnaise, increasing demand for new technologies to extend the shelf life and to keep/enhance the quality of different kinds of salads in mayonnaise. Nowadays, on the commercial network it is possible to find different modifications of salads in mayonnaise packaged in plastic containers with non-hermeticaly sealed lids, as well as salads packaged under vacuum or modified atmosphere (Levkane et al., 2008). An innovative approach to packaging that can increase shelf life of salads is necessary.

A perspective method to extend the shelf life of food products is vacuum packaging and packaging in the protective gas mixture or modified atmosphere (MAP) in which content of oxygen has been reduced and carbon dioxide content – increased (Devlieghere et al., 2000; Robertson, 2006; Spenser, 2005). Food packaging in modified atmosphere side by side with vacuum packaging prolongs the shelf life for some days or weeks, maintaining food quality, taste, and aroma. Many research studies have demonstrated the antimicrobial activity of gases at ambient and subambient pressures on microorganisms important in foods (Nyati, 2000; Wang et al., 2004). The major safety consideration in extending shelf life of foods by MAP technology is the loss of sensory cues to spoilage provided by bacterial growth. Without spoilage bacteria indicators, it is conceivable that a food could have acceptable organoleptic quality, but be unsafe. The effect of loss of competitive inhibition by spoilage bacteria is most pronounced on the facultative anaerobic pathogenic bacterial populations in foods under altered atmospheres (Wang et al., 2004).

'Sous vide' is an interrupted catering system in which raw or precooked food is sealed into a vacuumized, laminated plastic pouch or container, thermal treated (pasteurized) by controlled cooking, rapidly cooled, and stored at 0 to +4 °C refrigerated temperatures. The product is sold in the same package in which the product was processed and stored (Church and Parsons, 2000; Geeraerd et al., 2000). Pasteurization time should be kept to a minimum to retain maximum quality in *'Sous vide'* products, while ensuring consumer safety. A time-temperature treatment must be determined for each product in order to render the product free from non-spore forming pathogens effectively. The *'Sous vide'* method produces food with a better flavour, colour, texture and nutrient retention than conventionally cooked foods (Church and Parsons, 2000).

Salads in mayonnaise belong to the group of high risk ready-to-eat foods and relatively few data have been published on the survival and growth of spore-forming bacteria in the products packed by several packaging technologies. Several guidelines give interpretation of microbiological analysis of some ready-to-eat foods (Food Safety authority of Ireland, 2001; Ohosone, 1997), but there is not mentioned that those products are salads in mayonnaise. Some studies (Nissen et al., 2002) declare results obtained from three-year experimental '*Sous vide*' packed ready-to-eat foods testing, and find that in the '*Sous vide*' packed ready-to-eat products the chances of survival and growth of pathogens seem very low since psychrotrophic, toxin-producing strains of bacillus or *Clostridium spp.* are rare or nonexistent. Therefore at low storage temperature the health risk of these products seems small, accordingly for microbial testing of the ready-to-eat end products, traditional plating will suffice.

A novel process for preparing pasteurized meat and vegetable containing salads in mayonnaise having a long shelf-life under refrigerated storage was proprietary (US Patent 4191787, 1980). This process includes essential steps of acid food treatment to pH 4.5 and short time bulk heat treatment before packaging at the temperature of +65 to +75 °C. US Patent 5114733 (1992) relates to a process for preparation of salad mixture with oil emulsion not requiring any preservatives. Prepared salad is placed in container and airtight closed, pasteurized under increased pressure, refrigerated, and storage time achieved in several weeks. Another finding (US Patent 5320856, 1994) informs about separate independent ingredients specific thermal stabilization treatments, cooling and after combination into the desired complex food article which is finally sealed in a package.

Ready-to-eat products need preservatives or mild pasteurization to give them a commercially acceptable shelf life. As natural preservative and antimicrobial substance could be used PURASAL® – produced from natural L(+) lactic acid E325 (sodium lactate), widely used to enhance shelf life and food safety of several food products. Formulating salads and dressings with PURAC FRESH (lactic-acid-based acidulants) results in products with a milder flavour maintaining microbial stability and safety. The slightly salty taste of PURASAL S, sodium lactate, enhances the meaty flavor of meat and poultry products (Jay et al., 2005; Meng and Genigeorgis, 1994; PURAC: The source…, http://www.purac.com/).

The aim of this study was to extend the shelf life of the salad with meat in mayonnaise. To determine the effect of vacuum, '*Sous vide*' and modified atmosphere packaging, and the effect of natural preservative and antimicrobial PURASAL Powder Opti Form (sodium lactate) addition on the shelf life and quality, as well as to obtain information about the microbial growth of the salad with meat in mayonnaise prepared for retail by different packaging technologies, refrigerated, and stored at the temperature of +4±0.5 °C.

Materials and Methods

Experiments were carried out at the Department of Food Technology of the Latvia University of Agriculture in 2008. The object of the research was salads with meat in mayonnaise. Salads with meat in mayonnaise produced for a local market were used for the experiments. The ingredients in the salads were boiled potatoes and eggs, cooked beef, pickled cucumbers, and mayonnaise Provansa purchased on the local market. The characteristics of 18 investigated salad samples using different packaging and product treatment technologies are summarized in Fig. 1. Vacuum packed and '*Sous vide*' technology treated salads with meat in mayonnaise were placed in PA/PE film pouches with barrier properties thickness of 20/45 µm and size of 200 x 300 mm, as well as in pouches made from biodegradable, commercially produced in Brazil, plasticized poly–β-hydroxybutyrate (PHB) films with thickness of 65±2 µm, and polylactate (PLA) film thickness 40 µm, size 200 x 300 mm. Pouches were sealed by chamber type machine MULTIVAC A 300/16. For modified atmosphere, MAP (40% CO_2 and 60% N_2) packaging thermoformed ready-made polypropylene (PP) containers (size 210 x 148 x 35 mm) were placed in polyamide/polyethylene (PA/PE) film pouches with barrier properties of thickness of 20/45 µm. Pouches were sealed by chamber-type machine MULTIVAC A 300/16. As preservatives, PURASAL Powder Opti Form E325 (sodium lactate) in the amount of 5 g kg^{-1}, 10 g kg^{-1}, and 15 g kg^{-1}, and ethyl alcohol C_2H_5OH 96±1% in the amount of 2 ml were used for each packing. For '*Sous vide*' studies, the samples were pasteurized in a water bath – Clifton Food Range at the temperature of +65±0.5 °C. Generally the treatment time was within 50 min, including warming up (15 min), holding time (20 min) while the core temperature of the sample +63±0.5 °C was reached. The cooling occurred in two steps: with water from an artesian well at +10±1 °C temperature for 5 min, which was follow by ice water cooling at +1 to +2 °C for 5 min (Muizniece-Brasava et al., 2007). As a control the salad with meat in mayonnaise without preservatives was packed in traditionally used polyethylene (PE) containers covered with non-hermetical lids. Mass of each sample was 200±1 g. All samples were stored in Commercial Freezer/Colder ELCOLD at +4±0.5 °C temperature (recorded by MINILog, Gresinger electronic) within 52 days under fluorescent light (OSRAM Lumilux De Luxe) with radiant fix at 100–800 lux (measured by Light meter LX-107). Throughout the storage period, the samples were randomly interchanged to minimize temperature fluctuations and light conditions. At each time of measurement, two identical packages for each treatment were randomly selected on sampling days 1, 3, 7, 10, 15, 18, 25, 29, 42, and 52, for analysis.

To define pH values, all samples of 200±1 g were homogenised with mixer BOSCH Easy Mixx 260. The pH values of the salad with meat in mayonnaise samples were determined by JENWAY 3510 pH-meter using an electrode JENWAY (3 mol/KCl). Two identical packages were analyzed on three randomly selected locations on each sample. To control the shelf life of salads with meat in mayonnaise, the total plate count test was performed by the methods of colony count technique at +30 °C in accordance with International Standard ISO 4833:1991.

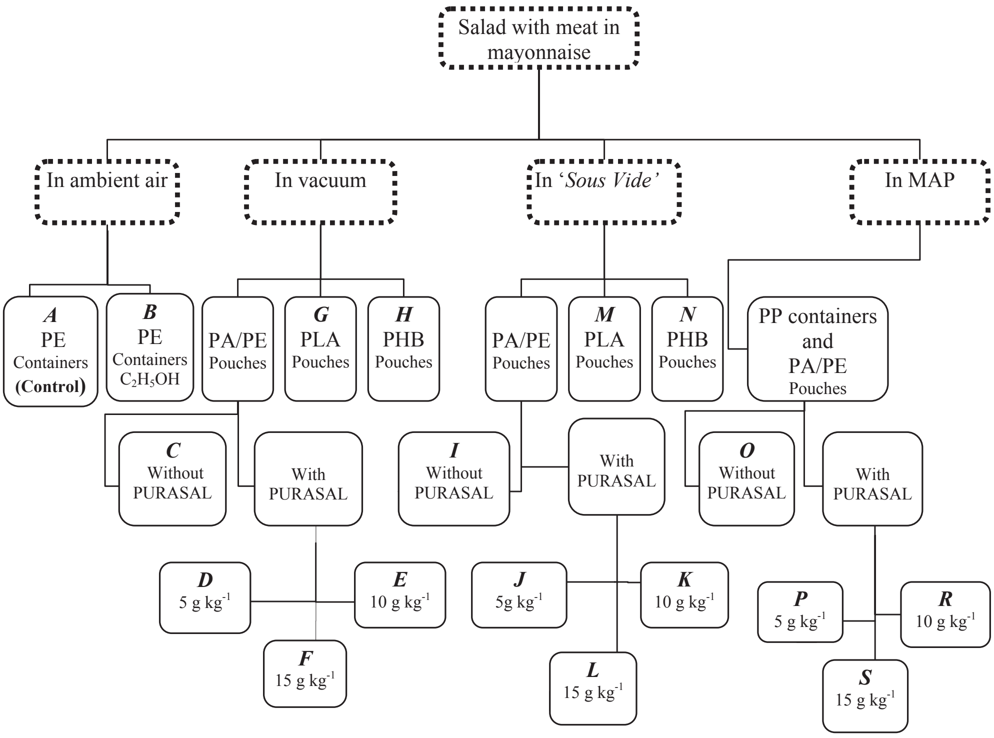

Figure 1. Structure of performed experiments.

A salad sample with meat in mayonnaise (amount of each 10 g) was removed from each package, placed in a stomacher bag, 90 ml of 0.1% peptone water were added and then homogenized with a stomacher (Bag Mixer 400) for three seconds. After preparing serial decimal dilutions of the homogenate with 0.1% peptone water, duplicate plates were prepared using pour plate method for enumeration. Total viable counts were determined on Plate Count Agar with incubation at +30±1 °C for 72±3 h. After the specified period of incubation, each dish containing 15–300 colonies, the total count of microorganisms (CFU) was counted and multiplied by the dilution factor to determine CFU g^{-1} of the salad with meat in mayonnaise. The results were evaluated by Guidance Note No. 3, 2001 Guidelines for the Interpretation of Results of Microbiological Analysis of Some ready-to-eat foods Sampled at Point of Sale (Food Safety Authority of Ireland, 2001). According to the guidelines, salads are adapted to vegetable food group (prepared mixed salads and crudités) and meat food group (meat, sliced (cooked ham, tongue)) which belong to category D, accordingly could be acceptable up to 10^6 - 10^7 cfu g^{-1}. The results are defined like < 10^6 cfu g^{-1} satisfactory (means that the test results indicate good microbiological quality), 10^6 - <10^7 cfu g^{-1} acceptable (is suggested to take account of the limitations in microbiological sampling, handling, testing and wide confidence limits in enumeration - due to these factors, some samples will fall between what is considered satisfactory and unsatisfactory), and ≥ 10^7 cfu g^{-1} unsatisfactory (indicates that the acceptability threshold has been exceeded) (Food Safety Authority of Ireland, 2001).

The results were processed by mathematical and statistical methods. Statistics on completely randomized design were determined using the General Linear Model (GLM) procedure SPSS 16.00. Two-way analyses of variance ($p \leq 0.05$) were used to determine significance of differences.

Results and Discussion

The goal of this experiment was to substantiate the extended shelf life of salad with meat in mayonnaise for each of 18 investigated variants and find out the optimum shelf life as well as to get the information about microorganism growth in the examined packaging and treatment modes of the salads.

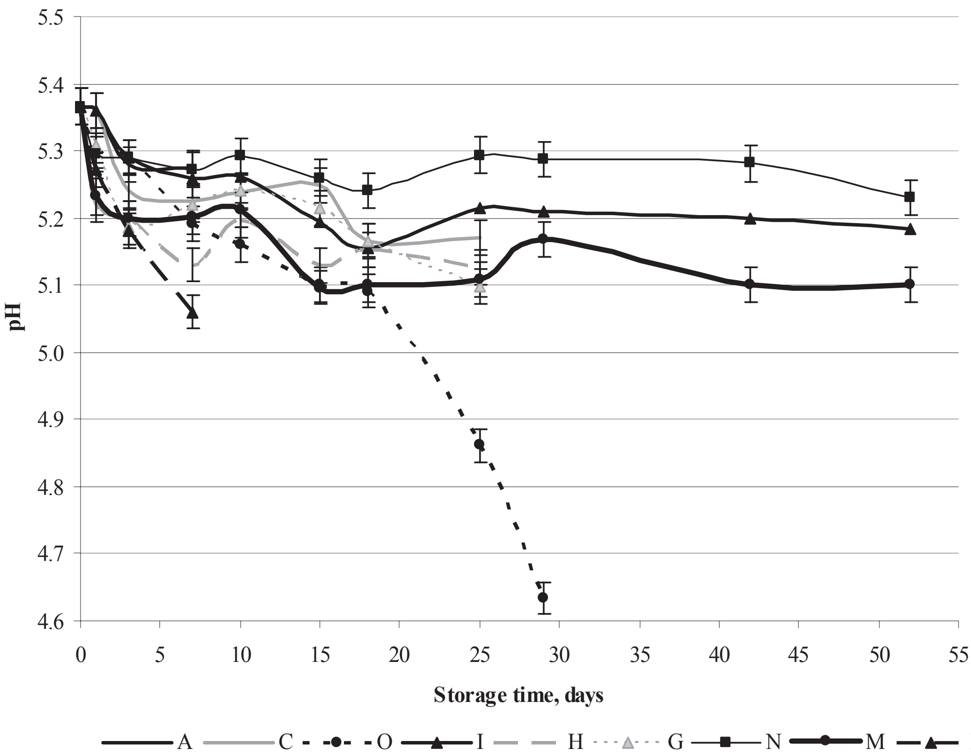

Figure 2. Dynamics of pH values at the storage time for the samples without PURASAL:

A – in ambient air (control); **B** – in ambient air, C_2H_5OH; **C** – in vacuum without PURASAL; **G** – in vacuum, PLA; **H** – in vacuum, PHB; **I** – in *'Sous vide'* without PURASAL; **M** –*'Sous vide'*, PLA; **N** –*'Sous vide'*, PHB; **O** –in MAP without PURASAL.

The pH value of a freshly prepared control sample was 5.3. Significant differences in pH values during the storage time of 52 days were observed among all investigated groups of the salad with meat in mayonnaise samples packed by different packaging technologies, using various packaging materials, pasteurization temperatures, and natural antioxidant additives ($p<0.05$). Whereas pH of the samples packed in MAP significantly decreased (from 5.3 to 4.6) already after 25 days of refrigerated storage at +4 °C. Significant differences in the pH values of the salads with meat in mayonnaise packed in pouches made from PHB and PLA composite materials, during the examined storage time from 25 till 52 days, were not found. The pH value of salads packaged under vacuum in pouches made from PHB and PLA films, decreased from 5.3 to 5.1, and using '*Sous vide*' technology – from 5.3 to 5.2 ($p<0.05$).

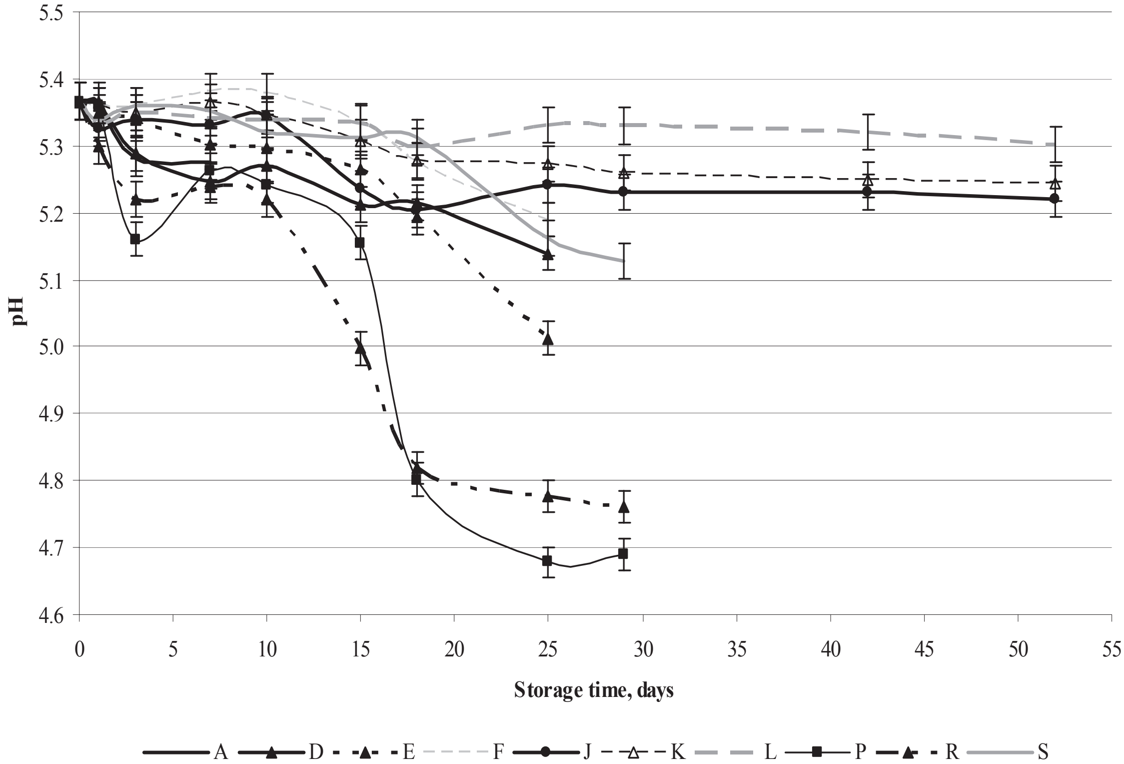

Figure 3. Dynamics of pH values at the storage time for the samples with PURASAL:

A – in ambient air (control); **D** – in vacuum with PURASAL 5 g kg^{-1}; **E** – invacuum with PURASAL 10 g kg^{-1}; **F** – in vacuum with PURASAL 15 g kg^{-1}; **J** – in '*Sous vide*' with PURASAL 5 g kg^{-1}; **K** – in *'Sous vide'* with PURASAL 10 g kg^{-1}; **L** – in *'Sous vide'* with PURASAL 15 g kg^{-1}; **P** – in MAP with PURASAL 5 g kg^{-1}; **R** – in MAP with PURASAL 10g kg^{-1}; **S** – in MAP with PURASAL 15g kg^{-1}.

Figure 3 shows the pH values after addition of PURASAL. The MAP technology in the amount of 5 g kg^{-1} and 10 g kg^{-1} decreased the pH values during the 29 day storage time of approximately from 5.3 to 4.7 ($p<0.05$), which has been recommended for successful shelf life extension to several weeks (PURAC: The source…, http://www.purac.com). Whereas in the pH of the samples packed in '*Sous vide*' with PURASAL in the amount of 5g kg^{-1}, 10g kg^{-1}, and 15g kg^{-1}, significant differences during the examined storage time till 52 days were not found (from 5.3 to 5.2). The pH of the salads with meat in mayonnaise in the vacuum technology with PURASAL in the amount of 5g kg^{-1}, 10g kg^{-1}, 15g kg^{-1} decreased only slightly - from 5.3 to 5.0.

The microorganism growth in salads with meat in mayonnaise was affected by the packaging methods (vacuum, '*Sous vide*' ,and MAP), as well as by addition of PURASAL (E325) and ethyl alcohol (C_2H_5OH) (Figs. 4 and 5). In order to evaluate the microbiological quality and acceptability of salads with meat in mayonnaise, in accordance with Guidance Note No. 3 (2001) they conform with prepared mixed vegetable salads as well as cooked meat which belongs to category D, accordingly could be acceptable till lg CFU 10^6–$<10^7$ cfu g^{-1}. The principal spoilage mechanisms that limit the shelf life of cooked and processed meat products as ingredients of the salad in mayonnaise are microbial growth, colour change, and oxidative rancidity. Consequently, spoilage of cooked meat products appears due to post-process contamination by microorganisms as a result of neglecting manufacturing hygiene and handling practices.

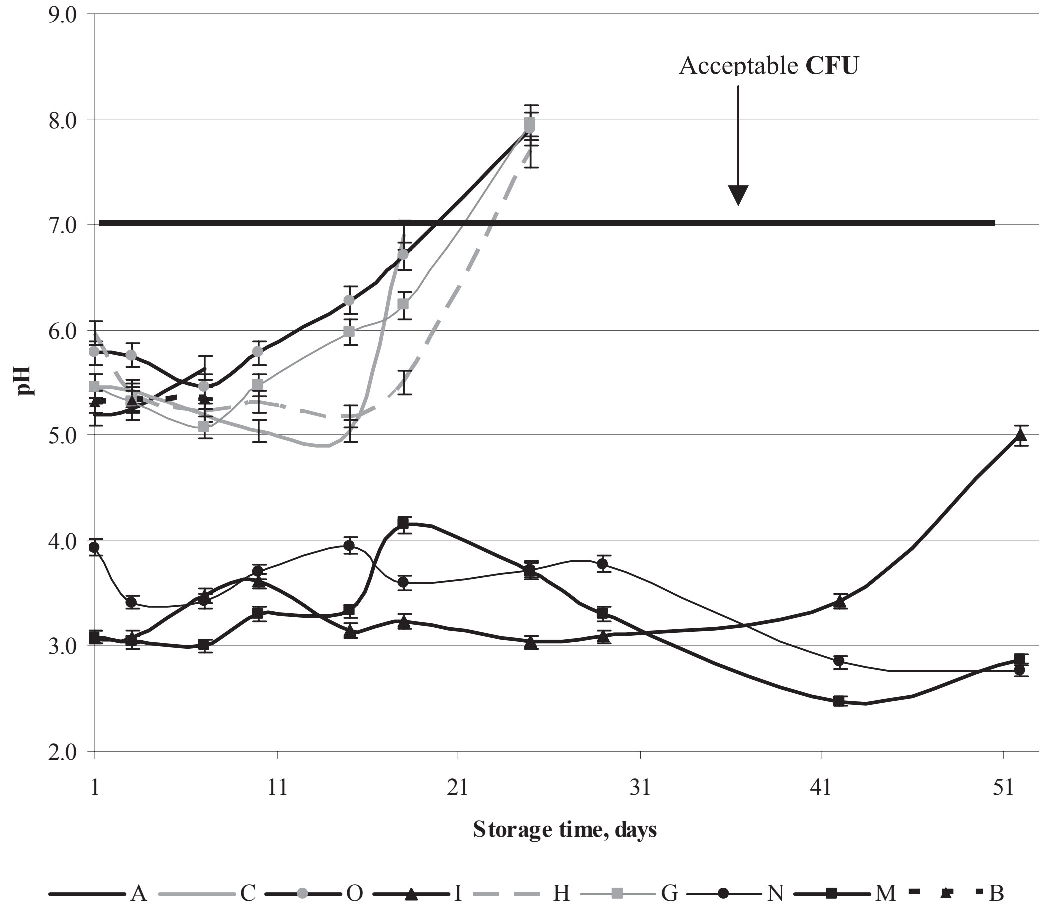

Figure 4. Microbial growth in the salads with meat in mayonnaise without PURASAL:

A – in ambient air (control); **B** – in ambient air, C_2H_5OH; **C** – in vacuum without PURASAL; **G** – in vacuum, PLA; **H** – in vacuum, PHB; **I** – in *'Sous vide'* without PURASAL; **M** – in *'Sous vide'*, PLA; **N** – in *'Sous vide'*, PHB; **O** – in MAP without PURASAL.

Packing foods in a modified atmosphere offers extended shelf life and improved product presentation in a convenient container, making the product more attractive to the retail customer. All investigated salad with meat in mayonnaise samples packed by different packaging technologies, using various packaging materials, pasteurization temperatures and PURASAL after one day storage show different results. Our experiments demonstrated that the storage time of vacuum and modified atmosphere (CO_2 - 40%; N_2 - 60%) packaged salads extends till 18 days, maintaining the quality of the salads by slowing chemical and biochemical deteriorative reactions and by slowing. or in some instances preventing, the growth of spoilage organisms. While the shelf life of control sample as well as of sample with ethyl alcohol addition packed in air ambiance is determined only seven days, experiment still need to continue. The thermal treatment process ('*Sous vide*') kills the vegetative bacteria cells and inactivates enzymes. For '*Sous vide*' it is important that cooking achieves at least a three-decimal reduction in CFU already after the treatment.

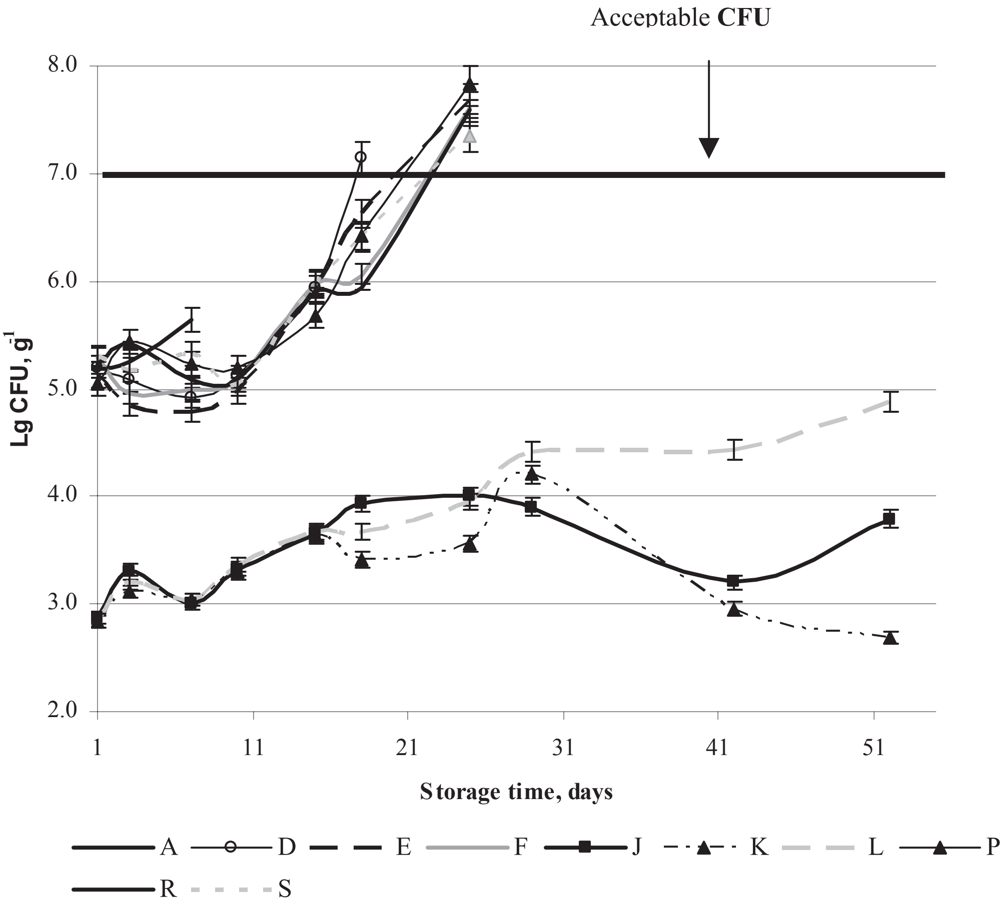

Figure 5. Microbial growth in salads with meat in mayonnaise with PURASAL:

A – in ambient air (control); **D** – in vacuum with PURASAL 5 g kg^{-1}; **E** – vacuum with PURASAL 10 g kg^{-1}; **F** – in vacuum with PURASAL 15 g kg^{-1}; **J** – in '*Sous vide*' with PURASAL 5 g kg^{-1}; **K** – in *'Sous vide'* with PURASAL 10 g kg^{-1}; **L** – in *'Sous vide'* with PURASAL 15 g kg^{-1}; **P** – in MAP with PURASAL 5 g kg^{-1}; **R** – in MAP with PURASAL 10 g kg^{-1}; **S** – in MAP with PURASAL 15 g kg^{-1}.

The results demonstrate that mild '*Sous vide*' treatment is an effective method to prevent microbial growth during all investigated periods of storage and enhances the shelf life of salads with meat in mayonnaise till 52 days. Packaging materials – PA/PE and environmentally friendly packaging plasticized PLA as well as PHB films - do not influence the microbial growth in meat salads with mayonnaise treated by '*Sous vide*' technology. Plasticized PLA and PHB films could be successfully used for '*Sous vide*' thermal treatment at the temperature not higher than +65±0.5 °C, and the pasteurization effect is similar to the other obtained using conventional packaging films.

Conclusions

Significant differences in pH values were found among all the salad with meat in mayonnaise samples packed in different kinds of material and technologies during 52-day storage. The addition of PURASAL to MAP technology in the amount of 5 g kg^{-1} and 10 g kg^{-1}, decreased the pH values during the storage time of 29 days approximately from 5.3 to 4.7.

The shelf life of salad with meat in mayonnaise (cooked beef, boiled potatoes and eggs, pickled cucumbers, salt, and mayonnaise) was affected by packaging methods (vacuum, *'Sous vide'*, and MAP), as well as by addition of PURASAL (E325). Mild *'Sous vide'* treatment of salads retarded the total plate count.

Environmentally friendly plasticized PHB and PLA packaging films could be suggested for '*Sous vide*' thermal food treatment at the temperature not higher than +65±0.5 °C.

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GEOGRAPHICAL DIFFERENCES IN GROWTH AND QUALITY CHARACTERS OF SCOTS PINE LATVIAN POPULATIONS

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Abstract

In the study the growth and stem quality characters of geographically different Latvian Scots pine (*Pinus sylvestris* L.) populations were evaluated. In various regions of Latvia proportionally to the distribution of Scots pine 21 sample plot was established in 85 to 95 years old pure stands in forest type *Myrtillosa* growing conditions. In every sample plot 100 trees were evaluated estimating height of the tree, diameter at breast height, stem volume, length and quality of the branch-free stem section, relative branch thickness, branch angle and stem straightness. Pine populations were compared in different seed zones (Western and Eastern), as well as in various regions (Western, Central, South-eastern, North-eastern). In order to describe the geographical differences of populations with help of growth features, tree height was chosen because the relation between height and stem quality features is positive. The populations of the Eastern seed zone substantially overcome the populations of the Western seed zone both in terms of growth features, as well as in stem quality. Substantial are also differences between populations growing in various regions in terms of average height, length and quality of branch-free stem section, relative branch thickness and branch angle, but not stem straightness. Western populations present the lowest growth feature values and stem quality. The height and stem quality features of the North-eastern populations considerably exceeded the features of other regions' populations.

Key words: Scots pine, populations, growth, quality traits.

Introduction

The Scots pine (*Pinus sylvestris* L.) among all other pine species is notable with the largest natural distribution area. The growing areas of Scots pine differ in longitude, latitude and altitude. Due to the fact that these factors change gradually within the borders of the area, the fluidity character of Scots pine populations is gradual (Правдин, 1964; Zobel and Talbert, 1984; Matras, 1998).

In order to clarify the influence of the geographical origin of Scots pine on progeny productivity and stem quality, as well as adaptation skills to different growing conditions and resistance against different pathogenic factors, provenance experiments have been arranged that enable to choose the most suitable seed material for the forest regeneration in concrete geographical region. In tests it has been found out that characteristics such as seed germination, tree height, diameter, survival, growth rate, shape of stem and crown, process of pruning, wood quality, resistance against unfavourable environmental conditions vary depending on geographical origin of seeds (Правдин, 1964; Ehrenberg and Gustafsson, 1971; Andrzejewski et al., 1998; Kohlstock and Schneck, 1998; Liesebach and Stephan, 1998).

Latvia, just like several other European countries (Poland, Lithuania, partially Estonia and Germany), is located in the optimum growth area of Scots pine. Therefore it is possible to compare the results of provenances' experiments carried out in these countries with the ones obtained in the territory of Latvia. In an experiment carried out in the central part of Poland it was found out that the largest differences both in progeny quantitative (height and diameter) and qualitative (stem straightness, branch thickness, branch angle) features are related to latitude and not longitude of origin site. Qualitative feature values and survival of progeny increase from South to North of origin site. Concerning longitude in direction from east to west of origin site, values of progeny quantitative features increase and stem quality decrease (Matras, 1998). Results of an experiment carried out in Germany show that there is a substantial connection between latitude of origin site on the one hand and progeny height (r^2=0.839) and diameter (r^2=0.888) on the other hand (Kohlstock and Schneck, 1998). Whereas other authors (Liesebach and Stephan, 1998) indicate that out of three parameters characterising geographical origin (latitude, longitude and altitude), only longitude has a substantial (negative) correlation with growth feature values, but the tree survival positively correlates with latitude of origin site. In another experiment in North Eastern Poland it was clarified that growth features correlate (negatively) more with latitude of origin site, but tree survival and stem quality – with longitude (Andrzejewski et al., 1998). In Lithuania a substantial influence of seed geographical origin on progeny growing was observed when it was grown in poor growing conditions. Besides, the influence of longitude of origin site was much more significant than the influence of latitude (Pliūra and Gabrilavičius, 1998). During studies in Estonia a substantial negative correlation (r=-0.80) between tree diameter and latitude of origin site was found out (Kurm, 2000).

In many studies the superiority of local populations is emphasised, because out of in south collected seeds in Nordic regions grow trees with worse quality, but out of in Nordic regions collected seeds in south – slower growing forest stands in comparison to forest stands that have been grown out of local seed material (Andrzejewski et al., 1998; Kohlstock and Schneck, 1998; Liesebach and Stephan, 1998; Matras, 1998; Zobel and Talbert, 1984). All Scots pine ecological forms better adapt to better growing conditions, therefore a transfer of Scots pine seed from north to east and from east to west is acceptable in a larger distance as vice versa (Вересин et al., 1985).

The most important Scots pine provenance experiments in Latvia have been established in 1975 in three geographically distant regions with different climatic conditions: Kalsnava, Zvirgzde and Barta. Evaluating experiments after 15 years, it was found out that progeny of the best Polish provenances are higher than local Scots pines in the western and central regions. Progeny of German provenances proved to be less suitable to Latvian conditions than progeny of Polish provenances, exceeding the local pine in relation to height only in the western part of Latvia. Polish and German pine in our conditions differ from the Latvian pine with a stronger crown and, in some cases, stem sinuosity can be observed (Бауманис et al., 1990). In all trials local pine has presented substantially better survival and stem quality (Baumanis et al., 1998). Defining the influence of geographical origin on growing of local pine progeny, in the experiment mentioned before it was found out that progeny of Latvia's western region provenances and seed orchards stand out with a slow growth rate in all experiment object at age of 5, 10, 15 and 28 years. The progeny of western origin more often has crooked stems and thick branches. The provenances of the central region are characterised by quite universal adaptation capability in all objects and average growing speed, with exception of provenance Misa-2 that invariably keep a high growth rate in all experiment objects. The progeny of the northeast provenances is characterised by average growth parameters, while it stands out with straight stems and thin branches. The progeny of the southeast provenances has presented comparatively good growth rate, but it has been more susceptible against needle cast infection (Бауманис et al., 1982; Baumanis et al., 1986; Бауманис et al., 1990; Baumanis et al., 1998; Baumanis et al., 2001). In two trials in Kalsnava, where the progeny of plus trees of various regions of Latvia are growing, the influence of origin region on progeny growth was evaluated, and it was found out that a growth advantage is characteristic to Scots pine progeny of the eastern origin (Dreimanis, 1993).

The distinctions of growth and stem quality of Scots pine populations growing in different regions of Latvia were taken into consideration, when defining the potentialities to use Scots pine reproductive material in the territory of Latvia. According to Regulations No. 648 issued by the Cabinet of Ministers (Latvijas Republikas…, 2003) there are two seed zones for the Scots pine – Western and Eastern – in the territory of Latvia. The reproductive material from the Western seed zone can be used only in this region, but the material from the Eastern seed zone is acknowledged as suitable for forest regeneration both in the Eastern and Western regions.

The aim of this study is to evaluate growth and quality distinctions of Scots pine populations of various regions of Latvia, as well as to ascertain about the necessity and validity to divide between the Western and the Eastern seed zones for the Scots pine in the territory of Latvia.

Materials and Methods

For estimation of Scots pine geographical differences in various regions of Latvia, proportionally to distribution of Scots pine 21 sample plot in 85 to 95 years old pure stands in forest type *Myrtillosa* growing conditions (Figure 1) was established. In every sample plot approximately 100 numbered trees were included. Every sample plot (population) got a name according to the name of state forestry in summer 2007 (Table 1). The following growth and quality features were investigated:

- height of the trees, m;
- diameter at breast height, cm;
- stem volume, m^3;
- branch-free tree length, m;
- branch relative thickness by three points scale, allotting one point to trees with relatively thin branches (in relation to stem diameter), two points – with medium branches, three points with thick branches;
- branch angle by three points scale, allotting one point to trees with right branch angle (about 90°), two points – with more acute branch angle (80°-60°), three points – with exceptionally acute branch angle

(smaller than 60°);

- stem straightness by three points scale, allotting one point to straight trees, two points – to trees with weak bends, three points to crooked trees;
- quality of branch-free stem section by three points scale, allotting one point to trees with smooth branch-free stem section, two points – medium, three points to trees with expressed whorls in the branch- free stem section.

Using the measurements of tree height and diameter at breast height the stem volume was calculated by the method of I.Liepa (1996):

$V=\psi * L^{\alpha} d^{\beta \lg L+\varphi}$ (1),

where V – stem volume, m^3;

L – stem length (in this case – tree height), m;

d – diameter at breast height, cm;

ψ, α, β, φ – coefficients.

The average values of measurements and the standard error of mean were estimated for features of each population. Using one-way analysis of variance (ANOVA) for the quantitative features, significance of origin factor and differences between the populations growth depending on origin were estimated. In order to estimate the significance of origin factor and differences between the populations quality depending on origin, non–parametric methods (Kruskal Wallis-H test and Mann Whitney U-test) for attributes were used by applying the software SPSS.

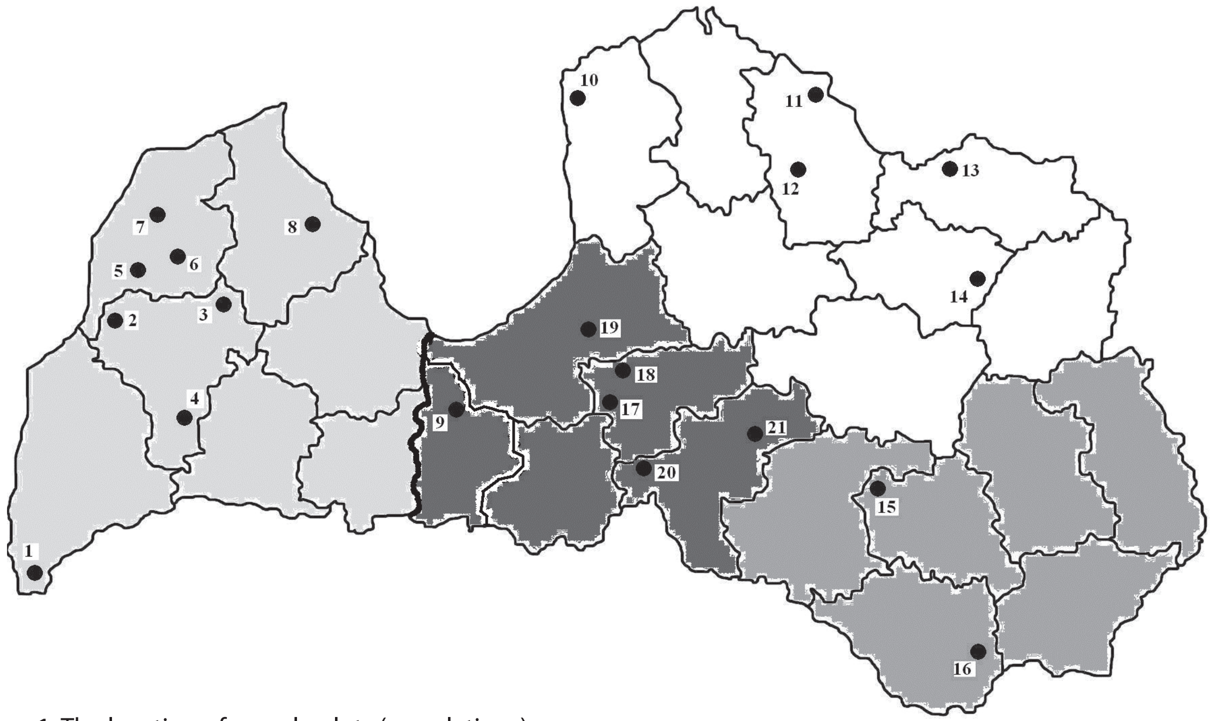

Figure 1. The location of sample plots (populations):

1-Nica	4-Skrunda	7-Ventspils	10-Salacgriva	13-Ape	16-Daugavpils	19-Ropazi
2-Alsunga	5-Terande	8-Vandzene	11-Valka	14-Gulbene	17-Birzgale	20-Jaunjelgava
3-Renda	6-Ugale	9-Lielupe	12-Smiltene	15-Livani	18-Ogre	21-Plavinas

the border between the Western and Eastern seed zones' populations

Regions:

Western Central South-eastern North-eastern.

Every population, according to its geographical location, is classified in the first place by belonging to the Western or Eastern seed zone. Further, according to the previous studies (Baumanis et al., 2001) populations are classified by belonging to different regions: Western (W), Central (C), South-eastern (SE), North-eastern (NE).

Results and Discussion

Values of different populations growth features (average height, diameter and stem volume) and branch-free tree length are demonstrated in Table1. The average tree height of different populations varies from 23.14 m (Nica) to 28.77 m (Valka), on average 26.18 m; average diameter – from 27.45 cm (Birzgale) to 31.99 cm (Ugale), on average 29.65 cm; average stem volume – from 0.70 m^3 (Birzgale) to 1.04 m^3 (Ugale), on average 0.85 m^3.

Table 1

Average Values of Quantitative Features for Different Populations

Population	Seed zone	Region	Height, m		Diameter, cm		Stem volume, m^3		Branch-free tree length, m	
			mean	std. error	mean	std. error	mean	std. error	mean	std. error
Nica	Western	W	23.14	0.21	30.32	0.56	0.80	0.03	4.09	0.24
Alsunga	Western	W	23.76	0.16	29.51	0.50	0.77	0.03	3.73	0.21
Renda	Western	W	26.65	0.22	30.00	0.57	0.89	0.04	5.43	0.23
Skrunda	Western	W	26.39	0.16	29.77	0.42	0.85	0.03	7.38	0.23
Terande	Western	W	24.67	0.19	30.36	0.55	0.85	0.03	5.00	0.21
Ugale	Western	W	27.66	0.21	31.99	0.56	1.04	0.04	7.62	0.23
Ventspils	Western	W	24.50	0.20	30.48	0.55	0.85	0.03	4.74	0.22
Vandzene	Western	W	24.24	0.14	29.01	0.46	0.76	0.03	3.26	0.20
Lielupe	Eastern	C	25.87	0.17	28.20	0.47	0.76	0.03	5.96	0.24
Birzgale	Eastern	C	25.36	0.14	27.45	0.39	0.70	0.02	8.74	0.20
Ogre	Eastern	C	25.44	0.17	28.19	0.38	0.74	0.02	6.83	0.22
Ropazi	Eastern	C	26.90	0.18	31.61	0.46	0.98	0.03	6.08	0.30
Jaunjelgava	Eastern	C	25.90	0.21	29.34	0.42	0.82	0.03	6.45	0.26
Plavinas	Eastern	C	27.11	0.16	28.63	0.49	0.82	0.03	6.33	0.17
Livani	Eastern	SE	25.76	0.16	28.74	0.50	0.79	0.03	4.70	0.20
Daugavpils	Eastern	SE	27.51	0.18	29.28	0.49	0.87	0.03	6.70	0.22
Salacgriva	Eastern	NE	26.58	0.22	29.91	0.59	0.89	0.04	5.66	0.24
Valka	Eastern	NE	28.77	0.18	28.48	0.46	0.85	0.03	6.60	0.22
Smiltene	Eastern	NE	28.05	0.21	30.77	0.52	0.98	0.04	6.61	0.27
Ape	Eastern	NE	28.41	0.20	30.70	0.59	0.99	0.04	7.49	0.41
Gulbene	Eastern	NE	27.27	0.21	30.44	0.53	0.93	0.04	7.18	0.25
Total	X	X	26.18	0.05	29.65	0.11	0.85	0.01	6.03	0.06

For characterisation of stem quality following features have been used, like branch-free tree length (defined in meters), relative branch thickness, branch angle, stem straightness and quality of branch-free section (defined in 3 point scale) (Tables 1 and 2). The values of branch-free tree length vary from 3.26 m (Vandzene) to 8.74 m (Birzgale), on average – 6.03 m. For features that have been defined in 1 to 3 point scale the quality of different populations is characterized with the proportion of those trees with evaluation of 1 point. In terms of relative branch thickness the best populations are Valka (95%), Ogre (91%), Ape (88%), but the worst – Terande (14%), Vandzene (16%), Ventspils (34%). In terms of branch angle the best populations are Valka (99%), Ogre (98%), Birzgale (93%), but the worst – Vandzene (17%), Alsunga (21%), Nica (22%). In terms of branch-free section quality the best populations are Birzgale (90%), Gulbene (87%), Plavinas (85%), but the worst – Lielupe (28%), Salacgriva (31%), Nica (32%). In terms of stem straightness there are less differences among populations than for other quality features. The proportion of those trees that have been evaluated with 1 point in terms of stem straightness in different populations range from 74 to 99% (on average 88%).

Table 2

Evaluation of Qualitative Features for Different Populations

Population	Features and proportion of trees (%) with estimation 1, 2, 3 points											
	branch thickness			branch angle			stem straightness			quality of branch-free section		
	1	2	3	1	2	3	1	2	3	1	2	3
Nica	46	53	1	22	71	7	76	24	0	32	62	6
Alsunga	54	39	7	21	74	5	88	12	0	37	60	3
Renda	56	41	3	41	56	3	91	9	0	43	54	3
Skrunda	69	31	0	52	48	0	87	13	0	33	57	10
Terande	14	77	9	38	58	4	97	3	0	60	40	0
Ugale	41	55	4	29	70	1	98	2	0	68	30	2
Ventspils	34	59	7	28	69	3	84	14	2	33	61	6
Vandzene	16	65	19	17	78	6	81	19	0	33	54	13
Lielupe	83	17	0	78	21	1	94	6	0	28	60	12
Birzgale	77	22	1	93	7	0	95	5	0	90	10	0
Ogre	91	9	0	98	2	0	85	15	1	85	15	0
Ropazi	44	49	7	36	53	11	90	10	0	37	56	7
Jaunjelgava	64	32	4	41	52	7	79	19	2	48	46	6
Plavinas	45	49	6	31	65	4	81	19	0	85	14	1
Livani	71	26	3	43	49	7	98	2	0	44	48	7
Daugavpils	74	25	1	62	37	1	80	20	0	56	36	8
Salacgriva	68	30	2	60	39	1	74	25	1	31	63	6
Valka	95	5	0	99	1	0	88	12	0	77	18	5
Smiltene	75	24	1	72	28	0	92	8	0	53	38	9
Ape	88	12	0	62	38	0	94	6	0	43	51	6
Gulbene	83	17	0	64	36	0	99	1	0	87	13	0
Total	62	35	4	52	45	3	88	12	0	53	42	5

The economical value of Scots pine is equally substantially influenced by productivity and stem quality. With help of one- way ANOVA it was found out that, in order to characterise population geographical differences, out of three growth features (height, diameter, and stem volume) the most suitable is tree height because higher trees present also higher stem quality, whereas for diameter and stem volume this correlation is in most cases opposed (Tables 3 and 4). Also in previous studies it was indicated that in order to improve stem quality, a selection according to tree height is more recommendable than a selection according to tree diameter or stem volume (Haapanen and Pöykkö, 1993). It must be mentioned that also a significant positive relation exists (α=0.001) between branch-free tree length on the one hand and branch thickness, branch angle, stem straightness (in one case) and quality of branch-free stem section on the other hand.

Table 3

Comparison of Quantitative and Qualitative Features (Branch Thickness and Branch Angle)

Feature	Differences between means of each two groups of branch thickness			Differences between means of each two groups of branch angle		
	1-2	1-3	2-3	1-2	1-3	2-3
Height	0.75^{***}	1.18^{***}	0.44	0.47^{***}	0.79^{*}	0.32
Diameter	-2.46^{***}	-5.29^{***}	-2.83^{***}	-1.83^{***}	-3.73^{***}	-1.90^{*}
Stem volume	-0.12^{***}	-0.27^{***}	-0.16^{***}	-0.09^{***}	-0.18^{**}	-0.09
Branch-free tree length	2.12^{***}	3.89^{***}	1.77^{***}	1.88^{***}	3.19^{***}	1.31^{***}

Significance: $^{*}\alpha$=0.05, $^{**}\alpha$=0.01, $^{***}\alpha$=0.001.

Table 4

Comparison of Quantitative and Qualitative Features (Stem Streightness and Quality of Branch-free Section)

Feature	Differences between means of each two groups of stem streightness			Differences between means of each two groups of quality of branch-free section		
	1-2	1-3	2-3	1-2	1-3	2-3
Height	0.49*	1.92	1.43	0.61***	0.51	-0.09
Diameter	0.45	-3.11	-3.56	-0.71**	-0.68	0.03
Stem volume	0.04	-0.09	-0.14	-0.019	-0.015	0.004
Branch-free tree length	1.14***	2.55	1.41	2.30***	3.21***	0.91***

Significance: *α=0.05, **α=0.01, ***α=0.001.

With help of the T-test by comparing tree height in the Western and Eastern seed zones it was found out that the average height of the Western populations (25.12 m) is significantly behind the height of the Eastern populations (26.82 m) (α=0.001). With help of one-way ANOVA it was clarified that there are significant differences in populations average height values in four regions. The smallest average height is in the Western region (25.12 m), larger – in the Central region (26.08 m) and in the South-eastern region (26.65 m), but the largest – in the North-eastern region (27.82 m) (Table 5).

Table 5

Differences of the Height and Branch-free Tree Length between Regions

Region	Height, m	Differences in height and branch-free tree length, m				Branch-free tree length, m
		W	C	SE	NE	
W	25.12	X	-0.96***	-1.53***	-2.70***	5.14
C	26.08	1.60***	X	-0.57**	-1.74***	6.74
SE	26.65	0.57*	-1.03***	X	-1.17***	5.71
NE	27.82	1.56***	-0.04	0.99***	X	6.70

Significance: *α=0.05, **α=0.01, ***α=0.001.

Above diagonal - differences in height; below diagonal – differences in branch-free tree length.

In the Western region the average height of Nica population is the smallest and it is behind (α=0.001) the average height of all other populations, except the Alsunga population. Comparatively high and mutually equivalent are the height values of Skrunda and Renda populations, but the average height of the Ugale population significantly exceeds the height of all other Western populations. Ropazi and Plavinas stand out among the Central region populations because their heights which are mutually equivalent exceed heights of all other populations. The South-eastern region is represented by just two populations, and their average heights differ significantly. Combining population Livani with populations of the Central region it was cleared that its height does not differ significantly from the Central region's largest group populations' heights, but population Daugavpils is equivalent to several North-eastern region populations in terms of height. Populations Valka, Ape and Smiltene are significantly stand out over other populations in the North-eastern region and are mutually equivalent.

The differences of branch- free tree length are connected with the tree height (r^2=0.278, p<0.001), but the influence of origin factor is confirmed, too. With help of the T-test significant (α=0.001) differences in branch-free tree length between the populations of Western (5.14 m) and the Eastern (6.57 m) seed zones, as well as between populations of several regions were found out. Branch-free tree length of the Western populations is significantly behind populations of other regions. The branch-free tree length of the North-eastern and Central regions' populations mutually does not differ and is longer than the branch-free tree length of the Western and South-eastern regions' populations. The longest average branch-free tree length (8.74 m) is for the Central region population Birzgale.

Comparing the proportion of trees with different quality and carrying out Kruskal Wallis H-test, it was clarified that tree quality in the Eastern seed zone is significantly better as in the Western seed zone (α=0.01), with exception of stem straightness that does not differ in both seed zones (p-value=0.662). Carrying out the Kruskal Wallis H-test and Mann Whitney U-test, it was found out that populations of different regions differ significantly (α=0.001) by branch thickness (with the exception of Central and South-eastern regions), branch angle and partially also by quality of branch-free stem section (Table 6), but not by stem straightness (p-value=0.707).

Table 6

Differences of Stem Quality Features between Regions (p-values of Mann Whitney U-test)

Region	Branch thickness	Branch angle	Quality of branch-free section
W-C	0.001	0.001	0.001
W-SE	0.001	0.001	0.106
W-NE	0.001	0.001	0.001
C-SE	0.223	0.008	0.002
C-NE	0.001	0.002	0.198
SE-NE	0.005	0.001	0.044

Concerning branch thickness and branch angle the best are the North-eastern (with the exception of Salacgriva population with an average result) and most of Central region populations. In the Central region the best populations concerning branch thickness and branch angle are Ogre, Birzgale and Lielupe, but populations Ropazi and Plavinas stand behind others. The Western populations present lower quality concerning branch thickness and branch angle, only the populations Skrunda and Renda present average values. Average quality is also presented by the South-eastern populations. Quality of branch-free stem section is also on the whole better in the Central (with the exception of Lielupe) and the North-eastern (with the exception of Salacgriva and Ape) regions' populations. For the Western populations quality of branch-free stem section is low (Vandzene, Skrunda) or average (Ugale, Renda), but for the South-eastern populations it is average.

The results obtained during the study on the whole correspond with the results of provenance experiments (Бауманис et al., 1982; Baumanis et al., 1986; Бауманис et al., 1990; Baumanis et al., 1998; Baumanis et al., 2001) that state that progeny of the Western region provenances and seed orchards stand out in slow growth rate and more often present crooked stems and thick branches, central region provenances are characterised by an average growth rate, but north-eastern provenances – by insignificant height advantage or an average growth, as well as straight stems and thin branches. In this study especially the North-eastern region populations stand out concerning average height, but concerning stem quality – several Central region populations. All in all the acquired results approve the necessity and validity of division between the Western and the Eastern seed zones for the Scots pine in the territory of Latvia.

Conclusions

1. The populations growing in the Eastern seed zone significantly surpass the populations growing in the Western seed zone concerning both growth features and stem quality. Substantial are also differences between populations of various regions (Western, Central, South-eastern, North-eastern) in average height, branch-free tree length and quality, relative branch thickness and branch angle, but not in stem straightness.
2. The Western populations present low growth feature values (with the exception of Ugale) and stem quality. The Central region populations are characterised by average growth feature values, and present comparatively good stem quality. The South-eastern populations are characterised by average growth and quality feature values. The height and stem quality results of the North-eastern populations considerably exceed the results of other regions' populations.
3. Estimating relationship between growth features (height, diameter, stem volume) and quality features it is found out that higher trees present also higher stem quality, whereas for diameter and stem volume this relationship is in most cases opposed. Therefore out of three growth features for the characterisation of populations' differences the tree height is recommended as the most suitable.

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CHRISTMAS TREE CULTIVATION AS AN ALTERNATIVE LAND USE – POSSIBILITIES AND PROFITABILITY

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Abstract

Cultivation of Christmas trees is not a very common activity in Estonia at the moment. There are about 290 000 hectares of former agricultural and pasture lands, which are out of use in Estonia (Aastaraamat Mets 2007, 2008). Taking into account the know-how from Europe, the hypothetical plantation was established and calculation of profitability was made. Profitability of Christmas tree cultivation was compared to the other alternative possibilities of land use. Achieving the output of saleable Christmas trees at least 50%, cultivation of Christmas trees is very competitive compared to other possibilities of land use, but at same time it is also the most capital-intensive.

Key words: alternative land use, Christmas tree cultivation, profitability.

Introduction

Traditionally Christmas trees have been collected in Estonia from forest areas – doing the thinning in young stands, cleaning the drainage ditches and forest compartment lines or clearing the areas under the power lines. In addition to that, former agricultural and pasture land areas, which have been out of use for about 7 – 8 years, are potential habitats for finding good-quality natural Christmas trees.

During the last three years (2006 – 2008), the understanding of and expectations about Christmas trees have started changing among Estonians. According to retailers, the trees which are specially grown and shaped for Christmas trees in plantations have become more and more popular compared to naturally grown trees. This affects not only exotic Christmas tree species (different fir *Abies* and spruce *Picea* species), but also our native and traditional Christmas tree – Norway spruce *Picea abies*.

There are about 400 hectares (2008) of so called professional Christmas tree plantations (where the activity is knowledgeable and systematic) in Estonia. Species which are grown are mostly Norway spruce *Picea abies*, but also Blue spruce *Picea pungens var. glauca*, Serbian spruce *Picea omorika*, and Fraser fir *Abies fraseri*. The most popular Christmas tree in Europe, Nordman fir *Abies nordmanniana*, has become quite popular among Estonians as well, but cannot be grown in Estonia due to the climate. Estonian climate is too cold - winters can be lethal for Nordman fir. According to different opinions it would be possible to grow Nordman fir on Estonian western islands where the climate is milder, but still it would be a very risky investment.

To sum up, growing Christmas trees as an activity is not very well known in Estonia. Despite the landowners' interest, the reason why the activity is not very active is the lack of knowledge and experiences. For this reason, most of the Christmas trees available on Estonian market are imported from abroad. In Europe, the biggest producers are Germany and Denmark. According to the data from the year 2005, Germany was producing 17 million and Denmark 10 million Christmas trees, from which 80% was Nordman fir (Østergaard, 2006). The countries which affect Estonian Christmas tree market the most, in addition to Germany and Denmark, are also Belgium and Poland (Statistics Estonia 2008).

Cultivation of Christmas trees can be one possibility, besides afforestation, for using former agricultural and pasture lands which are out of management in Estonia. One of the arguments in favour of Christmas tree cultivation is the rotation period. The length of investment in forestry (traditional silviculture) is exceedingly long – according to Estonian "Forest Act" (Metsaseadus, 2006) 60 – 130 years depending on tree species. Rotation period of Christmas tree cultivation is about 10 years (from planting to cutting). Although the rotation period is "just" 10 years, compared to silviculture there are also distinct features.

Supply and cultivation of Christmas trees can be seen from two different angles - whether it is an alternative use of land resource, the primary aim of which is the cultivation of high-quality Christmas trees, or a multiple use of forest of which the Christmas trees are secondary target. Due to the growth of economic well-being of the Estonian population, the demand for high-quality Christmas trees has increased. For this reason, the naturally grown Christmas trees are not attractive and can not compete on market with specially grown and shaped Christmas trees, despite the lower selling price. Growing Christmas trees should therefore be viewed as an alternative usage of land whose primary target is the cultivation of high-quality Christmas trees.

Although growing Christmas trees is not very common in Estonia, there are all presumptions to change that. Firstly, domestic demand for quality Christmas trees, especially for Norway spruce '*Picea abies*', has increased considerably during the last years. Secondly, landowners are interested in using their property for growing Christmas trees. Thirdly, in Estonia there are about 290 000 hectares of former agricultural lands (Aastaraamat Mets 2007, 2008) which are out of use at the moment and which would be a perfect resource for establishing Christmas tree plantations.

The goal of the current study is to find out the profitability of cultivating Christmas trees as well as compare it with other alternative land use possibilities.

Materials and Methods

The information about establishing Christmas tree plantations and about management actions was gathered from visiting 15 different plantations and from interviews with managers in Estonia, Poland, Germany and Denmark.The aim of the interviews was to elicit the peculiarities of cultivating different Christmas tree species and create optimal management actions for different Christmas tree species. Taking into account the know-how gathered from the interviews and the climatic conditions in Estonia, a hypothetical plantation with management actions was established (see Table 1), on the basis of which the profitability of Christmas tree cultivation was assessed.

Further presumptions were made for the calculations:

- cultivation of Norway spruce *Picea abies* as a Christmas tree;
- plantation is 1 hectare and will be established on a former agricultural land;
- plants will be planted with 1.3 m x 1.3 m spacing (5900 plants per hectare);
- rotation period will be 10 years (Christmas trees will be about 2 meters high);
- christmas trees will be sold as wholesale (EXW (Ex works) – Incoterms 2000).

Table 1

Management actions

Year	Action	Cost (EUR)
0	• Chemical weed control • Land preparation (tillage, cultivation) • Buying plants and planting • Fencing the plantation	102 58 1697 2237
1	• Chemical weed control	53
2	• Chemical weed control	53
3	• Chemical weed control • Fertilizing the plants	53 320
4	• Chemical weed control	53
5	• Chemical weed control • Shearing	53 895
6	• Chemical weed control • Shearing	53 895
7	• Chemical weed control • Shearing • Fertilizing the trees	53 895 320
8	• Chemical weed control • Shearing	53 895
9	• Chemical weed control • Shearing	53 895
10	• Chemical weed control • Marking the trees for selling • Cutting and bailing the trees • Selling the trees	53 depends on an output (0.03 EUR pcs^{-1}) depends on an output (0.6 EUR pcs^{-1})

Taking into account the impact of the output of saleable Christmas trees on the profitability (income – costs), the cost allocation was as follows:

1) fixed costs:
   - soil preparation;
   - buying of plants and planting ;
   - fertilization;
   - fencing the plantation;
   - chemical weed control;
   - shearing the trees.
2) variable costs:
   - christmas tree labels;
   - labeling the trees for selling;
   - christmas tree net;
   - cutting and bailing the trees.

Results and Discussion

The results of the profitability of Christmas tree cultivation are shown in Table 2. Cash flows are brought out with different output of saleable Christmas trees.

Table 2

Potential profitability of establishing Christmas tree plantation (1 hectar of *Picea abies*)

Output of saleable trees (%)	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Output of saleable trees (pcs)	590	1180	1770	2360	2950	3540	4130	4720	5310
Fixed costs (EUR)	9740	9740	9740	9740	9740	9740	9740	9740	9740
Variable costs (EUR)	302	603	905	1207	1508	1810	2112	2413	2715
TOTAL COSTS	**10042**	**10343**	**10645**	**10947**	**11248**	**11550**	**11852**	**12153**	**12455**
Cost per tree (EUR)	**17.0**	**8.8**	**6.0**	**4.6**	**3.8**	**3.3**	**2.8**	**2.6**	**2.4**
Income* (EUR)	2640	5279	7919	10558	13198	15837	18477	21116	23756
Profit before taxes (EUR ha^{-1} 10 $years^{-1}$)	-7402	-5064	-2726	-389	1950	4287	6625	8963	11301
PROFIT before taxes (EUR ha^{-1} $years^{-1}$)	**-740**	**-506**	**-273**	**-39**	**195**	**429**	**663**	**896**	**1130**

*Christmas trees will be sold as wholesale, 4.5 euros per piece.

The comparison of profitability of alternative land use is shown in Table 3.

Table 3

The comparison of profitability of alternative land use

	Grassland management (Ehrlich 2006)	Cultivation of barley (Värnik 2005)	Silviculture (*Picea abies*, rotation period - 80 years)	Silviculture (*Betula sp*, rotation period - 70 years)	Cultivation of christmas trees (*Picea abies*, output - 50%)	Cultivation of christmas trees (*Picea abies*, output - 60%
Income, EUR ha^{-1}	192	410	24399	15879	13198	15837
Production costs, EUR ha^{-1}	114	166	5532	3764	11248	11550
Profit, before taxes EUR ha^{-1} $years^{-1}$	78	244	236	173	195	429

As shown in Table 3, achieving the output of saleable Christmas trees at least 60% is the most profitable activity in this comparison. At the same time, it became obvious that cultivating Christmas trees is also the most capital-intensive. The main aspect to take into account when cultivating Christmas trees is that the investment expects to have the necessary capital available during the whole rotation period. Income will be earned only at the end of the rotation period while the costs should be made during the whole period. In addition to the availability of capital, cultivation of Christmas trees is a fairly labor-intensive and the profitability is primarily based on adequate knowledge.

According to different surveys in Estonia, the forest- and landowners are quite interested in using some part of their property for establishing Christmas tree plantations. Growing Christmas trees has become one of the main side-activities for landowners in Germany and Denmark. This could also be the same in Estonia. Until now former agricultural and pasture lands have been afforested in Estonia, but establishing Christmas tree plantations could be an alternative possibility for using this resource. In addition to profitability, it surely stimulates economic activity (employment for example) in rural areas more than afforestation does.

Conclusions

Although growing Christmas trees is not very common in Estonia, there are all presumptions to change that Firstly, domestic demand for quality Christmas trees, especially for Norway spruce *Picea abies*, has increased considerably during the last years. Secondly, landowners are interested in using their property for growing Christmas trees. Thirdly, in Estonia there are about 290 000 hectares of former agricultural lands which are out of use at the moment and which would be a perfect resource for establishing Christmas tree plantations.

The current study indicates that when achieving the output of saleable Christmas trees at least 60%, cultivating Christmas trees is the most profitable land use alternative compared to other traditional land use possibilities.

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BIOENERGY FROM PRE-COMMERCIAL THINNING, FOREST INFRASTRUCTURE AND UNDERGROWTH – RESOURCES, PRODUCTIVITY AND COSTS

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Abstract

This article is covering results of pre-commercial thinning, forest infrastructure and undergrowth harvesting field studies implemented in July, 2007 by Skogforsk and LSFRI Silava. A scope of the study was to estimate prime costs of biofuel production from small trees and to compare two types of harvester heads (Bracke C16.a and Ponsse EH25).

The productivity in pre-commercial thinning expressed as trees per E_0-h (effective hour) ranged between 53 (Ponsse) and 118 (Bracke) in the pine stand and 150 (Bracke) in the mixed spruce stand. In comparison the LVm^3 (LV – loose volume) ranged between 9.9 (Ponsse) and 14.1 (Bracke) in the pine stand and was 13.0 (Bracke) in the mixed spruce stand. In the forest infrastructure (roadside ditches) harvesting productivity was 8.2 LVm^3 E_0-h^{-1} for Ponsse and 12.5 LVm^3 E_0-h^{-1} for Bracke. Productivity was economically insufficient in undergrowth removal, both in harvesting (Bracke) and forwarding (Ponsse) operations, respectively 1.1 and 2.6 LVm^3 E_0-h^{-1}.

Prime costs of harvesting, forwarding, comminution and chip transport (50 km one direction) in pre-commercial thinning in calculation to LVL LVm^{-3} were 5.93 for Ponsse and 5.85 for Bracke. Prime costs in forest infrastructure in LVL LVm^{-3} were 4.97 (Ponsse) and 6.36 (Bracke). Only Bracke was tested in the undergrowth, where prime costs were 37.55 LVL LVm^{-3}. 'Environmental footprint' of biofuel production from small trees in terms of carbon (C) emissions ranged from 2.6 to 10.2 kg C LVm^{-3}, including road transport (50 km) to terminal.

Key words: pre-commercial thinning, forest infrastructure, biofuel, harvesting, productivity.

Introduction

When small roundwood is harvested in young stands, the trunk diameter at breast height usually is 3...10 cm (Karha, 2006). When small roundwood is used as bio-fuel, the whole tree including branches can be utilized. According to studies implemented in Sweden, when the harvested trees have a breast-height diameter around 10 cm, about half of all trunks are felled, corresponding to 44% of the total volume before felling (Liss, 2004). Harvesting of small trees requires rather high energy input, especially when trunks are used as pulp wood and only tops and branches are used for energy purpose. In Swedish studies about 30% of the harvested volume consisted of tops and branches (Liss, 2004).

Different techniques are used to harvest small dimension trees in thinning and forest infrastructure. With a mechanical feller-buncher several trees can be handled at the same time, improving the efficiency considerably, especially if used in a geometrical thinning pattern (Eriksson and Gustavsson, 2009). Another method is treatment of single tree at once. According to Finnish studies, the total supply chain cost when producing chips from whole tree in young stands is approximately 15 Euro MWh^{-1} (Karha, 2006). From the same studies follows, that efficiency of different machines depends on the conditions at the harvesting sites. When small trees are harvested on sites with short forwarding distances, energy wood harwarders are most efficient, while in young stands of larger trees and longer forwarding distances, the traditional two-machine system with harvester and forwarder is a more economic option (Karha, 2006). Bio-fuel production systems based on motor-manual work are the most competitive in the smallest diameter stands and are profitable (Bjorheden et al., 2003). In pine stands with average diameter at breast height 5.5-10 cm two machine system starts to become competitive (Bjorheden et al., 2003).

Industrial scale production of solid bio-fuel from slash in clear-cuts in Latvia started 4...5 years ago and the next step is utilization of non-conventional sources of forest bio-fuel, including small dimension trees in thinning and forest infrastructure. Joint stock company 'Latvijas Valsts Meži' (LVM) has identified bio-fuel from small-dimension stands and infra-structure objects as assortments of high strategic value in the light of increasing energy prices and in 2006 initiated broad study on potentials and harvesting technologies of different non-conventional forest bio-fuel resources, including small dimension stands. The main tasks of the study were:

- estimation of non-conventional forest bio-fuel resources in relation to their economic accessibility;
- evaluation of harvesting technologies in terms of productivity and costs;
- estimation of 'Environmental footprint' of different supply chains.

Efficient harvesting was the main point of the study, because earlier studies approved, that it is the key element to fully exploiting the potential of bio-energy, therefore focus of the project was study of harvesting machines and working methods.

This article comprises the productivity results of studies in pre-commercial thinning, forest infrastructure objects and undergrowth removal before clear-cut. The studies involved harvesting, forwarding and comminution at roadside, as well as evaluation of fuel consumption during different operations. The time consumption and productivity of all operations were recorded to calculate productivity and prime costs.

Materials and Methods

Two types of multi-stem handling aggregates with accumulating felling heads were studied, Ponsse EH25 and Bracke C16.a. The Ponsse EH25 was installed on Ponsse Gazelle forwarder with an extended frame and Ponsse K70 crane. The Bracke C16.a head was installed on old Lokomo harvester. Ponsse Gazelle was used also as a forwarder in all studies. Operators were experienced in handling their machines, but inexperienced in biomass harvest from young stands. Some of the studies were made by the experienced operator from Sweden.

All stands and woody vegetation of ditches (infrastructure objects) were measured (diameter at breast height and height in sample plots covering 10% of the stand area). Stands were also specially selected for certain suitability parameters for bioenergy production – average height of trees – at least 6 m, density of stand – at least 5,000 trees per ha. The stand data for pre-commercial thinning trials are summarized in Table 1.

Table 1

Stand Data for Pre-commercial Thinning

	Pine stand	Mixed spruce stand
Average height, m	12	10
Average diameter, cm	13.5	12.0
Basal area, m^2 ha^{-1}	42.0	24.7
Basal area after thinning, m^2 ha^{-1}	15.0	15.0
Growing stock, m^3 ha^{-1}	238	90.1

Biomass of trees were calculated using equations published by Mäkelä and Vanninen (1998) for pine, Briggs and Cunia (1982) for spruce (*Picea abies* (L.) H.Karst.), T. Johansson (1999a) for birch (*Betula pendula* Roth), T. Johansson (1999b) for aspen (*Populus tremula* L.), T. Johansson (1999c) for black alder (*Alnus glutinosa* L.) and T. Johansson (2000) for grey alder (*Alnus incana* (L.) Moench). Biomass of undergrowth bushes weren't estimated. Actual (produced during the field trials) volumes of wood chips were used in productivity and cost estimations. Comparison of theoretical estimations and actual volumes isn't included in this article.

Time studies in forest infrastructure were carried out in two sample plots with the Ponsse Gazelle EH25 and Bracke C16.a. Bracke was used in both sample plots, Ponsse – only in the plot No. 2. The width of the forest roads in average were 3.5 m, the total width of the studied area – 16 m, the harvested area was 12.7 m wide in the plot No. 1 and 16 m – in the plot No. 2. Dominant tree species in all plots was grey alder.

Biomass of trees and bushes was calculated using the same equations as in case of pre-commercial thinning with exception of willows (*Salix* sp.) and other bushes, where equations published by Lazdina et al. (2007) were used. The method is based on finding, that trunks of bushes follows to form of truncated cone, therefore no branches were taken in account.

Table 2

Stand Data for Infrastructure Object Cleaning

	Sample plot No. 1 (partially covered with vegetation)	Sample plot No. 2 (completely covered with vegetation)
Average height, m	7.9	8.5
Average diameter, cm	5.7	6.2
Number of stems per ha	3,014	6,333
Basal area, m^2 ha^{-1}	12.9	29.2
Growing stock, t_{dry} ha^{-1}	18.8	67.3

Productivity of removal of undergrowth trees was estimated in mature spruce stand (up to 110 years, 276 trees per ha) with somewhere well developed second layer consisting from pine, spruce and birch. Undergrowth consists from hazel-tree (*Corylus avellana* L.), willows and spruces. Approximate amount of biomass in undergrowth – 8 t_{dry} with total number of trees 5,233 ha^{-1}. Biomass was calculated using the same functions as in the case of infrastructure cleaning. Undergrowth was harvested by Bracke C16a head. In all cases the obtained volume after cutting was compared with the theoretical yield.

The time studies were conducted as work element studies, in which the work cycle was divided into short, well-defined work elements. The time consumption per work element was recorded throughout the study. In the pre-commercial thinning the operators used the method of cutting strip road and thinning the area around strip roads at once. Distance between strip roads was 20 m. During harvesting of road-sides trees were directly loaded on to forwarder when used the Ponsse; and left on the ground in bundles for further forwarding with the Ponsse, when used the Bracke. Results from earlier studies were used for road transport figures in cost calculation – transport of wood chips to 50 km distance costs 1.06 LVL m^{-3} (Thor et al., 2006).

The prime cost calculation were done on the base of a cost of machine hour (estimated using questionnaire method) and average productivity (estimated in the field trials). The machine hour cost included depreciation, fuel, service costs and salaries, based on averages from the questionnaires. The productivity of harvesting and comminution were converted to trees and, consequently, cubic meters per working hour, productivity of all kind of transport were divided to loading, unloading and driving to catch effect of distance.

Several quality parameters of solid biofuel were evaluated during this study, including gross and net energy content in calculation to cubic meters (MWh LV m^{-3}) according to CEN/TS 1514918, relative moisture according to LVS CEN/TS 14774-1, total carbon according to LVS CEN/TS 15104, ash content according to LVS CEN/TS 14775 and bulk density according to LVS CEN/TS 15150. Undergrowth trees weren't evaluated separately.

'Environmental footprint' of biofuel production was calculated on the base of assumptions from Table 3.

Table 3

Input Data for the Environmental Assessment

Input data	Value
Terrain transport distance (m)	300
Road transport distance (km)	40
Chip trailer volume (m^3)	70
Bulk density of chips (LVm^3 t_{dry}^{-1})	5
Carbon in wood (kg t_{dry}^{-1})	420

Results and Discussion

The productivity in early thinning in pine stand was 9.9...14.1 LVm^3 E_{15}-h (working hour with conversion factor from the efficient hour E_0-h 0.85). The harvested stock in LVm^3 ha^{-1} ranged from 173 to 217. The number of trees harvested per crane cycle ranged from 1.11 to 1.54 and the productivity expressed as trees E_0-h^{-1} ranged from 53.3 to 117.9. The productivity in the mixed spruce stand ranged between 6.7 and 12.1 LVm^3 E_{15}-h (LV – loose volume). The chipped volume LVm^3 ha^{-1} ranged between 53.3 and 85.5 (Table 4).

Table 4

Productivity of Harvesting in Pre-commercial Thinning

Work element	Pine stand		Mixed spruce stand	
(total work time)	Bracke C16.a	Ponsse EH25	Bracke C16.a	Ponsse EH25
Boom out (cmin[1])	2,983	1,936	4,010	3,154
Gripping (cmin)	3,889	2,461	7,914	2,602
Cutting (cmin)	1,437	955	3,509	747
Crane movement (cmin)	2,990	1,057	3,870	2,375
Putting down (cmin)	784	1781.5	1,566	1,094
Driving forward (cmin)	1,345	2,368	3,136	2,377
Cleaning (cmin)	186	529	481	688
Other work time (cmin)	738	632.5	442	625
Total time consumption (cmin)	14,352	11,720	24,928	13,662
Number of crane cycles	198	101	293	77
Cmin per crane cycle	72.0	240.0	85.1	177.4
Number of trees in crane cycle	1.42	1.17	2.88	3.55
Cmin per tree	50.9	105.5	29.6	50.0
Productivity				
Trees E_0-h	117.9	120.2	202.9	119.9
LVm^3 per tree	0.14	0.21	0.07	0.06
LVm^3 E_0-h^{-1}	16.6	12.1	14.2	7.9
LVm^3 E_{15}-h^{-1}	14.1	10.3	12.1	6.7
LVm^3 ha^{-1}	173.0	195.0	85.5	53.3

[1] cmin – centi-minutes, one hundredth part of minute.

In the pre-commercial thinning in pine stands the difference between operators was bigger than the difference between the two harvester heads; therefore, average results are used in cost calculations. Taking into account lack of experience of the operators, figures obtained in the study might be relevant to 'real world' figures and there is no need to downgrade productivity figures in an industrial scale planning process. Choosing of proper working method – compromise between productivity and good forest management principles – would lead to significant improvement of results.

When comparing the pine stand and mixed spruce stand, one can conclude that there was more of multi-stem handling in the mixed spruce stand. The number of crane cycles that only handled one tree was 35.4% in the mixed spruce stand compared to 53.5% in the pine stand. The number of crane cycles that handled 4 trees was 14.8% compared to only 3.5%, and the number of cycles with 5-6 trees was 5.5% in the spruce stand compare to none in the pine stand.

The productivity expressed as trees per E_0-h ranged between 53 (Ponsse) and 118 (Bracke) in the pine stand and 202 (Bracke) in the mixed spruce stand. To be competitive in small-dimension thinning, earlier Finnish experience indicate a level of 150-200 trees per hour as a threshold (Ahtikoski et al., 2008).

The studies in mixed spruce stand clearly indicate that the Bracke head and harvester base machine concept instead of forwarder is better fit for harvesting in small dimension stands. One reason for that is that the operator cut several trees in each gripping-cutting movement and therefore also handled as many as 3.55 trees per crane cycle. The collective handling of many stems is a key to high productivity. Another reason is the extracted volume; the Bracke head harvested 85.5 LVm^3 ha^{-1} compared to 53.3 LVm^3 ha^{-1} with the Ponsse head. A poor visibility in the stand was extra difficult using the Ponsse head, since it could not be positioned to individual trees.

The complete forest infrastructure study was conducted with the Ponsse head. The productivity (harvesting and forwarding) was 8.2 LVm^3 per E_{15}-h. The number of trees harvested per crane cycle was 1.65 (Table 5).

The simplified study of the Bracke C.16 resulted in productivity of 268 trees per E_0-h (16.2 LVm^3 E_{15}-h^{-1}), which was significantly higher than compared to the study of the Ponsse, but additional time consumption for forwarding (11.2 LVm^3 E_{15}-h^{-1}) should be taken into account as well.

Table 5

Productivity of Harvesting of Forest Infrastructure with Ponsse EH25

Work element (total work time)	Value
Booming out (cmin)	1,365
Gripping (cmin)	1,811
Cutting (cmin)	494
Crane movement (cmin)	1,203
Puting Down (cmin)	627
Driving forward (cmin)	287
Cleaning (cmin)	261
Other work time (cmin)	1,982
Total time consumption (cmin)	8,030
Number of crane cycles	77
Total time per crane cycle (cmin)	104.3
Number of trees per crane cycle	1.65
Cmin per tree	63.2
Productivity	
Trees E_0-h^{-1}	94.9
LVm^3 per tree	0.10
LVm^3 E_0-h^{-1}	9.65
LVm^3 E_{15}-h^{-1}	8.20
Thinned area (ha)	0.13
LVm^3 ha^{-1}	100
Terrain transport (150 m)	
Driving with load (cmin)	266
Unloading (cmin)	707
Driving empty (cmin)	300
Total time (cmin)	1,273
cmin LVm^{-3}	99
LVm^3 E_0-h^{-1}	61
LVm^3 E_{15}-h^{-1}	52

The productivity of Ponsse expressed as LVm^3 E_{15}-h was 8.2 in the road side study, including harvesting and forwarding. Nevertheless, this seems to be a relatively low productivity bearing in mind that the operator did not need to make any stem selection or consider any stems that should be left in the stand. Bracke demonstrated twice higher productivity for harvesting, but it should be taken in account, that in this case Bracke worked in area with significantly higher growing stock, which might be the main reason for high productivity.

Then forwarding studies in pre-commercial thinning were carried out with the Ponsse Gazelle Dual with slash gripper. The productivity was 12.7...15.5 LVm^3 E_{15}-h^{-1}. The average terrain transport distance was 300 m. The productivity when forwarding from mixed spruce stand was 15.5 LVm^3 E_{15}-h^{-1} (Table 6). The average terrain transport distance for the eight loads was 230 m.

Table 6

Productivity of Forwarding in Pre-commercial Thinning with Ponsse EH25

Total work time (cmin)	Pine stand	Mixed spruce stand
Boom out	3,811	2,938
Gripping	3,963	2,171
Boom in	2,338	4,166
Put down	3,850	1,452
Put right	1,058	
Driving forward	2,787	2,874
Driving with load	802	
Unloading	1,242	2,657
Driving empty	915	2,107
Other work time	1,662	377
Forwarding and unloading	5,638	2,267
Total time consumption	28,066	21,009
Forwarded volume (LVm^3)	70	64
Productivity		
LVm^3 E_0-h^{-1}	14.96	18.3
LVm^3 E_{15}-h^{-1}	12.72	15.5

In the pine stand productivity of different operators varied, as well as working quality in terms of damages to remaining trees. It seems that the main reason for the large difference in the pine stand was the operators' different skills and experience of forwarding.

The simplified study of the Bracke C.16 in the undergrowth removal resulted in productivity of 221 trees per E_0-h (1.2 LVm^3 E0-h^{-1}), which was an example of the lowest productivity and the smallest efficiency of utilization of machinery in the study. Low productivity can be explained by small size of trees, complicated working conditions (an operator tried to cut every, even the smallest bushes, which, actually, don't affect productivity of harvester in clear-cut). Productivity of forwarding also was low – 2.64 LVm^3 E_0-h^{-1}, because of small loads (3 LVm^3). Larger loads complicated manoeuvring of the forwarder in the stand, because strip roads weren't straight and there was no sufficient space for the forwarder manoeuvres at the end of strip roads.

Table 7 shows the results of calculations of prime cost of biofuel production and supply. The direct costs for biomass extraction from thinning were 5.85...5.97 LVL m^{-3}, from ditch cleaning – 6.27...7.27 LVL m^{-3} and from undergrowth – 37.37 LVL m^{-3}. The last figure is highly uncertain, although it is reasonable that the cost is significantly higher than road sides or small-dimension stands where the extracted volumes are much higher.

Costs (investments and maintenance) of new machines were used in the prime cost calculation, which is not typical situation for slash removal or thinning of young stands. Share of investments for certain machines was 19-23% from the prime cost. Variations in a part of investments may lead to different results in prime cost calculation, especially if an old amortized machinery is used.

Table 7

Prime Costs (LVL LVm^{-3}) for Biomass Extraction and Supply in Calculation to Current Fuel Prices

	Harvesting	Forwarding	Comminution	Road transport	Total
Pre commercial thinning[1]					
Ponsse Gazelle EH25	1.77	1.90	1.24	1.06	5.97
John Deere 970 Bracke C16.a	1.65	1.90	1.24	1.06	5.85
Road sides and ditches					
Ponsse Gazelle EH25	4.97		1.24	1.06	7.27
John Deere 970 Bracke C16.a	2.34	1.63	1.24	1.06	6.27
Undergrowth trees					
John Deere 970 Bracke C16.a	26.48	8.59	1.24	1.06	37.37

[1] Forwarding were carried out by Ponsse Gazelle

The concept with a harvester and Bracke head was more competitive in the studies, both, in early thinning and the ditch cleaning operations. The main advantages are that it is easier to handle multiple stems, and it is easier to manoeuvre the harvester in dense stands. Furthermore, the Bracke head seemed more fit to operate in very dense stands with poor visibility. However, the combine concept using a felling head on a forwarder has its advantages in the infrastructure objects. The recorded productivity was surprisingly low in the studies. There is room for improvement of the method and technology for that special type of operation.

Results of analyzes of the particle size distribution of biofuel demonstrated that dominant fraction in all of forest biofuels is 16...45 mm. Willows are contrasting with dominant 8...16 mm fraction. The least share of small fractions was detected in the naturally dried small trees sample. A sample from pine stand follows with similar results.

Gross energy content in different samples varied from 4.31 to 5.42 MWh t_{dry}^{-1}. Net energy content varied from 0.5 to 0.8 MWh LVm^{-3} and it was generally dependent on bulk density and moisture.

Fresh chips of deciduous trees harvested on road-sides contained 6% more relative moisture than chips produced from dried trees. The effect of drying was not so big as in case with a slash from clear-cuts.

Ash content was one of the most variable biofuel quality parameters evaluated in this study. It was very low in small trees, both – from winter road-side cleaning and pre-commercial thinning of pine (0.8...1.4%) and it was relatively high in fresh small trees from road-sides (3.9%).

Results of calculations of 'Environmental footprint' of biofuel production are presented in Table 8. Carbon balance (recovered biomass against fossil fuel) in forest thinning was 33 for Ponsse and 34 for Bracke; in roadside cleaning – 29 for Ponsse and 31 for Bracke; and in undergrowth removal – 9 for Bracke. The last figure means, that it is possible to produce and supply 9 units of biofuel using 1 unit of fossil fuel in terms of carbon content.

Table 8

Carbon Emissions During Harvesting of Small Trees in Pre-commercial Thinning

Machine	Ponsse EH25	Bracke C16.a	Forwarder	Chipper	Chip truck	Total emissions
Early thinning						
Ponsse EH25, kg LVm^{-3}	0.76	-	0.51	0.72	0.54	2.53
Bracke, C16.a, kg LVm^{-3}	-	0.71	0.51	0.72	0.54	2.48
Road-side cleaning						
Ponsse EH25, kg LVm^{-3}	1.06	-	-	0.72	0.54	2.32
Bracke, C16.a, kg LVm^{-3}	-	0.54	0.41	0.72	0.54	2.21
Undergrowth						
Bracke, C16.a, kg LVm^{-3}	-	6.07	2.22	0.72	0.54	9.55

Conclusions

The study demonstrated that, both, pre-commercial thinning and forest infrastructure may have significant role as a source of biofuel in future if biofuel targeted forest management approach is used (thinning should be done when trees reach optimal height, density of stand should be reduced earlier to not more than 5000 trees per ha, maximum reasonable intensity of thinning should be applied to improve working conditions).

Productivity of harvesting in pre-commercial thinning varied between 6.7 and 14.1 LVm^3 E_{15}-h^{-1}. Improvement in productivity might be reached also by using of proper machinery – Bracke C16.a seems to be better in pre-commercial thinning as well as in road-side cleaning, but use of modern harvester would increase productivity significantly.

Productivity when forwarding in early thinning ranged between 12.7 and 15.5 LVm^3 E_{15}-h^{-1}; in road side cleaning were 11.82 LVm^3 E_{15}-h^{-1}, which is rather low result, taking into account excellent working conditions.

Prime costs of biofuel range from 5.85 to 5.97 LVL LVm^{-3} in pre-commercial thinning and from 6.27 to 7.27 LVL LVm^{-3} in forest infrastructure cleaning. About one third of costs belongs to depreciation of machine cost. In 'real world' conditions new machines aren't used in such a kind of operations, thus actual costs would be significantly lower. But it is important to remember that administration and other activities not included in the model will raise costs of production.

Undergrowth trees are expensive to harvest and provide a rather small amount of biofuel, even taking into account, that the stand was specially selected for a high concentration and size of undergrowth trees. Other working methods, very simple and cheap machines or modern frame mounted harvesters experimentally used in coppice crops might be an efficient solution for undergrowth, but it should be evaluated separately.

Quality of biofuel produced from small trees is good and it can be used, both, for direct incineration and pellet production. The main issue might be moisture, because the study demonstrated, that long term storage doesn't work in case of full trees. It seems, that the pile is too wide (6...8 m, depending on length of trees) and air exchange conditions are insufficient).

'Environmental footprint' of production of biofuel from small trees in terms of carbon emissions is comparable to production of chips from slash in clear-cuts. In most cases 1 unit of fuel was necessary to produce and supply at least 30 units of biofuel in calculation to amount of carbon. An exception is undergrowth harvesting, but proper machinery and improved working method could improve the situation.

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TECHNICAL AND ENVIRONMENTAL ISSUES OF STUMP HARVESTING FOR BIOFUEL PRODUCTION IN LATVIA

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Abstract

This article represents the results of the research project 'Forest energy from small-dimension stands, infra-structure objects and stumps' realized in cooperation between Joint stock company 'Latvijas valsts meži' (Latvia's state forests), SKOGFORSK (The Forestry Research Institute of Sweden) and Latvian State Forestry Research Institute 'Silava'. The article is covering issues related to the results of stump harvesting field study realized in November, 2008. A scope of the study was to estimate costs of stump harvesting and to evaluate working methods and influencing factors related to extraction of stumps.

Better harvesting conditions (flat landscape and lack of stones in soil) led to increased productivity of stump extraction in Latvian trials (5.2 t_{dry} (t_{dry} – tons of dry mass) of stumps per effective hour (E_0-h)) in comparison to average figures in Scandinavian studies. Load sizes of the forwarder ranged from 5.5 to 9.3 t which is about half of the maximum load of forwarder. Average productivity of forwarding was 6.3 t_{dry} E_0-h^{-1}. Productivity of stump transport (distance – 7 km) was 3.5 t_{dry} E_0-h^{-1}. Productivity of comminution was 10 t_{dry} E_0-h^{-1}. Prime cost of the stump harvesting, including extraction, forwarding, stump transport (7 km one direction), comminution and chip transport (50 km one direction) was 6.3 LVL LVm^{-3} (LV – loose volume). 'Environmental footprint' of the stump harvesting in terms of carbon (C) emissions was 2.5 kg C LVm^{-3} of wood chips at terminal. Stumps demonstrated considerably higher heat value (5.7 MWh t_{dry}^{-1} against 4.7 MWh t_{dry}^{-1} for the hog fuel from a slash).

Key words: stumps, biofuel, harvesting, productivity.

Introduction

Interest in forest bio-energy is growing rapidly in Latvia. Only few years ago industrial scale production of the so called 'hog fuel' from a slash from clear-cuts was initiated in private and state forests. Now piles of drying slash are a common elements of our landscape. Total production of hog fuel in Latvia is not estimated, but increasing amount of sales in Joint stock company 'Latvijas Valsts Meži', 107,500 LVm^3, including 5,000 LVm^3 of crushed stumps in the first half of 2009 (A/s 'Latvijas valsts meži', 2009), demonstrates, that this kind of biofuel becomes a significant player in the energy market. It is approved, that the production of hog fuel from slash in clear-cuts is feasible and can provide a significant amount of renewable fuel (80 m^3 of biofuel per ha, including firewood (9 m^3 ha^{-1}) corresponding to 25% of volume of roundwood assortments) (Thor et al., 2006). Indicates from the forest research results demonstrate that stumps are next in line after a slash from clear-cuts in the terms of cost efficiency of available technologies and potential of resources.

Stump biofuel can be produced in all clear-cuts after forwarding of roundwood assortments and slash if it's collected for the biofuel. There might be environmental limitations of the stump lifting in areas with high risk of an erosion, technical limitations associated with large dimensions of stumps or lack of area to store stumps during field drying, and climatic limitations, like warm winters, which makes complicated forwarding of stumps in wet sites. Potential effect of those limitations is not researched in Latvia; thus, it is hard to predict the actual amount of stumps, which can be produced in state forests from the clear-cuts. The evaluation of bio-energy resources in this paper is based on the assumption that an average harvestable amount of stumps in calculation to dry tons is 12% of the harvested volume of roundwood in m^3 under bark (Thor et al., 2008). This assumption corresponds to average Swedish and Finnish conditions (Laitila et al., 2008). The very rough calculation demonstrates that the potential of Latvian state forests is about 400,000 t_{dry} or 32 t_{dry} ha^{-1} of stump biofuel yearly, which corresponds to about 2.4 mill.MWh. It should be taken into account that no availability criteria are applied to this calculation. If we assume, that harvesting of stumps will not be implemented in pine (*Pinus sylvestris* L.), oak (*Quercus robur* L.) and ash (*Fraxinus excelsior* L.) stands, because of deep root systems, and grey alder (*Alnus incana* L.) stands because of a rather small average dimension of stumps, total harvesting stock of stumps reduces to about 237,000 t_{dry} yearly (60% of theoretically available amount in clear-cuts) (Thor et al., 2008).

Another important group of issues affecting stump harvesting is forest regeneration requirements. Organization of stump lifting should be synchronized with afforestation activities to avoid unnecessary costs of additional soil preparation and weed control (Saarinen, 2006). The results of this study demonstrated that additional time of soil scarification is about 13% of the total working time, thus this method at least from the point of view of cost efficiency of soil preparation is much more beneficial than trenching, but silvicultural effect of this operation should be estimated separately. Stump harvesting in coniferous stands has also significant silvicultural potential, for instance, to reduce distribution of root rot (*Heterobasidion annosum* (Fr.) Bref.) in next generation of forests by removing most of infected biomass (Lipponen, 2007).

This article is concentrated on technical issues of stump harvesting, which are important to understand economical accessibility of stump resources, as well as to predict requirements of technical development taking into account local conditions, both, at resource and consumption side.

Materials and Methods

The study included the extraction and forwarding of stumps. Machines used in the study were a Hyundai LB21Lc crawler excavator for lifting operation and a John Deere 1110D prolonged forwarder. The excavator was equipped with a CBI stump lifting head with a shear blade. The forwarder had a slash grapple. Both operators were experienced with their respective machines, but inexperienced with this particular work. The study was carried out near Jelgava in January, 2008. The study site area was a 4.2 ha in total, clear felling was finalized in November, 2006. Further details are in Table 1 and Table 2. Characteristics of study plots differs from the average characteristics of the stand, because time studies were done only in certain parts of stands.

Table 1

Stand Characteristics Before Clear-cutting

Forest site	Zemgale forestry, former Garozas forest district, block No. 177, parcel No. 1 (2.7 ha) and No. 5 (1.4 ha)
No. of stems per ha (in average)	500
Tree species	parcel No. 5: 5B1P1S[1] (82 years old) 3P (120 years old) + S (65 years old) in the second floor parcel No. 1: 7S2P1B (102 years old) + A, O (102 years old) + S in the second layer
Harvested stock	parcel No. 5: 279 m^3 ha^{-1} parcel No. 1: 348 m^3 ha^{-1}
Average diameter of trees at breast height	parcel No. 5: 28 cm parcel No. 1: 35 cm

[1] B – birch (*Betula pendula* Roth), P – pine, S – spruce (*Picea abies* (L.) H.Karst.), A – aspen (*Populus tremula* L.), O – oak.

Table 2

Characteristics of Study Plots Before a Stump Lifting

	Plot 1	Plot 2	Plot 3
Soil characteristics	Sand (low land)	Sand (ridge)	Peat (40 cm)
Plot area, m^2	1,950	2,000	1,250
No. of stumps	94	102	52
Species, % (P:S:B,A,O)	12:53:35	28:59:13	31:52:17
Average diameter of stumps (cm)	34	36	35
Gross weight, t_{dry}	8.4	8.6	3.9

All stumps were measured (average height and diameter) and marked with numbers to accumulate productivity data of harvesting for individual stumps according to the harvesting conditions and tree species. The amount of material lifted and forwarded was estimated theoretically before calculations of productivity. Equations published by L.G. Marklund (1988) were used to calculate an amount of dry weight of stumps of pine and spruce. For birch stumps and other deciduous formulas from J. Repola et al. (2007) were used (Table 3).

Since many stumps had been harvested several centimeters higher than was regarded as normal, some extra weight had to be ascribed to the stumps. In this case the volume of the butt-off was calculated as a cylinder and then multiplied by dry-weight – pine 476 kg m^{-3}, spruce 394 kg m^{-3} and birch 500 kg m^{-3}.

Table 3

Formulas Used to Estimate Amount of Dry Weight per Stump

Species	Formula[1]	r^2	Source
Pine, stump	EXP(a+b·[D/(D+15)])	0.95	Marklund, 1988
Roots > 5 cm	EXP(a+b·[D/(D+10)])	0.90	Marklund, 1988
Spruce, stump	EXP(a+b·[D/(D+17)])	0.96	Marklund, 1988
Roots > 5 cm	EXP(a+b·[D/(D+8)])	0.94	Marklund, 1988
Birch, stump	EXP(a+b·(2+1.25·D)/((2+1.25·D)+26)+(c+d)/2)	0.95	Repola et al., 2007
Roots > 1 cm	EXP(a+b·(2+1.25·D)/((2+1.25·D)+22)+c·Ln(H)+(d+e)/2)	0.91	Repola et al., 2007

[1] a...d – constants; D – diameter at breast height in centimetres. In this case the diameter was estimated from the stump diameter according to the formulas presented in the publications by L.G. Marklund (1988) and J. Repola et al. (2007); H – tree height in m.

The validity of above formulas under Latvian conditions is not known. It seems that they will under-estimate the weights, especially for a pine but probably also for a spruce. Average results of productivity data were recalculated later according to the actual amount of produced wood chips. During unloading from the forwarder every grapple was weighed by the boom-tip mounted scale. Total weight achieved that way included soil and in-wood moisture. To adjust to this, the registered gross weight was corrected, first with a factor 0.5 (Thor et al., 2008) to adjust for moisture then with a factor 0.7 (Jonsson, 1985) to adjust for impurities (net weight = gross weight multiplied by 0.5...0.7). Allegro field computers with SDI software were used for time studies.

The time studies were conducted as work element studies, in which the work cycle was divided into short, well-defined work elements. The time consumption per work element was recorded throughout the study. Results from earlier studies were used for road transport figures in cost calculation – transport of wood chips to 40 km distance costs 1.06 LVL m^{-3} (Thor et al., 2006).

The prime cost calculation were done on the base of a cost of machine hour (estimated using questionnaire method) and average productivity (estimated in the field trial). The machine hour cost included depreciation, fuel, service costs and salaries, based on averages from the questionnaires. Productivity of extraction and comminution were calculated in cubic meters per working hour, productivity of all kind of transport (terrain forwarding, road transport of stumps and wood chips) were divided to loading, unloading and driving to see effect of distance.

Several quality parameters of solid biofuel were evaluated during this study, including gross and net energy content in calculation to cubic meters (MWh LVm^{-3}) according to CEN/TS 1514918, relative moisture according to LVS CEN/TS 14774-1, total carbon according to LVS CEN/TS 15104, ash content according to LVS CEN/TS 14775 and bulk density according to LVS CEN/TS 15150. Undergrowth trees weren't evaluated separately.

'Environmental footprint' of biofuel production were calculated on the base of assumptions from Table 4.

Table 4

Input Data for the Environmental Assessment

Input data	Value
Terrain transport distance, m	300
Stump road transport distance, km	7
Stump trailer volume, m^3	70
Road transport distance, km	50
Chip trailer volume, m^3	70
Bulk density of chips, $LVm^3\ t_{dry}^{-1}$	5

Results and Discussion

The site chosen for the study was very good stump extraction place – with a flat terrain and with no ground obstacles. Sandy soil simplified extraction of stumps and gave advantage when cleaning them, because sand didn't stick to the material, as clay does, therefore productivity of stump lifting was rather high in compare to average results in Scandinavian countries – 4.4 t_{dry} E_0-h^{-1}) (Laitila et al., 2008). Productivity in the stump lifting in the trials ranged between 4.5 and 6.5 t_{dry} E_0-h^{-1} (Table 5). Average productivity for different species was 2.9 (P), 5.8 (S) and or 6.1 (B) t_{dry} E_0-h^{-1}.

Table 5

Time Consumption and Productivity in a Stump Lifting (cmin t_{dry}^{-1})[1]

Operations / calculations	Plot 1	Plot 2	Plot 3
Craning out	133.40	184.67	190.32
Gripping	103.47	108.48	117.45
Lifting	203.25	350.75	307.52
Splitting/cutting	31.36	70.27	60.64
Cleaning	52.86	66.78	97.32
Craning in	92.66	105.57	117.20
Drop	91.23	97.44	104.71
Scarification	124.97	178.05	148.79
Moving to next stop	113.57	164.46	123.06
Other work time	3.44	2.09	2.04
Total cmin t_{dry}^{-1}	950.21	1,328.56	1,269.05
Time consumption per stump, cmin	2.00	3.50	3.00
T_{dry} E0-h^{-1}	6.31	4.52	4.73
Cost, LVL t_{dry}^{-1} [2]	5.97	8.33	7.96
Cost, LVL ha^{-1} [3]	191.04	266.56	254.72

[1] cmin – centi-minutes, one hundredth part of minute.
[2] The costs are calculated under the assumption of 38 LVL per machine hour.
[3] average stock – 32 t_{dry} ha^{-1}.

Total volume of roundwood assortments produced in the studied stands was 1,131 m^3 under bark or 269 m^3 ha^{-1}. An alternative way of calculating the output of stump volume is from the amount of roundwood, by mass or by volume, according to simple rules of thumb. Actual volume of stump biomass was 698 LVm^3 or 166 LVm^3 ha^{-1} after comminution (Table 6). The estimated biomass of stump from functions was 38 t_{dry} ha^{-1}, whereas actual measured mass was 32 t_{dry} ha^{-1}.

Table 6

Calculations of the Volume of Stumps

Parameter	Units	Value
Volume of stumps calculated accordingly to the volume of roundwood (*20% by volume or 14% by mass*)	m^3	226
Theoretical output of stumps	LVm^3	678
Calculated volume of stump storage	LVm^3	1,194
Volume of transported stumps	LVm^3	1,505
Calculated comminuted volume	LVm^3	631
Actual volume and calculated mass of chips in a lorry	LVm^3	698
	LVm^3 ha^{-1}	166
	t_{dry} ha^{-1}	32

Costs for the stump excavating averaged in 237 LVL ha^{-1}, assuming a machine cost of 38 LVL E_0-h^{-1}, or 7.4 LVL t_{dry}^{-1}. Productivity of the forwarding of stumps ranged between 5.6 and 7.7 t_{dry} E_0-h^{-1} depending on estimation of the amount of impurities in the material. Actual capacity of forwarder load is 10 t_{dry}. In Table 7 wood material has been assumed 70% of total weight, mainly based on old Swedish studies (Jonsson, 1985). To get dry mass, another 50% were subtracted.

Table 7

Time Consumption and Productivity of Forwarding in cmin t_{dry}^{-1}

Operation	cmin t_{dry}^{-1}
Crane out	91.78
Gripping	112.54
Crane in	109.77
Drop	75.20
Arrange (on load)	7.67
Move to next stop	36.70
Reload[1]	15.61
Other work time	3.48
Driving empty	71.46
Driving loaded	82.62
Unloading	294.29
Total forwarded, t_{dry}	16.00
Total, cmin t_{dry}^{-1}	901.13
T_{dry} E0-h^{-1}	6.66
Total cost, LVL t_{dry}^{-1} [2]	3.10

[1] The work element "Reloading" is time to pick up dropped pieces of stumps or roots that has been but slipped off the load carrier.

[2] Costs are calculated on a machine cost of 18 LVL E_0-h^{-1}.

Sump transportation to the terminal and crushing took place right after forwarding, which isn't normal practise in an industrial scale production, but was necessary to estimate the actual amount and quality trends of biofuel produced from stumps. A Specialized lorry equipped with two containers (35 m^3 both) and crane with slash-grapple were used for stump transportation. The average productivity of the stump transport was 3.5 t_{dry} E_0-h^{-1}. Such a low productivity was caused by low load density – it was more than twice looser than load density of wood chips. Stump road transport seems to be one of the key elements, where technical development is needed to increase efficiency. Another solution would be to avoid the stump transport at all by introduction of lighter mobile crushers, which can work directly beside piles of stumps at roadsides. It is also important to have the loaders with as long as possible cranes to be able to make wider piles of stumps at roadsides.

The average productivity of the crushing machine was 10 t_{dry} E_0-h^{-1}. It is at least 4 times less, than in case if the crusher is fed with roundwood. At the same time, the fuel consumption was rather high – about 2 l LVm^{-3} (this number might be overestimated, as it is based on average figures of fuel consumption, not on measurements during the field trials). Considerably low productivity of comminution leads to the conclusion that other type of crushers – with less 'horse powers' and feeding system suitable for irregular material might be more beneficial in the stump comminution.

The prime cost of the biofuel production was estimated using machine hour cost and the productivity based spreadsheet model, which includes the main positions of machine costs and salaries, but doesn't include administrative costs and profit. Total cost of all operations (extraction, forwarding, stump transport to 7 km distance, comminution and chip transport to 50 km distance) were 6.3 LVL LVm^3. Distribution of costs is presented in Figure 1.

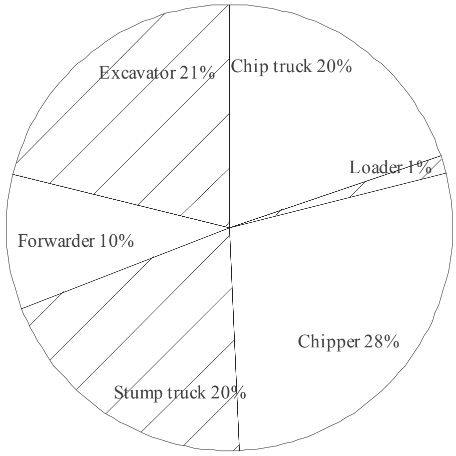

Figure 1. Percentage of prime costs of stump harvesting and chip production.

The evaluation of environmental effects of the stump harvesting within the field study included estimation of C emissions against gains according to the fuel consumption in different operations. Total C emissions to extract and to bring 1 LVm^3 of wood chips made of stumps to the terminal located in 50 km distance is 2.5 kg, in other words – 30 g of C has to be released to produce 1,000 g of C in renewable wood fuel. Figure 2 demonstrates, that the comminution and transport of stumps are very important working elements, where significant savings of emissions, as well as costs, are possible.

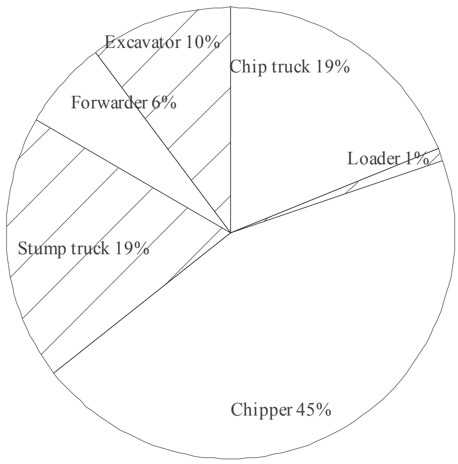

Figure 2. Percentage of C emissions during stump extraction, production and transportation of chips.

Stumps have considerably high gross energy content (5.7 MWh t_{dry}^{-1}), but due to high moisture, net energy content in stump chips is lower, than in chips produced from the slash (Table 8). Analysis of the particle size distribution shows significant share of small size particles (up to 7 mm in diameter), which reduces the quality of biofuel. This might be associated with a large share of sand in chips, because comminution was done directly after extraction and transport due to research needs, in spite of the fact that normal practise would be to leave stumps for 6...12 months in piles to wash out residual soil. The most significant qualitative issue found in the study was high ash content – 8.9% in average. According to literature data, proper management and storage of stumps may reduce ash content to 1.5% (Hakkila, 2003 and Kärhä, 2007).

Table 8

Comparison of Quality of Certain Types of Solid Biofuel (Data about Full Trees from Forest Infrastructure, Slash from Clear-cuts and Willows are Taken from Research Projects Elaborated by LSFRI Silava and Skogforsk (Thor et al., 2006, 2008))

Fractions	Stumps (data from field trials)	Full trees from forest infrastructure[1]	Slash from clearcuts[1]	Willows
Particle size distribution				
45...63 mm, g kg^{-1}	16	10	0	0
16...45 mm, g kg^{-1}	289	517	433	96
8...16 mm, g kg^{-1}	252	243	230	533
3.15...7 mm, g kg^{-1}	281	150	179	246
below 3.15 mm, g kg^{-1}	151	78	157	125
Energy content				
Gross, MWh t^{-1}	5.68	5.42	4.71	5.26
Net, MWh LVm^{-3}	0.71	0.67	0.90	0.51
Other options				
Relative moisture, g kg^{-1}	530	430	320	560
Total carbon, kg t^{-1}	431	414	414	454
Ash content, g kg^{-1}	8.9	0.8	4.2	1.7
Bulk density, kg LVm^3	220	181	218	170

[1] Naturally dried material.

Conclusions

The time studies indicated high productivity in a comparison to average Swedish conditions, which means that this working method is easy to learn, but still more attention has to be paid to splitting of stumps to do in such a way, which simplifies further forwarding and comminution operations.

The most significant difference between plots was found for one work element – lifting. In the plot No. 2 it took more than 3.5 min on average per stump compared to 2 min in the plot No. 1 and 3 min in the plot No. 3. Second plot was situated on a sand ridge where the stumps often had deep roots, which took more time to lift them up. From peat soil (plot No. 3) stumps were easier to lift, but more difficult to 'clean'.

Forwarding has significant potential to increase efficiency, because load sizes during studies were 5.5...9.3 t which is slightly more than a half of the maximum load of the forwarder.

Road transport of stumps is costly and time consuming operation due to the low density of loads and significant time consumption for loading and unloading; therefore, this operation should be eliminated by using lighter mobile crushers suited for irregular biomass and direct transport of chips to end use site.

The prime cost of the stump biofuel (6.3 LVL LVm^3) is comparable to the market price of wood chips, but it should be reduced to left space for profit and additional costs, which arises in 'real world' conditions. Significant reduction may be reached by the optimization of transportation and comminution of stumps.

The field study may a give wrong impression about the quality of chips produced from stumps, because they were comminuted fresh; consequently, moisture and ash (mostly residual soil) content were high, but the net energy content – low.

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FEEDING ENTIRE MALE PIGS *(SUS SCROFA DOMESTICA)* WITH HIGH AMYLOSE BARLEY CULTIVAR (*HORDEUM VULGARE*): IMPACT ON BOAR TAINT AND PERFORMANCE

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Abstract

The effect of dietary supplement with 17% high-amylose barley (*Hordeum vulgare*, HAB) 'Karmosé' on boar taint was studied on 72 crossbred entire male pigs (*Sus scrofa domestica*) Swedish Yorkshire dams x Swedish Landrace sires). All pigs were fed the same commercial diet (12.4 MJ metabolised energy (ME) per kg, digestible crude protein (CP) 13.5%) twice a day until the average live weight (LW) in the pen reached 100 ± 11.8 kg. Then, 32 out of 72 pigs received an HAB diet. Half of these pigs received HAB for 14 days and the other half for 28 days. The pigs were slaughtered at an average LW of 122.3 ± 8.6 kg (age 167.2 ± 7.5 days). The HAB diet did not affect performance, carcass and meat quality characteristics, and puberty status, but reduced plasma skatole levels in the pigs (least squares means, 3.6 vs. 2.0 ng ml^{-1}, $P = 0.037$). However, this diet failed to reduce skatole, indole and androstenone levels in fat ($P > 0.10$). Nevertheless, it is desirable to continue investigation of HAB to optimise the feeding procedure to improve efficiency of HAB effect on fat skatole levels. Additionally, validation of a greater amount of HAB in the diet should be performed.

Key words: high amylose barley starch; pig; boar taint; meat quality.

Introduction

Barley (*Hordeum vulgare*) is commonly used as an ingredient in animal diets in Sweden. Nutritional properties of barley depend on a range of factors including the starch composition of the grains (Svihus et al., 2005). The composition of barley starch is highly variable due to the differences in genetic background and growing conditions. Amylose content, i.e. mainly the linear component of starch, in barley ranges from 0% to 45% (Li et al., 2001), which greatly influences various starch characteristics including digestibility. Generally, starch can be either digested in the small intestine by the digestive enzyme alpha-amylase, or fermented in the colon. Starch with high amylose content is thought to be more resistant to digestion with amylase (Xue et al., 1996). Digestibility of starch in the small intestines of pigs was higher when amylopectin-rich barley with lower amylose content was compared with regular barley (Pettersson and Lindberg, 1997). Recently, K.Anker-Nilssen et al. (2006) compared vitro starch degradation of numerous barley cultivars with different amylase contents, and reported that starch from two high-amylose cultivars 'Sts 2-11' and 'Karmosé' (SW 2904) were degraded more slowly compared to regular and waxy cultivars. The above results suggest that the digestibility of starch declined as the amylose content increased.

Increased hindgut fermentation implies an increased production of gases (e.g., hydrogen, methane, or carbon dioxide) and short-chain fatty acids (SCFA) (Topping and Clifton, 2001), particularly butyrate, which has an inhibiting effect on cell apoptosis in the large intestine of pigs (Mentschel and Claus, 2003). This can in turn affect the availability of the amino acid tryptophan and intestinal synthesis of skatole (3-methylindole), which can otherwise be absorbed through the intestinal walls, and partly accumulated in the adipose tissue.

Accumulation of high skatole concentrations in the adipose tissue is associated with an offensive faecal-like odour in pork products, called boar taint (Bonneau, 1982). Indole, another tryptophan metabolite, is also reported as a boar taint compound but to a much less extent. Besides skatole and indole, androstenone is an important contributor to the boar taint; it is formed during puberty together with testicular hormones (Bonneau, 1982). To reduce the boar taint, a castration of male piglets is performed in many countries. However, other methods than the castration are intensively studied nowadays due to the increasing debate about negative effects of the surgical castration on animal welfare. Consequently, the reduction of boar taint by dietary manipulations is a focus of great interest.

Previous studies have found that some carbohydrates can significantly reduce production of skatole in the large intestine. Dietary supplementation of raw potato starch

(RPS) significantly reduces skatole levels in tissues from the castrated pigs (Claus et al., 2003) and entire male pigs (Zamaratskaia et al., 2005; Chen et al., 2007). The portion of starch which is resistant to digestion in the small intestine and is a substrate for the bacterial fermentation in the large intestine (resistant starch, RS) is thought to be responsible for this reduction in skatole levels (Claus et al., 2003).

Generally, RS can be classified into four main types: type 1 includes physically unreachable starch within whole plant cells; type 2 includes native starch granules that are resistant to amylases action; type 3 includes retrograded amylose, formed after hydrothermal treatment and cooling; and type 4 includes chemically modified starches. The formation of RS type 3 is highly dependent on the amylose content of starch. Gelatinisation of high amylose cereals during pelleting may induce more RS type 3 than would occur from low amylose containing cereals. Thus, the including of high amylose barley (HAB) to a commercial diet may increase the total content of resistant starch in the diet after pelleting. This property makes HAB an appropriate candidate as a skatole-reducing feed additive.

Until now, the effect of the diet with HAB on the sensory characteristics, e.g. odour, of pig carcasses has not been evaluated. The aim of our study was to evaluate whether a new commercial barley cultivar ('Karmosé') with high amount of amylose can reduce skatole and indole levels in entire male pigs or not. In addition, the puberty status and performance of the experimental pigs were evaluated.

Materials and Methods

The care of the pigs and the experimental design of this study were approved by the Local Animal Ethics Committee in Tierp, Sweden.

A total of 72 crossbred entire male pigs (*Sus scrofa domestica*, Swedish Yorkshire dams x Swedish Landrace sires) were included. The sires used were randomly selected from available AI sires. The piglets within litter were randomly assigned to two groups: a control group and a treatment group. All pigs were raised in single-sex pens with 8 pigs in each. The study included two trials with 40 pigs in trial 1 and 32 in trial 2. The experimental period started when the pigs were at a live weight (LW) of 27.8 ± 5.2 kg (mean ± standard deviation) and an age of 69.9 ± 3.0 days. All pigs were fed the same commercial diet (12.4 MJ metabolised energy (ME) per kg, digestible crude protein (CP) 13.5%; Table 1) twice a day according to appetite (semi ad libitum) until the average live weight in the pen reached 100 ± 11.8 kg. Then, 16 out of 40 (trial 1) and 16 out of 32 (trial 2) pigs received a diet containing 17% HAB (Svalöf Weibulls AB, Svalöv, Sweden, 'Karmosé'; Table 1). Half of these pigs received this diet for 14 days and the other half for 28 days. LW of all pigs were recorded at start of the experiment and thereafter biweekly until their final weighing one day prior to a slaughter. Feed consumption was recorded on a daily basis and feed conversion ratio was calculated pen wise. The pigs were slaughtered at an average LW of 122.3 ± 8.6 kg (age 167.2 ± 7.5 days). There slaughter was performed with two occasions per pen, the four heaviest pigs at one occasion and the remaining four pigs 14 days later. All pigs were slaughtered after 2 h of lairage at the abattoir. Fat samples from the neck region were taken at slaughter, transported to the laboratory within 1 h and stored at -20 °C until analyses were done. Blood samples were taken one day prior to the slaughter by jugular venipuncture and collected into vacutainer tubes with heparin. Plasma were separated by centrifugation at 2000 x g for 15 min at 4 °C and stored at – 80 °C prior to analysis.

Skatole and indole in plasma were analysed as described by G.Zamaratskaia et al. (2004). Skatole, indole and androstenone in fat were measured as described by G.Chen et al. (2007). Estrone sulphate (E1S) in plasma was measured using a commercial radioimmunoassay (RIA) kit from the DSL® (DSL-5400, Cherwell Innovation Centre, Upper Heyford, UK).

Reproductive organ measurements were performed at slaughter. Testes and bulbourethral (Cowper's) glands were removed and dissected from extraneous tissue. The length of both bulbourethral glands was measured to record the average length, and testes were weighed as pairs.

Carcass characteristics were evaluated in all pigs. Before cooling, the carcass weight was recorded and lean meat content was determined with the Hennessy Grading Probe. Ham from the right carcass half was weighed with skin and fat, defatted and reweighed to determine meat and bone. The proportion of meat and bone in ham was used for the estimation of lean meat percentage in the whole carcass (lean meat percentage = 0.729 × % meat and bone in ham; I. Hansson, personal communication, 2005).

In the first trial, technological meat quality was measured on samples of *M. longissimus dorsi* (LD) and *M. biceps femoris* (BF) approximately 24 h after slaughter. Ultimate pH was measured, using a portable pH meter (Knick, Berlin, Germany) equipped with a combination gel electrode (SE104, Knick, Berlin, Germany) calibrated to chilling room temperature. Internal reflectance (FOP) was measured, using a fibre optic probe (FOP, 900 nm; TBL Fibre Optics Group Ltd., Leeds, UK).

Table 1

Ingredient composition and calculated nutrient content of the control diet and the diet with high amylose barley (HAB)

Item	Control	HAB
Ingredients (g kg^{-1})		
Rye wheat	264	-
Wheat	150	260
Oats	150	-
Middlings	150	180
Peas	150	-
Barley	75	121
Barley, high amylose	-	170
Rye	-	100
Rapeseed meal	28	120
Malt sprout pellets	-	13
Soybean meal	7.5	-
Calcium carbonate	13	-
Limestone	-	14
Monocalcium phosphate	5.0	4.0
Sodium Chloride	2.8	3.0
Blended fat (Akofeed)	-	10
Vitamin and mineral premix	4.7	5
Calculated nutrient content (g kg^{-1})		
Fat	30	39
Crude protein	135	146
Lysine	7.1	7.0
Methionine	2.2	2.2
Threonine	4.0	4.0
Metabolizable energy (MJ)	12.4	12.4

Data were analysed with the Statistical Analysis System, version 9.1 (SAS Institute, Cary, NC, USA). The final model in procedure mixed included treatment (control and HAB) and trial (trial 1 and 2) as fixed factors, and litter and pen within trial as random factors. Treatment HAB included all the pigs fed HAB because the duration of feeding HAB (14 vs. 28 days) did not significantly affect any of the investigated variables ($p > 0.10$). The number of degrees of freedom was estimated with the Satterthwaite method. The levels of E1S, skatole and indole in plasma and androstenone, skatole and indole in fat were log-transformed to normalize the distribution. Back-transformed least-squares means (LS means) and 95% confidence interval were used in Results and Discussion section. A 95% confidence interval was obtained by calculating on the transformed scale and then transforming the endpoints of the interval back. The intervals are not symmetric due to asymmetric distribution of the values on the original scale after back-transformation.

Results and Discussion

Skatole levels were significantly reduced in plasma in the pigs fed the HAB diet ($p = 0.037$; Table 2). The levels of skatole in fat were numerically lower in the pigs fed HAB but not statistically significant ($p = 0.169$; Table 2).

Table 2

Concentrations of indolic compounds and steroids in fat and plasma, and testis weight and bulbourethral glands length

Item	Control	HAB	P-value
Skatole in plasma (ng ml^{-1})	3.6 (2.4-5.5)	2.0 (1.3-3.2)	0.037
Indole in plasma (ng ml^{-1})	1.0 (0.7-1.5)	0.9 (0.6-1.5)	0.794
Estrone sulphate in plasma (ng ml^{-1})	5.3 (2.5-11.1)	4.4 (1.93-9.87)	0.684
Skatole in fat (µg g^{-1})	0.08 (0.05-0.11)	0.06 (0.04-0.08)	0.169
Indole in fat (µg g^{-1})	0.05 (0.03-0.06)	0.04 (0.03-0.06)	0.705
Androstenone in fat (µg g^{-1})	1.3 (1.0–1.8)	1.0 (0.7-1.4)	0.231
Testis weight, pairs (g)	582 ± 20 n = 40	615 ± 25 n = 21	0.239
Bulbourethral gland length(cm)	13.4 ± 0.3 n = 38	12.8 ± 0.4 n = 23	0.253

Skatole, indole, E1S and androstenone levels are presented as least squares means and 95% confidence interval after back-transformation to the original scale. Testis weight and bulbourethral gland length are presented as least squares means and standard error. Number of plasma and fat samples in control group is 40 (plasma) or 39 (fat), in group with high amylose barley (HAB) is 30.

The obtained result is surprising because the changes in skatole concentrations in plasma are usually paralleled by the changes in fat. The inconsistency between the effect of HAB diet on skatole levels in plasma and fat might be due to overall low skatole levels in fat in the present study. Only 7 out of 69 pigs expressed fat skatole levels above 0.2 (µg g^{-1}), the threshold level used to detect tainted carcasses in Sweden; 5 of those 7 pigs were from the control group, and 2 from the HAB group (data not shown). Similarly, M.Øverland et al. (2007) demonstrated that dietary supplements of formic and benzoic acids resulted in significantly lower skatole levels in plasma, but not in fat. However, fat being part of the edible carcass and heavily used in pork by- products (e.g. sausages, pate, ready to eat dishes) is the main tissue of interest in the discussion on boar taint. There have been numerous attempts to modify skatole levels in fat by dietary means. Addition of dietary sources of carbohydrates, such as sugar beet pulp, chicory roots or raw potato starch, reduced skatole levels (Jensen et al., 1995; Claus et al., 2003; Zamaratskaia et al., 2005; Hansen et al., 2006; Chen et al., 2007). Although the mechanism(s) by which dietary carbohydrates reduce skatole accumulation in fat is not fully understood, it is believed that their fermentation products in the large intestine decrease the availability of tryptophan – the precursor of skatole (Claus et al., 2003). However, this theory cannot explain the selective reduction of skatole accumulation without reduction of another tryptophan metabolite – indole (Chen et al., 2007). A new barley cultivar ('Himalaya 292') containing high amylose fed to pigs resulted in an increase in the large-bowel fermentation and short-chain fatty acid (SCFA) concentrations (Bird et al., 2004). Because increasing fermentation might result in skatole reduction, this cultivar may be potentially used as a skatole-reducing means. However, the increase in butyrate formation, which is believed to be the major component affecting tryptophan availability (Claus et al., 2003), was mainly observed in caecum and proximal part of the colon (Bird et al., 2004), a site of indole synthesis (Claus et al., 1993; Jensen and Jensen, 1994; Knarreborg et al., 2002). The butyrate concentrations in distal part of the colon, the major site of skatole synthesis (Knarreborg et al., 2002), was not altered by the diet (Bird et al., 2004). If the same holds true for HAB used in the present study, a reduction in indole, rather than in skatole, would be expected. The opposite was true (Table 2). This suggests that the decrease in plasma skatole in the present study is unlikely due to increased butyrate formation.

As discussed by G.Zamaratskaia et al. (2005), both the carbohydrate type and the amount of carbohydrate affect skatole synthesis in the large intestine. D.Lösel and R.Claus (2003) demonstrated that the magnitude of skatole reduction in fat due to RPS was dose-dependent. Likewise, skatole response to HAB may not be noticeable until a certain intake level of HAB is reached. In the present study, 17% of HAB in diet was used. Probably, a level of HAB higher than 17% is needed to reduce skatole levels also in fat. Furthermore, the conditions employed in the pelleting process in our study were probably not optimal for the formations of RS. It is known that hydrothermal treatment, cooling and storage lead to retrogradation of starch and the formation of RS type 3. Increased amylose content in barley starch is associated with increased capacity of retrogradation (Silverio et al., 2000). Alterations in temperature and moisture content in the system could modify chemical and physical properties of the diet giving a higher yield of RS.

In the study using HAB 'Himalaya 292' no negative effect of diet on growth was found (Bird et al., 2004). Similarly, growth in our study did not differ between control pigs and pigs fed HAB (Table 3).

Table 3

Performance and carcass quality for entire male pigs fed control diet or a diet with high amylose barley (HAB). Data are presented as least squares means and standard error

Item	Control n = 40	HAB n = 32	p-value
Initial weight (kg)	27.6 ± 1.0	28.6 ± 1.1	0.478
Final weight (kg)	121.7 ± 1.4	122.8 ± 1.6	0.590
Daily weight gain (g)	964 ± 15	961 ± 16	0.847
Feed conversion ratio	2.90 ± 0.16	2.87 ± 0.17	0.656
Carcass weight (kg)	90.8 ± 1.1	92.1 ± 1.2	0.456
Dressing percentage	74.6 ± 0.3	74.9 ± 0.3	0.386
Estimated lean meat content (%)	60.2 ± 0.4	60.3 ± 0.4	0.845
pH_{LD}*	5.45 ± 0.02	5.54 ± 0.03	0.106
pH_{BF}*	5.53 ± 0.03	5.58 ± 0.03	0.366
FOP_{LD}*	35.0 ± 1.4	31.0 ± 1.7	0.157
FOP_{BF}*	38.5 ± 1.1	38.9 ± 1.3	0.849

Only first trial; Number of samples in control group is 23, in HAB group is 16.
*FOP; fibre optic probe

Puberty status was not affected by dietary composition, as demonstrated by similar levels of E1S, testes weight and bulbourethral gland length in both groups (Table 2). No differences were observed in daily weight gain, carcass and meat quality among the pigs fed the different diets (Table 3). Furthermore, diet did not affect the meat quality and carcass characteristics.

It should be emphasised that our study had several limitations. Firstly, the methodological concept of the study suffered from the fact that the two diets were apparently not composed under the same conditions (i.e. exchange of common barley versus high amylose barley at constant dietary composition) and the composition of the control and the experimental diets differed in many aspects (Table 1). Secondly, amylose contents of control and test barley diet were not measured to confirm that a claim for higher amylose content holds true. Moreover, we have no evidence about the formation of resistant starch during the pelleting process employed.

Further research is needed to increase efficiency of HAB effect on fat skatole levels. Additionally, HAB may have much broader implications than just manipulating boar taint level, considering its potential positive effect on animal health such as plasma cholesterol reduction (Bird et al., 2004).

Conclusions

The present study indicated that diet with HAB may have a potential to reduce plasma skatole levels in entire male pigs. However, this diet was not associated with an overall reduction of boar taint in pig's carcasses because it failed to significantly reduce skatole, indole and androstenone levels in fat. Puberty status, performance, carcass and meat quality characteristics were not affected by the HAB diet. Further research is needed to optimise the pelleting process to improve efficiency of HAB effect on fat skatole levels. Additionally, validation of a greater amount of HAB in the diet should be performed.

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EFFECTS OF ACEPROMAZINE MALEATE ON INTRAOCULAR PRESSURE AND PUPIL DIAMETER IN DOG'S EYE

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Abstract

The research was performed at the Faculty of Veterinary Medicine of the Latvia University of Agriculture. At the moment the research in veterinary anesthesia is in its infancy stage. The aim of this study was to determine the effects of the acepromazine maleate on intraocular pressure (IOP) and horizontal pupil diameter (HPD) in a dog's eye. Ten adult dogs of different age, breed and sex were examined clinically and ophthalmologically. All animals were clinically and ophthalmologically healthy. Animals received acepromazine intramuscularly. IOP and HPD were measured every 5 minutes for the total period of 60 minutes.

It was established that the acepromazine maleate intramuscular injection causes an IOP decrease in booth eyes. A significant IOP decrease was observed from 35 till 60 minutes after the acepromazine injection. The pupil contruction was observed 5 minutes after the treatment and continued to contruct till the end of the research.

As acepromazine maleate causes a significant decrease of intraocular pressure, it is not contraindicated to be used in the case of corneal trauma, perforation, glaucoma and corneal ulcers.

Key words: dog, eyes, acepromazine maleate, intraocular pressure, horizontal pupil diameter.

Introduction

It is known that the intraocular pressure (IOP) is controlled and regulated by the central nervous system (CNS), that maintains the balance between the aqueous humor production and outflow (Brunson, 1980). Factors like external mechanical pressure, scleral rigidity and intraocular changes, the same as some drugs that influence the production of aqueous humor and outflow, do influence IOP (Cunningham and Barry, 1986). In the case of corneal lesions it is important not to use drugs that can cause an IOP increase, thereby causing a corneal rupture, even iris prolapse (Brooks, 1990; Chmielewski et al., 1997).

Acepromazine maleate is a phenothiazine derivate that is commonly used in small animal premedication to calm the animal and to gain a faster and deeper animal sleep during the narcosis. Acepromazine maleate blocks α – adrenoreceptors in the walls of blood-vessels which causes the dilatation of blood vessels and decreases arterial blood pressure (Muir et al., 1975; Thurmon et al., 1996).

Considering the fact that in literature only few data are found dealing with the effects of acepromazine maleate on the intraocular pressure and pupil diameter in dogs (*canis familiaris*) and animals generally, this research is very actual.

The aim of this study was to determine the effects of acepromazine maleate on the intraocular pressure and pupil diameter in dogs.

Materials and Methods

All animals were out-patients examined at the Preclinical Institute of the Faculty of Veterinary Medicine of the Latvia University of Agriculture in 2008. This study was accepted by the Animal Protection and Ethical Commission of the Latvian State Food and Veterinary Service. In all cases an informed consent was obtained from the pet owners for the study.

All animals included in this study were examined clinically and ophthalmologically. Examination included slit lamp-biomicroscopy, direct ophthalmoscopy and monocular indirect ophthalmoscopy with Pan Optic® (Welch Allyn, USA). The information on the animal breed, age and sex was noted. In this investigation we used ten healthy dogs of different age, breed and sex, all patients were determined to be free of ocular lesions that could alter IOP from normal.

To ascertain the effect of acepromazine maleate on intraocular pressure and pupil diameter in the dog's eye, we injected 1% acepromazine maleate intramuscularly in the dose of 0.1 mg kg^{-1}. The dose of acepromazine maleate was recommended by researchers as suitable for the premedication in dogs (Booth, 1982).

All tonometric measurements were performed by the same person with the rapid and minimal stress - inducing method of rebound tonometry with a tonometer (TonoVet®, Tiolat Ltd. Finland) using values that achieve less than 5% standard deviation. For this tonometer it is not necessary to use topical anaesthesia. Some authors have noticed that the corneal endothelial and systemic toxicity could occur with a frequent use of topical anaesthesia (Judge et al, 1997; McGee and Fraunfelder, 2007).

The horizontal pupil diameter was measured with Jameson callipers (USA) under fixed day light conditions at the same time of the day. The IOP and HPD were measured every five minutes, for a total period of 60 minutes.

To process the data of this research we used statistical data program MS Excel (Microsoft® Office Excel 2003). To determine the effect of intramuscular acepromazine maleate, arithmetic mean values (X) and standard deviation (SD) of the IOP and HPD were calculated for each eye. Changes in IOP and HPD between the right and left eye and between the pre-treatment and treatment period in the time period were evaluated using a paired two-sample T-test. P - values less than 0.05 were considered to be statistically significant (Arhipova and Bāliņa, 2006).

Results and Discussion

At first we estimated the initial position of the animals' eye – IOP before the acepromazine maleate injection. It was establish that there was no significant difference between IOP in the right and left eye ($p > 0.05$), that was within a range of 14 ± 2.90 mmHg. Generally these results did not differ from the other author's data where normal IOP ranged between 16.7 ± 4 mmHg and 18.7 ± 5.5 mmHg (Miller et al., 1993; Gellat and MacKey, 1998).

The influence of the acepromazine maleate is shown in Figure 1. First of all, it should be pointed out that the acepromazine maleate injection caused irregular IOP changes in both eyes: in the first five minutes IOP decreased from 14 ± 2.90 mmHg to 12 ± 2.97 mmHg, in next five minutes it increased almost to the pre-treatment level, in 15 minutes of treatment IOP repeatedly decreased, gaining IOP in the right eye 11.5 ± 2.99 mmHg, and 10.6 ± 2.98 mmHg in the left eye ($p < 0.05$). Thus the IOP level remained the same for 20 minutes after the treatment. Twenty five minutes after the injection IOP again significantly increased up to 13.2 ± 3.15 mmHg in both eyes. IOP significantly decreased 30 minutes after the treatment and 35 minutes post-treatment it gained the lowest IOP level 10.2 ± 2.28 mmHg ($p < 0.05$). During the time period from 40 to 50 minutes after the treatment IOP increased a little but did not reached the initial IOP level (Figure 1.); further until the end of the investigation IOP decreased to 9.41 ± 1.71 mmHg ($p < 0.05$). That demonstrates a significant decrease of intraocular pressure.

Therefore, we can consider that the acepromazine maleate intramuscular injection at the dose of 0.1 mg kg^{-1} on the one hand cause fluctuating and irregular IOP changes, on the other - the total tendency is a significant IOP decrease, especially 35 - 60 minutes after the treatment. Unfortunately, we did not find similar data in the literature, to compare with this research. Literature presents data on the influence of 1% topical acepromazine maleate on IOP in monkeys. It was reported that in monkeys without changes in functional parameters of the eye acepromazine did not change IOP but in animals with glaucoma IOP decrease was observed one, four, eight and even 32 hours after topical the acepromazine administration (Hayreh et al., 1991). In dogs after the intramuscular administration of the acepromazine maleate and hydromorphone no significant differences in IOP were recorded 10 and 25 minutes after the treatment (Stephan et al., 2003). Apparently, the hydromorphone has somehow blocked the acepromazine maleate effect on IOP.

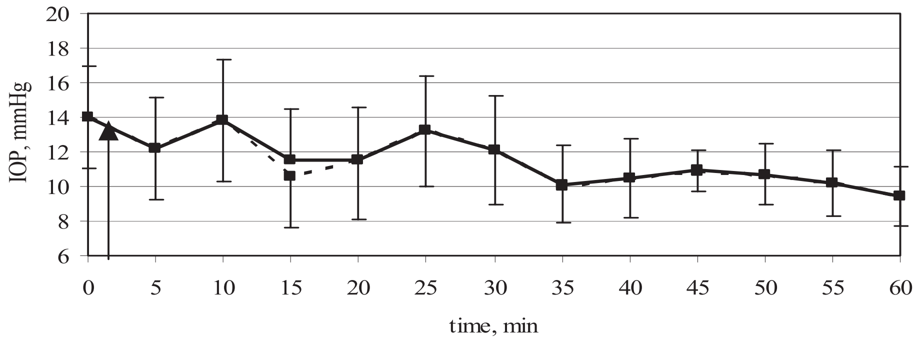

Figure. 1. Effects of acepromazine maleate intramuscular injection on intraocular pressure (mean values) in dog's eye : –– right eye; ····· left eye; ↑ –time of injection.

The influence of the acepromazine maleate on the horizontal pupil diameter (HPD) is shown in Figure 2.

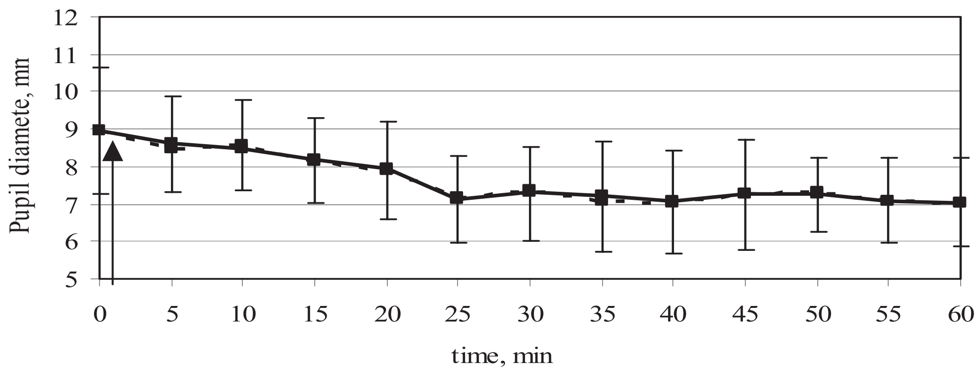

Figure. 2. Effects of the acepromazine maleate intramuscular injection on the pupil diameter (mean values) in a dog's eye: –– right eye; ····· left eye; ↑ –time of injection.

HPD before the acepromazine maleate injection was on average 8.95 ± 1.67 mm in the right and left eye.

Already five minutes after the acepromazine maleate injection, the horizontal pupil diameter started to decrease gaining 8.6 ± 1.37 mm in the right eye and 8.5 ± 1.29 mm in the left eye. The pupil diameter continued to decrease regularly up to 20 minutes after the treatment, then during next five minutes it decreased to 7.13 ± 1.10 mm in the right eye and 7.18 ± 1.16 mm in the left eye ($p < 0.05$). Starting from the 25th minute the pupil diameter was more or less stable at the level of 7.05 ± 1.16 mm (Figure 2.). During the entire research period the pupil diameter was practically equal in both eyes.

In the above mentioned research where the acepromazine maleate was administrated in dogs in the combination with the hydromorphone, the pupil contruction was also established. Significant changes were observed in 16 out of 17 dogs, 25 minutes after the intramuscular injection (Stephan et al., 2003) the same as we observed.

The conclusion may be drawn that the acepromazine maleate intramuscular injection causes a significant pupil contruction, especially 25 minutes after injection.

Conclusions

1. The acepromazine maleate intramuscular injection at a dose of 0.1mg kg^{-1}, on the one hand causes fluctuating, irregular IOP changes in the dog's both eyes, on the other – the total tendency is a significant IOP decrease, especially 35 - 60 minutes after the injection.
2. In dogs, five minutes after the acepromazine maleate injection the horizontal pupil diameter decreased. The lowest HPD level was obtained 25 minutes after the injection.
3. As the acepromazine maleate decreases the intraocular pressure, its administration is not contraindicated to use the cases of corneal trauma, perforation, glaucoma and corneal ulcers.

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HELICOBACTERS AND MORFOLOGICAL CHANGES IN THE GASTRIC MUCOSA OF DOMESTIC DOGS (*CANIS FAMILIARIS*)

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Abstract

This study was performed to detect morphological changes of the gastric mucosa according to the prevalence of helicobacters in the gastric mucosa of domestic dogs (*Canis familiaris*) from the Small animal clinic of Faculty of Veterinary Medicine, Latvia within 2008 year period. Mucosal samples were taken from several places of cardiac, fundic and pyloric gland region of the stomach to detect helicobacters with light histological examination. Seventeen dogs of eighteen sampled animals showed presence of tightly spiraled helicobacters. Compared to gastric regions our study showed significantly higher prevalence of helicobacters in the cardiac and fundic gland region than in the less effected pyloric gland region of the stomach. Histological examination also showed the depth of location of helicobacters in gastric pits and deeper glandular epithelium of the gastric mucosa in different regions of the stomach. In the pyloric gland region helicobacters are located deeper in the gastric pits and glandular epithelium than in the gastric mucosa of cardiac and fundic gland region Morphological changes of gastric mucosa was divided into 4 groups: 1) mucosa without morphological changes, 2) mucosal hyperemia, 3) mucosal erosions, and 4) mucosal polips. Morphological changes especially mucosal polips are significantly more in the pyloric gland region than in the cardiac and fundic gland region. The amount of morphological changes in the helicobacter positive and negative samples were not significantly different in the cardiac and fundic gland region, but in the pyloric gland region morphological changes of the gastric mucosa are significantly more in the helicobacter positive samples than in the helicobacter negative samples.

Key words: helicobacters, dogs, gastric, hyperemia, erosions, polips.

Introduction

Since the first isolation of *Helicobacter pylori* from humans with gastritis and gastric ulcer in 1984 (Marshall and Warrens, 1984), helicobacters have been detected in several animal species, such as dogs, cats, pigs, cheetahs, ferrets, polar bears, sea lions, monkeys, and rodents (Bronson et al., 1991; Lee et al., 1992; Eaton et al., 1993, 1996; Fox and Lee, 1997; Jalava et al., 1997; Hanninen et al., 1998; Neiger et al., 1998; Hwang et al., 2002; Oxley et al., 2004). Our previous study shows that helicobacters are detected also in the gastric mucosa of feral raccoon dogs (Bērziņa and Birģele, 2006).

Research about helicobacters and their influence on morphological and functional status of gastrointestinal tract is still actual. Literature shows that *Helicobacter* species are mostly microaerophillic, gram-negative, spiral-shaped bacteria with multiple terminal flagellae. Due to the spiral-shape and flagellae helicobacters can move and reach the gastric epithelium. They produce enzymes to dissolve mucus and to damage membranes of the epithelial cells. Helicobacters also have high-level urease activity. Urease divides urea into the carbon dioxide and ammonium and neutralizes gastric acid. Due to the urease activity helicobacters support neutral environment around them and protect themselves form a harmful effect of hydrochloric acid. (Eaton et al., 1996; Happonen et al., 1996).

Partly helicobacters may form a part of the host`s indigenous gastrointestinal microflora (Simmons et al., 2000). However some helicobacter species have been formally recognized and have often been associated with condition of gastric disease including different types of mucosal inflammation, mucosal erosions and ulcers and even neoplasms such as mucosal polips of the stomach (Fox et al., 1995; Lehmann et al., 2000; Oberhuber and Stolte, 2000; Solnick and Schauer, 2001).

Up to now many diagnostic methods have been developed to detect *Helicobacter pylori* infection: some invasive, such as rapid urease test, brush cytology, histology, electronmicroscopy, culture, polymerase chain reaction, and others non-invasive, such as serology, urea breath test (Happonen et al., 1996) and recently *H. pylori* antigen is also determined in feces (Happonen et al., 1998).

One of the most frequently used diagnostic methods of helicobacter detection is histological examination. It is reported that appearance of helicobacters and histopathological changes in the mucosa of stomach can be detected with several histological staining methods, such as hematoxylin and eosin, Giemsa-Wright and Warthin-Starry stains (Hermanns et al., 1995; Happonen et al., 1996; Neiger et at., 1998). Histological examination also allows evaluation of the mucosal status and shows high sensitivity and specificity. This is also pointed out in other studies (Megraud, 1996); however, comprised to urease test and brush cytology it is more expensive and labor intensive (Chu et al., 1997; Bērziņa and Birģele, 2006).

The aim of our study was to detect morphological changes of the gastric mucosa according to the prevalence of helicobacters in the gastric mucosa of domestic dogs (*Canis familiaris*).

The main tasks of this work:

1) to detect helicobacters in the mucosal samples of the stomach with histological examination;
2) to establish the prevalence and location depth of helicobacters in the gastric mucosa of the cardiac, fundic, and pyloric gland region;
3) to evaluate morphological changes of the gastric mucosa in the cardiac, fundic and pyloric gland region.

Materials and Methods

Mucosal samples of the stomach were taken from eighteen domestic dogs immediately after the death of the animal (under agreement of the owner) in the Small animal clinic of Faculty of Veterinary Medicine, Latvia within 2008 year period.

Mucosal samples were obtained from strictly determined seventeen sites of the stomach: four sites of cardiac gland region, eight sites of fundic gland region, and five sites of pyloric gland region. In total, during this study there were examined 306 gastric mucosal samples of domestic dogs for detection of helicobacters.

Gastric mucosal samples for histological examination were fixed in 10% neutral buffered formalin, routinely processed in Tissue Auto processor *Tissue-Tek II* (Netherlands), embedded in paraffin, sectioned in 4 μm thick sections with microtome *SLEE Mainz Cut 4055* and stained with *Diff–Quick* method (Happonen et al., 1996). Helicobacters were detected at the gastric mucosa with light microscope *Leica DM5000B* at 1000 magnification.

Histological examination also included evaluation of the location depth of helicobacters in the gastric pits and deeper glandular epithelium with the *Image-Pro Plus* program for obtaining, analyzing and measurement of microscopic images.

The morphological changes in the helicobacter positive and helicobacter negative samples of the gastric mucosa were conditionally divided into 4 groups as follows: 1) gastric mucosa without morphological changes, 2) hyperemia of the gastric mucosa, 3) erosions of the gastric mucosa and 4) polips of the gastric mucosa (Lehmann et al., 2000; Oberhuber and Stolte, 2000).

Statistical analyses of results were performed by SPSS 11.5 program. Occurrence of helicobacters and morphological changes in the gastric mucosa of the cardiac, fundic and pyloric gland regions were analyzed with *Chi-Square test* of independence (Paura and Arhipova, 2002; Arhipova and Bāliņa, 2003).

Results and Discussion

Seventeen of eighteen examined domestic dogs showed helicobacter positive results by histological examination. Spiral-shaped bacteria were observed in 236 (77.1%) of examined 306 samples of the gastric mucosa by the histological examination. The results of the histological examination for detection of helicobacters in the gastric mucosa of the cardiac, fundic and pyloric gland regions are demonstrated in Figure 1.

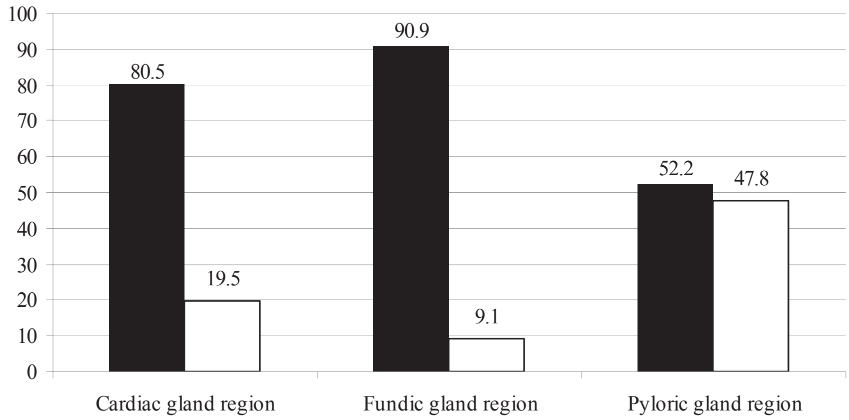

Figure 1. Occurrence of helicobacters in the gastric mucosa of the cardiac, fundic and pyloric gland region (■ Helicobacter positive samples, ❑ Helicobacter negative samples).

Comprised to the helicobacter occurrence in the gastric mucosa of different parts of the stomach, most effected are the fundic gland region with 90.9% of helicobacter positive samples and the cardiac gland region with 80.5% of helicobacter positive samples. In general this is approximately half more than the amount of mucosal samples from the pyloric gland region with 52.2% of helicobacter positive samples ($p<0.05$). These results are quite close to other studies of *Helicobacter* like microorganisms in domestic dogs where the highest detection rate of helicobacters has been found in the fundic gland region of the stomach (Happonen et al., 1996). Our study shows that detection rates of helicobacters in domestic dogs are different in comparison with the prevalence of helicobacters in the gastric mucosa of feral raccoon dogs. There were no significant differences ($p>0.05$) in occurrence of helicobacters in the samples of different gastric parts in the feral raccoon dogs (Bērziņa and Birģele, 2006).

Concerning the location depth of helicobacters and morphological changes in the gastric mucosa of different gland regions of the stomach, firstly, the results of cardiac gland region are discussed.

Helicobacters are located up to 170 µm of depth in the gastric pits and up to 350 µm of depth in the deeper glandular epithelium of the cardiac gland region. Morphological status of gastric mucosa in the cardiac gland region is demonstrated in Figure 2.

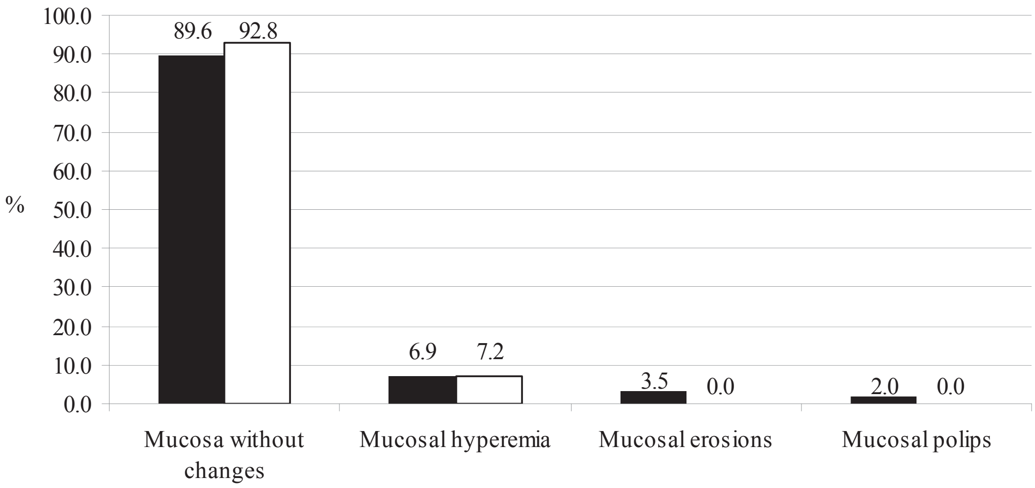

Figure 2. Morphological changes of gastric mucosa in the cardiac gland region
(■ Helicobacter positive samples, ❑ Helicobacter negative samples).

In the cardiac gland region the gastric mucosa was not morphologically changed in the most of cases in the both helicobacter positive – 89.6% and helicobacter negative samples – 92.8% ($p<0.05$). Hyperemia of the gastric mucosa was in the less number of samples – 6.9% of helicobacter positive and 7.2% of the helicobacter negative samples. Mucosal erosions were only in the 3.5% of the helicobacter positive samples and mucosal polips were detected only in the 2.0% of the helicobacter positive samples. It has to be emphasized that there were no mucosal erosions and mucosal polips in the helicobacter negative samples from the cardiac gland region.

In the fundic gland region helicobacter are located equally with cardiac gland region up to 170 µm of depth in the gastric pits and up to 350 µm of depth in the deeper glandular epithelium. Morphological changes in the gastric mucosa of the fundic gland region are demonstrated in Figure 3.

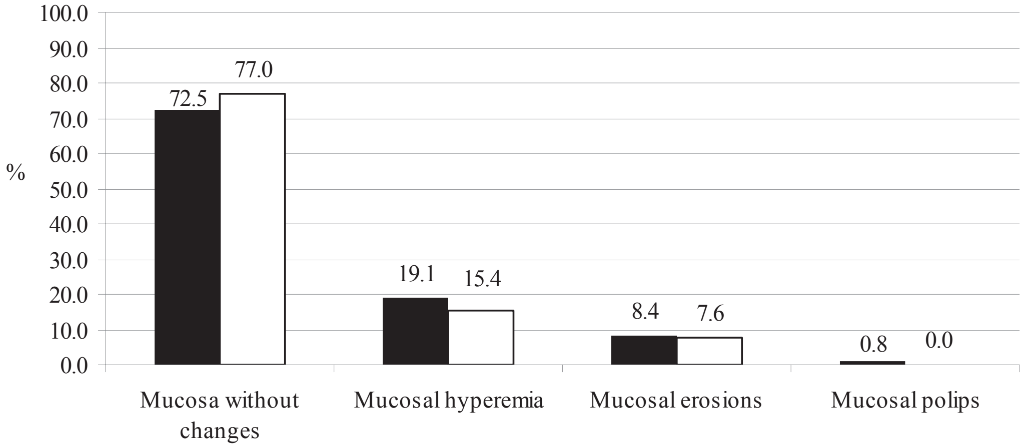

Figure 3. Morphological changes of gastric mucosa in the fundic gland region (■ Helicobacter positive samples, ❑ Helicobacter negative samples).

Similarly with the cardiac gland region also in the fundic gland region there are no morphological changes in the most ($p<0.05$) of the helicobacter positive samples (72.5%) and helicobacter negative samples (77.0%). Mucosal hyperemia of the stomach was only in the 19.1% of the helicobacter positive samples and 15.4% of the helicobacter negative samples. Mucosal erosions of the stomach were little less – only in the 8.4% of helicobacter positive samples and 7.6% of the helicobacter negative samples. Mucosal polips of the stomach were only in the 0.8% of the helicobacter positive samples, but in the helicobacter negative samples there were no mucosal polips in the gastric mucosa of fundic gland region.

Consequently, the morphological examination shows that the gastric mucosa without changes are little more common in the cardiac gland region than in the fundic gland region. Furthermore there are no big differences of these parameters in the helicobacter positive and helicobacter negative samples. In general macroscopic changes like mucosal hyperemia, erosions and polips are little more common in the fundic gland region than in the cardiac gland region.

Regarding the pyloric gland region of the stomach helicobacters are located up to 350 μm of depth in the gastric pits and up to 760 μm of depth in the deeper glandular epithelium of the gastric mucosa. So helicobacters are deeper in both gastric pits and glandular epithelium in the pyloric gland region than in the cardiac and fundic gland regions.

Morphological changes of the gastric mucosa in the pyloric gland region are demonstrated in Figure 4.

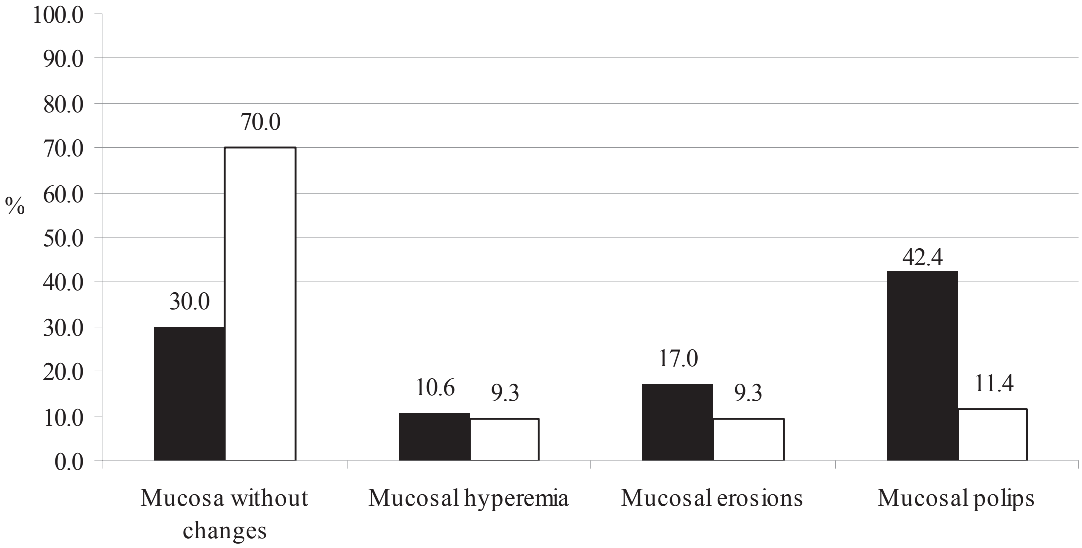

Figure 4. Morphological changes of gastric mucosa in the pyloric gland region (■ Helicobacter positive samples, ❑ Helicobacter negative samples).

In the pyloric gland region superiority of the helicobacter negative samples (70.0%) have no morphological changes of the gastric mucosa. However, helicobacter negative samples have less morphological changes – only 30.0% of cases ($p<0.05$). Helicobacter positive samples in 42.4% of cases have mucosal polips. It is significantly more than the number of samples with mucosal polips in the cardiac and fundic gland region, where mucosal polips are only in the 2.0% and 0.8% of the helicobacter positive samples respectively. However, the helicobacter negative samples of the pyloric gland region have only 11.4% of the cases with mucosal polips ($p<0.05$). Mucosal erosions and hyperemia are only in the 17.0% and 10.6%.of helicobacter positive samples respectively. This is little more than the number of samples with mucosal hyperemia and erosions of helicobacter negative samples – 9.3% of cases.

Thereby, in the pyloric gland region morphological changes especially polips of the gastric mucosa are significantly more in the helicobacter positive samples than in the helicobacter negative samples.

This study is going to be continued about quantitative histological changes of gastric mucosa according to the location and amount of helicobacters in the gastric mucosa of domestic dogs.

Conclusions

1. The amount of heliocbacters in the gastric mucosa of domestic dogs (*Canis familiaris*) is almost half more in the cardiac and fundic gland region than in the pyloric gland region.
2. In the pyloric gland region helicobacters are located deeper in the gastric pits and glandular epithelium than in the gastric mucosa of cardiac and the fundic gland region.
3. Morphological changes especially mucosal polips are significantly more in the pyloric gland region than in the cardiac and fundic gland regions.
4. In the cardiac and fundic gland regions number of morphological changes in the helicobacter positive and negative samples were not significantly different. But in the pyloric gland region morphological changes of the gastric mucosa are significantly more in the helicobacter positive samples than in the helicobacter negative samples.

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THEORETICAL AND ECONOMIC ASPECTS OF THE REFORMED COMMON AGRICULTURAL POLICY OF EUROPEAN UNION

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Abstract

Agricultural and food industries constitute a significant part in the economy of European Union (EU), thus providing 15 million jobs and creating 4.4% of the gross domestic product. EU Common Agricultural Policy (CAP) is adopted in all 27 member states and a significant part of budget is allocated to implement it - in 2008 it was 58.8 billion EUR or 44.5% of the total budget. This research performed the analysis of the theoretical, historical and economic aspects of the CAP. Eight main stages of the reform can be distinguished in the CAP development. They have their own characteristics, goals and main support tools. The process of the CAP reform has not been finished yet.

Key words: common agricultural policy, development, goals.

Introduction

EU CAP provided the framework for the measures of the agricultural and rural development of Member States. A wide range of scientists is studying the EU CAP and the tendencies of its development nowadays. In Latvia these aspects have been researched by E.Grinovskis (1996), G.Libermanis (2006), E.Deksnis (1998), D.Saktiņa (2000), G.Salputra and A.Miglavs (2007), D.Jasjko, A.Miglavs, D.Feldmans (2004), I.Pilvere (2007), R.Karnīte (2006), D.Auers (2007), Saktiņa D., Meyers W.H. (2005) and others. In foreign countries research has been performed by J.A.Usher (1988), M.Tracy (1996), J.Reiljan and D.Tamm (2008), J.P.Chauffour (2008), F.Tongeren (2008), K.Ash (2005) and others.

The leading international organizations have also gone into CAP research – Organization of Economic Cooperation and Development (OECD) (2005), United Nations Food and Agriculture Organization (FAO) (2008) and the World Bank (WB) (2008). These studies reveal the topical CAP issues of the respective period, but the common regularities in its historical development have been little researched.

It determined the **goal** of this research – to analyze the theoretical aspects and the historical development of CAP reforms. A research **hypothesis** was put forward: in more than 50 years of its existence CAP has been reformed several times and has developed according to the globalization tendencies in the world, thus changing also its initial goals.

The following **objectives** were derived from the research goal:

1. Analysis of CAP theoretical aspects and synergy with other policies.
2. Formation and characteristics of the stages of historical development of CAP reforms.
3. Evaluation of the goals of CAP reforms and research of multifunctionality.
4. Research of the main CAP indicators.

Materials and Methods

To achieve the objectives, the **methods** of analysis, synthesis and logical construction **were** applied, as well as scientific discussion.

Research of different authors - D.Saktiņa (2000), I.Vaidere, E.Vanags, I.Vanags, I.Vilka (2005, 2006), E.Grinovskis (1996), I.Pilvere (2007), R.Karnīte (2006), J.Reiljan and D.Tamm (2008), K.Ash (2005) and others were used in studying the topic, as well as the research of international organizations - OECD, FAO and WB. Laws and regulations and information of EU and the Republic of Latvia were used.

Results and Discussion

1. CAP theoretical aspects and synergy with other policies

The beginning of CAP can be traced back in West Europe in the 50-ies of the 20th century, the society of which was injured by WWII and where agriculture was destroyed and could not satisfy people's need for food. CAP has developed constantly reflecting the changes of needs in both agriculture and society as such (EC, 2008 b). Over the course of time EU CAP transformed into the policy of rural development implemented within the framework of the policy of regional development with the help of structural policy. The need to facilitate the synergy of structural, employment and rural development policy is also emphasized in the Basic Strategy Positions of Community Rural Development (Council decision ...., 2006).

Therefore, there appears a need to define several categories related to this development process: agricultural policy, policy of rural development and structural policy which has a significant role in the development of the industry and in increasing its competitiveness.

Agricultural policy is a notion that comprises the preconditions for the development of one industry. The historical development of EU CAP proves that it is impossible to analyze agricultural processes without the complex problems to be solved in the rural territory.

In the invalid Law on Agriculture of the Republic of Latvia (Law on Agriculture, 1996) agricultural policy was defined as the attitude of the state to agricultural manufacturing and a set of measures to implement it. J. Reiljan and D. Tamm (2008) also consider that the policy of agricultural development is implemented with the help of a state introduced and regulated set of measures to facilitate the development of agricultural industry.

When analyzing work of different authors and the laws and regulations, it can be concluded that the main goals of agricultural policy coincide with the goals formulated in the framework of EU CAP. K.Ash (2005) distinguished two main directions of agricultural policy: providing balance or optimal resource allocation, which is related to providing income from agricultural farms, and correcting market deficiencies. The other goal is related to executing different social functions, such as nature protection, maintaining the rural landscape, water management, food safety because the market mechanism in agriculture does not provide for the results acceptable to all members of society. The latest OECD study (Tongeren, 2008) places the goals of agricultural policy into three groups based on their character of impact (see Fig. 1).

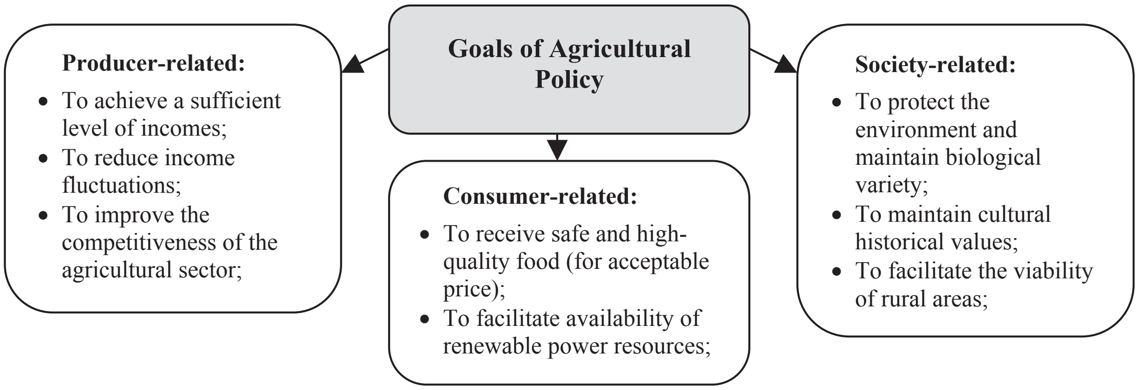

Figure 1. Goals of agricultural policy.

Source: author's construction based on F. Tongeren, 2008.

Regional development policy is a part of the total country's development policy. Regional development is directed towards a balanced and sustainable development of the territory and in the context of regional policy, development is understood as a progression of change processes of nature, environment, cultural environment, social environment and business activities beneficial for society. Regional policy tries to adjust free market economy to achieve two mutually related goals – economic growth and improvement of social distribution and the following objectives are usually set to achieve these goals:

- providing a balanced economic development of the region;
- even and effective allocation and use of the material, labour and other resources of all the regions of the country;
- facilitating the economic growth of underdeveloped regions;
- leveraging unfavourable differences between regions (Vanags et al., 2005; Vaidere et al., 2006).

Law on Regional Development of the Republic of Latvia (2002) provides that:

- *regional development* is "favourable changes in the social and economic situation in the entire territory of the country or some of its parts" and
- *regional development policy* is 'the position and targeted action of the government to facilitate regional development through coordinating development of industries according to the priorities of separate parts of the country's territory and through providing direct support for the development of separate parts of the country's territory'.

The author of the research considers that to concord the provisions of laws and regulations, *regional development policy* should be defined as 'the implementation of regional development policy in rural territories' because regional development and its policy provides both harmonized development of industries and inclusion of all the other aspects in the successful development of each separate territory and the entire country.

Although the notion 'structural policy' is widely used when analyzing different process of economy development, its definition cannot be found in the normative documents of Latvia. Structural policy as a part of agrarian policy has been studied by E.Grinovskis (1996) and I.Pilvere (2007). R.Karnīte (2006) has offered a definition of the structural policy of economy and has analyzed its correspondence to the goal of the economy development. D.Saktiņa (2000) has analyzed EU structural policy as a way of solving regional problems on EU scale. I.Vaidere, E.Vanags, I.Vanags, I.Vilka (2005, 2006) in their research have also defined structural policy as a constituent of regional policy. All the authors consider that structural policy is one of the constituents of the country's economical policy. R.Karnīte (2006) emphasizes that the goal of *the structural policy of economy* is the creation of the desirable economy structure, and it is defined in long-term strategic documents in the aspect of industries, problems or economy. According to the definition given by the economic explanatory dictionary, structural policy reflects country's attitude to the development of separate industries and regions (Explanatory Dictionary ..., 2000).

E.Grinovskis (1996) has defined *agricultural structural policy* as a total of indicative planning measures that provide the dominating tendencies of the industry development and the parameters of its macro- and microstructure and the anticipated changes in them. It can be concluded that the goals of regional development policy and structural policy are similar although part of the authors consider that issues related to the economic development of the territory are solved within the framework of structural policy while the regional development policy attempts to balance both the economic and the social aspect.

Based on D.Saktiņa's (2000) definition and I.Vaidere's, E.Vanags' and others (2006) research, it can be concluded that in the practice of European Union the notions of regional and structural policy are often used synonymously because in the result of implementing regional policy, the economic and social structure of the regions and also of the entire country changes.

2. Historical development of CAP

Table 1 summarizes the main stages of the development or reforms of the EU CAP and the policy changing measures performed during them, as well as development of the structural policy within the framework of CAP.

Table 1

Stages of Reforms of Common Agricultural Policy and Structural Policy within EU

<table>
<tr><th rowspan="2">Reform Periods</th><th colspan="2">Stages of CAP Reforms</th><th rowspan="2">Development of Structural Policy</th></tr>
<tr><th>Goals and Hallmarks</th><th>Measures Taken</th></tr>
<tr><td>1958-1968</td><td rowspan="2">• Food safety
• Improving productivity
• Market stabilization
• Income support</td><td>• Target prices
• Intervention prices
• Minimum import prices
• Export subsidies</td><td>• Creation of European Agricultural Guidance and Guarantee Fund</td></tr>
<tr><td>1969-1983</td><td>• Agro-monetary measures</td><td rowspan="2">• The Mansholt Plan – establishment of structural policy
• Directives for structural measures
• Support for Mediterranean farmers
• Integrated regional support programs
•</td></tr>
<tr><td>1983-1988</td><td rowspan="2">• Surplus production
• Rapidly growing budget expenses
• International discords
• Structural measures</td><td>• Introducing quotas
• Guaranteed purchase prices
• Freezing support prices
•</td></tr>
<tr><td>1988-1992</td><td>• The system of stabilizers introduced
• Program 'Leaving fallow land'</td><td>• Increasing funding for structural measures
• Determining priority goals
• Principle of co-financing and complementation</td></tr>
</table>

Table 1 continued

<table>
<tr><th rowspan="2">Reform Periods</th><th colspan="2">Stages of CAP Reforms</th><th rowspan="2">Development of Structural Policy</th></tr>
<tr><th>Goals and Hallmarks</th><th>Measures Taken</th></tr>
<tr><td>1992-1999</td><td>• Reducing stock
• Environment
• Income stabilization
• Budget stabilization</td><td>• Transition from price support to direct income support
• Reduction of intervention prices
• Compensation for losses to farmers
• Measures of rural development</td><td rowspan="2">• McSherry reform that comprises the programme of agricultural environment</td></tr>
<tr><td>Programme 2000 (Agenda 2000)</td><td>• Deepening the reform process
• Competitiveness
• Rural development</td><td>• Reducing support for intervention prices, export subsidies and manufacturing
• Increasing direct payments
• Environmental protection
• Rural development policy</td></tr>
<tr><td>2003</td><td>• Market orientation
• Consumer interests
• Rural development and environment</td><td>• Reforms in CMO* sectors
• Common payment
• Cross compliance
• Modulation
• Consultative system of fisheries
• New measures of rural development</td><td>• Cross compliance</td></tr>
<tr><td>2007-2013</td><td>• Increase of the influence of the World Trade Organization
• CAP optimization
• Decentralization
• Rural management</td><td colspan="2">• European Agricultural Guarantee Fund
• European Agricultural Fund for Rural Development
• CAP ‘health check’
• Simplification of CAP
• Revising budget expenses
• Reducing customs tariffs, market liberalization
• Further separation of direct payments from production
• Increasing support for measures of rural development
• Charge for managing ‘public goods’
• Increase of the role of national ministries in acquiring structural funds</td></tr>
</table>

*Common Market Organizations

Source: designed by the author based on research of various scientists.

Discussions about the CAP development in the future are still continuing because the last CAP reforms were evaluated as not sustainable and not compatible with further liberalization of the global trade. Future changes of the CAP system are determined by four tendencies: changing consumer interests, market liberalization, reduction of the number of rural residents and a new idea of the farmer’s role (Auers, 2007).

3. Goals of CAP reforms and multifunctionality

The initial goals of EU CAP were formulated in Article 33 of Rome Agreement. As F.Tongeren (2008) indicates, formulation of the goals of agricultural policy is historically related to the attitude of public to agriculture in the respective period.

Current CAP strategic goals are to facilitate the existence of multifunctional environmentally friendly and landscape protecting agriculture, to increase the competitiveness of agricultural industry in the global market observing strict standards of the environment, food innocuousness and animal welfare and to facilitate sustainability and dynamics of rural economy. In the historical CAP development the political choice of society is observed – to continue to support EU agriculture simultaneously taking into consideration the desires of the inhabitants, tax payers and consumers and as little as possible distorting international trade (EC, 2008 b).

Table 2 compares the initial goals of CAP and the changes in these goals under the impact of CAP historical reforms and globalization of economics.

Table 2

Evaluation of the Current Topicality of EU CAP Goals

<table>
<tr><th>Goal in the Constitutive Agreement of European Community</th><th>Current Goal</th><th>Current Topicality of the Initial Goal</th></tr>
<tr><td>• Increasing agricultural production by facilitating technical progress and providing rational development of agricultural production, as well as rational use of production factors, special labour force</td><td rowspan="2">• Ensuring an acceptable level of life for EU farmers, at the same time creating the opportunity to update and develop agriculture
• Maintaining agriculture in all EU regions
• Care for the welfare of the inhabitants of rural regions
• Maintaining the environment for future generations
• Providing better health and welfare conditions for animals</td><td>Topical, but it is supplemented by the environment protection and food safety requirements</td></tr>
<tr><td>• Providing acceptable standards of life for farmers, especially increasing the income of those employed in agriculture</td><td>The emphasis is placed on the multifunctional role of agriculture</td></tr>
<tr><td>• Market stabilization</td><td></td><td rowspan="2">Problem issues in the circumstances of market liberalization</td></tr>
<tr><td>• Ensuring production and resource accessibility</td><td></td></tr>
<tr><td>• Providing reasonable prices of food for consumers</td><td>• Providing people with food harmless for health, for acceptable prices
• Improving the quality of European food products
• Guaranteeing food innocuousness</td><td>Significant changes – from quantity to quality</td></tr>
<tr><td></td><td>• CAP implementation is possible with minimal EU budget expenses</td><td>Current topicality increases due to the pressure of society</td></tr>
</table>

Source: designed by the author based on research of various scientists

CAP main goals are criticized by international organizations (World Trade Organization, FAO, OECD, WB), the activity of which is directed towards liberalization of the agricultural market to solve the world food crisis – to reduce the price for food and to increase the availability of food in all regions of the world.

CAP goals that refer to entire society. Figure 1 of the research depicts the classification of the goals of agricultural policy that is compatible with the initial goals of EU CAP and their currently actual versions. Special attention should be paid to the target group that according to this classification refers to total society, because it indicates to the main priorities in the further CAP development. Basic strategic positions of EU rural development indicate to the multifunctional role of agriculture in providing sustainable rural development through producing healthy and high-quality products, using environmentally friendly production methods, creating renewable raw materials and providing protection of biological variety.

FAO (2008) emphasizes that nowadays farmers have become the managers of world's largest natural resources. Environmental services incurred as secondary consequences from primary land management are defined as 'public goods' because people cannot avoid gaining benefit from consuming them and by using them, one person does not reduce the opportunities of other people to use these goods. From the economical perspective, the largest threat is the non-charge character of public goods because they do not belong to anyone, and thus there is no motivation to preserve them. There is no market tool either that would signal about their insufficiency or worsening of the situation - the value of these goods can be expressed only with the amount of expenses required to renew or substitute them. FAO distinguishes the following main groups of public goods managed and influenced by farmers:

- preventing significant climate changes by reducing the amount of emissions of agriculture;
- protection of water resources because agriculture industry uses more than half of the world's total water consumption;
- preserving biological variety by reducing production activity in biologically varied regions, facilitating biological variety within a farm and preserving the existing biotopes;

- developing and preserving the aesthetics of rural landscape (FAO, 2008).

As a result of discussion, it was found out that as a result of further reforms of agricultural policy, rural regions could have two categories of the employed directly involved in maintaining agriculture and rural environment: rural entrepreneur and rural manager. Part of the rural entrepreneurs and managers' functions are absolutely opposite. The objective of the rural entrepreneur is to develop an intensively producing market oriented structural unit, simultaneously providing correspondence of agricultural production to a good practice of public goods management. It is anticipated that in the future the rural manager's functions could be completely separated from those of the rural entrepreneur.

The multifunctional role of agriculture and the employed in the context of common development of EU rural territories and under the impact of the globalization process of economics is depicted in Figure 2.

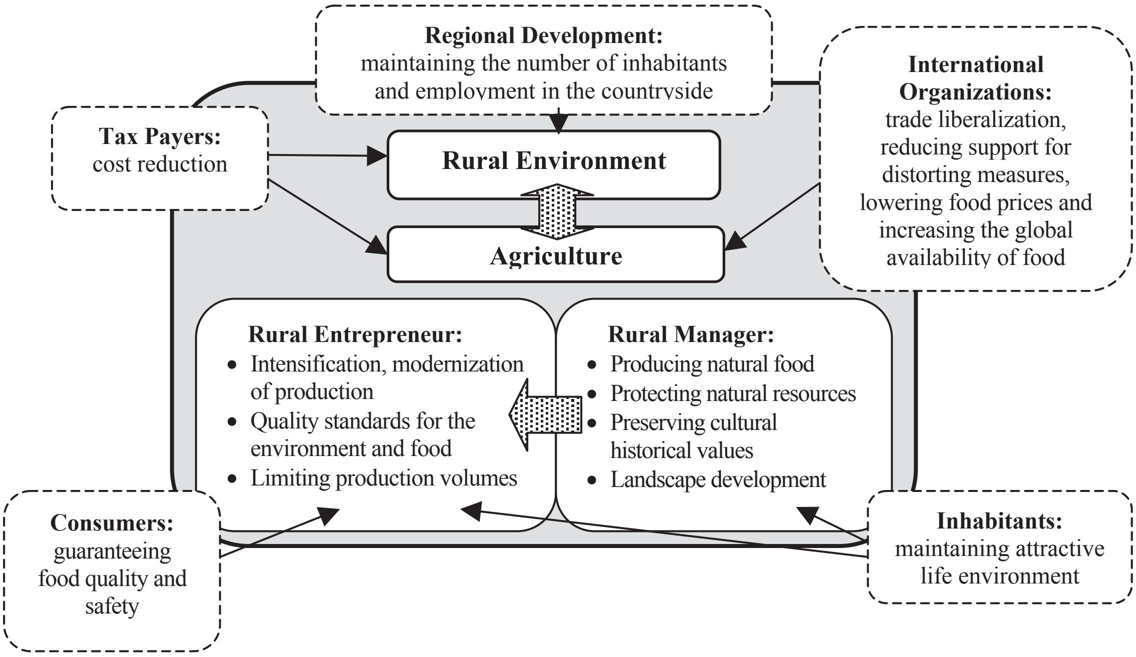

Figure 2. Multifunctional role of agriculture in the globalization of EU economics.
Source: the author's construction.

4. Main indicators characterizing CAP

At present, both agricultural and food industry make a significant part of EU economics – they provide 15 million jobs (8.3% of the total number of jobs) and constitute 4.4% of the gross domestic product. EU is one of the largest world exporter's of food and the largest importer. Besides, food is mainly imported from developing countries. Farmers perform different functions, starting with producing food and non-food goods and finishing with managing rural territories, preserving nature and providing services of rural tourism. Agriculture and forestry uses 77% of EU land territory. Rural development is vitally important area of politics. According to OECD definition, based on the population density, rural regions (municipalities in which the population density is less than 150 inhabitants per km^2) constitute 92% of EU territory. 19% of the inhabitants live in regions with the dominating proportion of rural inhabitants, while 37% - in regions within a significant proportion of rural inhabitants. The mentioned regions create 45% of the gross added value in EU and they provide 53% jobs, but these lag behind other regions concerning several social economic indicators (Council decision …., 2006).

As the most completely harmonized area, CAP is allocated a significant part of EU budget. However, it has reduced from the maximum possible – almost 70% of EU budget in the 70-ies of the 20th century – to 34% of the budget between 2007 and 2013.

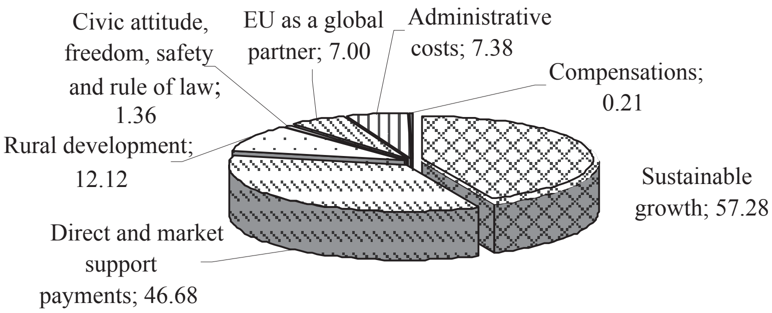

Figure 3. EU budget appropriation for 2008, billion EUR.
Source: EU general budget..., EC, 2008 a.

As a result of reforms, part of agriculture expenses is allocated for rural development (11% of the budget in the mentioned period) and for expanding other areas of EU responsibility. According to budget data from 2007-2013, it is planned to spend 43% of the total EU budget on environment protection, restructuring and diversification of rural economics, as well as on facilitating sustainable fishery. The distribution of EU budget appropriations for 2008 is depicted in Figure 3. In 2008, EUR 58.8 billion (44.5% of the total budget amount) are allocated for implementing CAP, including EUR ~ 47 billion or ¾ of CAP expenses for agriculture market and direct support payments, but EUR 12 billion or ¼ of CAP expenses – for rural development.

Conclusions

1. CAP notion comprises the synergy of several policies – rural development, regional development and structural policy. As a result of CAP reform process, structural policy has become a part of rural development policy.
2. The goals of agricultural policy are manifold and are aimed at three main target groups – producers, consumers and the entire society. The initial goals of EU CAP have partly lost their topicality or have transformed. For example, the accent of food supply has changed from quantity of food to quality, but the increase of the production effectiveness of agricultural enterprises should be a subject to restrict to the requirements of environment protection, animal welfare and food safety.
3. During the globalization of economics the multifunctional role of agriculture is gaining more significance. Nowadays farmers have become the managers of the world's largest environment services or the so-called 'public goods'.
4. EU CAP is constantly developing and improving. Eight main stages of the reform can be distinguished in its development. Each of the stages has its own characteristics, goals and main support tools. The CAP reform process is not finished yet because the last CAP reforms are evaluated as not sustainable and not compatible with the further liberalization of the global trade.
5. Agriculture and food industries together constitute a significant part of EU economics – they provide 15 million jobs and constitute 4.4% of the gross domestic product. A significant part of the total budget (44.5% in 2008) is still spent in implementing the CAP. As a result of reforms, part of the agriculture expenses is allocated to rural development.

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SOCIO-ECONOMIC IMPACT OF THE COHESION FUND IN LATVIA

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Abstract

The purpose of this article is to establish the social and/or economic impact of the implemented Cohesion Fund (CF) projects on development of regions of Latvia. Three tasks are addressed to achieve this goal – to study CF projects by regions; analyse distribution of funding by sectors of economy and their compliance with CF objectives; to draft recommendations for improving the absorption of funds and achieving the goals of the European Union (EU) regional policy. The article consists of three chapters, an introduction and conclusions. New scientifically grounded recommendations are developed for improving socio-economic impact of the CF in Latvia. The key recommendation relates to the EU involvement in dealing with problems of increase in costs, namely – by proving that the increase in costs affects several of the new EU member states or Community regions, the EC will have to take part in addressing the problem. Further assessment of the socio-economic impact of the CF on development of regions of Latvia requires additional research.

Key words: Cohesion Fund, project, regional development.

Introduction

The topicality of this article is determined by the fact that Latvia as the EU member state has an access to significant financial assistance through Community financial instruments including the CF. Inflow of such funds into Latvia is essential for the development of the environmental sector and the transport sector, as well as for the national economy in general. A characteristic feature of the CF is that it co-finances particularly important environmental protection and transport infrastructure projects, the implementation of which significantly affects the quality of life of many people in Latvia. There are many project implementations which without this significant financial assistance would be impossible or would have to be postponed for several years, their scale would be smaller and consequently their impact – less significant. Therefore, it is crucial to distribute these funds purposefully and competently and absorb them as efficiently as possible.

However, such goals require an adequate scientific basis of the economy. At the same time the uniqueness and substantial scale of the projects make them scientifically interesting as objects or subjects of research. Scientific publications in European countries already include the results of some studies on the support of EU financial instruments, including the operation of the CF in Latvia (Pilvere et al., 2006; Millere, 2006); the topic has been addressed also by Polish, Lithuanian and other European researchers (Mickiewicz et al., 2006; Čiulevičiene et al., 2004). Nevertheless, analysis of such publications leads to the conclusion that the impact of CF funds absorption on development of national economy and decreasing disparities in development levels among the regions of Latvia has been so far insufficiently scientifically studied (Āboliņa, 2007).

Taking into consideration that the attracted significant funds have to be absorbed over the few coming years it is important to study the progress in absorption of the funds in order to avoid possible mistakes and to ensure full absorption of the funding. It is important to identify and analyse the mistakes made in the course of already implemented projects. Particular attention must be paid to distribution of the funds – especially when investing money in less developed regions.

At the beginning, when studying the CF administration system and the monitoring system of EU financial support under the Cohesion Fund (Āboliņa, 2007), particular attention was paid to compliance of the administration system with EU legislation and national legislation of the Republic of Latvia, the project implementation system, and its stages. Also, the funding monitoring system was studied and recommendations were provided on improving it. The studies revealed that the system has been built according to EU and national legal acts, yet it needs to be improved to increase the efficiency of the absorption and monitoring processes and to guarantee that irregularities are avoided in project implementation or that such shortcomings are eliminated already during project implementation so that it does not lead to sanctions from the side of the EU.

The research covered in this article has been based on the following hypothesis – absorption of CF funding allocated to regional development can be improved by linking project objectives to national strategic development plans and regional development concept papers, particularly focusing on the problems of the least developed regions and to development of strategically important objects.

The purpose of the research is to establish the socio-economic impact of the implemented CF projects on development of regions of Latvia.

Within this purpose the following terms of reference have been identified:

- to study CF projects by regions;
- to analyse distribution of funding to sectors of economy and their compliance with CF objectives;
- to prepare recommendations for improving the absorption of funds and achieving the goals of the EU regional policy.

Materials and methods used in addressing these terms of references.

For implementing the research programme and fulfilling the terms of reference, information is searched in electronic databases as well as scientific publications; legal acts of Latvia and the EU are used, as well as statistical data and unpublished materials of the Ministry of Finance. An analysis method has been used in the research to assess and analyze the distribution of funds by regions and economic sectors, as well as a comparative method to prove and assure that projects are implemented in compliance with the objectives of the Latvian and EU regional policy. The logical construction method for defining the possibilities for improving the absorption system of CF funding is used as well.

Results and Discussion

1. Cohesion Fund projects by regions

EU financial support under the CF has been available to Latvia since 2004 when Latvia joined the EU, and the amount of this support in the 2004-2006 programming period was EUR 515 million. Before that, in 2000-2004, Latvia had access to co-financing from ISPA (Instrument for Structural Policies for Pre-accession) – EUR 195 million. These projects are now co-financed by the CF (European Commission, 2007). All committed funds in the amount of EUR 710 million shall be absorbed by 2010.

As can be seen from Council Regulation (EC) No. 1164/94 of 16 May 1994 establishing a Cohesion Fund, Article 2(1), 'the Fund shall provide financial contributions to projects, which contribute to achieving the objectives laid down in the Treaty of the European Union, in the fields of the environment and trans-European transport infrastructure networks in Member States with a per capita gross national product (GNP), measured in purchasing power parities, of less than 90 % of the Community average which have a programme leading to the fulfilment of the conditions of economic convergence referred to in the Article 104c of the Treaty' (European Commission, 1999). Distribution of CF projects by regions of Latvia is shown in Table 1.

Table 1

Distribution of Cohesion Fund co-financed projects and amount of funding by regions of Latvia, in the programming period 2000-2006

Regions		Project funding			
		Total		Of which CF funding	
Region	Number of projects	M EUR	Share, %	M EUR	Share, %
Trans-regional	11	537.17	39.56	274.98	38.69
Riga	15	242.89	17.88	152.85	21.50
Kurzeme	9	255.71	18.82	132.26	18.61
Latgale	6	90.36	6.65	48.56	6.83
Zemgale	3	222.45	16.38	98.27	13.83
Vidzeme	2	9.59	0.71	3.86	0.54
Total	46	1358.17	100	710.78	100

Source: the author's calculations based on the data of the Ministry of Finance (2007).

As can be seen from Table 1, in the programming period 2000-2006 funding was mainly attracted to trans-regional projects.

Some of the most evident examples are investments in improvement of roads. One of the main objectives is the improvement of the Via Baltica Pan-European transport corridor. For achieving this objective several projects are implemented, which together are part of the Via Baltica road improvement scheme according to the national ISPA strategy of Latvia. Altogether, five projects are implemented to improve and reconstruct the Via Baltica, and total eligible expenditure of these projects amounts to EUR 184.83 million, EUR 72.5 million of which is CF co-financing (Ministry of Finance, 2007).

A particularly important project for Latvia is the construction of Saulkrasti bypass and improvements of the Via Baltica on the main state road A1 (Riga – Ainaži). Total eligible expenditure of this project is EUR 123.99 million, of which EUR 40.02 million is CF co-financing. In Skulte rural municipality, a 20.2 km long road with an 11.5 m wide bituminous concrete surface was built. The bypass has 17 various traffic constructions – bridges, overpasses, pedestrian tunnels and access roads, with a total length of 13 km. Seven two-level road overpasses with lighting were constructed, as well as eight new bridges. For the needs of pedestrians and cyclists two tunnels were built, as well as footpaths with a total length of 4.4 km. In several locations anti-noise walls, solid and wire fences were erected, and fir-tree hedges were planted. The project also included reconstruction of the existing road in the section between Lilaste and Skulte. This is the first newly-built road since Latvia regained independence. Additional benefits from implementing the project include the significant amount of travelling time saved by avoiding driving through Saulkrasti town, as well as improved traffic safety and air quality in the town (Ministry of Finance, 2007).

A huge amount of funds has been invested specifically into the Riga region. In the region, a total of 15 CF projects are being implemented; thus, 21.5% of funding available through the CF is used in Riga region. However, this share is not particularly big taking into consideration that Riga planning region is home to almost half (48%) of the population of Latvia (Ministry of Regional Development and Local Government, 2007). In Riga region, the most interesting projects which are socially most important for the people of the region are projects in water services sector, such as development of water services in Riga and Jūrmala.

Within the framework of the project for development of water services in Riga measures were implemented for improving the quality of drinking water and ensuring sewage treatment. Within the framework of the project reconstruction was completed in 'Zaķumuiža – D' – one of the drinking water sources– by constructing nine new wells, laying 4.4 km of piping, constructing a 2000 m^3 water reservoir, reconstructing one and building one new pumping station, as well as implementing a control and automation system of the station. The construction of sewage tunnel-collector between Vairoga Street and Gaujas Street was completed – a 2.1 km long tunnel-collector was constructed as well as 13 access shafts. Within the framework of the project approximately 59 km of sewage pipelines and approx. 33 km of water mains were constructed, as well as 6 sewage pumping stations. CF contributed more than EUR 20 million to the project.

In the city of Jūrmala, the biggest benefits of the implemented project were the reconstruction of two iron removal stations and construction of one new station in Kauguri. This project also involved a significant CF contribution – EUR 10 million.

Some of the projects implemented in Riga region were technical assistance projects with the objective of facilitating implementation of CF projects in Latvia.

When analyzing data in Vidzeme region, where 10.6% of Latvia's population lives, it must be concluded that this region cannot be proud of large amounts of CF funding; although the figure is a relative one, because Vidzeme region is being supported through various trans-regional projects, for instance – in the towns of Limbaži and Valmiera significant funds are being invested in developing water and sewage systems within the framework of the Eastern Latvia river basin project.

When studying Kurzeme region, where 13.5% of Latvia's population lives, it can be seen that it has received a very high proportion of overall available CF funding – 18.61%. Among the more interesting projects implemented in this region are those connected with waste management, development of water services, development of port access roads, as well as improvement of the heat supply system in Ventspils city. This is the first project of this type in Latvia, and in the result of it a connection between the heat supply networks of both banks of the Venta River will be constructed, as well as building of a co-generation (combined heat and power) plant by using the best available technology for the coal-powered CHP plants – circulating boiling layer technology.

In Zemgale region, three large projects are being implemented attracting 13.83% of CF funding. This includes two road projects, a project for Jelgava city water services, and Zemgale region waste management project, the purpose of which is to create an environmentally-friendly, economically stable and sustainable solid waste management system in Zemgale region, which will fully comply with national and EU requirements.

In Latgale region, six separate CF projects are being implemented, together representing 6.83% of the total CF funding. These include projects for development of water services in Rēzekne and Daugavpils, as well as three projects in the field of waste management. A noteworthy project is the construction of the reception yard at the Rēzekne Railway Station II, which includes construction of a new reception yard with six full-length railway tracks, one 106-metre long railway track, sidetracks for trains, tracks for railway machinery, as well as 27 rail switch points, telecommunications and power supply systems, an administrative building, reception yard infrastructure, extended signal and switch control tower, and development of the atmospheric pollution control system (Ministry of Finance, 2007).

When analysing distribution of CF funding among planning regions of Latvia, as well as development indices of planning regions for 2006 (Table 2), it can be concluded that serious consideration must be paid to the distribution of funds to ensure achievement of CF goals – social and economic cohesion not only among EU member states but also among different regions of a country.

Table 2

Development indices of planning regions, 2006

Planning region	Territorial development index
Riga region	1.011
Kurzeme region	-0.520
Zemgale region	-0.574
Vidzeme region	-0.851
Latgale region	-1.341

Source: Data of the State Regional Development Agency (2007).

It must be noted that it is difficult to assess the impact of trans-regional projects on the development of individual regions as the goals of these large-scale transport projects are much more global than environmental projects. It must be taken into account that the CF co-finances the road projects that correspond to Trans-European Transport Networks (TEN-T). Thus, the regions where such roads are located are in a more favourable situation compared to regions where unfortunately there are no such roads with importance at the European level. However, it should be underlined again that any investment in improving the road infrastructure is important for the development of the national economy.

2. Distribution of funding by sectors of economy and compliance with Cohesion Fund objectives

In the previous programming period 2000-2006, according to Council Regulation (EC) No. 1164/94 of 16 May 1994 establishing a Cohesion Fund, Article 10(2), 'A suitable balance shall be struck between projects in the field of the environment and projects relating to transport infrastructure. This balance shall take account of the Article 130s (5) of the Treaty', CF funding was distributed evenly between environmental and transport sectors, as well as allocated to one technical assistance project aimed at increasing the capacity of the Managing Authority (European Commission, 1999).

Table 3

Cohesion Fund funding available to Latvia for individual sectors (EUR)

Sector	Total CF funding	Funding for approved ISPA projects	Funding for CF projects
Transport	257,933.331	38,864.826	219,068.505
Environment	257,933.331	76,447.053	181,486.278

Source: Ministry of Finance (2007).

As shown in Table 3, co-financing of the CF for the programming period 2004-2006 has been distributed in line with the requirements of the Regulation.

Table 4

Cohesion Fund funding available to Latvia, distribution by sectors of the national economy, total amounts 2000-2006

Sector	Number of projects	Total eligible expenditure for a project		Average value of a project, M EUR	CF co-financing		
		M EUR	%		M EUR	Total, %	For the sector, %
Roads	6	377.37	27.8	62.90	150.93	40.0	21.2
Railways	5	260.77	19.2	52.15	159.40	61.1	22.4
Roads and railways, total	11	638.14	47.0	58.01	310.33	48.6	43.7
Airport	1	23.50	1.7	23.50	16.56	70.4	2.3
Ports	2	43.40	3.2	21.70	24.40	58.4	3.4
Transport sector, total	14	705.04	51.9	50.36	351.29	49.9	49.4
Waste management	10	98.81	7.3	9.88	55.33	56.0	7.8
Development of water services	11	426.42	31.4	38.76	234.81	61.6	33.0
Development of heat supply	1	81.21	6.0	81.21	34.61	42.6	4.9
Environmental sector, total	22	606.44	44.6	27.56	324.75	57.9	45.7
Technical assistance	10	46.69	3.4	4.67	34.76	76.6	4.9
TOTAL	46	1,358.17	100	29.52	710.78	54.3	100

Source: the author's calculations using the data of the Ministry of Finance (2007).

From the information provided in Table 4 and its analytical study several conclusions can be made:

- Traffic quality development projects have received the largest CF support – half of the funding available;
- A relatively large amount of funds have been allocated also to development of other branches of transport infrastructure – airports and ports; while all branches of this infrastructure together account for 49.4% of CF co-financing;
- Particularly favourable support is provided to water services development projects – 33% of CF co-financing and 29.1% of total funding;
- The rate of CF co-financing differs significantly among different sectors – if technical assistance projects are not taken into consideration, then the highest rate – 70.4% of project expenditure is co-financed for the airport development; similarly, railways have received a higher rate of support than road projects. This can be explained by the problems Latvian railways encounter when faced with the need for integration into the overall European railway network.

3. Discussion on better solutions for achieving the goals of the EU regional policy in Latvia

Considering the above, there is a substantial potential for improving the absorption mechanisms of EU CF funding. The first and main problem to be discussed and solved is the distribution of funding among regions in Latvia.

Analysis of macroeconomic and regional statistical data points out the need to act carefully to ensure that investment of significant CF funding into improving international competitiveness of Riga planning region (capital of Latvia) does not create new problems for Riga and other regions of Latvia, because the disparities in levels of development among regions of Latvia are significant not only in comparison to other EU member states but also within Latvia.

Of course, such redistribution of funds by shifting the focus to development of peripheral regions must be in line with the main principles of EU regional policy and objectives of the Cohesion Fund, since by increasing competitiveness of regions they will achieve the CF objectives more quickly.

However, it must be taken into consideration that channelling CF funding to Riga planning region carries the risk that the development rate of Riga planning region may greatly exceed the development rates of the rest of Latvia, and Riga may be included in a NUTS 2 level region. This means that Riga planning region will no more be eligible for CF funding. This fact must be taken into account when planning allocation of funds in the new programming period to avoid situations when significant funds are spent on planning and drafting a project, yet its implementation is impossible, because project expenditure is recognised as ineligible.

3.1 Problems in the construction sector

One of the biggest problems that could dramatically reduce absorption of CF funding is the current unexpected situation in the construction market. CF projects are characterised by their large scale – generally overall project expenditure is at least EUR 10 million. This means there are large-scale procurements for these projects; they are often announced EU-wide to ensure compliance of public procurement procedures with requirements of the legislation. Due to the huge size of these projects, there are only few companies in Latvia that have the capacity to implement them. In addition, often there are situations when companies specialising in, for example, development of water service projects, move to the real estate sector, in particular - housing construction.

The restricted market does not promote competition. Unfortunately, our market is not attractive enough for international construction companies. In particular the lack of competition hampers implementation of good-quality and fixed-term projects.

It must be understood that attracting major companies requires favourable conditions and an interesting, attractive business environment. Currently, this is to large extent threatened not only by the weak legislation environment in, for instance, the construction sector, but also migration of labour, leading to insufficient supply of inexpensive labour, which initially was one of the factors attracting foreign companies to Latvia.

Currently, solutions are being looked for by informing foreign embassies on the announced tenders, and large-scale procurements are divided into lots as required by the law, in order to increase the number of potential tenderers.

Even when informing foreign embassies there is a risk that foreign companies will still not show interest in these tenders because it is difficult to enter this market not only because of the migration problems, but also due to the poor legislation environment, which discourages rapid entry of foreign companies into Latvia. Likewise, not always these promotion campaigns guarantee the entry of new operators into the market, even if they reach the target audience.

When dividing procurement tenders into lots, there is a risk of violating tender procedures. Such splitting of procurement tenders would require gaining additional confidence that these procurement tenders comply with the EU and Latvian legislation, to avoid the threat of ineligibility of funds. Thus, it would create additional bureaucratic burden for implementation of projects. Still this solution, by eliminating problems at the very beginning of project implementation, would reduce the potential risk of significant funds being declared ineligible for reimbursement from the Community budget.

Therefore, this would be one of the best and most favourable solutions to the problem in implementation of large-scale projects. By splitting the largest procurement tenders into lots preconditions would be created, so that also regional and/or smaller companies could participate in the tenders, which otherwise not always meet the requirements of these large-scale tenders. Correspondingly, this would promote a more positive competition, which would improve the quality and progress of implementation.

The next recommendation is that the government should more carefully plan funds and inform the public on their absorption and the timeframe for absorption. Accurate information that, for instance, during the following seven years a certain amount of funds will be invested into implementing projects for development of water services, could promote entry of new companies into the particular market segment. Similarly, the government should review which are its key sectors, development of which has stagnated, yet which are crucial for development of the national economy or, for example, implementation of directives (in the sector of water management); therefore, it should plan the state aid to business development by taking into consideration the importance of the particular company in the development of the national economy.

3.2. Increase in costs

The problem discussed in the previous chapter leads to the next problem – increase in costs, which can threaten successful and high-quality implementation of several CF projects.

Often, in order to solve a problematic situation, additional funds are requested from the state or the EC budget. Unfortunately, not always these institutions can provide for the growing needs. The cost increase causes situations where project implementers have to reduce the scale of planned projects to be able to implement the project at all and to achieve the planned goals. However, it is possible if the implementing body is not a state budget institution, e.g., joint stock company *Latvian State Roads*, or if already during the planning stages various alternatives for achieving goals are provided for the project (Ministry of Finance, 2008).

In order to avoid such problems, initial planning of projects must be performed very carefully. If works, costs and possible risks are planned in detail, it is possible to avoid abnormal and unjustified increase in costs during the implementation of a project. Furthermore, in the future, these cost increase risks should be shared between the contracting authority and the contractor. This would solve situations where a company that has been awarded a tender and proved its ability to perform the works for a certain amount of money suddenly announces a year later that it had not included something in the plans or that prices in separate market segments have increased.

In our fast-changing economic environment such projects should include a reserve for the purposes of safeguarding particularly against unplanned, sudden and unexpected cost increase caused by circumstances beyond the contractor's control, i.e., *force majeure*.

Another yet underused option is involving the EC in dealing with the problems of cost increase. Although individual member states have shown some initiative to increase the role of the EC in dealing with the problems caused by cost increase, this is the area which requires more active steps from the side of member states including Latvia. Member states need to draw the EC's attention to this problem, as it is not the problem characteristic to a single member state but to whole regions of the EU.

Currently, the Baltic States in particular are facing problems of cost increase, which in some instances reaches even 300% of planned costs. For other Cohesion countries this problem is not so striking, for example in Poland, where the CF support is the biggest compared to other CF countries – EUR 4.18 billion, cost increase does not exceed 30% of planned costs. Malta and the Czech Republic for the time being do not have such a problem, which can be explained by the fact that for Malta CF co-financing and the number of projects is significantly smaller than in Latvia – only EUR 21.94 million. In the Czech Republic, where CF financing is EUR 936.05 million, the situation is better, because in this country there is carefully developed construction legislation in place, which requires careful estimation of all planned construction expenditure.

Cooperation of the Baltic States must be developed for raising this issue at the EU level by proving that it is indeed a problem of the whole Community, as it affects a large territorial region of it, and other member states also experiencing this problem should be involved as far as possible. If it is proven that this problem is important at the EU level, the EC will have to get involved in dealing with it not only by financially supporting the hardest-affected member states, but in other ways as well, e.g., by agreeing that within the framework of a project indicators to be achieved can be reduced, or even by considering the possibility to extend the timeframe allowed for implementing the requirements established in directives. Another solution that could be proposed by the EC is to postpone implementation of individual stages of projects to the next programming period, as a result of which additional funds would be freed up that could be used to cover the cost increase in other projects and ensure achievement of goals of at least these projects. However, as already mentioned before, this issue must be considered in the context of understanding shown by the EC in form of agreeing to extend the deadlines for implementation of directives (with regard to environmental projects).

Conclusions and Recommendations

1. Large-scale CF projects are being implemented in Latvia; they attract EUR 1.4 billion, yet they do not particularly promote reduction of disparities in socio-economic conditions among the regions of Latvia, as the largest part of this investment is concentrated in Riga and Kurzeme regions.
2. CF co-financing is distributed evenly between environmental protection and transport infrastructure projects, in line with EU requirements.
3. A large proportion of the CF co-financing allocated to transport infrastructure goes to Latvian railways with less being allocated to motor roads. In the area of environmental protection, projects for development of water services dominate absolutely both in terms of number of projects and amount of funds.
4. Channelling CF funding to Riga planning region carries the risk that the development rate of Riga planning region may greatly exceed the development rates of the rest of Latvia, and Riga may be included in NUTS 2 level and will not receive financing of CF in future.
5. Large-scale procurements should be divided into lots to allow also regional and/or smaller companies to participate in procurement tenders, which otherwise not always meet the requirements of these large-scale tenders. Correspondingly, this would promote a more positive competition, which would improve project quality and progress of implementation of these projects.

6. The unplanned cost increase causes situations where project implementers have to reduce the scale of planned projects.
7. If works, costs and possible risks are planned in detail, it is possible to avoid abnormal and unjustified increase in costs during the implementation of a project.
8. Cost increase risks should be shared between the contracting authority and the contractor.
9. The results of the research corroborated the hypothesis that absorption of CF funding can influence the growth of less developed regions more efficiently if project objectives are linked to national regional strategy plans.

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EUROPEAN UNION FUNDS AND THEIR INFLUENCE ON THE REGIONAL DEVELOPMENT OF LATVIA

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Abstract

In the EU funds planning period 2004 – 2006 in total 1141.44 million Euros have been allocated to Latvian national economy. The most part of financing was assigned to the development of infrastructure, development of entrepreneurship and innovation and human resources. Analysing division of the Structural Funds allocation between the regions, most part of the Structural Funds financing of 2004 – 2006 – 49.52% from all the financing has been allocated to the Riga region. That points to unequal division because Riga region has three times bigger Gross Domestic Product then Latgale region. Direct link to the social economic indexes indicating the development of the region and attracted EU funds financing can be surveyed – most developed regions have received most important part of the financing and underdeveloped regions the smallest part. EU funds regional support has to be planned and there should be regional development policy in EU funds distribution. Possible means to endorse the development of the undeveloped regions of the country by support programmes include creating specific support programmes, giving larger aid intensity for projects from regions, consultation work in project development and implementation and other ways.

Key words: European Union funds, regions, development.

Introduction

Development of the country depends on the strong and competitive regions that would create value added for the development of the country. It is important to enhance the development of all regions, find out the possibilities of the regions, both those that are already developed and those that are not so developed. Currently there are significant regional disparities in Latvia, therefore it is essential to analyse this situation from different points of view and especially from the point of view of the EU funds investment and suggest the best ways for the improvements.

When Latvia became European Union accession country, Latvia gained possibility to obtain European Union funds financing. Since that period various EU funds have been allocated to Latvian economy and one of the aims of these funds is to stimulate regional development in the country. It is significant for the sustainable development of the country to analyse the implementation of this aim. Object of the paper is regional development of Latvia characterized by indicators.

The aim of the paper is to create the best solution how to enhance the development of regions in Latvia using EU funds financing. Tasks of this paper include:

- analysis of available EU funds financing for the planning period 2004 – 2006 and 2007 – 2013 according to regional development aspect;
- analysis of the indicators showing regional development in Latvia;
- analysis of regional planning on Latvian and European level;
- pointing the problems that hamper regional development of Latvia;
- offering important solutions for the regional development problems using EU funds financing.

Materials and Methods

Materials used include Latvian Cabinet of Ministers and European Commission legal documents, data from the Ministry of Finance, State Regional Development agency and Central Bureau of Statistics of Latvia. Also conference proceedings, research paper on the regional development, and personal experience in the field are used.

The methods used to achieve the aim of the paper include economic analysis research, logically constructive method, analysis of statistics, statistic grouping, and historic approach making conclusions on analysis of past developments.

Results and Discussion

1. Available financing of the European Union funds

Analysing the Structural funds planning period of 2004 – 2006, it can be concluded that in total 1141.44 million Euros have been allocated to Latvian national economy.

Cohesion fund financing was allocated to transport infrastructure – railway and road development, and to environmental systems – waste and water infrastructure development of national importance. Structural funds financing was divided by priorities. If structure of the structural funds allocations for Latvia in the programming period 2004 – 2006 is analysed, Latvia has received EU funds financing of 625.57 million euros that was divided in five priorities.

Table 1

EU funds allocations for Latvia

	Structural funds 2004 – 2006 (Million euros)	Cohesion Fund 2004 – 2006 (Million euros)	Total (Million euros)
Latvia	625.57	515. 87	1141.44

Most part, 32.6%, from this funding was allocated to the priority "Promotion of Territorial Cohesion", 25% - for "Promotion of Enterprise and Innovation", 21.2% - for priority "Development of Human Resources and Promotion of Employment", 18.5% - to "Development of Rural Areas and Fisheries", and 2.7% to "Technical Assistance" priority (Ministry of Finance, 2007). Analysing Structural funds division by priorities it can be concluded that the most part of financing is assigned to the development of infrastructure, development of entrepreneurship and innovation and human resources; also financing for rural areas and fisheries has been significant. In general, most part of Structural funds financing has been allocated to transport infrastructure development.

Table 2

Structural funds financing divided between the priorities

Priority	Name	Fund	%	Structural Fund, EUR	Co-financing, EUR	Total, EUR
1	Promotion of Territorial Cohesion	ERDF	32.58%	203 810 000	65 389 046	269 199 046
2	Promotion of Enterprise and Innovation	ERDF	25.00%	156 392 000	52 130 670	208 522 670
3	Development of Human Resources and Promotion of Employment	ESF	21.22%	132 745 000	42 146 542	174 891 542
4	Development of Rural Areas and Fisheries	EAGGF FIFG	18.49%	115 668 000	65 183 128	180 851 128
5	Technical Assistance	ERDF ESF EAGGF	2.71%	16 953 826	5 651 283	22 605 109
		Total:	100%	625 568 826	230 500 669	856 069 495

Source: Ministry of Finance, 2007.

Almost all EU funds financing can be considered as an instrument for the regional development of Latvia because financing is granted to all the regions of Latvia in different spheres that enhance overall development with its contributions to the spheres of infrastructure, entrepreneurship, education and social development.

Analysing division of the Structural Funds allocation between the regions, most part of the Structural Funds financing 2004 – 2006 – 49.52% from all the financing has been allocated to the Riga region. Kurzeme region has received 15.27% from the financing that is the second biggest allocation. Vidzeme and Zemgale region has received around the same portion – 12 to 13% from the EU funds financing. The smallest part of the financing – 9.8% was allocated to Latgale region. Riga region has received almost half of all financing thus worsening regional differences in the country.

Table 3

Structural funds financing divided between the regions

Region	Financing (mln. euro)	% from total financing
Latgale region	58.8	9.80%
Vidzeme region	72.3	12.05%
Zemgale region	80.1	13.35%
Kurzeme region	91.6	15.27%
Riga region	297.0	49.52%

Source: State Regional Development agency, 2009.

2. Regional development analysis

To determine the situation it is important to analyse the development of regions. For this reason the indicator – Gross Domestic Product per capita – is chosen and regional disparities in 2000, 2003 and 2006 are found using a new indicator – GDP in regions in percentage from the highest rate – Riga region GDP.

Analysing the GDP data from years 2000 and 2006 it has to be pointed out that in 2006 regional disparities, except for Pieriga region, have even increased. If we take Kurzeme region in 2000, its GDP was 56.03% from Riga region GDP, but in 2006 this indicator was only 43.93%. The lowest rate in general is in Latgale region – only 27.35% from Riga region GDP in 2006. It means that Riga region is three times more developed then Latgale region. Riga region has almost two times higher GDP per capita ratio then in Latvia in total. Development problems in underdeveloped regions are connected with low entrepreneurship activity, low income level, rather high unemployment rate and lack of high – quality infrastructure.

Table 4

Gross domestic product by statistical region

	Per capita, LVL					
	2000	% from Riga region	2003	% from Riga region	2006	% from Riga region
Latvia	2 002		2 749		4 883	
Riga region	3 459		4 869		8 516	
Pieriga region	1 351	39.06%	1 786	36.68%	3 954	46.43%
Vidzeme region	1 127	32.58%	1 646	33.81%	3 033	35.62%
Kurzeme region	1 938	56.03%	2 412	49.54%	3 741	43.93%
Zemgale region	1 178	34.06%	1 574	32.33%	2 819	33.10%
Latgale region	975	28.19%	1 418	29.12%	2 329	27.35%

Source: Central bureau of statistics, 2009.

The positive trend is that in total the rate of GDP per capita has increased in all regions of Latvia since 2000 which points to some development even thought sharp increase has not been observed.

In general regional development in Latvia is measured by regional development indexes calculated by State Regional Development agency. This index is the most sophisticated indicator showing regional development and regional disparities. It is calculated based on range of indicators – unemployment rate, GDP per capita, personal income tax per capita, non financial investment, demographic situation, population amount and density, amount of entrepreneurs, value of land in the region (Locāne et al., 2009).

Table 5

Regional development indexes 2007

Region	Development index in 2007	Received EU funds financing (%)
Latgale region	- 1.267	9.80%
Vidzeme region	- 0.853	12.05%
Zemgale region	- 0.516	13.35%
Kurzeme region	- 0.647	15.27%
Riga region	+ 0.999	49.52%

Source: State Regional Development agency, 2009.

Most developed and the only positive indicator is for Riga region, Latgale region is less developed with - 1.267 points. Direct link to the social economic indexes indicating the development of the region and attracted EU funds financing can be surveyed – most developed regions have received most important part of the financing and underdeveloped regions the smallest part. That has also been admitted in research (Locāne et al., 2009) published by State regional Development agency.

Also in this research it is stated that 88.7% EU funds financing have territorial impact but it is not possible to agree to such calculations because there has been regional inequality in funds division and no regional development aims have been achieved from the year 2000 as shows GDP analysis. Therefore specific measures have to be taken to improve the regional disparities situation.

After EU funds investment there is no significant impact made on the regional disparities and this funding has not achieved the aim of regional development.

3. Regional planning on European Union and Latvian level

Official regional planning document of the European Union "The Community Strategic Guidelines on Cohesion 2007-2013" developed by the European Commission and approved by the Council state that regional and cohesion policy should seek to target resources on the following three priorities that are essential for the future development:

- improving the attractiveness of regions and cities by improving accessibility, ensuring adequate quality and level of services, and preserving their environmental potential;
- encouraging innovation, entrepreneurship and the growth of the knowledge economy by research and innovation capacities, including new information and communication technologies;
- creating more and better jobs by attracting more people into employment entrepreneurial activity, improving adaptability of workers and enterprises and increasing investment in human capital. (The Council of the European Union, 2006)

According to Regional policy guidelines aims of Latvian regional policy include growth of competitiveness of Latvian regions comparing to other European regions, equal opportunities for living, employment and environment circumstances to all Latvian regions, equal opportunities for entrepreneurship in Latvian regions and increase of international competitiveness of capital Riga. EU funds financing can be used to achieve these aims with programmes supporting business development and investment in Latvian regions, employment, education, transport and environment in specific regions that are most underdeveloped. Innovation and high-tech centre development programme should be created for the development of capital.

According to Dr. John Rigg policy of urban economic development should be complementary for the requirements of the economies of the rural areas. Cities have significant potential advantages, they provide concentration of economic resources and assets, potential to exploit economies of scale but that is not sufficient. Successful cities are those that are attractive for people to live and work, close to sources of knowledge and innovation. That usually means network of education and research institutions together with good governance principles (Rigg, 2006). It implies that development strategies and specialization branches should be arranged and complementary both for biggest cities and surrounding rural areas.

4. Future perspectives

Analysing all the available Structural fund programmes in 2004 – 2006 which are past developments, and the

2007 – 2013 planning period which will result in future and their division by support areas, it can be concluded that actually many of these programmes could enhance regional development.

There are also a few of programmes in various spheres like business development, social sphere, transport and environment (see table 6) that are directly oriented to regional development in the 2007 – 2013 planning period where mostly applicants from Riga and Riga district cannot apply. Like in the 2004 – 2006 planning period we can see good possibilities for regional development also in the 2007 – 2013 planning period. Using these programmes properly it would be possible to stimulate regional development.

Table 6

EU funds programmes for regions 2007 – 2013

Programme	Financing sphere
Support for investment in specially supported areas Business incubators	Business
Social services systems development in planning regions Development of the social rehabilitation and social care institutions in regions	Social sphere
Attraction of specialists to planning regions, towns and districts Capacity building of development planning in regions	Administration
Public transport outside Riga Development of infrastructure in small ports Traffic safety improvements in populated areas	Transport
Development of water management in populated areas with population under 2000 Development of Regional waste disposal systems	Environment
Growth of national and regional importance development centers for sustainable development of country	Sustainable development

Source: Ministry of Finance, 2009.

Conclusions

1. It can be concluded that EU funds offer diverse financing and great possibilities for the development of regions both in planning period 2004 – 2006 and planning period 2007 – 2013. But the most important aspect is that these financial means have to be allocated properly for those projects in those regions that will give the highest return and have impact on the development.
2. Unequal regional division of EU funds financing is unacceptable and therefore activities proposed should be taken to minimize regional differences in structural funds allocations and increase structural funds support in regions.
3. After all EU funds investment in 2004 – 2006 there is no significant impact made on the regional disparities and consequently this funding has not achieved the aim of regional development. According to the analysis of Gross Domestic Product and other indicators EU funds financing options have not enhanced the development of the regions in Latvia. It is important to find out the reasons why it is like that and suggest the best ways to improve the situation.
4. It can be concluded from the analysis that regions are supported in an unarranged way that does not promote the development of the regions and consequently the development of the country. Support has to be planned starting from the common State development plan and there should be regional development policy in EU funds distribution.
5. There is a purposeful action to be taken to arrange regional planning, finding the best ways of the support and increase the activity and capability of the regions to apply and implement EU funds to enhance development. There is a need to have united regional quotation for EU financing. That would mean definite amount of financing allocated directly for the development of specific regions. Now because of luck of this quotation financing is granted to those who are more active and more informed and mostly closer to capital. Rural Support Service has some quotation principles but other institutions do not have them and work rather independently.

6. Future investment in regional development has to be based on the long-term regional planning principles. Consequently, long term regional development plans for all the regions of Latvia need to be elaborated including such parts as:
   - urban and rural development – construction, reconstruction;
   - infrastructure – public services, reconstruction of roads and streets, water supply etc.;
   - development of entrepreneurship – business incentive schemes, special production areas, business incubators;
   - innovation and science development – research institutions, innovation development centers;
   - education sphere development –elementary, secondary, higher and professional education for youth and lifelong education.

EU funding support for regions should be aimed at the range of programmes involved in elaborated regional development plans and connected with public services, entrepreneurship development, innovation and knowledge economy development and human capital investment. Implementing this scope of programmes with definite aims and locations in Latvian regions it will be possible to achieve the development aims.

7. Before allocating direct EU funds aid there is a need to perform a research and investigate which are the strong sides of the regions, what are the most important potential development industries. Clustering has to be supported from the existing enterprises in the spheres that are the strong sides of the regions.
8. In order to facilitate the development and competitiveness there is a need to concentrate on the strong sides of the regions and not on the prevention of the weak sides because the state aid oriented to weak sides will not bring the desired result. On the other hand, by developing strong sides and industries, it is possible to achieve significant result and economic progress. Every region has its strong sides and industries it should concentrate on; it is not effective to develop all the sectors everywhere.
9. One possible way of the development would be to introduce specialisation of the regions on some core industries. This can be implemented when funding and state aid is available just for stated branches, and different clusters of branches are made in every region enhancing development in one purposeful direction. Riga region can be definitely seen as innovation and high value added production centre. It is quite incredible to create such centre in Latgale region, in the regions bordering Russia and Belorussia, but these regions have other strong sides – they are transit and agriculture centres. In Zemgale region, wood industry and agriculture connected with plant growing products could be the core industries. Kurzeme with its ports is a transit region and also has perspectives and background in metal and machinery components industry. Vidzeme region has strong traditions in food processing industry.

Both urban and rural territories of the country should be strong because towns act as a catalyst for innovation and regional development which stimulates development of rural areas.

10. Riga region and Kurzeme region are also regions that need to develop and, for example, entrepreneurs from Riga district should have possibilities for development. Support programmes for these regions should be with different aims and having smaller co-financing rate from EU funds.
11. New EU funds regional allocation system has to be implemented according to the suggestions and improvements offered. In general, possible means to endorse the development of the undeveloped regions of the country by support programmes could be divided into three parts:
    1) Creating specific support programmes for the development of regions. It implies specific support programmes that are designed with definite aims like water supply development in towns with definite population amount. Project applicants from Riga, Riga region and largest towns usually cannot apply for such kind of programmes. This is the most effective way to achieve specific development results.
    2) Having criteria allowing giving more points for projects in regions. This option implies that there are specific project evaluation criteria in which those projects from regions can gain more points than projects from Riga, Riga region and largest towns. This option has a drawback as it creates a not very fair competition between applicants because all good and appropriate projects that could enhance development of every region deserve financing.
    3) Giving larger aid intensity for projects from regions. It means that projects coming from regions or specially supported areas can gain larger co – financing from EU and government side than projects from Riga, Riga region and largest towns so they have more options to implement projects.

This is a very acceptable way for supporting more those regions that do not have possibilities for large co–financing rates.

12. Applicants from regions need to be active enough, to develop and submit projects in order to receive financing. Project application and implementation capacity has to be increased in regions.
13. For implementation process of all the Structural Fund programmes there should be created united regional branches of implementing agencies. Their functions should include project application reception and information on support programmes. Thus regions would have more information and consultations on different aid programmes, which would increase the participation of regions and project applicant activity in regions, which in its turn would assist to achieve regional balance objective.
14. In order to ensure effective project implementation there is a need to demand regional cooperation in entrepreneurs and public institutions. large programmes, for example, Business incubator development, Cohesion fund programmes. As Latvia is a rather small country it is not effective to implement such projects in all the municipalities separately. To achieve development results, neighbour municipalities should work together.
15. One of the important aspects is that it is not enough just to have support programmes, but there should be special working party organized that first of all lends assistance to the development of projects as such and gives preliminary assessment if this project is suitable and effective for the development of the region. Consultation work has to be organized for regions to increase regional potential. After that when projects are approved, this working party supervises implementation of projects in regions and offers free consultations. This actually would mean consultative work that is available free of charge for a range of applicants from underdeveloped regions both for

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THE THEORETICAL AND LEGAL ASPECTS OF AREA PAYMENTS IN LATVIA

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Abstract

The study summarises the theoretical and legal aspects of the main types of area payments in Latvia. From the point of view of theoretical and legal arrangements, the area payments may be broken down in two large groups: direct payments and area payments foreseen under Rural Development Programs. The legal package regulating Area Payments consists of the EU regulatory enactments (Council or Commission Regulations) and regulatory enactments of Latvia (Laws and the Cabinet (MK) Regulations). The institutional implementation system of each group of Area Payments is relevant and distinct. The present study analyses 11 different types of Area Payments. Over the period 2004 – 2007, farmers have received LVL 430 million in different Area Payments constituting 58.5% of the total amount of support.

Key words: Area payments, rural development, agriculture.

Introduction

The Accession Agreement foresees common rules for application of the direct support payment schemes in accordance with the Common Agricultural Policy (CAP). Through accession, Latvia has transposed the EU agricultural legislation, its goals and underlying principles. The total costs of the EU CAP are ~ EUR 53 billion per year which in 2007, took up 40 % of the total budgetary outlays (The Impact of..., 2008).

In Latvia, the direct payments are implemented within the Single Area Payment Scheme (SAPS). It means that agriculturalists have access to SAPS, as well as Complementary National Direct Payments (CNDP), a part of which are also Area Payments. Direct Area Payments in Latvia is an essential source of income for agricultural holdings. The EU statutory provisions foresee gradual increase of direct payments in the New Member States, stipulating that the new Member States will reach the level of the "old" Member States in 2013. (Agriculture and Rural..., 2007).

As a type of financial support Area Payments have been designed among other purposes, also to encourage rural development, furthermore having in view the coming CAP changes in the EU. In Latvia, it is a rather recent and scientifically understudied type of support. Separate issues of agriculture and rural development support have been studied at the Latvian State Institute of Agrarian Economy: A. Miglavs, G. Salputra (2008), V. Bratka (2005), D. Saktiņa, W.H. Meyers (2005), as well as at the Latvia University of Agriculture: I. Pilvere (2007), I. Pilvere and A. Rukmanis (2004, 2006), G. Mazūre (2005), V. Buģina and Ģ. Krūmiņš (2005).

Some research has been conducted also in other EU Member States, e.g., Lithuania where it is underlined that "...the role of agriculture in rural policy ...changed from a resource supplier for the industrial sector to an important and competitive sector of the economy" (Vidickiene, 2007), Poland "...the majority of people (particularly farmers) are convinced that the EU budget may endlessly provide funds for compensating chances and development of rural areas" (Kondratowicz-Pozorska and Mickiewicz, 2004). The scientists of Portugal consider that "Agriculture still not only plays an important role for rural communities` standard of living, but it is also responsible for ties of cooperation between members of local communities" (Piecuch, 2006).

Regarding the above, the following **hypothesis** was set forth for this study: in Latvia, relevant legal arrangements and institutional system was put in place for the implementation of Area Payments which constitute a material part of the total amount of the support financing. Thus, the above conditions and considerations suggested the **goal** of this study: study of the theoretical and legal aspects of Direct Payments, as well as the institutional system. The following **assignments** were formulated for the achievement of the identified goal:

- Study the theoretical aspects, types of support and the basic conditions for receiving support under Area Payments;
- Identify the main regulatory enactments governing Area Payments and the institutional system;
- Analyse the main results of the Area Payments' implementation in Latvia.

Materials and Methods

The following **methods** were applied: analysis of the regulatory enactments and findings of other scientists, theoretical discussion and classification. For delivering the assignments set forth in the study, a number of sources were used: EU documents, Republic of Latvia Laws, Cabinet Regulations governing Area Payments in Latvia, information obtained from the Ministry of Agriculture (MOA) and the Rural Support Service (RSS), publications and specialized sources.

Results and Discussion

1. Theoretical Aspects of Area Payments in Latvia

Area Payments are the annual financial support to agriculturists disbursed for every unit (ha) of the farmed agricultural land (AL). As from 2007, in addition to SAPS and CNDP, farmers are eligible for support for crops with high energy value (CHEV) (The procedure for.., 2007).

Area Payments are foreseen also in the Latvian Rural Development Plan for 2004-2006 and the Rural Development Program for 2007 – 2013 (RDP). Specifically:

- Less-favoured area support payment (LFA), accessible to farmers whose farmland is situated within the territory of LFA. The objective of this support payment is underpinning of sustainable agricultural activity making use of environmentally-friendly methods and providing for the income increase in agricultural holdings situated in less favoured areas. LFA cover 74.4 % of the whole territory of Latvia, comprising 1.81 million ha of agricultural land including arable land, meadows, pastures, permanent grassland.
- Support for farming in areas with environmental restrictions (AER). It is accessible if the farmland is situated within territories under special restrictions of the entrepreneurial activity.
- Agro-environment Measures incorporating several sub-measures: Development of Organic Farming (DOF), Maintenance of Biodiversity in Grasslands (BG), setting up of Buffer Zones (BZ) and Containing Erosion (CE) (Latvian Rural Development..., 2004; 2007).

The schematic breakdown by types of Area Payments is reflected in Table 1 below.

Table 1

Types of Area in Latvia in 2008

Direct Payments		RDP measures
Production-coupled payments	CNDP for arable crops	LFA
	CNDP for areas under feed crops	
	CHEV	Natura 2000
Decoupled payments	Decoupled area CNDP	
	Decoupled CNDP for young farmers in specific cases	Agri-environment measures
	SAPS	

Source: authors according to DSS data of 2005-2007.

The coupled payments constitute support related to current activities of the farmers (e.g. support for the cropped areas or the produced product units).

The de-coupled payments constitute support unrelated to agricultural activities: production of specific products, raising of bovine animals or use of specific production factors at the current moment. The payments de-coupled from production are called also historical payments for they constitute support granted for agricultural activities completed over a certain period in history or a reference period, which in Latvia is 2006.

Farmers (irrespective of their legal status), farming AL, engaged in agricultural activities (production of agricultural products, growing and harvesting crops, etc.) or maintaining land in good agricultural and environmental condition (irrespective of the land tenure - ownership, rent or use) and undertaking all the related business risks, investing assets in land management or production of agricultural products are eligible to receive the Area Payments. (Guidebook on Receiving..., 2007).

The revenue of farmers from Area Payments depends upon the rate and the number of hectares actually farmed in conformity with the respective conditions for receiving support.

Table 2

Rates for Different Types of Area Payments in Latvia, EUR

Type of Support	2004	2005	2006	2007	2008	2009[1]
CNDP for arable crops, for ha	65.96	68.06	69.54	39.38	28.37	39
CNDP for feed crops, for ha	17.90	15.64	12.75	11.32	9	7
Support for crops with high energy value, for ha	x	x	x	45	45	45
SAPS for ha	20.66	26.44	32.83	37.84	46.14	57
Decoupled Area CNDP, for reference ha	x	x	x	25.53	30.51	~35
Decoupled CNDP for young farmers, for reference ha	x	x	x	26.75	27.61	~27
LFA, for ha	33*/46**/64***				25*/40**/58***	
AER (Natura 2000), for ha	38/33*/30**/26***				44	
Agri-environment, DOF , for ha	139 or 82				108-419	
Agri-environment, BG, for ha	138				123	
Agri-environment, BZ, for ha	0.102^/0.180^^/0.256^^^					

[1]provizional rates for direct payments

LFA category 1, category 2 **, and category 3****

Source: authors according to data of RSS of, 2005-2007.

From the above information presented in Table 2, it follows that over the period of 2004-2009:

1. The SAPS rate has grown considerably: more than 2.7 times due to the outcome of the accession negotiations for Latvia needs to reach the direct payment level of the old Member States in 2013.
2. The Decoupled Area CNDP rate has also increased: by 37% in 2009 in comparison with 2007 and the Decoupled CNDP for young farmers has grown by 1%.
3. CNDP rates for arable crops have substantially decreased: by 41%, due to the introduction of decoupled payments from 2007 and areas under feed crops: from 17.90 EUR ha^{-1} to 7 EUR ha^{-1}.
4. The support for crops with high energy value has been introduced anew in 2007 applying a flat support rate.
5. LFA support payments are subdivided in 3 categories. LFA rates are substantially decreasing starting from 2008. The rate for LFA category 1 is dropping by 25%, for category 2: by 14% and for category 3: by 10%.
6. The support for farming in areas with environmental restrictions has also been subject to changes. Up to 2007, this payment was disbursed depending on the region in which the particular area was situated: if, the area did not lie in LFA territory, the rate per ha was 38 EUR, whereas, if, it was situated in LFA territory Category 1 the AER support rate was 33 EUR ha^{-1} etc. Starting from 2008, this Measure was renamed Natura 2000 applying a flat rate of 44 EUR ha^{-1}.
7. The least changes affect the support under sub-measure BZ of Agri-environment. There are three types of BZ support: 0.102 EUR m^{-1}, for setting up a bufferzone of collecting ditches^, 0.180 EUR m^{-1}, setting up a field bufferzone^^ and 0.256 EUR m^{-1} for setting up a waterbody bufferzone^^^.
8. Ample changes are introduced in support to organic farming. The beneficiaries continuing their commitments undertaken under RDP of 2004-2006 may continue to receive support under the same scheme, i.e., receive 82 EUR ha^{-1} for transition fields and 139 EUR ha^{-1} for fields approved for DOF. At the same time, pursuant to RDP for 2007-2013 it is possible to transform the commitments undertaken into new ones; in this case not only the support conditions but also the support rates are changed further depending upon the crops raised by the particular farm. The new DOF support rates vary from crop to crop constituting 108-419 EUR ha^{-1} (Latvian Rural Development.., 2007).

The maximum support rate provided for by the European Commission may deviate from the rate actually applied if the area registered for support by the beneficiary is actually larger than the reference rate. Therefore, it is important to know the reference rates for the total support funding has been calculated for the reference area, so, in case it is exceeded, the fixed support rate for ha is accordingly reduced. In Latvia, the reference rates have been fixed as on the moment of accession to the EU and are constant:

- SAPS 1 475 000 ha (pursuant to Annex XXI of the EC Regulation 1973/2004);

- CNDP for arable crops 443 580 ha;
- CNDP for feed crops 395 200 ha (paragraph 1 of EC Decision 06/VII/2004 C (2004) 2316).
- Areas registered for CHEV support totally in the EU - 2 000 000 ha (Laying down detailed…, 2004a).

Funding sources of Area Payments and eligibility conditions vary:

1. In the period 2004-2006 – Guarantee Section of European Agriculture Guidance and Guarantee Fund (EAGGF). However, the apportionment differs: direct payments are 100% funded from the Guarantee Section of EAGGF and constitute 100% subsidy to beneficiaries while 80% of the Measures under RDP are funded from Guarantee Section of EAGGF and 20% of the government budget of Latvia, the latter constituting 100% of compensations to beneficiaries (Pilvere, 2007).

2. In the period 2007-2013:

- Direct payments: from European Agricultural Guarantee Fund, funded 100% from this fund as a 100% subsidy to beneficiaries.
- RDP measures: from European Agricultural Fund for Rural Development which is the sole EU funding source currently available for rural development programs (The Impact of..., 2008). However, the co-financing from the national budget is mandatory (Miglavs and Salputra, 2008), of different size depending upon the measure. The support is disbursed to agriculturists as 100% compensation.

To qualify for the Area Payments, agriculturists need to prove compliance with a number of conditions explained both, in the EU and Latvian regulatory enactments analysed in the next chapter.

2. Legal background of Area Payments in Latvia

The regulatory enactments governing CAP support instruments can be divided in two parts according to their origin:

1. European Union Regulatory Enactments.
2. Latvian National Regulatory Enactments.

European Council and Commission Regulations form multi-level, cross-referenced packages of legal documents the most important of which are the following:

Council Regulation (EC) No. 1782/2003 is the main document providing for support payments to agriculturists. It establishes common rules for direct support schemes under the common agricultural policy and establishes certain support schemes for farmers.

Commission Regulation (EC) No. 796/2004 laying down detailed rules for the implementation of cross-compliance, modulation and the integrated administration and control system.

Commission Regulation (EC) No.1973/2004 laying down detailed rules for the application of Council Regulation (EC) No 1782/2003 as regards the support schemes provided for in Titles IV and IV a of that Regulation and the use of land set aside for the production of raw materials.

Council Regulation (EC) No. 1257/1999 on support for rural development from the EAGGF.

Commission Regulation (EC) No. 817/2004 laying down detailed rules for the application of Council Regulation (EC) No 1257/1999 on support for rural development from the EAGGF.

Commission Regulation (EC) No. 27/2004 laying down transitional detailed rules for the application of Council Regulation (EC No 1257/1999 as regards the financing by the EAGGF Guarantee Section of rural development measures in the new Member States. The Regulation foresees detailed rules for the adjustment of the euro agri-monetary regime in the new Member States.

Commission Regulation (EC) No. 141/2004 lays down provisions for application of the Council Regulation (EC) No. 1257/1999 in relation to rural development transition measures in the New Member States as well as planning and evaluation of the rural development measures.

For implementation of the Direct Support and RDP payments in Latvia, a number of regulatory enactments had to be drafted and put in place which as to their hierarchy can be classified as follows:

1. Laws.
2. Cabinet Regulations.
3. Documents adopted by Ministry of Agriculture and RSS required for implementation of specific measures.

Laws of Republic of Latvia or comparable documents thereof are:

Accession Agreement (1993) lays down provisions on rights and duties of the Member States including Latvia, as well as provisions on the mandate and competency of the EU bodies in the field of agriculture.

Law on Rural Support Service (2000). Its objective is to ensure a unified implementation of the agricultural and rural support policy, as well as a national administration system of the EU support.

Republic of Latvia Law On Especially Protected Nature Territories (1993) lays down the underlying principles of the system of especially protected nature territories, the procedure for establishment of such territories and their safeguarding.

Regulatory enactments adopted by the Cabinet are summarised in Figure 1.

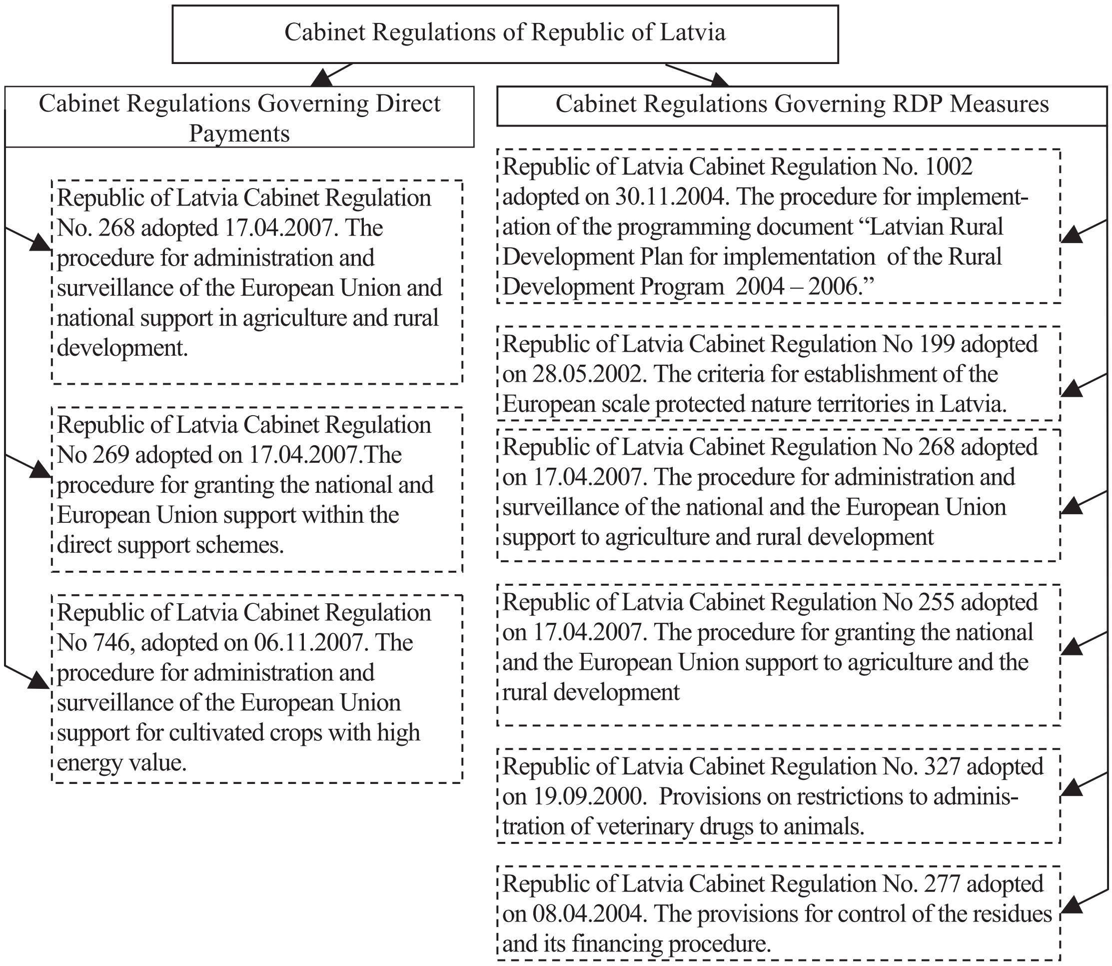

Figure1. Republic of Latvia Cabinet Regulations in 2008.
Source: drafted by authors according to regulatory enactments.

Republic of Latvia Cabinet Regulation No. 268 adopted on 17.04.2007 lays down the procedure for administration and surveillance of the European Union and national support in agriculture and rural development measures from the Guarantee Section of the EAGGF. The Regulation governs the following support schemes: SAPS and CNDP for arable crops and feed crops, LFA and support under sub-measures of Agri-environment (DOF, BG, BZ).

Republic of Latvia Cabinet Regulation No 269 adopted on 17.04.2007 lays down the procedure for granting the national and European Union support within the direct support schemes. And identify the types of national and the EU support as well as the eligibility conditions for potential beneficiaries.

Republic of Latvia Cabinet Regulation No 746 adopted on 06.11.2007 lays down the procedure for administration and surveillance of the European Union support for cultivated crops with high energy value.

Republic of Latvia Cabinet Regulation No. 1002 adopted on 30.11.2004. lays down the procedure for implementation of the programming document "Latvian Rural Development Plan for implementation of the Rural Development Program 2004 – 2006.

Republic of Latvia Cabinet Regulation No. 327 adopted on 19.09.2000 lays down certain restrictions for administration of veterinary drugs to animals. Republic of Latvia Cabinet Regulation No. 277 adopted on 08.04.2004 provides a list of residual substances included in the residue control program the presence of which is monitored in animals, animal feed, products, potable water and surface water. The regulations are related to eligibility of receiving support under LFA and/or Natura 2000 payments.

3. Institutional System for implementation of Area Payments

The institutional system for implementation of the area payments is derived from the EU and Latvia's regulatory enactments described in the previous chapter. The institutional system for direct payments and the RDP measures is diverse: see Table 3.

Table 3

Institutional System for Implementation of Area Payments in 2008

Direct Payments		RDP	
Name of the Institution	**LR Institution**	**Name of the Institution**	**LR Institution**
Competent Authority	MOA	Competent Authority	MOA
Paying Agency	RSS	Paying Agency	RSS
Certification Body	Selected by MOA according to the public procurement procedure	Certification Body	Selected by MOA according to the public procurement procedure
		Managing Authority	MOA
		Monitoring Committee	Fellowship institution uniting 21 representatives of different stakeholders

Source: drafted by authors according to Cabinet Regulations No. 267, 2007.

Thus, the implementation of RDP involves more institutions than direct payments. This is caused by the necessity of drafting, if appropriate, amending the RDP, its co-ordination with the European Commission and monitoring of its implementation. Main purpose of the Competent Authority: accreditation of the Paying Agency and the related structures, clarification of bookings for EAGGF and EAFRD. Paying Agency carries out granting and disbursement of support. Certification Body carries out accreditation of the Paying Agency and certification of accounts according to delegation of MOA. Managing Authority is responsible for efficient and appropriate management and implementation of RDP. Monitoring Committee is acting on the basis of self-approved By-law, provides the monitoring of the implementation of RDP.

4. Area Payments' Implementation Results in Latvia

The amount disbursed over the given period within the direct payments' scheme is reflected in Table 4.

Table 4

Area Payments in Latvia over the Period of 2004-2007, Thousand LVL

Indicators	**2004**	**2005**	**2006**	**2007**	**Totally**	**Structure, %**
SAPS applications, number	69585	78610	80429	77640	306264	x
SAPS	17441.0	26708.0	33651.5	39033.9	116834.4	27.2
CNDP	23300.2	25060.6	24943.1	15397.2	88701.1	20.6
Decoupled CNDP	x	x	x	10003.0	10003.0	2.3
Crops with high energy value	x	x	x	793.5	793.5	0.2
LFA	27492.9	35043.8	37187.9	29896.8	129621.4	30.1
AER	x	1390.9	1592.8	1277.9	4261.6	1.0
Agri-environment payments	4265.0	10391.4	24845.8	21407.8	60910.0	14.2
Force Majeure	x	323.9	18856.4	x	19180.3	4.5
Total Area Payments	72499.1	98918.6	141077.5	117807.0	430302.2	100.0
TOTAL Support Payments, MLN LVL	110.5	219.7	213.3	191.5	735.0	x
Proportion of Area Payments in total support, %	65.6	45.0	66.1	61.5	58.5	x

Source: drafted by authors according to RSS data of 2004-2007.

From information presented in Table 4, several conclusions can be derived:

- Over the period 2004 – 2007, RSS has processed 306,264 applications for Area Payments, requesting SAPS payments and has disbursed more than LVL 116.8 MLN within this scheme.
- Since 2007, changes have been introduced in the CNDP, dividing it in two parts: CNDP and the decoupled CNDP. The decoupled CNDP can be received for the number of ha for which CNDP has been received for the previous year. Of all types of Area Payments, the highest proportion has been disbursed under LFA;

however, in 2008, the situation is expected to change for the support rates for LFA are going to be reduced.

- Force Majeure (FMA) support is envisaged for emergency cases from the state budgetary allocations to mitigate the damages to agriculture by unfavourable weather conditions. In 2006, this type of support was disbursed for injuries caused by the draught to arable crops and feed crops. Thus in 2006, LVL 18.9 MLN was disbursed under FMA support scheme. In 2005, this type of support was paid to farmers to compensate damages caused by excess precipitation.
- Of the total support funding disbursed, Area Payments take up more than 50%; up to now the highest point has been reached in 2007 with 66.1%, disbursing over 141 MLN LVL.
- Over the period 2004-2007, the amount of support disbursed within Area Payment schemes amounts to LVL 430.3 MLN substantially increasing from 72.50 MLN LVL in 2004 to 117.8 MLN LVL in 2007. It is expected that this amount could still continue to grow in 2008 as new measures are becoming available and the support rates for several support types are increased.

Conclusions

1. One of the most important elements of the CAP common market organization is direct area payments: a support to agriculturists on annual basis fully funded from the EU common budget. The former support for products is gradually being replaced with direct support to producers.
2. In Latvia, agriculturists may receive support within the Single Area Payment scheme incorporating SAPS, CNDP, CHEW (as from 2007) as well as decoupled payments.
3. Rural Development Plan for 2004 – 2006 and Rural Development Program for 2007-2013 foresee several area payments: LFA, AER support and support under sub-measures of Agri-environment, disbursed as compensation and subject to eligibility conditions.
4. The process and operation of the Area Payment implementation is regulated by enactments on different levels of legislation the most important of them being EU Regulations and Commission Decisions, Republic of Latvia Laws and Cabinet Regulations.
5. The institutional system established in Latvia for implementation of the Direct Payments is compliant with the EU requirements.
6. Over 2004 – 2007, Area Payments have been disbursed to 76 566 agriculturists in Latvia (yearly average) in the total amount of LVL 430.3 MLN constituting 58.5% of the total support disbursed in Latvia.

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DEVELOPMENT OF SOCIAL TRANSFERS IN THE SOCIAL SECURITY SYSTEM IN LATVIA

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Abstract

In the paper, the philosophical and historical evolution of social transfers and their role in Latvia's social security system have been investigated. Definitions of social transfers have been studied, and a classification of social transfers has been made.

The most suitable social security system, which, to a great extent, depends on social policies and a socio-economic situation in a country, is elaborated in every country. Latvia's social security system includes state social insurance, state social benefits, social services, and social assistance that are based on financing from both the state basic budget and the state special budget, and municipal budgets.

Social transfers have a significant role in the social security system in order to provide protection for the population in social risk situations; they impact the welfare of the population during this period.

Key words: social transfers, social security system, state social insurance.

Introduction

The capacity of the social security system and sustainable development play a significant role in preventing social tension and providing welfare in society, which protects society's individuals in social risk cases and provides the disabled with means of subsistence.

Maintaining the financial stability of the social security system and promoting the system's development, as well as achieving a better understanding of the public about the role of the social insurance system are the main tasks to be solved, according to the Latvian National Development Plan 2007-2013, in order to provide a sustainable social security system in Latvia.

Every country has its own history and traditions that served for providing welfare; every country has a specific economic situation and development strategy, as well as a big role is played by decisions and priorities in social policy. Yet the role of globalisation increases, information and experience exchange among countries also increases, which more and more emphasizes the common tendencies in social insurance systems.

To reach as high social welfare level as possible in Latvia, a social security system – a totality of social policy measures – was developed. Its goal is to compensate the population for material, moral, and physical losses. Social risk situations are as follows: disability due to a sickness or occupational trauma, physical incapacity, age, unemployment, maternity, death of a relative, loss of a breadwinner (Social Processes in Latvia, 2003).

Studies on the state social security and the welfare system in Latvia were done by I. Saulāja (Saulāja, 2006), L. Bite (Bite, 2003), V. Kalniņa (2000) where the major attention was paid to the integration of individuals in the labour market after leave for child care; state social benefits that are received during leave for child care as well as the pension system, and an impact of state social policy on the welfare of the population were reviewed.

Within the project 'Studies of the Ministry of Welfare' of the national program 'Labour Market Studies' financed by European Union structural funds, the study 'An Optimal, Employment-oriented Tax and Social Benefit System' (2005-2007) was conducted, the general goal of which was to promote the creation of employment and social policy programs based on the study results, which would stimulate the emergence of an inclusive labour market in Latvia. The study presents the trends in employment and business and gives an evaluation for social insurance benefits in Latvia.

Yet so far few studies on the historical evolution, nature, types, and role of social transfers in the social security system have been done.

The hypothesis: an increase in the average amount of social transfers reduces social risks for the population.

The research aim is to investigate the nature and development of social transfers in Latvia.

To achieve the research aim, the following research tasks were set forth:

- to investigate the philosophical and historical evolution of social transfers;
- to characterise the social security system in Latvia;
- to investigate the nature of social transfers.

Materials and Methods

To investigate the philosophical and historical evolution and socio-economic role of social transfers in the social security system, scientific publications, legal materials, and special and economic literature were used in the research.

Information of the Central Statistical Bureau of the Republic of Latvia - 'Income and Living Conditions in Latvia' (2007) and Latvian Statistical Yearbook 2007 (2007), as well as data of the State Social Insurance Agency (SSIA) were used in the research.

The research is based on monographic, abstractly logical, analysis and synthesis, deductive and inductive research methods, as well as dynamic time-array analysis.

Results and Discussion

The quality of life is based on the welfare of individuals, security, and the sustainability of society. Since the times of Adam Smith and Carl Marx, possibilities for social activity and an ability of individuals to act have been regarded as the main preconditions for the welfare of people. C. Marx included it in a formula: 'free development of any individual is a precondition for free development of all individuals' (Review of Population Development 2004/2005, 2005).

In the European culture, philosophers Plato and Aristotle are considered the first ones who have given a fairly systematic and quite broad analysis, which is preserved till nowadays, in their works. For many ancient Greek philosophers, society is identical to the state. The views differed only in the issue of emergence of society (state).

Plato (428-347 B.C.) was one of the first philosophers known to the modern world who solved political problems at a philosophical level. It was absolutely clear to Plato that there is no equality in society, and a certain internal division is characteristic of it (Catlaks et al., 2003).

One can borrow several ideas from Plato's views in the aspect of human development conceptions:

1. all people are not born equal, society is divided into two groups: free and unfree people;
2. any social stratum performs specific functions, which ensures that the whole state exists;
3. a state is a political and economic entity with a goal to solve all its contradictions.

Aristotle (384-322 B.C.) emphasised that the function of the state is to redistribute incomes; excessive wealth is condemned. He also pointed out that a happy life has to be provided for people. In contemporary views, exactly this function provides both educational and health, and social security activities.

Thomas Robert Malthus (1766-1834) developed the theory of population. He objectively pointed out that irrespective of human will, wishes, and morale, factors hindering population growth exist; however, it is good from the point of view of the whole mankind. The problem of overpopulation is topical in many places in the contemporary world, and in some places, society is forced to supplement natural regulatory factors with ones introduced artificially. Presently, an opinion that a lot of residents – it is good – dominate in Latvia, which might be quite short-sighted (Brīvers, 2001).

In the second half of the 19th century, a socialistic movement started to emerge; the common goal of its various sub-movements was to accentuate the role of government interventions in the economy and to highlight social problems and contradictions among social classes. The key representative of this movement was **Carl Marx** (1818-1883) who can be ranked as an economist in the classical school. He believed that the whole social life is determined by the economic life of society or the type of production. Right here the main classes appear – the one having a means of production (factories and raw materials), and the second one having nothing like that. The first one rules over the life of the second one.

In the second half of the 20th century, a heterogeneous teaching, which accentuated welfare, appeared. It determined an optimal level of welfare under limited resources, exposing factors for maximising welfare. **Arthur Cecil Pigou** (1887-1959) is considered a founder of welfare economics. To measure welfare, the term 'nation's dividends', which means gross domestic product, was introduced. Income redistribution issues take an important position in Pigou's conception in order to provide support for poor strata. Government interventions are required both in a direct and indirect form. These issues were especially expanded by another economist, **John Atkinson Hobson** (1858-1940). The authors of welfare economics presented a formulation of the problem itself by making a qualitative evaluation of the economy. It became a basis for real welfare models, the development of which was so popular in the second half of the century.

The above-mentioned teachings emphasised the need for government intervention in economy. Yet one has to add that these views were exceptions in those times because the dominating view supported an idea of free market economies. However, the preconditions for government interventions emerged gradually, and the 1928-1933 Great Depression caused a substantial need for reconsidering the role of government in economy. In this way, the conception of government interventions developed by **John Maynard Keynes** (1883-1946) emerged, laying foundations for the whole macroeconomic theory. Keynes' economics tends to solve problems of economic instability. It is a very active price, wage, fiscal, and monetary policy. Overproduction in society is related to an insufficient demand, but demand is not just a problem of individuals. A government can stimulate solvent demand by various social benefits, by setting a minimum wage. With increase in purchasing power, demand will grow, thus stimulating output and engagement of the unemployed in economic activities. To make entrepreneurs interested in it, the government might pay subsidies, give loans, reduce taxes, as well as found state-owned enterprises, creating jobs in them.

As a conception, Keynesianism became very useful in real economic policy during the period from the end of World War II to 1980ies. In fact, the welfare level of industrially developed countries was achieved owing to the advice of Keynesianism (Population Development, 2002).

The term welfare originated from a psychological need for counterbalancing a tendency to research only psychological dysfunction. Scientist Riff started asking a question about what are the main positive features of psychological functioning (Smith, 2000).

State social policy is based on questions related to factors improving the welfare of people and factors endangering it. Welfare is a term to be hard to define. There is no single understanding of it, just like there is no single way of how to analyse it. It includes the welfare of both society and individuals, but the economic, political, and moral and ethical definitions for welfare differ. Economists would probably consider wealth one of the indicators of welfare. It would seem to political scientists that social capital and democratic participation are important. Moral and ethics analysts could ask questions about resource distribution and possibilities for life perspectives as welfare providers for society. Although social welfare is viewed in a positive sense in all these aspects – as a social benefit, sometimes it is used to be perceived as an unfavourable dependence on resources of society. For instance, a large number of claimants for social support/guarantees is considered a problem arising from dependence on social security, especially in the USA (Dudareva et al., 2003).

In a broader sense, 'welfare' means prosperity; preconditions for it are created by each individual's activity, good work and diligence, as well as economic development of a country, social and economic stability etc. (Explanatory Dictionary of Economics, 2000).

In studies, the term welfare is quite often substituted by the term 'life quality'. According to the ideas of Haug and Folmar (Haug et al., 1986), life quality is a term that is freely used to describe general welfare.

It is defined in the Latvian National Development Plan 2007-2013 that the quality of human life is determined by a certain level of material and emotional satisfaction, so that people, inspired by positive emotions, invest their mental and physical potential in developing the state and society. 'Life quality is a complex social, economic, and political term that includes a broad range of life conditions of the country's population. It is characterised by a consumption level available to individuals, an assortment and quality of social services, a possibility to acquire education, live a long and healthy life, participate in the country's political life, by eliminating any discrimination due to gender, nationality, race, religion, individuality, sexual orientation, and age, thus creating possibilities for individuals to realise their potential in the process of raising the welfare of society'.

In the last quarter of the 19^{th} century, social insurance with government participation started developing in various countries. Historically, social insurance began due to mutual assistance organisations. Originally, those were 'Friend Societies' in England and mutual assistance societies in France.

The first country that introduced compulsory social insurance was Germany, and it became a pattern for other industrially developed countries. Compulsory insurance against accidents spread the most and fastest, followed by health insurance, pensioner insurance and unemployment insurance.

The welfare system of the Republic of Latvia started emerging right after its independence was declared on 18 November 1918. In 1920, a law insuring employees against sickness was passed. The law required not only employees, but also their family members to be insured.

The state social protection system lays a foundation of social security for the population in case of social risks, and its main task is to reduce losses and their impact on an ability of people to provide the necessary life quality for themselves in each particular life situation. The main tasks of the social security system are to provide state social insurance and social assistance.

The security level of every socio-economic system is mainly characterised by the lifespan and quality of the population. A longer lifespan and a higher standard of living of the population indicate the security of a respective socio-economic system and vice versa – a shorter lifespan and a lower standard of living of the population indicate social tension and the insecurity of a socio-economic system. Therefore socio-economic systems and their security status lay a foundation of national security, the goal of which is to protect the population's political rights and freedoms, normal development of personality and society (Bergs, 2006).

Scientist J. Krūmiņš (Krūmiņš, 2008) pointed out in his studies that the population's expected lifespan can be analysed from two aspects. First, it is considered an average weighted value gained from life spans of separate population groups (men and women, urban and rural residents, regional residents, the dead by death causes etc.). Second, lifespan components can be analysed from a qualitative aspect. For instance, the length of life that is taken by the economically active period, the pension period, time period people have good health, number of years taken away by illnesses can be calculated.

According to Latvian Statistical Yearbook 2007 (2007), the expected lifespan of the population is 71.27 years (65.85 for men and 76.78 for women). There is a difference in the expected lifespan for urban and rural residents, i.e. 71.99 years in towns and 70.77 in rural areas.

In 1991 after Latvia regained its independence, the government had to start to think of creating a new political and economic system. The first years of independence wrecked illusions about fast economic growth. The transition to a market economy changed relations between the population and the state, increasing the role of people in socially protecting themselves and their families. It goes without saying that developing the model of Latvian social security system started soon after regaining the independence. Along with the economic reforms in the country, new laws regulating the social security were elaborated and passed, which was an instant reaction of the government to urgent and fast growing needs of the population.

In 1997, the elaboration of the Latvian Welfare Reform Project was completed and a loan contract between the Republic of Latvia and the World Bank was signed; as a result of it, Latvia received DEM 30 million to finance the introduction of this large project.

The Latvian Welfare Reform Project was implemented during 1997-2002. It included several welfare branches with the purpose of establishing a more economical and efficient social welfare system that would provide a possibility for protecting socio-economic rights and the health of every person.

In 1991, a social tax was introduced. The social security budget comprised payments of employers, employees, self-employed persons, government budget funds and other revenues.

In 1996, social tax payments were personalised, i.e. an insurance account, in which social tax payments were registered, was opened for each socially insured person.

In 1998, the law 'On State Social Insurance' came into force, which brought changes in the field of financing the social insurance. The term social tax was replaced by 'social security payments', thus addressing the principles of social insurance (Social Security Reform, 2008).

In a general case, the rate of social security payments when employers are protected by all kinds of social insurance remains unchanged since 2003, i.e. 33.09%, which is divided into two parts – the employer rate is 24.09%, while employees pay 9%.

In Latvia, the social security system includes state social insurance, state social benefits, social services, and social assistance that are based on financing from both the state basic budget and the state special budget, and municipal budgets.

Social insurance – a composite of measures organised by the state to insure persons or their dependents against the risk of losing income from employment due to insured persons' sickness, disability, maternity, unemployment, age, industrial accident, or occupational sickness, as well as against additional expenses due to child care and the death of insured persons or their dependents (Latvian Law on State Social Insurance, 1997).

One of the ways of guaranteeing the social security system is social transfers. The term 'social transfers' is mainly used in the field of social insurance, and it consists of two parts – 'social' and 'transfer'. To gain a more complete understanding of it, each component of the term has to be separately analysed.

The term 'social' originates from the Latin word societas, meaning society.

The term social is explained in the literature of various branches. The most popular ones are:

- related to society, human life, and relations in society; characteristic to them (Dictionary ot Foreign Words, 1999)
- related to social order, human relations in society; public (Dictionary of Latvian Language, 1987).

The term 'transfer' originated from the Latin word ***transferre***, a direct translation of it means to 'bear across, carry over'.

In the Dictionary of Foreign Words, the word 'transfer' is explained as follows: a money transfer from one financial institution to another or from one country to another (Dictionary ot Foreign Words Svešvārdu, 1999).

In the Economic and Financial Dictionary, the term 'transfers' means redistribution payments. Redistribution payments, transfer payments, and transfers, in their turn, are payments paid by the government to households – pensions, unemployment a.o. social benefits, state scholarships. They are not the government's reward for the supply of labour resources in a certain period of time (Economic and Financial Dictionary Ekonomikas, 2003).

The Economic Explanatory Dictionary explains the term 'transfer' as a money order or transfer. A money transfer is one of the types of money settlement operations used by legal and physical entities in order to make their payments. A money transfer can be carried out by a bank or a post office (Explanatory Dictionary of Economics, 2000).

The law 'On Budgetary and Financial Management' (1994) gives the following definition for the term 'transfer': a transfer is an annual transfer of budget funds especially prescribed in the State Budget Law, which can be done within one level budget – the state basic budget, the state special budget, the municipal basic budget, the municipal special budget – or among budgets of various levels. Transfer beneficiaries can use the received budget funds both for covering expenses and transferring them further to other transfer beneficiaries.

In the Central Statistical Bureau's (CSB) publication 'Household Budget 2004' and in the Latvian Statistical Yearbook (2004), the term 'transfers' is explained as follows – pensions, social security benefits, state social benefits, municipal social support benefits, alimonies, cash and material assistance from other households (Household Budget, 2004).

In her book 'The Budget of the Republic of Latvia: Yesterday, Today, Tomorrow', Doctor in economic sciences G. Rešina (2003) defines the term 'transfers' as follows: transfers are direct financial support in interbudgetary relations based on the legislative framework.

In the publication 'Income and Living Conditions in Latvia' (CSB, 2007), transfers are classified as follows: social transfers and private transfers (monetary support and alimonies from a person living in another household).

After compiling all the above-mentioned, social transfers can be defined as follows: social transfers are the government's temporary management of a part of the population's income, which provides incomes for particular population groups in social risk situations and in situations related to lowered incomes.

In Latvia, social transfers consist of state pensions and benefits. However, the system of benefits can be divided into three large groups, respectively, state social insurance benefits, state social benefits, and social support benefits, which are shown in Fig.1.

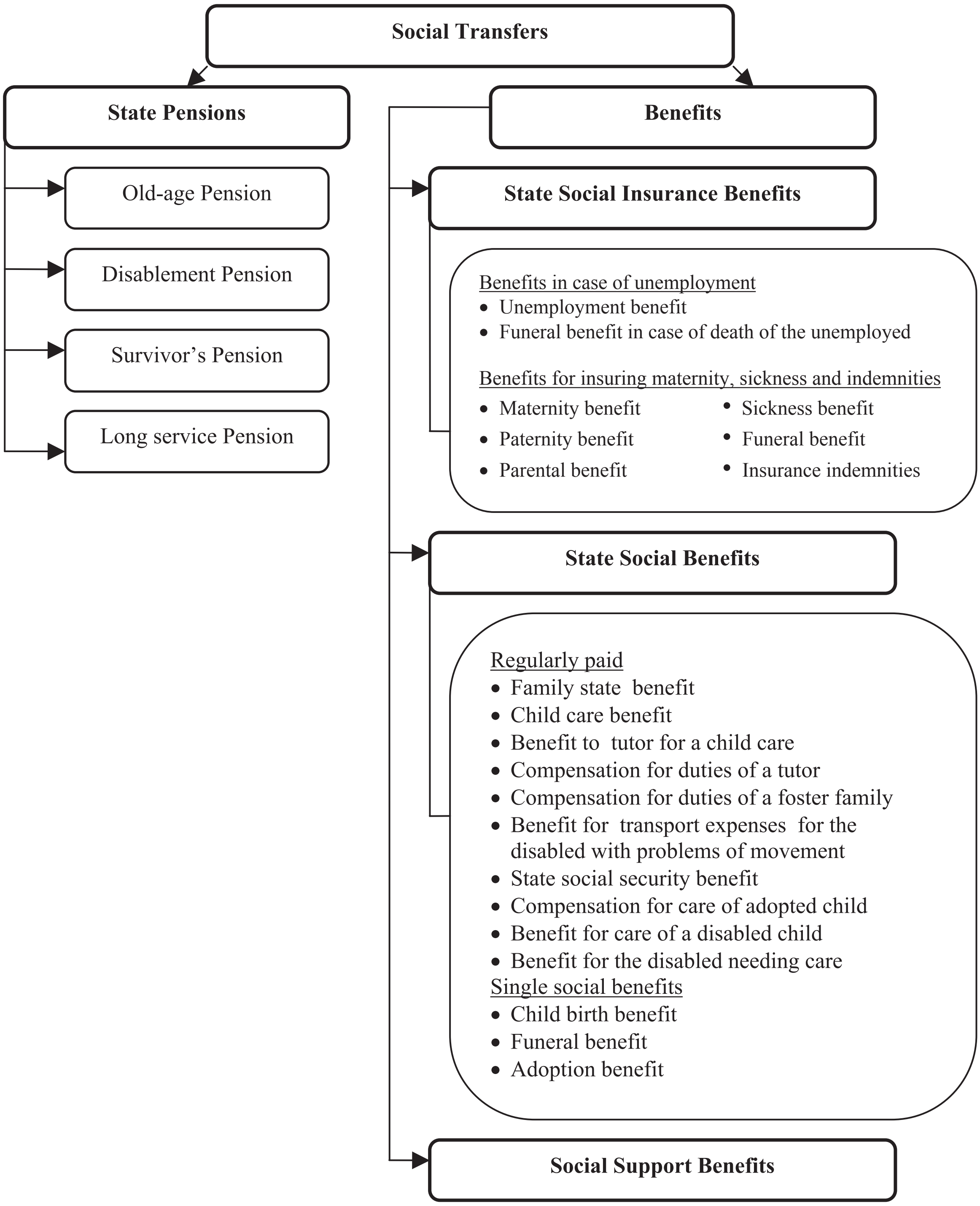

Figure 1. Types and a classification of social transfers in Latvia.
Source: developed by the author.

In general, the social security system is regulated in Latvia by the law 'On Social Security' (1995). It sets the principles of formation and operation of the social security system, the main social rights and obligations and their implementation conditions for persons, as well as regulates the types of social services, including social support and upbringing assistance, thus promoting social justice and social security.

The purpose of the law is to ensure that social services are rendered on time and institutions responsible for rendering these services are easily available.

When rendering social services, a different attitude is prohibited to persons due to race, ethnicity, skin colour, gender, age, individuality, health condition, religion, political and other views, national or social descent, material and family status, or other aspects.

To investigate the trends regarding social transfers, the author used the data of the SSIA from 2001 to 2007 (see Table 1).

Table 1

Average Amounts of Social Transfers and Average Wages of Socially Insured Persons in Latvia during 2001-2007, LVL

Types of Social Transfers	Years							Average absolute increase	Average increase rate, %
	2001	2002	2003	2004	2005	2006	2007		
All Pensions	59.41	61.4	63.44	69.71	78.86	93.11	107.16	7.96	10.3
Old-age pensions	60.65	62.92	65.19	71.66	81.3	96.39	111.57	8.41	10.7
State Social Insurance Benefits Unemployment benefit	40.54	42.48	51.02	57.06	63.92	78.81	107.19	11.11	17.6
Funeral benefit in case of death of the unemployed	100	98.17	90.86	104.92	105	134.58	135	5.83	5.1
Maternity benefit	297.3	326.79	384.97	479.01	557.48	647.1	830.25	88.83	18.7
Paternity benefit	-	-	-	77.39	83.98	103.98	131.93	21.99	19.5
Sickness benefit	79.92	86.45	96.55	109.61	121.77	144.48	175.68	15.96	14
Funeral benefit	196.36	170.62	213.14	218.03	206.63	293.1	328.77	22.07	9
Average Wage of Socially Insured Persons	145.36	154.57	172.32	191.84	219.92	273.93	364.55	36.53	16.6

Source: author's estimates using SSIA data

According to Table 1, one can conclude that the average amount of social transfers tends to increase, which is mostly related to an increase in the average wage of socially insured persons, as well as to changes in the legislation. The increase in the average wage of socially insured persons, in its turn, was impacted by an increase in the minimum monthly wage, an increase in the gross wages of employees, as well as by scrambling against the cash wages paid 'under the table' (Mistre et al., 2008). The greatest average absolute increase was observed for maternity benefits, which can be explained by an increase in the average wage of socially insured persons. To estimate a differentiation of social transfers among regions, as well as that of pensions and benefits between urban and rural residents, further studies are necessary.

Conclusions

1. Historically, the social security system began with mutual assistance organisations in England and France. Social insurance started emerging in the last quarter of the 19th century, and the first country that introduced it was Germany. The social security system of the Republic of Latvia started emerging right after the independence of Latvia was declared on 18 November 1918.
2. In Latvia, the social security system includes state social insurance, state social benefits, social services, and social assistance that are based on financing from both the state basic budget and the state special budget, and municipal budgets.
3. Any explanation of the term 'social transfers' is rarely available in Latvia. This term is only explained in a publication of the Latvian Central Statistical Bureau; therefore, the definitions are homogeneous and need to be improved.
4. In Latvia, social transfers consist of state pensions and benefits. However, the system of benefits can be divided into three large groups, respectively, state social insurance benefits, state social benefits, and social support benefits.
5. The average amount of social transfers tended to increase during 2001-2007, which can be explained by an increase in the average wage of socially insured persons, which, in its turn, was influenced by an increase in the minimum monthly wage.

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RESULTS AND LEGAL RESTRICTIONS OF DEBT RECOVERY IN LATVIA

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Abstract

Credit is an important impellent of economics and promoter of welfare that is the reason why government politics supported credit accessibility to legal and physical persons, which has led to the delayed payments in every business sector. The amounts of crediting in late years has sharply risen, wherewith increases the amount of inhabitants and enterprises, who can't repay their civil liability commitment. It is important to recover commitments to get finance for other investments. The amount of debt recovery is rising in Latvia peripheral economical breakdown that proves demonstrated information in the article about the situation at present.

Only in year 2008 banks slacked the speed of lending, but amount of debt recovery is just rising.

There was not all civil liability commitment entered that has appeared to legal and physical persons in Latvia, in Register of Debtors. Now when the Credit Register has come to the operation, the situation is clearer than it was before.

One of the ways for creditors to return their funds is through court. Between years 2003 and 2008 approximately 11% of plaintiff actions have been satisfied already in court, terminating them. 61% of plaintiff actions have been satisfied with judgment of court.

Take a note, that requirements in debt recovery change, as well as the interpretation of the laws and regulations. Whereby the debt collectors change contract regulations unhesitatingly to provide positive result in courts.

Key words: crediting, Credit Register, commitment recovery, court, restrictions of debt recovery.

Introduction

Unconsidered choice of financing source can pay high for an enterprise. If the enterprise has already started action and successfully become stable in the market, the enterprise can get extra finances in a way of borrowed money or a loan. Loans and credits are the most popular sources of financing. Need for finances appear to guarantee the consistency of the capital movement. So credit can be used profitably by one's enterprises free funds and for other enterprises needs.

But using a credit means, it must be repaid too. The problem of repay of liabilities is particularly important today when banks are affected by the recent world wide financial crisis. Their difficult financial situation may have an adverse impact on financing the development of agriculture and rural development. (Siudek, 2009).

Materials and Methods

In the research, one hypothesis has been proposed – to clear that there can be recovered commitment through court and a legal restriction influences the amount of debt recovery in Latvia.

The primary aim of this research was to clear the results and legal restrictions of debt recovery in Latvia.

In the framework of the research, the following tasks were undertaken:

- to clear the banks lending tendency;
- to examine the result of debt recovery through court in Latvia;
- to define the legal restrictions of debt recovery in Latvia.

The banks lending tendencies research included the years of 2000 – 2008. The results of debt recovery included the years 2003 – 2008.

In the research there were following methods used: abstractly logical, monographic, graphical, analysis, synthesis, comparison method.

Results and Discussions

Despite the fact that for a couple of years experts have forecasted that approximately 12 – 13% of households had loans and financial situation could allow taking loans for approximately 15% of households, since households plan and are willing to make investments in real estate renovation and/or buying (Kārkliņš, 2007), in the year 2008, banks slacked the speed of lending. Net loans granted by banks in Latvia in years 2000 – 2008 are given in Figure 1.

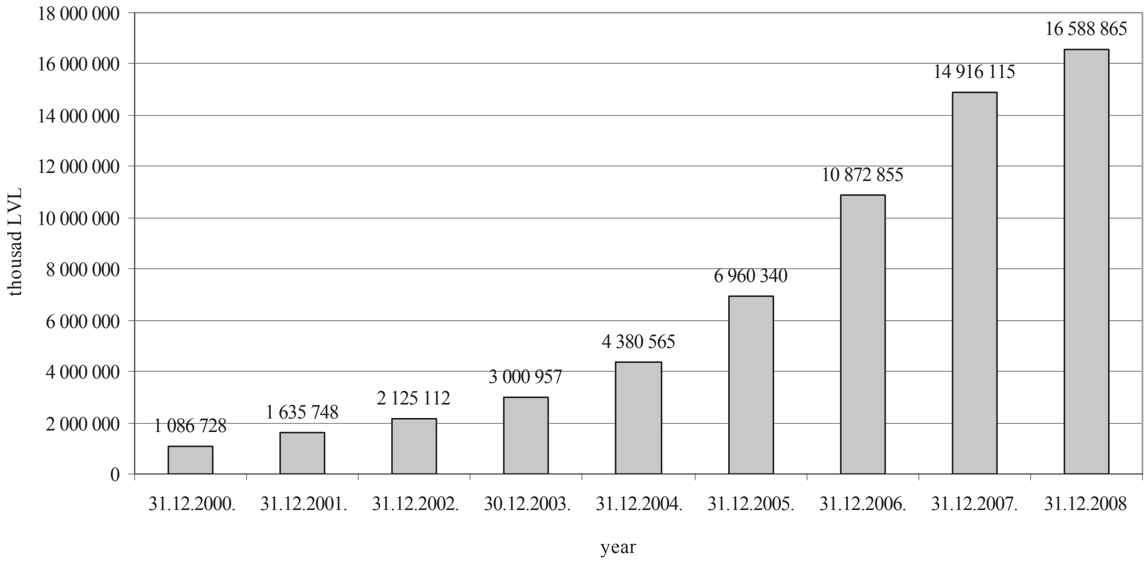

Figure 1. Net loans granted by banks in Latvia in years 2000 – 2008, thousand LVL.

Source: the author's designed chart, data used from The Financial and Capital Market Commission's statistics about banks balance sheet. (http://www.fktk.lv/lv/statistika/kreditiestades/ceturksna_parskati/).

The amount of net loans granted by banks in Latvia on 31 December 2008 is 16,588.865 thousand LVL, 15,502.137 thousand LVL more than on 31 December 2000. Although the amount of loans given by banks has risen sharply during last years, in year 2008, the amount of given loans stopped to increase. Decline of net loans granted by banks in Latvia during years 2000 – 2008 in percent compared with previous year is shown in Figure 2.

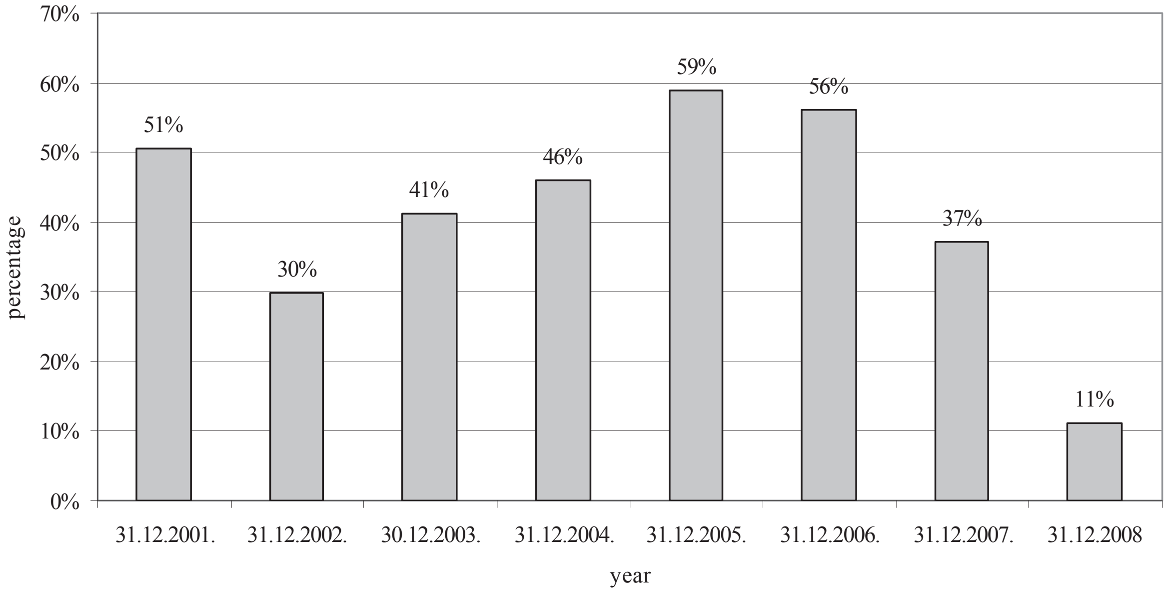

Figure 2. Changes of net loans granted by banks compared with previous year in Latvia in years 2001 – 2008, percentage.

Source: the author's designed chart, data used from The Financial and Capital Market Commission's statistics about banks balance sheet. (http://www.fktk.lv/lv/statistika/kreditiestades/ceturksna_parskati/).

As it is shown in Figure 2, since year 2005 increase of net loans granted by banks compared with previous year declined from 59% to 11% in year 2008. It was caused by the government's inflation decreasing plan policy, caution in lending of banks, producing amounts fall in enterprises, intensified solvency problems in enterprises, increase of borrowers, who cannot pay back undertaken debt to banks.

More and more Latvian inhabitants sink in big credit flow, not realizing all risks which they will face there. Most risk is for the long repay terms credit takers, because the rise of interest rate can substantially increase monthly payment. Monthly payment could increase for 25 – 30% totally. But also that kind of interest rate increase in monthly payment structure can affect credit takers paying ability, because income of credit takers could be lesser and it can be made lesser by the influence of inflation. That generates credit takers solvency problems.

Considering world economical processes, there is no surprise that during last months banks risk appetite has decreased. One year ago banks were ready to finance up to 90% from projects implementation, but now entrepreneurs need to consider that the finance will not be bigger than 70%. Banks expect that the enterprise itself is ready to take a risk and divide it with a bank. The residual finance for implementing projects enterprises need to invest themselves or attract other investors. On the background of the present time economical development, precisely – fall, each new project becomes more risky, because it is very complicated for both the bank and the enterprise to gather information about all possible risks and to forecast future potentialities. In addition entrepreneurs become more cautious and pragmatic, have more realistic view on future; therefore, new projects have lately become less (Dēliņš, 2008).

In 2008, household crediting speed shrinks. On the one hand, time of cheap money has ended, when banks struggled for their market share and people could get a loan easily and in large amounts. Because of the world finance crisis the requirements to get loan in banks have become more stringent and credit percent rates – higher. On the other hand, bank clients have become more cautious and pragmatic, they calculate precisely, how much extra finance they need and what they can afford. Now credits are not being taken just for taking. Latvia's inhabitants do not expect rise of wages and incomes and, considering that, reduce the amount of money to repay credit. The decline of sold new motor vehicles and long-term goods amount shows that many in the nearest future have decided to be more modest and not be carried away buying new goods (Ukenābele, 2008).

Government failure in the time of crisis is that spiral of inflation and wages promotion that based on credits had not been evaluated. Modern bank system stimulated credits expansion in Latvia. Latvia's privilege momentarily turned into disaster. There was a feature in Latvia and in Eastern Europe that was less widespread in the world – Latvians were credit free and they were capable to take credits and they had a chance to take credits, and banks had a chance to give the credits. People took credits inconsiderately, self-confidently believing that they will always have occupation and wages will be rising in rapid speed every year, and if wages do not rise – people will take a loan again. After Soviet time credits were mostly used to buy real estate that developed real estate market. The real estate market became unreasonable and was not balanced with productivity (Rībele, 2008b).

Experts' opinion is that in the crisis will survive those, who have made savings. This is related to countries, enterprises and individuals. This is the most perfect solution, but Latvian government and others had not expected crisis. So more actual is – where to get money, since many need funds for everyday cash flow, not money for development. Up to now Latvian entrepreneurs traditionally borrowed money in banks. But now banks give loans cautiously, because banks for themselves cannot raise funds. It is not so that banks do not give loans for national economy, but underlines that banks will give loans only for truly competitive projects. It means that every submitted plan is examined in detail. Investors now have become very cautious investing in Latvian economy. Anyway, remember, that banks basic activity is not to keep money, but earn on lending. It means loans are going to be granted.

Loans recently were easy to get in unlimited amount with attractive interest rate. Now banks study rigorously their clients and it is a little bit harder to get loans now – no bank wants to lend money to the enterprise, which can go bankrupt in the time of economical crisis in Latvia. Now banks evaluate size of enterprises less, but competitiveness of projects, credit risk and ability of enterprises to invest its own funds more. Experts indicate that enterprises just like persons could be divided in two categories – ones that had calculated precisely and had borrowed little or at least reasonably, and others – that had lived with confidence – if money is obtainable, it has to be taken and spent, inconsiderately judging real incomes, thinking they are going to rise anyway. Banks are not willing to see neither enterprises, nor persons from the second category. Now the very same enterprises and persons are in most difficult situation and are the first in bankruptcy line. But enterprises with well-grounded plans always have a chance to foundation from banks, question is only about the price, banks costs and every clients risk. Banks do not lend money for business now, so business this money does not put back in deposits, and it causes the situation when there is no money for banks to grant for business. Other solution to get money is to sell enterprise shares, but now investors are willing to pay less for the shares and that is not so profitable for enterprises. It is easier to take money in bank than partly lose control of one's own enterprise, letting in investors. Experts assume that some entrepreneurs, to keep their business and to solve at least short-term problems, are willing to borrow in the black market. But interest rate offered by black markets can directly promote enterprises bankruptcy. (Pelane and Ukenābele, 2009).

Lately theoretical money has become a little bit cheaper. In banks of Europe interest rate is decreasing, also interbank credit rates have decreased. But it is no problem to borrow money in black market, namely from enterprises and individuals whose main occupation is not financial operations. Though money is lent starting 5 percent in month that is 60 percent in a year. Some in reduced circumstances are ready to borrow money on 100 percent in a year. This is a specific business, and there cannot be voluntary loan repay, because the amount of it very high. Money on loan frequently will be recovered with enforce. (Pelane and Ukenābele, 2008).

Real credit losses are very small – in Baltic under 2 million euro, in Latvia – under 1 million euro. (Rībele, 2008a). Economical rules work on one's own whether you like it or not. (Ērgle, 2009).

Creditreform Latvia, Ltd checks all enterprises entered in Commercial register, evaluating their solvency. Information shows that compared with the year 2007, when most enterprises coefficient of solvency risk was medium, in the year 2008, significant figure of enterprises now has low coefficient of solvency risk. Money has become heavier and longer, besides in the state the measure problem is still understated. Rare realize, that delayed payments today after some time (four or five months) means insolvency, lost of employment place and accordingly total economical activity decline. (Procevska, 2008)

One of the ways for creditors to return their funds is through court. In the battle against the nonpayer, the last instance is court. During last years the amount of claims in debt recovery has risen in courts high over 225% in years 2004 – 2008 compared with the year 2003. Many agricultural enterprises sue claims to recover their debts. Especially this tendency is actual for diary enterprises, where payments for diary products delays.

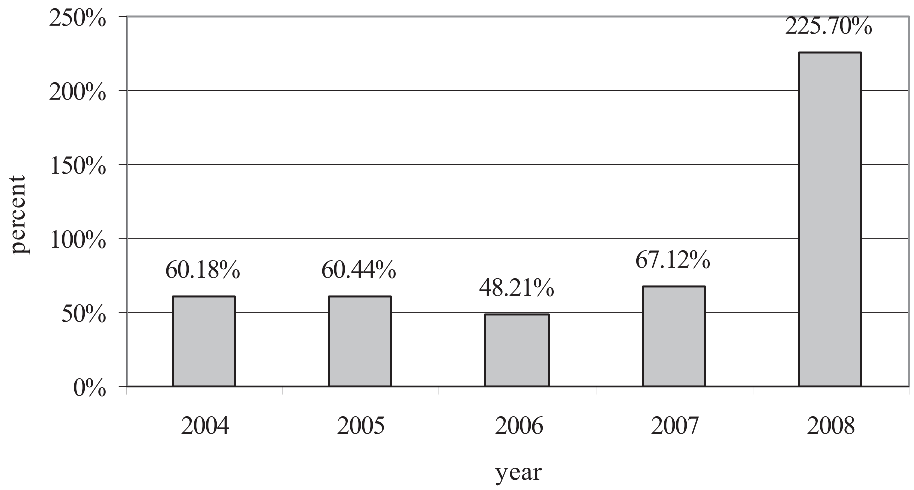

Figure 3. Amount of sued claims in debt recovery in Latvia compared with year 2003, in years 2004 – 2008, percentage.

Source: the author's designed chart, data used from Court information system.

To register debtors there was a Register of Debtors in Latvia, which was incomplete, so it was supplemented in Credit Register started action on January 1st, 2008. Amount of entered commitment and claims in courts are given in Figure 4.

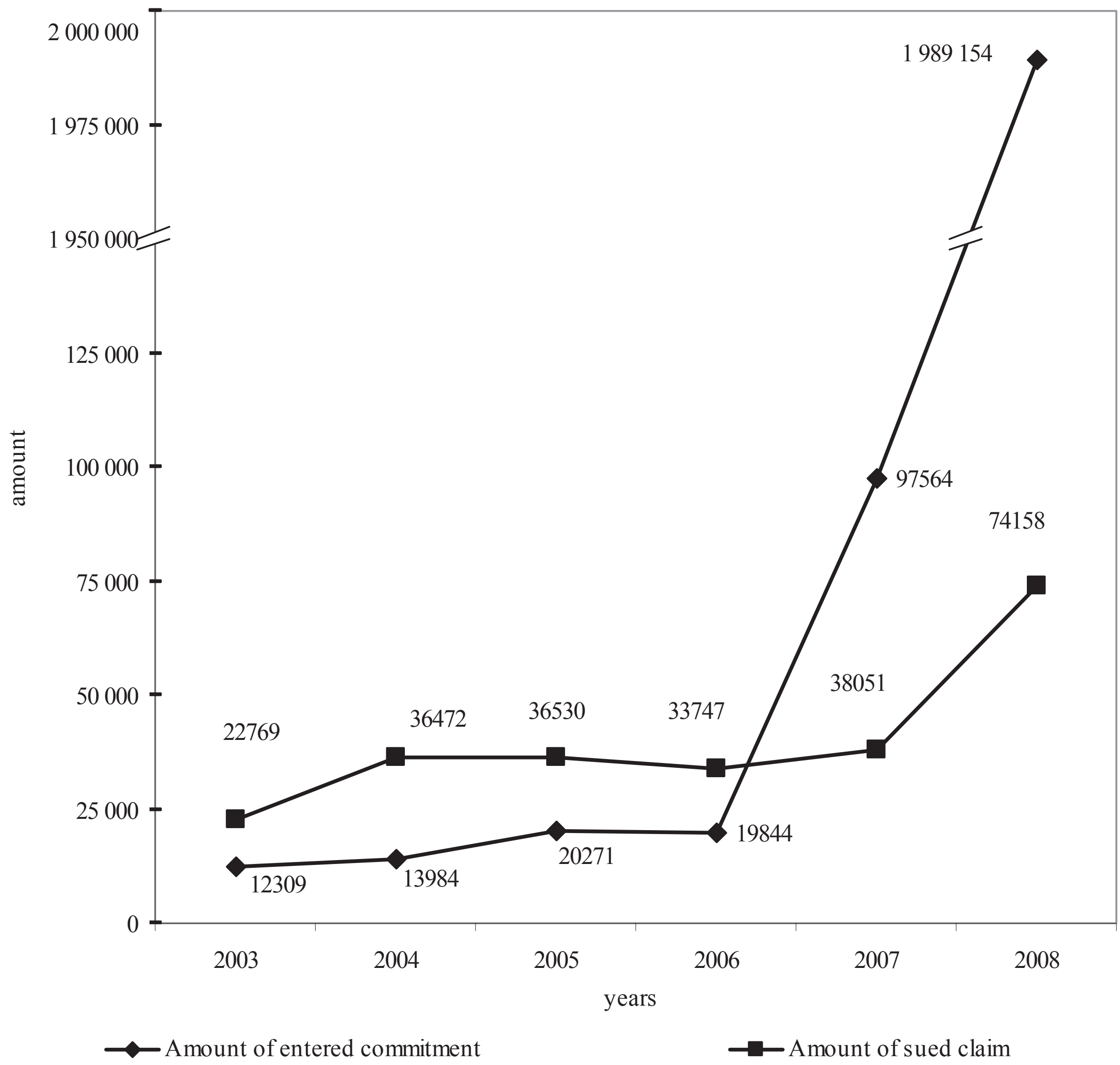

Figure 4. Amount of entered commitment and sued claims in debt recovery in Latvia in years 2003 – 2008, amount.

Source: the author's designed chart, data used from Court information system, Register of Debtors and Credit Register.

As it is seen in Figure 4, there were not all civil liability commitment entered in Register of Debtors until year 2008, which had appeared to legal and physical persons in Latvia. Now when the Credit Register has come to the operation, situation is clearer than before. In year 2008 the amount of entered commitment in Credit Register is 1,989.154 and amount of sued claims in debt recovery was 74,158, that's only 3.7% of all entered commitment in Credit Register.

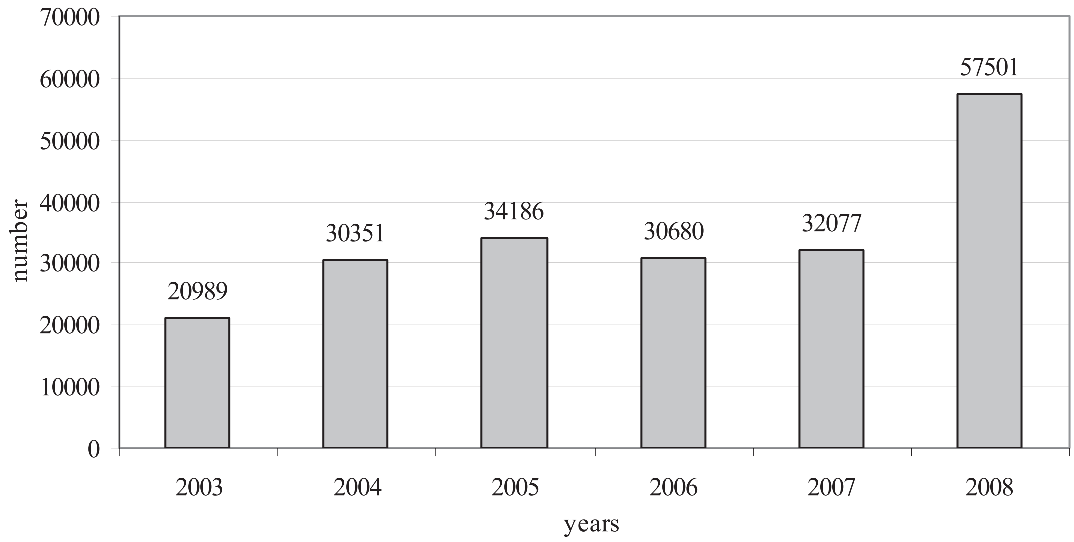

Figure 5. Number of heard debt recovery cases in courts of Latvia in 2003 – 2008, number.

Source: the author's designed chart, data used from Court information system.

As it is seen in Figure 5, the number of heard debt recovery cases in courts of Latvia has risen gradually from years 2003 until 2007. There was a little fall of heard debt recovery cases in courts of Latvia in year 2006 for 3506 cases or approximately 10%, in comparison with the year 2005, when the amount of heard debt recovery cases in Latvia was 34186. But the number of heard debt recovery cases in courts of Latvia has risen sharply in the year 2008. It was caused by aggressive lending of banks and private persons. In the year 2007 it was easier to repay borrowed money, but in the year 2008 inflation rate, reduction of incomes and economical breakdown caused the rise of sued debt recovery claims.

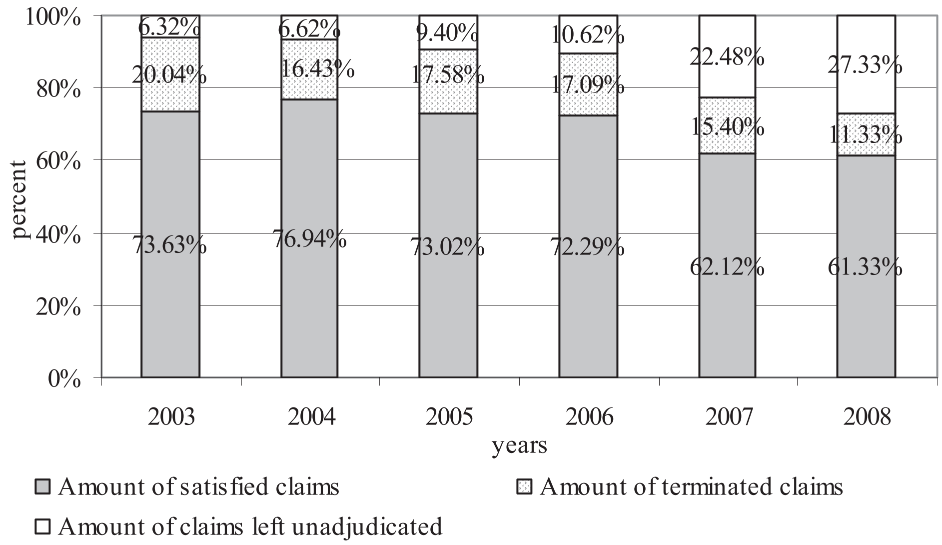

Figure 6. Structure of sued debt recovery claim results in courts of Latvia in 2003 – 2008, percent.

Source: the author's designed chart, data used from Court information system.

The structure of debt recovery claim results in courts of Latvia is given in Figure 6. Although the amount of satisfied claims in structure of debt recovery claim results in courts of Latvia decreases in years 2003 – 2008, the amount of satisfied claims with judgment of court rises, in year 2008 even till 35,268, approximately 56.5% more than in 2007. That shows that more and more persons cannot pay off their commitments. Also the amount of terminated claims in structure of debt recovery claims results in courts of Latvia decrease in years 2003 – 2008. Only 11.33% of claims in legal procedure have been satisfied already in court, terminating them in 2008. The increasing number of claims left unadjudicated in the structure of debt recovery claim results in courts of Latvia in years 2003 – 2008 connected with claims in debt recovery in Compulsory Execution of Obligations in Accordance with Warning Procedures, where claim is left unheard if a person do not receive recorded delivery with notification from court.

The legal requirements, the interpretation of the laws and regulations change debt recovery. Changes are made to protect persons from greedy creditors and debt collectors.

Legal contracts are made to reach certain economical result. This economical result could be considered as main consequences of the contract. But signing an agreement does not immediately bring expected result – goods/service - money circulation. In most cases contract creates commitments done only in the future. The contract can be disadvantageous, hard to implement for one contractor, even enslave him/her. But this contractor has made an agreement and undertaken obligations to implement this contract. Every contractor takes some risk that will not be able to implement contract through unforeseen circumstances.

Legal persons have to notice that signing an agreement with a physical person and agreeing in contracts to settle disputes only in court of arbitrage, will lead to the negative result in courts of Latvia in case of the claim statement about the execution of the arbitrage court judgment. The reason of the negative result is that one of contractors of the contract is a consumer. The contractor-consumer is a physical person, who does not use goods or services to provide its commercial or professional activity. The contractor-consumer is subordinated to consumer's rights legal regulations. The law of protection of consumers' rights item 7 of the paragraph 3 of Article 6 establishes that provisions of the contract that contractors have not discussed mutually are unfair, if it established in the contract essential non-compliance with a condition in the contractors rights and obligations disadvantageous to the consumer. Unfair contract conditions are considered those that establish to settle disputes only in court of arbitrage, in such a way excluding or delaying consumer rights to turn into consumer rights protection institutions or in court. (Jelgava court judgement, 2007).

The same unfair condition is prohibitive demurrage. Judges have already started counter requests about prohibitive demurrage in debt claims in Latvian Courts.

This tendency has already transposed in amendments in Civil Procedure Law that come into effect in March 1, 2009. These amendments in Civil Procedure Law affected Compulsory Execution of Obligations in Accordance with Warning Procedures. Compulsory execution of obligations in accordance with warning procedures is not permitted if demurrages outweigh principal debt.

But take note, that the debt collectors change contract regulations unhesitatingly to provide positive result in courts.

Conclusions

1. Credit can profitably be used by one enterprise's free funds for other enterprise needs.
2. One of the main reasons why experienced enterprises feel necessity for extra finances as current assets and capital assets is for expanding their actions. Loans and credits are the most popular sources of financing.
3. Although the number of loans given by banks has risen sharply during last years, in year 2008 number of given loans stopped to increase.
4. Banks expects that the enterprise itself is ready to take a risk and share it with a bank. The residual finance for implementing projects claims enterprises to invest themselves or attract other investors.
5. Government failure in the time of crisis is that the spiral of inflation and wages promotion based on credits were not evaluated.
6. There was a feature in Latvia and Europe that was less widespread in the world – Latvians were credit free and they were capable to take credits and they had a chance to take credits, and banks had a chance to give the credits.
7. People took credits inconsiderately, self-confidently believing that they will always have occupation and wages will be rising rapidly every year, and if wages do not rise – people will take a loan again.
8. Loans recently were easy to get in unlimited amount with attractive interest rate. Now banks study rigorously their clients, and it is a little bit harder to get loans – no bank wants to lend money to the enterprise, which can go bankrupt in the time of economical crisis in Latvia.
9. Real credit losses are very small – in Baltic under 2 million euro, in Latvia – under 1 million euro.
10. Rare realize that delayed payments today after some time (four or five months) means insolvency, lost of employment place and accordingly will lead to the

total economical activity decline.

11. One of the ways for creditors to return their funds is trough the court. During last years the amount of claims in debt recovery has raised in courts high over 225% in years 2003 – 2008 compared with the year 2003.
12. There was not all civil liability commitment entered in Register of Debtors until the year 2008, which was made of the legal and physical persons in Latvia. Now when the Credit Register has come into the operation, the situation is clearer than it was before. In year 2008 the number of entered commitments in the Credit Register was 1,989.154 and the number of sued claims in debt recovery was 74,158; that is only 3.7% of all entered commitments in the Credit Register.
13. Although the number of satisfied claims in the structure of debt recovery claim results in courts of Latvia decreased in years 2003 – 2008, the number of satisfied claims with judgment of court rose, in year 2008 even up to 35,268, approximately 56.5% more than in 2007. That shows that more and more persons cannot pay off their commitments. Only 11.33% of claims in legal procedure have been satisfied already in court, terminating them in 2008.
14. The legal requirements, the interpretation of the laws and regulations changes in debt recovery. Changes are made to protect persons from greedy creditors and debt collectors.
15. Legal contracts are made to reach certain economical result. This economical result could be considered as main consequences of the contract. But signing an agreement does not immediately bring expected result – goods/service - money circulation.
16. Legal persons have to notice that signing an agreement with a physical person and to settle in contract to settle disputes only in court of arbitrage, will lead to a negative result in courts of Latvia in case of the claim statement of execution of judgment of court of arbitrage. The reason of the negative result is that one of the contractors of the contract is a consumer.
17. Judges have already started counter requests about prohibitive demurrage in debt claims in Latvian Courts. This tendency have already transposed in amendments in Civil Procedure Law that come into effect in March 1, 2009.
18. The debt collectors change contract regulations unhesitatingly to provide a positive result in courts.

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THE THEORETICAL MODEL OF ACTIVITY-BASED BUDGETING IN AGRICULTURAL ENTERPRISES

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Abstract

Business activity of an enterprise is almost inconceivable without planning. Therefore today there are many discussions about the importance of activity planning of the enterprise and forecasting of the resources, necessary to reach the set tasks. For this reason the scientists and practicians offer to implement the budgeting system in the enterprises. This paper introduces the new budgeting model – Activity-Based Budgeting (ABB) model. It also contains the survey of advantages of this model and its applicability in theoretical aspect. The key objective of this paper is to present Activity-Based Budgeting (ABB) as an important means of planning and coordination of activity of the agricultural enterprise (or any other type of an enterprise). After performance of analysis of the main principles of Activity-Based Budgeting (ABB) model the reasoned conclusions can be drawn that application of this model in the agricultural enterprises could be the alternative means against the variable and changing economical and business conditions. It should be emphasized that contrarily to the traditional budgeting models, ABB can help to establish the connections between the incurred costs and the company processes. The paper contains ABB analysis based upon the scientific studies and the fragments of practical application of the model.

Key words: Activity-Based Budgeting (ABB), budgeting system, cost, activity.

Introduction

Today there are many discussions about the importance of activity planning of the enterprise and forecasting of the resources, necessary to reach the set tasks. Hereby the problem of competitive ability of the enterprises is solved. Organizations cannot succeed by standing still. If the enterprise is not improving, then its competitors will soon catch up. For this reason many scientists offer to use the budgeting system as the budgets usually contribute to successful realization of the strategies of the enterprises. In practice two basic methods of budgeting of the enterprises exist: from achieved level (incremental budgeting), and from zero level (zero-based budgeting). A zero–based budget begins by preparing an operating plan or budget that starts with no authorized funds. For this type of budget, an enterprise must justify each activity every time it prepares a new budget. Incremental budgeting is a budget prepared using a previous period's budget or actual performance as a basis with incremental amounts added for the new budget period. The choice of the budgeting method depends on the competence and the aims of the management of the enterprise. Many budget styles exit, each with a different purpose. This paper introduces the new generation budgeting system – Activity-Based Budgeting (ABB) which has gained popularity over the last few years because of its ability to link activities to expenses, giving executives a better understanding of the full costs of service and resource allocation. Activity-Based Budgeting is an outgrowth of Activity-Based Costing (ABC) and is similar to zero-based budgeting. There are many publications about the advantages of activity-based budgeting and its application in the management of activity of organizations. But there is a **problem:** we lack deeper analysis of application of this model and more detailed research in the agricultural sector. Under current complicated economic conditions, characterised by growing inflation, decreasing sales of products, increasing activity costs and many other reasons influencing the agricultural activity, the activity-based budgeting can be treated as a preventive means, being able to coordinate and balance all spheres of activity of the enterprise.

The aim of the paper – to introduce the activity-based budgeting as an important means of planning and coordination of activity of agricultural enterprise and the alternative to the cost-effective activity.

The object of the paper is the process of activity planning and control of the agricultural enterprise.

The methods of investigation. In the first part of the paper, the efficiency of activity-based budgeting (ABB) is analyzed in theoretical aspect, by employment of the methods of scientific analysis. In the second part, ABB model of agricultural enterprise is supplied which could be put into practice, theretofore having adapted it by the managers of the enterprise in the management environment of activity, developed by them. The results of research and their interpretation are supplied in the third part of the paper.

Materials and Methods

Materials and Methods of Activity-Based Budgeting (ABB)

In the scientific literature many different opinions are supplied about the budgeting methods, their application and utility for organizations. There are observable tendencies to criticize the traditional budgeting system. Traditional budgeting system does not work in many organizations because the process is used as an agent of restrictive type of control. In reality this does not mean that the tool is no good only that it isn't being used properly. The difference is that new approaches to budgeting require a more strategic approach. The conceptual model of Activity-Based Budgeting was codified by R. Kaplan and Robin Cooper in *Cost and Effect* (Harvard Business School Press, 1998). The most of scientists support the opinion that the new budgeting must become a strategic continuous improvement process rather than an operational control tool (Chr. Babbini (1999), Ch.T. Horngren (2004), G. Steven (2007), J.M. Shane (2005), G. Cokins (2008) and other). The majority of Lithuanian enterprises apply the traditional budgeting methods in planning and management of their activity (G. Kalčinskas (2004), R. Kalčinskaitė (2004, 2005), V. Jagminas (2004) and others). However, the macroeconomic environment in Lithuania, sharp competition between the organizations and striving to keep their market positions encourage the managers of the enterprises to look for more improved means of planning of their activity.

In the process of analysis of scientific materials it was noticed that Activity-Based Budgeting really has many advantages in comparison with the traditional company budgeting system. In the case of traditional budgeting system, the constant disputes and negotiations between the managers and the directors do not make any substantial changes to the existing situation - the budget of the past year is rarely reviewed. This is a sore point, as in the process of solving of production effectiveness and rational use of resources problems, many questions arise. When applying the Activity-Based Budgeting method, the managers have to plan the resources of raw materials. First of all, the managers suppose the approximate production and sales volumes for the forthcoming periods. Under such system all activities developed by the enterprise shall be forecasted. ABB provides more information to the managers about the variable medium and long-term development tendencies of the fixed costs. In other words, the fixed costs are the uniform costs, as the decisions of the managers and the managers themselves can give a more flexible response to the changing production of raw materials and the environment.

The group of scientists from UK (L. Liu, J. Martin, J. Robinson) treats the Activity-Based Budgeting (ABB) as the converse method to Activity-Based Costing (ABC) (see Figure 1).

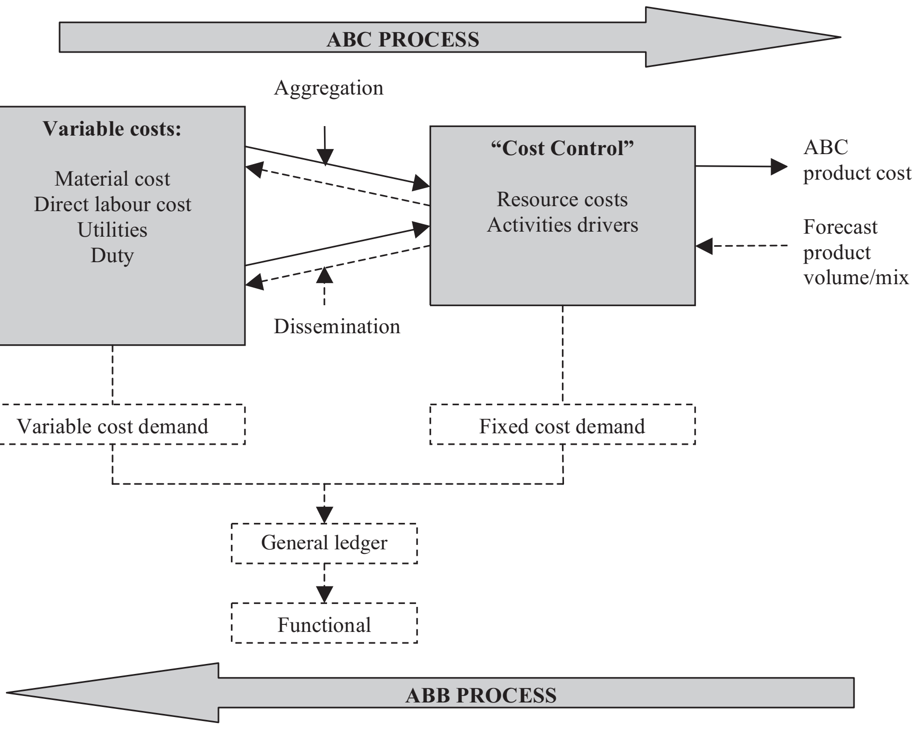

Figure 1. Differences in model design specifications between ABC and ABB (Liu et al., 2002).

The Activity-Based Budgeting (ABB) model was designed on the basis of ABC in reverse. In summary, ABB holds promise as a solution to the faults and frustrations of traditional budgeting methods:

1) traditional budgets don't identify waste; ABB exposes non value costs;
2) traditional budgets focus on workers; ABB focuses on workload;
3) traditional budgets focus on division cost; ABB also focuses on process cost;
4) traditional budgets focus on fixed versus variable costs; ABB also focuses on used versus unused capacity;
5) traditional budgets measure effect; ABB measures root cause.

After evaluation of the advantages of Activity-based budgeting in the enterprise in general, it is interesting to find out what methodological consistent patterns of budgeting are developed in the agricultural enterprises. Based on the studies of scientists (White, 2007), G.L. Greaser, J.K. Harper (1994), D. Doye, R. Sahs (2005), broad tendencies of application of the traditional budgeting systems are observed. Agricultural economics specialists are maintaining that enterprise budgets are designed to provide a decision framework for short- and long-range economics analyses of production agriculture. Enterprise budgeting system assists in understanding the costs and returns of a production activity, identifying potential sources of risk, and evaluating alternatives. Knowledge of budgeting and the ability to use them help producers make sound business decisions.

The main uses of an agricultural enterprise budget are:

1) clearly identifying all of the inputs needed to produce that enterprise;
2) easily identifying top 5 expenses for cost control management;
3) which helps to determine potential changes in the operation;
4) determining how much revenue can be generated from the enterprise;
5) Breakeven analysis for price and yield.

According to aforementioned main uses, the budgeting system of agricultural enterprises does not discover the cause-effect relationships, on identifying leading and lagging measures. To predict financial results more accurately, managers must be confident about their productions of operational metrics. So, the activity-based budgeting model offers an in-depth model for improving planning, budgeting and general management in agricultural enterprises.

Activity-Based Budgeting (ABB) application on agricultural enterprise

The rural economy specialists believe that the enterprises budgets represent estimates of income, costs, and profits associated with production of agricultural products. The information contained in the enterprise budgets can be used by agricultural producers, financial institutions and over making decisions in the food and fibre industry.

Classical model of enterprise budgeting system should be prepared with specific objectives. G.L. Greaser, and J.K. Harper are of the opinion that "budgets can be used to: 1) itemize the income received for an enterprise; 2) list the inputs and production practices required by an enterprise; 3) evaluate the efficiency of farm enterprises; 4) estimate benefits and costs for major changes in production practices; 5) provide the basis for a total farm plan; 6) support applications for credit; 6) inform no farmers of the costs incurred in producing food and fibre crops". In fact, these aims of use of the budgets are reasoned and sound; however, it would be expedient to closer relate the costs incurred by the agricultural enterprise with the processes in the enterprise. Clear relations between the costs and processes enable better control and planning of the enterprise resources (land, labour, equipment, etc.). Establishment and assignment of variable, fixed costs to the definite products and Breakeven analysis give the particular results which shall be accepted and supplied as the fact. And application of the principles of Activity-Based Budgeting provides wider opportunities of management and control of agricultural activity. Growing complication of economic situation any additional information obtained from the budgets is useful for further development of the enterprise activity and for reengineering process.

Hence, analyzing the theoretical aspects of Activity-Based Budgeting model, we can notice that accumulation of costs first of all is related to the activities of the enterprise. There is a direct dependence between the resources and the incurred costs. In order to clarify such dependence it is recommended to split the big enterprises into smaller, easier managed units, so called cost centres. The cost centre can be defined as the function or subdivision of the enterprise, being able to take the corresponding solutions, to control the resources and accept responsibility for taken solutions and for achieved results. Each of above mentioned cost centres is treated as an independent activity of the enterprise. Such splitting of activity of the enterprise allows the directors and the managers to control the corresponding income and the cost flows better. It is possible to make the value chain from the cost centres (see Figure 2). That demonstrates which activities of the enterprise contribute to the value of the created product and which does not. It could be the first step on the way to Activity-Based Budgeting (ABB).

Figure 2. The value chain of the enterprise.

As it was mentioned, it is very important to identify the enterprise activities, and to measure the enterprise resources and output. The enterprise activities and resources can be direct and indirect. The direct activities are such that directly impact the product. The indirect activities just support necessary creation of the product, as well as some of them create the certain reaction with respect to the product. The direct resources are necessary for the maintenance of the direct activities, while the same resources are indirectly used for obtaining of the other resources. In the agricultural enterprise, the labour, forage, premises/land administration, etc., create the costs which can be related to corresponding activity. Hereby the way is defined, how the corresponding activities create the costs and how the necessary resources are used in accordance with the assigned criterion.

The agricultural enterprise can be one-branch and multi-branch (it can develop several activities, for example, dairying, stockbreeding, and the plant cultivation). Both one and the other types of the enterprises can apply ABB. In Figure 3, the algorithm of application of Activity-Based Budgeting method in the agricultural enterprise is supplied. The steps of this algorithm could be as follow:

1) the supplied organizational structure of the enterprise shall be clear (hierarchy, subordination connections of personnel);
2) establishment of the cost centres (stockbreeding, plant cultivation or dairying activities);
3) determination of costs being accumulated in the cost centres;
4) establishment of relation between the costs and the processes in the enterprise.

The managers of agricultural enterprises should harmonize traditional cost and budgetary view on a vertical alignment, whereas work is along a horizontal axis and in so doing its have not only lost sight of the true (see Figure 3). The vertical alignments show the costs directions towards the enterprise activities (having determined theretofore the cost bearers and their volumes), and the horizontal alignment – the structure of processes of the enterprise. Process moves across the functions in the enterprise. Activity-Based Budgeting address these basic truths. With ABB resources are linked to the level of activity undertaken and the efficiency with which it is performed. ABB uses the driver volume of major activity drivers as the basis of forecast activity levels and efficiency improvement is measured and forecast as a reduction in the Unit Driver Costs. ABB captures multiple functional inputs to both individual activities and to a workflow.

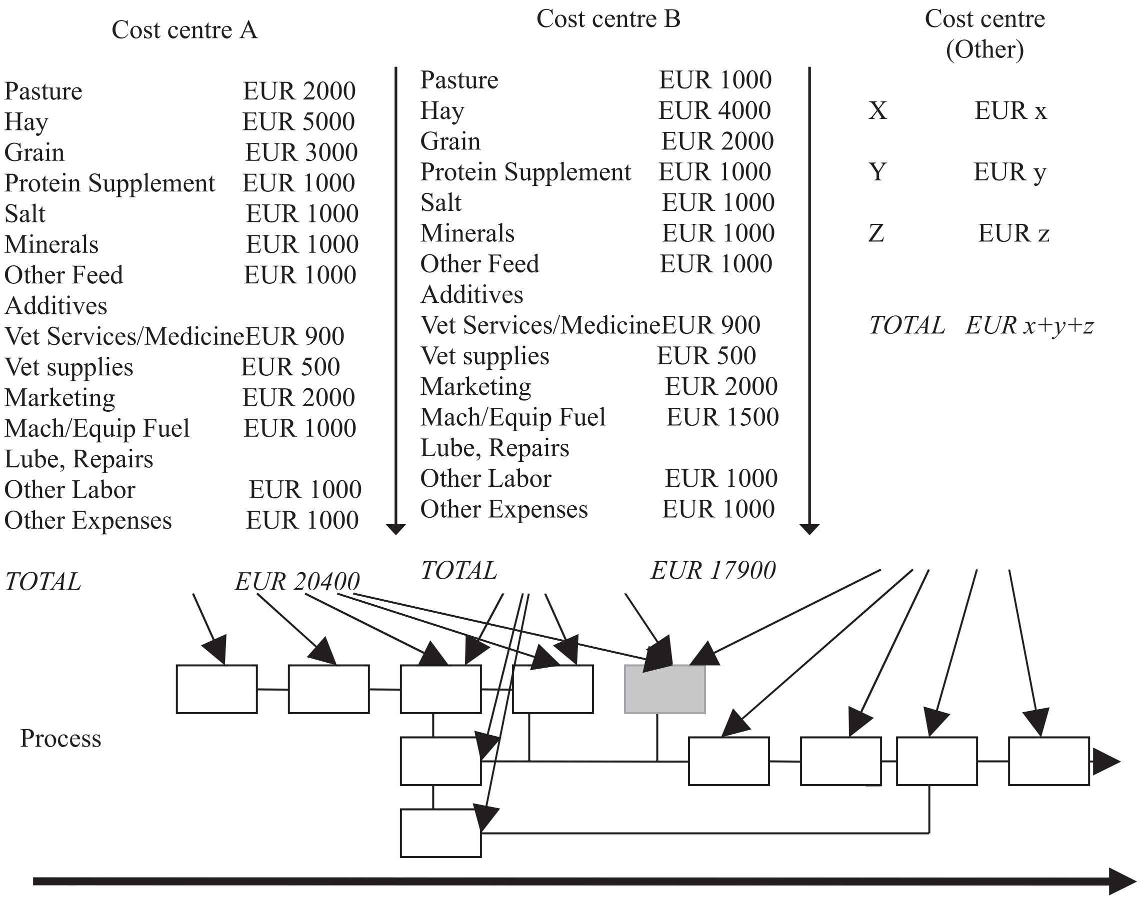

Figure 3. Activity-Based Budgeting model in the agricultural enterprise.

Thus the Activity-Based Budgeting model is suitable for the agricultural enterprises, not only managing the resources, but also endeavouring at concretization of striving for strategic objectives. According to this model to each activity of the enterprise the tasks and solutions can be assigned, which that activities will enable to take. Due to employment of ABB methods, the participant of every activity will know what to do and how to do, which resources and how much of them should be used in pursuance of the set tasks.

Results and Discussion

This paper presents the advantages of ABB and the possibility to apply this model in the agricultural enterprises. It may be questioned whether the Activity-Based budgeting system will be useful for the enterprise or it will just increase the costs of activity. The answer will depend on the managers of the enterprises, responsibly evaluating the possibilities and aims of their companies, and their knowledge of where they want to find themselves with the enterprises they run. We should agree that it is difficult to manage the enterprise without the budget. CFO Research Services (2006) polled the enterprises about the alternative budgeting methods. This survey shows that the managers of the companies realize the significance of budgeting. It is important to understand that the new budgeting model will not solve the problems of the enterprise. First of all it is necessary to review the company processes, strategy, objectives, and tasks. Moreover, the results of the current year should be compared not only with the last year, but also with the gains of the competitors. Thus the reasoned action plans of how to reach the particular goals would be drawn. So, in my opinion, we should not be afraid of experiments, as the more precise forecast of the results will influence not only the quantitative (products volumes, sales, income, profit, etc.), but also qualitative (motivation of the employees, competence, etc.) indexes.

Conclusions

1. Based on scientific research, application of Activity-Based Budgeting (ABB) in the agricultural enterprises could be an alternative means against the variable and changing economical and business conditions.

2. Contrarily to the traditional budgeting models, ABB can help to establish the connections between the incurred costs and the company processes.
3. The ABB model explicitly emphasizes and links operational performance with financial results. This model encompasses the demand for product services, related activity requirements, resource requirements, capacity requirements, and interrelationships.
4. Without the preparation of an Activity-Based Budget many managers are paralyzed into defending the status quo.

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ANALYSIS OF ENTRY BARRIERS IN HIGHLY CONCENTRATED SECTORS OF LATVIAN ECONOMY: CASE OF GRAIN PROCESSING INDUSTRY

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Abstract

Encouraging of competitive relations and strengthening of competitive position of domestic producers on both national and EU common market of products and services become one of the main priorities of national economic policy. Latvian national interests are closely related to the maintenance of the competitive environment as an important factor for increase of competitiveness of separate commodity, enterprise or industry, which is able to provide economic growth in the circumstances of declining the business activity and strong competition on internal and external markets. However, fair market competition takes place only on the markets where there are no any essential obstacles and barriers for potential entry of new market actors. That is why the present article is prepared on the basis of case study carried out for Latvian grain processing sector with the purpose to describe and qualitatively assess the effects of various entry barriers, which really exist on the domestic market.

Key words: Entry barriers, concentration, Competition Council, Herfindahl-Hirsman index, grain processing sector.

Introduction

The current development of Latvian national economy is strictly oriented on close integration into the Common European economic environment. The main precondition for such successful integration is inevitably related to the increase of efficiency and competitiveness of the main sectors of Latvian economy.

At the same time the encouraging of competitive relations and strengthening of competitive position of domestic producers on both national and EU common market of products and services become one of the main priorities of national economic policy. Latvian national interests are closely related to the maintenance of the competitive environment as an important factor for increase of competitiveness of separate commodity, enterprise or industry, which is able to provide economic growth in the circumstances of declining the business activity and strong competition on internal and external markets.

However, fair market competition takes place only on the markets where there are no any essential obstacles and barriers for potential entry of new market actors. Therefore to analyse and monitor the market concentration in case of different industries of Latvian economy as well as to identify potential entry barriers, which nowadays exist is extremely important.

The present article was written with the purpose to acquaint the readership with the main results of research carried out by RISEBA group of scientists, making the analysis of competitive environment and entry barriers exist on Latvian market of grain processing products. The article is prepared on the basis of case research carried out for Latvian grain processing sector within the research project requested by Ministry of Economics with the purpose to identify the highly concentrated sectors of national economy as well as to describe and qualitatively assess the effects of various entry barriers, which really exist (RISEBA, 2008).

In order to succeed the main purposes of the article the following tasks were carried out: 1) on the basis of calculated concentration ratios and other concentration indicators to assess the level of concentration in Latvian grain processing industry; 2) on the basis of scientific sources and legislative documents to identify the main types of entry barriers exit on the market; 3) to characterise the competitive environment in Latvian grain processing industry; 4) to provide the practical proposals to the Ministry of Economic of Latvia and Competition Council for improving of competitive environment.

The article consists of three main parts. The first is devoted to describing of main materials and methods used during the research. The economic performance of the Latvian grain processing sector with particular emphasis on the description of main market players is reflected in the second part of the article. The third part contains the discussion and main results referred to entry barriers' analysis. The conclusions present the main outcomes of case study.

Materials and Methods

Assessment of entry barriers was done on the basis of quantitative analysis of the market shares of the industry as well as on the results of survey organised among the various market actors (newcomers and experienced market players). Taking into account specificity of the topic, the lack of information and applied character of the research made, a lot of various sources of information and materials were used. Very often the authors were obliged to use the legislative acts and documentation, statistic information, scientific sources as well as other publications available in mass media and internet (see the References).

General description of Latvian grain processing industry and main market actors

The Latvian production of cereal products is one of the biggest industries in national sector of food and beverages' production. According to the data of Ministry of Economics, in 2007 grain processing made 18.2% of total value-added produced in Latvian sector of food and beverages (Ministry of Economics, 2008).

Data of Central Statistical Bureau (CSB) shows that in 2006 a total of 25 enterprises were operating in grain processing and starch production sector. The number of enterprises is relatively stable since year 2004.

In 2006, the industry is total turnover was LVL 45.4 mln. The list of 15 largest enterprises in the industry is seen in Table 1.

Leader positions in grain processing industry (NACE 15.6) are taken by two joint stock companies 'DOBELES DZIRNAVNIEKS' and 'RĪGAS DZIRNAVNIEKS'. In 2006, their total share in total industry's turnover was more than 75%.

At the same time, many of the enterprises indicated in Table 1 are engaged not only in grain processing, but also in bread production, e.g. 'DOBELES DZIRNAVNIEKS', 'DOLLE', 'LATGALES MAIZNĪCA', 'RĒZEKNES DZIRNAVNIEKS', and 'ZEMZARI'.

'POPCORN CINEMA' is engaged in production of popcorn as well as in the trade and repairing of technical equipment for food producing companies.

'ALOJA-STARKELSEN' is one of the main producers of starch and starch products in Latvia.

Table 1

The list of 15 biggest grain processing and starch producing enterprises in Latvia in 2006 (in alphabetical sequence)

No.	Enterprises
1.	'AILANS' Ltd
2.	'ALOJA-STARKELSEN' Ltd
3.	'AUCES DZIRNAS' Ltd
4.	'DOBELES DZIRNAVNIEKS' J.s.c.
5.	'DOLLE' Ltd
6.	'JELGAVAS DZIRNAVAS' J.s.c.
7.	'LATGALES MAIZNĪCA' Ltd
8.	'MĀRUPES DZIRNAVAS' Ltd
9.	'MILZKALNE' Ltd
10.	'POPCORN CINEMA' Ltd
11.	'RĒZEKNES DZIRNAVNIEKS' J.s.c.
12.	'RĪGAS DZIRNAVNIEKS' J.s.c.
13.	'ROVEL' Ltd
14.	'VENTSPILS DZIRNAVNIEKS' Ltd
15.	'ZEMZARI' farm

Source: CSP non-published data.

On the basis of quantitative analysis of specially ordered unpublished information from CSB it is possible to conclude that Latvian grain processing industry can be classified as highly concentrated sector of national economy. In the year 2006, the share of four biggest grain processing enterprises was 88% in the total industry turnover.

Table 2

Production output and sales in 2004.-2007., thsd. LVL

Production of cereal products, starch and starch products (Code 15.6. according to NACE 1.1.red.)	2004	2005	2006	2007	Deflection, 2007/2004, %
Production output, thsd. LVL	25 647	26 248	27 221	36 497	42.3%
Total sales, thsd. LVL	26 232	26 890	27 348	36 811	40.3%
Sales on local market, thsd. LVL	22 999	22 930	22 781	27 842	21.1%
Export, thsd. LVL	3 233	3 960	4 567	8 969	177.4%

Source: CSP data.

In addition, for the same year calculated Herfindahl-Hirsman index value (HHI = 3219) illustrates quite high level of concentration between all enterprises in the industry, as the value calculated considerably exceeds critical border of the concentration (when HHI is higher than 1800 - 2000).

As CSB data shows, production volumes of grain processing industry are growing every year and in 2007 succeeded already LVL 36.5 mln. (CSB, 2008) (see Table 2).

Approximately 75% produced in the industry are spent in the local market, but other 25% are exported, mainly to Estonia, Lithuania and Russia. It needs to mark the rapid increase in export volumes, which in 2007 increased by 2.8 times (177.4%) in comparison with the year 2004. At the same time, volumes of sales of domestically produced grain products on the local market increased only 1.21 times (21.1%) or by LVL 4843 thsd. during the same period of time. Essential increase in export volumes in 2007 was observed because of the high grain harvest in Latvia as well as significant increase in grain prices on the world market.

The main Latvian starch producer, 'ALOJA-STARKELSEN' Ltd, exports approximately 70% of the total amount of starch produced, mainly to Estonia and Lithuania.

Strong competition on the domestic market and rapid increase in production costs were two main problems identified by domestic producers of cereal and starch products in Latvian grain processing industry in the middle of 2008.

As industry experts have indicated, after joining the European Union, competitive behaviour of the market actors in grain processing and starch producing sector should not be analysed only within the Latvian territory as grain and starch products are being sold on Latvian market not only by local manufacturers, but also by enterprises from other EU member countries.

For example, Estonian enterprise 'TARTU VESKI' takes forth place in sales volumes of flour on Latvian market. In the sector of other grain products there is intense competition among local producers and 'NESTLE' and 'KELLOGG'S' products.

Therefore Latvian grain processors are obliged to compete not only against each other, but also against foreign companies which import their products to Latvia from abroad.

Results and Discussion

Analysis of entry barriers on Latvian grain processing market

Analysis of entry barriers and identification of potential competitors becomes extremely important for assessment of real market power and competitive environment on any given market analysed (Farnham, 2005). However, there are a number of important gaps in the textbook analysis (Davies and Lam, 2001). The first is that they pay no attention at all to the possibility of market power on the part of the firm's customers or their suppliers, which are important features of many industries. The second is that they pay no attention to the factors that determine the key dimensions of market structure (Keat and Young, 2005). Entry, for instance, is said to be entirely free or entirely blocked without any consideration of the factors make it so. Rivalry exists in oligopoly, but not in any other market structures, and the models pay no attention to the factors that determine the intensity of rivalry (Davies and Lam, 2001). In order to fill these gaps left, the best-known approach of 'five forces' developed by Michel Porter was used as a basis for analysis of entry barriers made (Porter, 1980). According to the Guidelines of the Competition Council of Latvia "On the definition of concrete markets and assessment of competitive environment", among the most essential barriers of entry for new market players (new-comers) are (Competition Council of Republic of Latvia, 2006): 1) economic restrictions; 2) administrative and managerial restrictions (including restrictions for environment and quality issues); 3) disparity of market infrastructure; 4) barriers related to vertical integration/collusions of market actors; 5) barriers related to strategic behaviour of market players; 6) potential market limitations.

All barriers mentioned above were qualitatively assessed in case of Latvian grain processing sector on the basis of survey results obtained from the sector experts, representatives of companies operating on the market.

1.1. Economic restrictions

The main obstacles to enter into grain processing market are related to large investment necessity for organization of technological processes, to large losses in a business cessation case, to achievement of the minimum level of effective operations, and to availability of necessary funding.

In order to start business activities in grain processing industry, large investments are required.

For instance, 'DOBELES DZIRNAVNIEKS' owns not only mills (which production power is 300 tons of grain per day), but also elevators (capacity of 100 thsd. tons), feed production plants, groceries and packing manufactures, quality control laboratory, and experimental bread bakery (Dobeles dzirnavnieks, 2008).

In the grain processing sector, the necessary amount of investments for starting of actions is dependent on the way of specialisation. According to industry expert estimations, one mill costs LVL 3 millions, but to build an up-to-date grain processing plant with the ability to meet all necessary standards requires about LVL 20 million. To enter industry market on the segment of ecological flour production requires about LVL 1 million. That is why the amount of necessary starting capital can be considered as essential obstacle for new enterprises, planning to enter on the market.

According to the expert view, the credit accessibility could be another important obstacle to the potential market entrants. There are no essential difficulties to obtain the credit for large EU corporations and their daughter companies. However, it might be a problem for those who do not have their own „credit history" (new market actors). At the same time, in the case of bankruptcy, there will be problems to the banks or other financial institutions to sell specific equipment because of negligible second-hand or scrap value.

The requited minimum level of efficiency is relatively high in the industry. This fact could affect seriously the decision of newcomers to enter the market. However, in case of large EU corporations there is no any essential obstacle, because they can afford to invest essential funding into up-to-date production technologies. It is necessary to mention that among the shareholders in leading grain processing enterprises as 'DOBELES DZIRNAVNIEKS' and 'RĪGAS DZIRNAVNIEKS' there are quite powerful foreign enterprises which provide additional support for modernization of production and training of technical staff.

For instance, 80% of shares of Latvian grain processing enterprise 'DOBELES DZIRNAVNIEKS' belong to the biggest grain processing enterprise in Estonia 'Tartu Veski' (Dieziņa, 2008).

At the same time, 'RĪGAS DZIRNAVNIEKS' is part of 'Lantmännen' group (Sweden Peasants association of Agricultural marketing, which is one of the largest agriculture and food industry business holding company in Europe) and its largest owner is Sweden enterprise AB 'Nord Mills' (Rīgas dzirnavnieks, 2008).

As industry experts point out, in comparison with new, modern factory built, it is not easy task for large industry enterprises to achieve superiority in the cost level, because modernization of already existing enterprises also requires large investments. "Old" enterprises perform the modernization gradually. So, 'RĪGAS DZIRNAVNIEKS' plans to invest essential funding in energy resource optimization, which will allow reducing the energy and heat consumption (LETA, 2008).

As industry experts conclude, purchase of raw materials does not create additional obstacles for new market participants as the main raw material is cultivated in Latvia or can be easily imported from abroad.

At the same time, manufacture of the ecological products can be considered a new niche for the potential market actors taking into account quite rapidly developing biological agriculture in Latvia, which could create favourable conditions for production of the ecological products.

Economic risks are also considered to be a serious obstacle for potential market actors in Latvian grain processing industry. The new risks have appeared in relation to the essential fluctuations in energy prices as well as start of macroeconomic recession at the end of 2007 accompanied by slowdown rate of economic development, unemployment increase, decrease of demand and the economic activity in Latvia and abroad. Therefore, the fluctuating prices of raw materials and necessary production resources, as well as general entrepreneurial activity decrease in the country can be considered as a serious obstacle for new-comers in the industry.

Assessing the impact of border regimes as well as import-export tariffs applicable it is possible to conclude that this obstacle must not be considered as being influential.

To control volume of grain trade in third countries (emerged markets), there is a licence regime for export and import applicable according the Council Regulation (EK) No. 1784/2003, which describes common market organization measures, including EU grain market as well. Rural Support Service (RSS) accepts the applications for grain importers and exporters by issuing special licences (RSS, 2008).

Border tariffs that are used for Latvian products export to the third countries can not create considerable obstacles for annually growing export of Latvian grain processing and starch products. For instance, 'RĪGAS DZIRNAVNIEKS' develops its business mainly by increase of export volumes. During last years the export of oat and wheat flour to Russia has grown three times, and the enterprise plans to continue its active strategy on the Baltic markets by developing direct deliveries to neighbour countries (LETA, 2008).

1.2. Administrative/managerial restrictions

Food turnover is one of the most regulated business areas and production spheres. Being involved in any food production process, any enterprise has to be ready to fulfil the obligations of diverse set of normative acts, including EU regulations and resolutions, Latvian laws and clauses of the Cabinet of Ministers.

Companies, which would like to start business activity related to grain processing and starch production have to go through the approval procedure including assessment of the company's ability constantly to meet necessary requirements, accepted by Food and Veterinary Service. Approved companies are able to distribute their product in all territory of EU market without any limitations.

Starting the business, any grain processor and starch producer has to receive the permission of B category for pollution performance. Such permission should be received according to the regulation of the Cabinet of Ministers No. 294 'About A, B and C category pollution performance declaration and A and B category permission issuing procedure'. Permission is being issued according to the law 'About Pollution' by Regional Environment Department according to the place where polluter is located (according to Article 28 of the law).

In the permission it is required to provide the information about equipment used and its operations, about raw and auxiliary materials, emission sources for the equipment, environmental conditions in the place of location, information about substances emitted into the air, water and soil, as well as about possible environmental effects and possible measures which should done in order to prevent or reduce the production of wastes, wastes' treatment, and procedures for pollution monitoring.

For the export purposes, grain processors should get the licence which is being issued by Rural Support Service only after approval procedure passed in Food and veterinary service (Ministry of Agriculture, 2003).

According to the EU council Regulation No.1868/94, potato starch producing company additionally is required to get the sales quota within the framework of entire system of EU sales quotas for potato starch manufacturers. During the yield years 2007/2008 and 2008/2009, potato starch quota for 'Aloja – Starkelsen' Ltd was assigned on the level of 5778 tones.

According to the requirements of national normative acts, grain processing and starch producing companies are also responsible for harmlessness and quality of food products produced.

Since January 2006, food turnover and safety is being monitored by EU law on food production hygiene, which is based on nine EK Regulations and two Directives.

Regulations give the rights to each manufacturer or processor to be responsible on their own for compliances and confidence to requirements of Regulations. For instance, the processor can substantiate its compliances on the basis of the company's HACCP (Hazard Analyses and Critical Control Points) procedure.

HACCP is a company's self-control system, which does not allow the health-harmful products to come down to the consumer. HACCP establishes the general principles and methods of the quality management system. Following them every company makes its own relevant and easy-in-use self-controlling system according to the production specificity.

If the company would like to extend its activities and increase the range of its customers as well as to approve its business on the international level, it is quite useful to get ISO standard 9001:2000 certificate which has been already received by many enterprises in Latvia. This certificate verifies the fact that the company maintains its quality management system and meets united quality standards.

1.3. Barriers related to vertical integration/collusions of market actors

According to the opinions of industry experts, companies, which work already for a long time, have the contracts with grain suppliers, but these are not long-term contracts.

'DOBELES DZIRNAVNIEKS' is engaged not only in grain processing, but also deals with cultivation of grain in

Latvia and Ukraine, taking significant amount of sowing areas on lease. That is why the company has certain advantages compared to the newcomers and other players on the industry market. Additionally, 'DOBELES DZIRNAVNIEKS' organizes different advisory support for its main suppliers in the way of informative seminars and campaigns for grain producers about availability of new agro-technologies, qualitative equipment and machinery, variety of new sorts of crops as well as procurement requirements. It allows to make close contacts with grain suppliers and to strengthen the cooperation.

The industry processing companies produce not only products for further processing, but also for the final consumption. Depending on processors' clients, the distribution channels for products produced are also different. Essential share of the product produced is sold to the bakeries and confectionaries for further processing. Afterwards big processors bring forward strict requirements to the price and quality of the products supplied. Usually, before signing the contract, they announce the tenders for the grain processors. The ISO standard 9001:2000 and HACCP certificates are among the most important obligations during the tender. These requirements make additional barriers for the newcomers, participating in the tenders.

In case of products produced for the final consumers, the big processing companies use their own sales networks as well as sell production through the big retailer chains.

In general, the close relationships between grain suppliers and grain processors, and their agreements made on availability of certificates necessary for the tender procedures organised by big bakeries as well as contracts signed with the retail supply chains for sales of food products cause important obstacles for potential newcomers to enter the market.

1.4. Disparity of market infrastructure

Disparity of market infrastructure can be an important barrier for the newcomers, because companies working in the industry have already developed their own logistics system required (mostly based on their own transport) or signed the long-term contract with transport companies. They have built and equipped the warehouses (as in case of 'ALOJA-STARKELSEN' Ltd). Big grain processor owns elevators for grain storage, drying, cleaning and reloading of grains into the trucks or railway transport.

Newcomers need time and essential funding to develop their own infrastructural objects required. Market players long-time operating on the market already have advantage in this respect.

1.5. Barriers related to strategic behaviour of market players

Each company of the industry makes and carries out its own strategic behaviour on the market.

One of the leading companies in Baltic States, 'DOBELES DZIRNAVNIEKS', which also is one of the biggest companies in Latvia, merged with the leading wheat and rye flour manufacturer in Estonia J.s.c. 'Tartu Veski' in 2008. This merging provided the opportunity to increase the competitive position of the company and to improve the company's competitiveness on domestic and EU markets. Merging of these two companies allowed them also to modernize the production lines, to improve the technological processes, and to discover new possibilities of developing the personal staff (Dobeles dzirnavnieks, 2008).

The occupation of the leading position on the markets for the companies mentioned made additional obstacles to the market newcomers to strap their business.

1.6. Potential market limitations

Insomuch as the national market has relatively limited capacity for sales, Latvian companies try to promote their product on the external markets – in the EU and third countries. Demand of flour has shrunken in the domestic market, because of increase in grain prices and increase in purchasing power of Latvian population (because of wide use of substitutes for bread and flour). Additionally, the major part of domestic market of flour is occupied by the two biggest grain processing companies 'DOBELES DZIRNAVNIEKS' and 'RĪGAS DZIRNAVNIEKS'.

Limited demand of the domestic market affects significantly the decision of potential newcomers to enter the market. Restricted demand could be considered as a very important and hardly removable barrier for new market players. In order to increase the potential volume of sales, new market actors would be obliged to sell their product abroad searching the additional export potential.

Conclusions

Assessing the competitive environment in Latvian grain processing industry (according to NACE 1.1.red. classification industry code 15.6) on the basis of research results described above, provides opportunity to conclude:

1. The industry market is relatively concentrated, as four by turnover the largest enterprises in 2006 formed 88% of Latvian market. The calculated value of Herfindahl-Hirshman index (3219) shows relatively high concentrations of enterprises in industry as well.

2. However, a deeper analysis of each separate entry barrier in the sector allows to conclude that competitive environment should not be characterized by concentration indexes (CR4 and HHI) alone. It is very important to analyse specificities related to the sector structure and operations. For instance in a local market the major part of the flour supply is provided by several leading grain processing companies. Many industry's enterprises deal not only with grain processing but with production of bread as well. Vertical integration allows them to get additional competitive advantage on the domestic market.
3. At the same time, on the domestic market the grain and starch processing products could be easily supplied by other enterprises importing products to Latvia from the EU. That is why even on the national market Latvian producers and processors are obliged to compete not only with each other, but also with a wide range of foreign enterprises which are importing their products from abroad.
4. Production of ecological products can be considered as a reasonable alternative for the potential domestic new actor who is going to enter into the business, as biological agriculture develops quite fast and is supported by national government.
5. Since the capacity of national gain processing market is limited, Latvian manufacturers are trying to export their products to the EU and third countries.

On the basis of the analysis of entry barriers, the following proposals could be addressed to LR Ministry of Economy and LR Competition Council:

- to promote export for domestically produced product, through supporting the participation of Latvian enterprises on the different international business forms and fairs;
- to promote cooperation among domestic enterprises by creation of mutual business activities and development of business clusters;
- to analyse the competitive environment on the domestic market, look over geographical market borders especially during the Competitions Council proceedings devoted to acquisition of enterprises. By mutual cooperation and active merging, enterprises are able relatively quickly to achieve the leading positions on the local market. However, national restrictions do not allow them to reach the reasonable size in order to be competitive on the integrated EU market as well.

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BEEF CONSUMPTION TRENDS IN LATVIA

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Abstract

Over the last few years, the increase of society stratification and inequality of income that has favoured significant shifts in household dietary patterns and a growing demand for products of animal origin, particularly meat and milk can be observed. On the consumption side, meat plays an important role in improving the nutritional status of low-income households by addressing micro and macro nutrient deficiencies. In this context, this paper investigates beef consumption trends and aims to corroborate theoretical expectations with empirical findings. The aim of the research was to characterize main tendencies of beef consumption and to find out factors affecting beef consumption in Latvia. In order to achieve the set aim, the following research objectives were defined: 1) to characterize household expenditure for purchasing beef; 2) to describe overall beef consumption in Latvia; 3) to investigate beef consumption in households with different income level. The study was based on annual statistical data, statistical bulletins covering results of the Household Budget Survey from 2002 to 2007, scientific publications and special literature. To carry out the research, adequate research methods were used. The results of this study showed that beef consumption in the country has been more or less stable, although in relatively small amounts. The main factor that influences beef consumption and expenditure on beef is income level. The results also suggested that higher beef consumption is characteristic of urban households, which have higher income level than rural ones. Therefore, within increase of income level of Latvia's inhabitants, beef consumption and demand for beef could significantly increase.

Key words: beef, consumption, expenditure, quintile, Latvia.

Introduction

Consumption of fresh meat heavily declined during the 1990ies in most European countries. Explanations for this decline are increasingly sought and found in factors other than traditional economic ones. According to W.A.J. Verbeke and J. Viaene (1999) livestock production today faces a difficult task of meeting emerging consumer concerns effectively while remaining competitive on major target markets. Therefore quality aspects, ways of shopping, cooking methods, and purchase motives are key factors affecting meat consumption trends (Grunert, 2006).

Unlike other kinds of meat, beef consumption declined most sharply in the nineties. A recent, comprehensive study on consumption trends for dairy and livestock products in the new European Union member states showed that greatest beef consumption fall of - 68% was observed in Latvia (IAMO, 2004).

According to classical economic theory consumers are independent market observers who act to satisfy their needs. And this is possible only if products that are offered in the market comply with consumer requirements or desires. Satisfaction of consumer multiform interests is principal essence and mission of agriculture and all national economy. Nonetheless, the structure, interests and potentialities of consumers persistently change. E. Špakoviča (2004) points out that at current market economy conditions analytical assessments discover more and more new problems, topicalities, dominants and aspects in consumer behaviour, which demand for further scientific research. However, information on aspects of beef consumption and its influencing factors in Latvia have not been published yet.

Such evaluation of current situation encouraged us to carry out this research, and let us highlight the following aim of the research – to characterize main tendencies of beef consumption and find out factors affecting beef consumption in Latvia. In order to achieve the set aim, the following research objectives were defined:

- To characterize household's expenditure for purchasing beef;
- To describe overall beef consumption in Latvia;
- To investigate beef consumption in households with different income level.

The research object was beef consumption.

Materials and Methods

To analyse beef consumption trends, household expenditure for purchasing beef and beef consumption in households with different income level were emphasized. For data summarizing, showings (i.e. expenditure for purchasing beef (LVL month^{-1}) and beef consumption (kg year^{-1})) of the following entities were used:

- Household: a person or a group of persons who are kinsfolk, who have common expenditure for food and who live in one residential unit (house, flat etc.) and cover residence expenses collectively (Central Statistical Bureau of Latvia, 2004);
- Quintile: one fifth or 20% of surveyed households grouped in ascending order according to their gross income (Central Statistical Bureau of Latvia, 2005).

The principal materials used for this research were as follows: different sources of scientific literature and research papers, published data from Central Statistical Bureau of Latvia (Central Statistical Bureau of Latvia, 2003; 2004; 2005; 2006; 2007; 2008) as well as database of Household Budget Survey done by CSB.

Both qualitative and quantitative research methods were used in this study: analysis and synthesis, data grouping, logical and abstract constructive methods.

Results and Discussion

1. Household Expenditure for Purchasing Beef

Households are the least economic unit of society and to a great extent they represent both the development of national economy and social situation and problems of inhabitants. Therefore, it is important to clarify food consumption expenditure and structure. In our study structure of household food expenditure can be assessed as an indicator that quite precisely characterises consumption priorities.

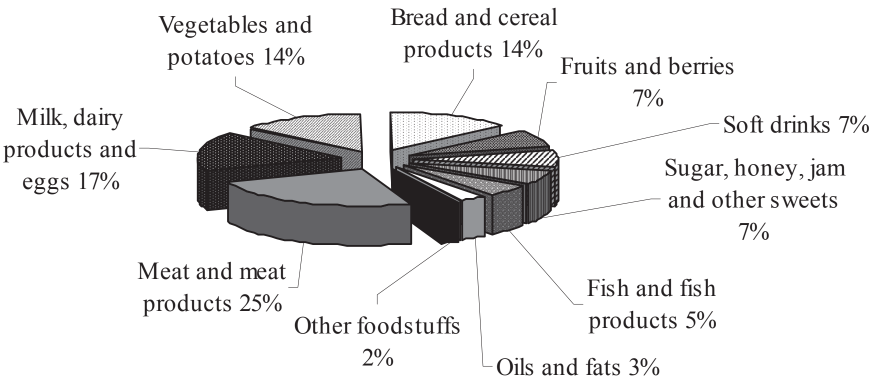

Figure 1. Structure of household food expenditure (% from total food expenditure), 2007.

Source: Central Statistical Bureau of Latvia, 2008

Data presented in Figure 1 indicates that in all households the main consumption priorities are expenditure on meat and meat products (25%), milk, dairy products and eggs (17%). The third priority is vegetables and potatoes, bread and cereal products (14%). Considerably less money is spent on purchasing such products as fruits and berries, soft drinks, sugar, fish, oils and fats. In general, such structure of household food expenditure is characteristic of Latvia's households, because lately it has not practically changed.

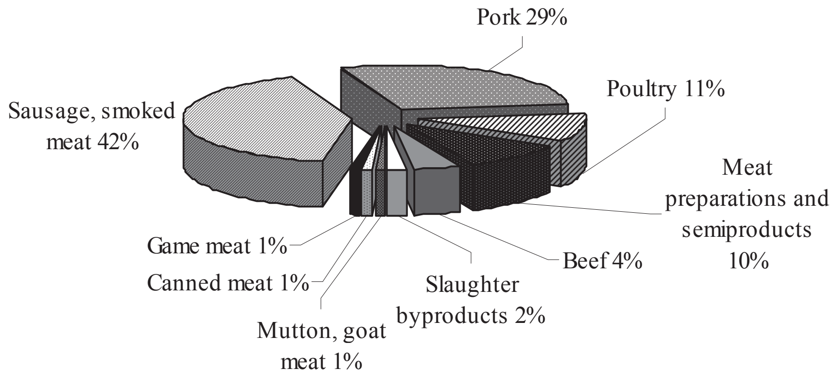

Figure 2. Structure of household expenditure on purchasing meat and meat products (% from total meat and meat products expenditure), 2007.

Source: Central Statistical Bureau of Latvia, 2008

Analyzing the structure of household expenditure on purchasing meat and meat products, we can see that in 2007 most of money households spent on purchasing sausages and smoked meat (42% from total meat and meat products expenditure) and pork (29%). Considerably less money was spent on beef purchase – only 4% from total meat and meat products expenditure (Figure 2).

In order to characterize household expenditure on purchasing beef, dynamics of household expenditure on purchasing beef was further examined (Figure 3). From data and calculations arranged in Figure 3 the following conclusions could be made:

- From 2002 to 2003, the tendency to increase expenditure for beef was observed. In 2003 for purchasing beef household spent 6.9% from total meat and meat products expenditure or 0.56 LVL month^{-1};
- Diametrically opposed processes were observed from 2004 to 2006, when specific weight of expenditure decreased consequently;
- Small growth of expenditure occurred in 2007, when expenditure for beef was 0.56 LVL month^{-1} or 4% from total meat and meat products expenditure.

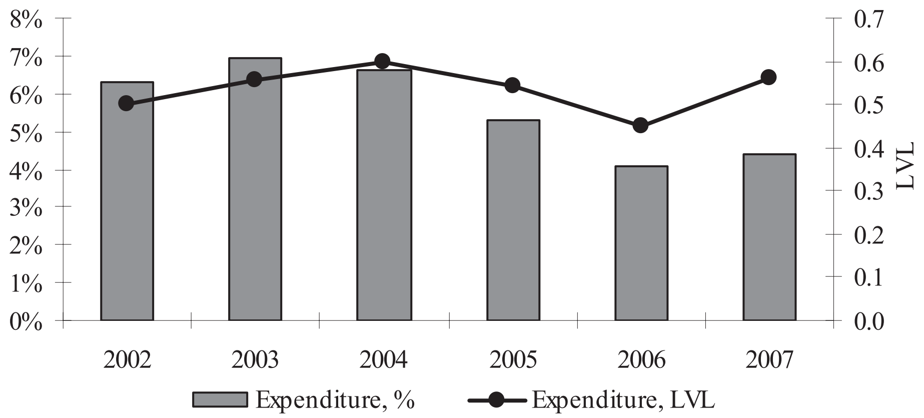

Figure 3. Dynamics of household's expenditure on purchasing beef (% and LVL month^{-1} from total meat and meat products expenditure), 2002 – 2007.

Source: The author's calculations based on the data from Central Statistical Bureau of Latvia, 2003; 2004; 2005; 2006; 2007; 2008

Analyzing our findings we can agree to those authors who points out that general trends in the food industry indicate that the sector is in transition with shifts in consumer expenditure from basic products (fresh meat) to more prepared products (meat products) (Newman et al., 2002).

Although some authors indicate that changing pattern of food consumption is more influenced by socio-demographic factors, instead of price and income factors (Newman et al., 2002; Burton et al., 1999), we think that in Latvia's situation the main factor that influences food expenditure structure and food consumption is income level. This is indicated by the increase of society stratification, which can be characterized by the growth of Gini coefficient from 0.30 in 1996 to 0.35 in 2007 (Central Statistical Bureau of Latvia, 2008). The Gini coefficient is used as a measure of inequality of income distribution or inequality of wealth distribution. It is defined as a ratio with values between 0 and 1: a low Gini coefficient indicates more equal income or wealth distribution, while a high Gini coefficient indicates more unequal distribution (Kalniņa and Meņšikovs, 2002).

To characterise the level of household expenditure in households of different prosperity level, data about quintile groups and households in rural and urban areas were used.

In statistics quintile groups are developed by arranging all households in ascending order by their disposable income per one household member and dividing them later in five equal parts. Each of them represents one fifth or 20% of households. Thus, in the 1st quintile the poorest households are included, but in the 5th quintile – the richest ones.

Expenditure on beef of the poorest households (1st quintile) in 2007 constituted 0.30 LVL month^{-1} on average per one household member. Expenditure on beef of 1st quintile households comprising one fourth of the total number of persons belonging to households in the country constituted only 54% of the average level of household expenditure on beef.

Beef consumption expenditure of the richest households (5th quintile) comprised 0.83 LVL month^{-1} per household member and was 1.5 times higher as the average indicators and almost 3 times higher as the indicators of the lowest quintile. The same tendency can be observed in longer time period (Figure 4).

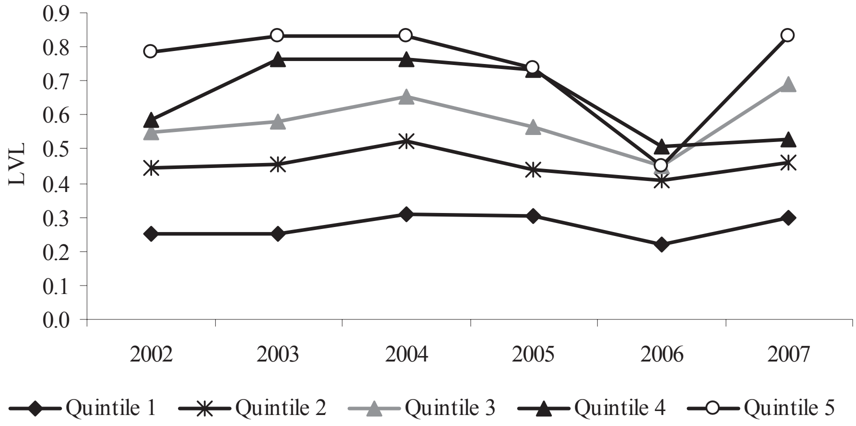

Figure 4. Dynamics of expenditure for purchasing beef in households with different income level (LVL month^{-1}), 2002 – 2007.

Source: The author's calculations based on the data from Central Statistical Bureau of Latvia, 2003; 2004; 2005; 2006; 2007; 2008

From Figure 4 we can conclude that during the last six years the least financial resources for purchasing beef spent the poorest households (1st and 2nd quintile). Although common tendency shows that the richest households (5th quintile) spent most of money on purchasing beef; however, in definite years some exceptions can be observed. For instance, in 2005 and 2006 expenditure on purchasing beef between 3rd, 4th and 5th quintile didn't differ significantly. Such situation, when poorest households spent considerably less expenditure on beef than richest households, can be explained by the fact that beef retail price is comparatively high, but disposable income of 1st quintile households is small. This also determines limited potentialities for purchasing beef of mentioned households.

At present in compliance with data from the CSB 68% from total Latvia's population lives in cities, but 32% – in rural areas (Central Statistical Bureau of Latvia, 2008). Income inequality between these households can be observed. For example, in 2006 disposable income of urban households was about 30.9% or 52.94 LVL month^{-1} higher than in rural households. Therefore, it is logical that urban households spent considerably more money on purchasing beef than rural households (Figure 5).

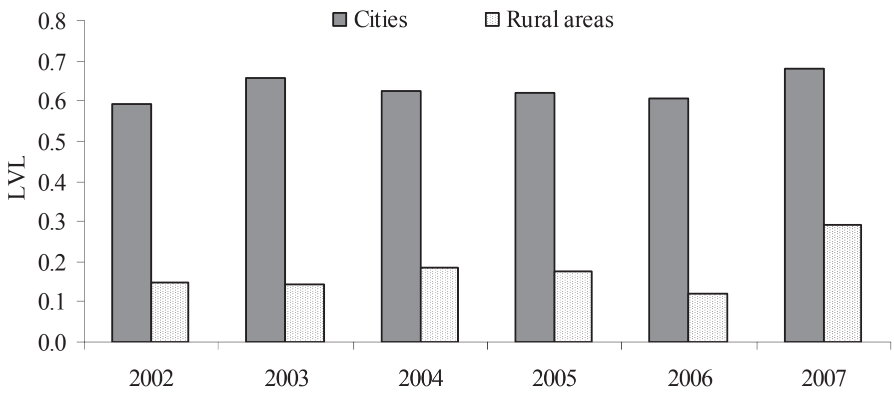

Figure 5. Dynamics of expenditure for purchasing beef in rural and urban households (LVL month^{-1}), 2002 – 2007.

Source: The author's calculations based on the data from Central Statistical Bureau of Latvia, 2003; 2004; 2005; 2006; 2007; 2008

Dynamics of expenditure for purchasing beef in rural and urban households shows that in time period from 2002 to 2006 urban households spent on average for 75% more money than rural households. Only in 2007 this predominance decreased, as urban households spent about 57% more money for purchasing beef than rural households.

Substantial differences between expenditure of urban and rural households could be explained with lower beef retail prices or with supply of cheaper and less qualitative production in rural area. Probably small expenditure for purchasing beef depends on both these factors.

In general, analysis of household expenditure on beef showed that in 2005 and 2006 expenditure for purchasing beef decreased; furthermore, the amount of expenditure substantially differs between households with different income level. For verification of drawn conclusions total beef consumption and beef consumption in rural and urban households were further analyzed.

2. Beef Consumption

In 2007, the total consumption of beef in Latvia has slightly increased in comparison with the previous year (Table 1). In 2005 and 2006, consumption of beef fell down because foot and mouth disease broke out in Europe. Moreover, decrease of beef consumption took place in all European countries (Ministry of Agriculture Republic of Latvia, 2007).

For the last six years, beef production as well as consumption fluctuates; however, it has a positive trend. In 2006, production reached 20.7 thsd. t, but in 2007 beef production increased by 10% compared to the previous year, meaning that production growth is balanced to consumption growth which also increased in 2007.

According to statistics data, consumption of beef compared to consumption of pork is considerably lower. For instance, in 2007 Latvia's inhabitants consumed 3.5 times more pork than beef.

Table 1

Beef balance and pork consumption in Latvia, 2002 – 2007

	2002	2003	2004	2005	2006	2007
Beef consumption, thsd. t	23.3	27.3	27.4	22.6	20.8	22.5
Pork consumption, thsd. t	60.9	66.2	66.7	71.4	74.6	78.1
Beef production, thsd. t	16.0	21.2	21.6	20.4	20.7	22.8
Self-sufficiency ratio in domestic market, %	68.7	77.7	78.8	90.3	99.5	101.3

Source: The author's calculations based on the data from Central Statistical Bureau of Latvia, 2003; 2004; 2005; 2006; 2007; 2008

By analyzing the statistics data, it is clear that the beef consumption in the country has been more or less stable, although in relatively small amounts. According to the opinion of Latvian researchers (Jemeļjanovs and Šterna, 2008; Melece, 2008) reasons of comparatively small amounts of beef consumption could be searched in the historically established diet traditions.

However, in literature we can find information affirming that within improved living conditions and consequent shift towards healthier life style diet traditions, inter alia beef consumption trends, might change (Akbay et al., 2007). Therefore, in order to investigate beef consumption in households with different income level, we analyzed beef consumption in rural and urban households (Figure 6).

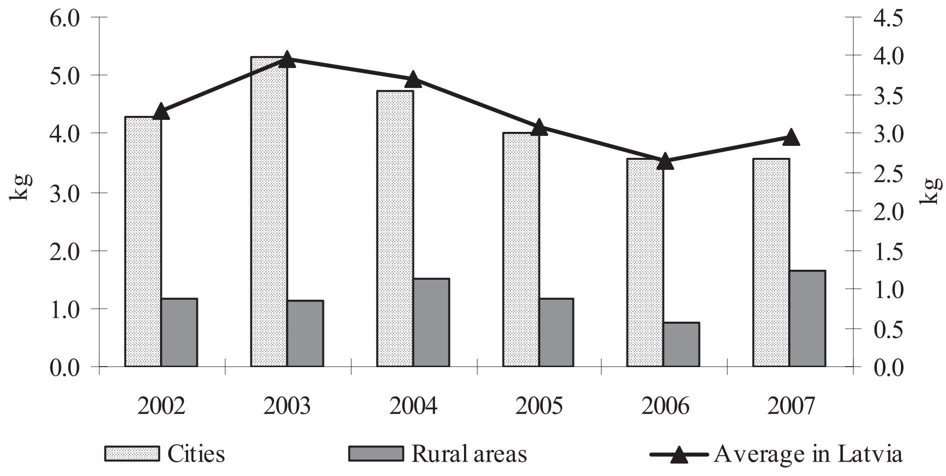

Figure 6. Beef consumption in rural and urban households (kg year^{-1}), 2002 – 2007.
Source: The author's calculations based on data from Central Statistical Bureau of Latvia, 2003; 2004; 2005; 2006; 2007; 2008

According to summarized data, better secured urban households consume beef about 3.7 times more than rural households. Situation changed in 2007 when beef consumption in rural households increased, but beef consumption in urban households, in comparison with previous year, remained unchanged. In 2007, the average beef consumption per one household member in rural households was 1.7 kg year^{-1}, but in urban households – 3.7 kg year^{-1}. This could be explained with increased beef production amounts in 2007. According to Latvian researchers (Melece, 2008) approximately one third of consumed beef in rural households is home-made production.

Overall, higher beef consumption is characteristic of urban households that have higher income level than rural ones. It means that income level has positive effect on beef consumption.

Detailed study of beef consumption let us formulate certain developmental visions:

- Increase of income level of Latvia's inhabitants, could promote beef consumption and significantly increase demand of beef;
- Ongoing urbanization processes could increase number of urban population that tends to consume more beef than rural population;
- Living and acting in single European economic space food, inter alia beef, consumption patterns could change;
- Development of breeding of specialized cattle breeds could positively change consumer's attitude towards beef consumption.

Conclusions

1. In Latvia's households the main consumption priority is expenditure for meat and meat products (25% from total food expenditure); furthermore, most of this money households spend on purchasing sausages and smoked meat (42%), but on purchasing beef – only 4% from total meat and meat products expenditure.
2. Analysis of dynamics of household expenditure on purchasing beef showed that household expenditure on beef during the last six years has been fluctuated.
3. Amount of expenditure substantially differs between households with different income level: urban households spend on average for 71% more money for purchasing beef than rural households, while richest households (5th quintile) – for 64% more money than poorest ones (1st quintile).
4. Beef consumption in the country has been more or less stable, although in relatively small amounts. Reasons of comparatively small amounts of beef consumption could be searched in the historically established diet traditions.
5. Quantities of beef consumed in 2007 in the urban households are roughly double than those consumed in rural households.
6. Income has a positive and significant effect on beef consumption, and it means that within increase of income level of Latvia's inhabitants, beef consumption and demand for beef could significantly increase.

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GROSS ECONOMIC EFFECT OF DAIRY SECTOR IN LATVIA AND OTHER BALTIC STATES

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Abstract

Implementation of special support measures and resolving its main problems with effective methods in medium-run may allow to maintain the dairy sector as a significant traditional element of the Latvian economy. It is important to know the gross economic effect of the Latvian dairy sector in order to take informed and rational support decisions. Authors have developed and approbated methods and by applying these have obtained new, unpublished data that characterize economic effect of the sector.

The data have been analysed in Latvian and the Baltic states context. It is concluded that the dairy sector is significant to the Latvian economy mainly due to gross value added and especially because of its role in providing work opportunity. Authors call attention to reserves in gross value added growth per full time equivalent unit in the secondary production in all Baltic states. The data of the primary dairy sector level in turn indicate lower potential of growth that is evidenced by even a slight decrease in indicators of the comparatively more effective Estonian producer structure. Therefore, it can be expected that the weight of dairy sector secondary level in the dairy sector gross value added will increase. Authors point out certain possible solutions of the Latvian dairy sector's problems such as promotion of joint ownership structure.

Main analysed indicators are gross value added at factor cost, use of labour in full time equivalent units and labour use effectiveness.

Key words: dairy sector, economic effect, value added.

Introduction

Dairy farming is one of the most significant traditional branches of the Latvian agriculture. Closely connected milk products processing has a significant weight in the manufacture of food products. A unified term 'dairy sector' is used in the paper to include both branches. Dairy sector is a net exporter that is evidenced by the positive milk balance of Latvia. The sector plays an important role in providing work opportunity and is distributed rather equally across Latvian rural territory where unemployment problem is most important. Latvia possesses appropriate natural resources, a developed capital resources base and experience in the dairy sector.

However, the sector is faced by significant economic problems that have especially escalated since the 1st quarter of 2008. Dairy sector is influenced by such internal factors as: fragmented milk production and processing, comparatively high level of intermediate consumption in primary production, milk processing is dominated by mass products such as milk, cultured products, cheese and butter, the price of which cannot be influenced by the producers (Leimane et al., 2006). Research at dairy sector primary level indicates that the total economic effectiveness is determined by level of milk yield, additional income for high quality milk and increase in labour productivity; economic effect increases as the number of cows per holding grows (Melece, 2004). There are different production-related direct payments in the European Union agricultural products market that have the most negative influence and varied rates of decoupled payments (Miglavs et al., 2008).

The Competition Council of Latvia has concluded that there is an unequal distribution of market power between milk processing companies and retail companies which are able to influence supply price, because they sell most or a significant proportion of the producers' products. Existing branch and competition structures and poor relations between the dairies and the food trade in Germany have resulted in lower ability to use modern methods of inter-enterprise cooperation using efficient customer response tools and consequently in gaps in dairy sector's turnover (Obersojer et al., 2005). Research carried out in other EU countries also evidences that larger processing units are needed to shift the emphasis on to more value added products and adequate investment in research and development, e.g. in Ireland (Briscoe and Ward, 2006). Latvian dairy sector is characterised by poor relations among primary, secondary production and trade market players and relatively small processing units.

Still the dairy sector in the period until 2007 had proved itself to be a part of economy with stable development and future prospects in export potential and increasing competitiveness in the European Union market (Jasjko et al., 2007). Revealed comparative advantage analysis shows that Latvian indicators in the group of dairy and dairy products have become positive since 2004 and are growing rapidly (Saboniene, 2009).

Factors mainly related to significant decrease in world economic growth rate in 2008, affecting the fragmented dairy sector that suffers from EU common market distortions have subjected it to a deep crisis.

Achievement of Latvian dairy sector development goals and sustainable growth on the whole is threatened in such conditions. Therefore it is very significant to develop an economically acceptable solution for facilitating dairy sector sustainability. In this respect, it is important to know the gross economic effect of the Latvian dairy sector in order to take informed and rational support decisions. In scientific literature evaluation of economic impact of sectors and dairy sector in particular is often analysed in terms of its income, value added and employment impacts (e.g. Cabrera et al., 2008).

Neither in scientific nor other data sources the authors have encountered a calculation of gross economic effect of the dairy sector applicable taking into account local data availability. These circumstances determined the need to develop appropriate methods, to approbate them, thus obtaining new, unpublished data. Interaction among the Baltic States' dairy sectors is observed, and they are affected by several similar factors. Therefore, the authors consider data from the Baltic States appropriate for comparative analysis. Authors use the previously unpublished data in a new aspect in order to identify trends in neighbouring countries that can affect the Latvian dairy sector.

The aim of this paper is to evaluate the role of dairy sector in the Latvian economy and to carry out its comparative analysis in the framework of the Baltic States. The following tasks had been set to reach the aim:

1) calculation of gross economic effect of the dairy sector, including milk production and processing in Latvia, Lithuania and Estonia;
2) analysis of main indicators of gross economic effect.

The main hypothesis of the paper is that dairy sector is an important part of the Latvian economy. An additional hypothesis is that Estonian and Lithuanian dairy sectors, while being in similar conditions, have produced better results than the corresponding Latvian sector.

Due to format limitations of the paper other significant indicators that characterize the special role of Latvian dairy sector have not been analysed: influence on export-import balance, social security, state budget, regional development which are very material in this sector due to its wide distribution across the territory of Latvia, the Latvia's net exporter status of milk and its products and other aspects.

Materials and Methods

Data from Eurostat, Central Statistical Bureau of Latvia (CSB), Statistics Lithuania, Latvian, Lithuanian and Estonian Farm Accountancy Data Network (FADN) and Economic Accounts for Agriculture (EAA), Ministries of Agriculture of Latvia and Estonia as well as Latvian State Institute of Agrarian economics (LSIAE) research, as well as other authors' research (Jasjko et al., 2007; Melece, 2004) were used in order to carry out the research tasks. Detailed Latvian FADN data have been obtained from series of LSIAE publications "Agricultural Holdings. Results of Economic Analysis".

Abstract-logical, constructive calculations and statistical analysis methods were used in order to achieve the aim of the research.

Value added at factor cost was used to evaluate the gross economic effect because since it most closely characterises the impact of the sector on the economy. An additional indicator of economic effect in the paper is labour use in full time equivalent units.

Statistics or data necessary for calculations at needed level of detail in accordance with Statistical Classification of Economic Activities in the European Community (NACE) were available only for obtaining value added at factor cost indicators. Therefore, value added calculations were not carried out using the national accounts methodology. Authors consider that in current conditions value added at factor cost is a better option to characterise the gross contribution to the economy because it includes EU rural development support payments that the sector indirectly attracts. The amount is significant (in 2006 it was approximately 63 M EUR, since 2007 – even more), and it must be taken into account during assessment of the sector's primary level significance.

Gross value added (GVA) at factor cost was calculated by adding up GVA created at dairy sector primary and secondary level. GVA at dairy sector primary level was obtained using a calculation method developed by the authors (see Formula 1). In accordance with FADN methodology its data are directly referable to holdings sized starting 2 economic size units (ESU). FADN data analysis shows that the GVA relative amount of smaller holdings does not significantly differ from the data of larger holdings. Therefore, the FADN data were directly referred to the primary level on the whole. Eurostat structural business statistics data on manufacture of dairy products (NACE Rev. 1.1 DA 15.5) were used for characterising dairy sector secondary level.

GVA at dairy sector primary level in Latvia at factor cost was calculated using the following formula:

$$GVA_f = (NVA_H + D_H) \times \sum_{FADN} N \times \frac{\sum C}{\sum_{FADN} C} \quad (1)$$

where: GVA_f – gross value added at factor cost at dairy sector primary level; NVA_H – average net value added in FADN grazing cattle holdings; D_H – average depreciation in FADN grazing cattle holdings; $\sum N_{FADN}$ – number of cattle in FADN sample with grazing cattle specialisation; $\sum C$ – total number of dairy cows in Latvia; $\sum C_{FADN}$ – total number of dairy cows in FADN sample grazing cattle specialisation holdings.

Labour use in full time equivalent units at Latvian dairy sector primary level was calculated using the following formula:

$$L_{FTE} = \left(L_{FADN} \times \sum_{FADN} N \right) + \left(L_{2-4\,ESU} \times \sum_{<2\,ESU} C \right) \quad (2)$$

where: L_{FTE} – use of labour at dairy sector primary level in full time equivalent units; L_{FADN} – average use of labour in FADN grazing cattle specialisation holdings; $\sum N_{FADN}$ – number of holdings in FADN sample with grazing cattle specialisation; $L_{2\text{-}4\,ESU}$ – average use of labour per dairy cow in FADN grazing cattle specialisation holdings whose size is 2-4 ESU; $\sum C_{<2\,ESU}$ – total number of dairy cows in holdings which are smaller than 2 ESU.

Comparatively higher use of labour in the smaller holdings that the FADN data are not referred to was taken into account in calculation of labour use at dairy sector primary level (see formula 2). The total number of cows in holdings that are smaller than 2 ESU was determined by subtracting the FADN sample (≥2 ESU) results from the total number in the country.

Gross economic effect includes value added at factor cost in dairy farming, growing feed grain, preparation of grass fodder as well as milk processing. The actual gross economic effect can be larger because the calculation due to limited availability of data does not take into account value added in other sectors as a result of dairy sector's existence.

The credibility of research results is determined by credibility level of used FADN data. Taking into account the fact that results are rather well comparable across the years as well as a relatively large sample of holdings surveyed (in 2006 data from 274 research-relevant specialised holdings were collected) it can be concluded that the level of credibility is appropriate for achieving the aim of the research. As an additional measure another method (Economic Accounts for Agriculture) was used for checking calculation methods and the obtained results were similar. The research period ends in 2006 due to structural business statistics on dairy sector secondary level being published 18 months after end of the reporting year.

Results and Discussion

Dairy Sector Characteristic Indicators in Latvia

Authors have used two main indicators for characterisation of dairy sector gross economic effect – GVA at factor cost and use of labour in full time equivalent units. Dairy sector primary level is the most significant part of the Latvian agriculture according to its weight in GVA at factor cost in agriculture. Dairy sector primary level GVA at factor cost increased 2.9 times in the period of 2000-2006 mainly due to growth in state and EU support payments as well as in milk purchase price (from 150 EUR up to 240 EUR per tonne). The data of GVA at factor cost at the secondary level of dairy sector are unstable; however, they do not indicate a substantial upward trend. Total dairy sector GVA at factor cost in the relevant time period increased 2.3 times mainly due to the growth at the primary sector level. GVA of primary dairy sector level increased in 2006 by 17.6 percentage points over 2000 resulting in significant changes in dairy sector GVA structure. The GVA of dairy sector at factor cost, related to the gross domestic product (GDP) of Latvia calculated according to the national accounts methodology does not allow to precisely evaluate the sector's weight in GDP; however, it indicates a significant and stable position of the sector in the structure of the economy with a growth trend during the period (Table 1).

Table 1

Latvian Dairy Sector Gross Value Added Dynamics, 2000-2006

Indicator/year	2000	2001	2002	2003	2004	2005	2006
GVA at factor cost at dairy sector primary level (evaluation), M EUR	79.0	105.3	127.5	109.4	210.0	202.1	229.3
GVA at factor cost in agriculture, M EUR	187.7	228.1	222.3	224.9	354.7	389.2	487.9
Dairy sector primary level weight in agriculture GVA at factor cost, %	42.1	46.2	57.4	48.7	59.2	51.9	47.0
GVA at factor cost in manufacture of dairy products (NACE Rev. 1.1 DA 15.5), M EUR	46.0	60.7	61.1	41.0	42.4	52.7	54.5
Dairy sector GVA at factor cost, M EUR	125.0	166.0	188.6	150.4	252.4	254.8	283.8
Dairy sector primary level weight in dairy sector GVA at factor cost, %	63.2	63.4	67.6	72.7	83.2	79.3	80.8
Dairy sector GVA related to GDP at current prices, %	1.5	1.8	1.9	1.5	2.3	2.0	1.8

Sources: FADN, EAA, Eurostat, CSB and authors' calculations.

Labour use in full time equivalent units at dairy sector primary level has decreased in 2006 over the year 2000 by 35% (Table 2). Irrespective of that, the sector has a significant role in Latvian employment structure due to use of 5-6% of the total labour usage in full time equivalent units. This takes a special significance at times of economic crises. The weight of labour used at dairy sector primary level in an analogous indicator on agriculture on the whole has decreased in 2006 over the year 2000 by 9.7 percentage points, in contrast with the GVA at factor cost created in the dairy sector primary level, whose weight has not decreased. This indicates a comparative effectiveness increase of dairy primary level in agriculture. Labour use in full time equivalent units at dairy sector secondary level within time period of 2000-2006 has been unstable, however, it ensures only approximately 10% of total labour use in the dairy sector. Dairy sector labour use in full time equivalent units weight in total labour use in the economy decreases. Still in 2006, the indicator's value 5.5% indicates the significant role the sector plays in ensuring work opportunities in Latvia.

Table 2

Labour Use Indicators in Latvian Dairy Sector, 2000 – 2006

Indicator/year	2000	2001	2002	2003	2004	2005	2006
Labour use in full time equivalent units at dairy sector primary level (evaluation), thousand	65.8	56.9	53.1	49.5	45.8	40.9	42.4
Dairy sector primary level weight in labour use in agriculture in full time equivalent units, %	44.3	39.2	37.1	35.2	32.8	29.6	34.6
Labour use in full time equivalent units in manufacture of dairy products (NACE Rev. 1.1 DA 15.5), thousand	4.9	6.0	5.6	4.0	4.1	4.0	4.2
Total dairy sector labour use in full time equivalent units, thousand	70.8	62.9	58.7	53.6	49.9	44.9	46.6
Total dairy sector labour use in full time equivalent units weight in the economy, %	-	-	-	-	6.2	5.6	5.5

Sources: FADN, EAA, Eurostat, CSB and authors' calculations.

Dairy sector primary level GVA at factor cost per utilised full time equivalent labour unit has significantly increased in the period from 2000 till 2006 (Table 3). If in 2000, it was slightly lower than in the agriculture on the whole then within the period until 2006 the value of the indicator increased 4.5 times and in 2006 it was 35% higher than the average indicator in agriculture. In the processing the trend is rather opposite. The GVA at factor cost per utilised full time equivalent labour unit in milk processing in 2000 was 27% higher than average in manufacturing. However, in 2006 it was only 14% higher. In 2000, the GVA at factor cost at the dairy sector secondary level was 7.7 times higher than at the primary level, but in 2006 the ratio had decreased to 4 times. Although the GVA at factor cost at dairy sector primary level per full time equivalent labour unit value is lower than in manufacturing, the functioning of the sector's primary level provides a possibility to produce at the secondary level higher value added than average in the manufacturing.

Table 3

Gross Value Added per Labour Unit in Latvian Dairy Sector, 2000-2006

Indicator/year	2000	2001	2002	2003	2004	2005	2006
GVA at factor cost per utilized labour in full time equivalent units at the dairy sector primary level, thousand EUR	1.2	1.9	2.4	2.2	4.6	4.9	5.4
GVA at factor cost per utilized labour in full time equivalent units in agriculture, thousand EUR	1.3	1.6	1.6	1.6	2.5	2.8	4.0
GVA at factor cost per utilized labour in full time equivalent units in manufacture of dairy products (NACE Rev. 1.1 DA 15.5), thousand EUR	9.3	10.1	11.0	10.1	10.3	13.3	13.1
GVA at factor cost per utilized labour in full time equivalent units in manufacturing, thousand EUR	7.3	10.1	8.8	9.8	8.6	9.5	11.5

Sources: FADN, EAA, Eurostat, CSB and authors' calculations.

Dairy Sector Comparison in the Baltic States

Dairy sector in both other Baltic States is not less significant than in Latvia. Moreover, the market is closely connected; therefore, it is important to carry out Baltic scale analysis while evaluating the situation and prospects of the sector in Latvia. At this level data are available for the 2004-2006 period that provides a view on the sector indicator level and development trends in the Baltic States. In several cases the trends are different.

GVA at factor cost at Estonian dairy sector primary level during 2004-2006 tended to decrease, in Latvia and Lithuania this indicator was unstable but a growth trend was observed. Evaluating the weight of specific states in total Baltic GVA at factor cost separately at primary and secondary level, it was established that within 2004 – 2006 time period the contribution in the total GVA of individual states had not changed by more than 3 percentage points. Total Baltic dairy sector economic effect expressed in GVA at factor cost in 2004 was 958.8 M EUR and increased to 1060.6 M EUR in 2006. Analysis of individual state contribution to this indicator shows that 58% were created in Lithuania, 26% in Latvia and 15% in Estonia. The proportion of GVA by state had not changed significantly in 2006 compared to the situation in 2004.

Table 4

Dairy Sector Gross Economic Effect Indicators in the Baltic States, 2004-2006

State	Latvia			Lithuania			Estonia		
Indicator/year	2004	2005	2006	2004	2005	2006	2004	2005	2006
GVA at factor cost at dairy sector primary level (evaluation), M EUR	210.0	202.1	229.3	452.8	526.7	479.4	134.8	129.8	119.3
GVA at factor cost in manufacture of dairy products (NACE Rev. 1.1 DA 15.5), M EUR	42.4	52.7	54.5	94.6	101.3	135.7	24.2	30.2	42.4
Dairy sector GVA at factor cost, M EUR	252.4	254.8	283.8	547.4	628.0	615.1	159.0	160.0	161.7
Dairy sector primary level weight in dairy sector GVA at factor cost, %	83.2	79.3	80.8	82.7	83.9	77.9	84.8	81.1	73.8
Dairy sector GVA related to GDP at current prices, %	2.3	2.0	1.8	3.0	3.0	2.6	1.6	1.4	1.2

Sources: FADN, EAA, Eurostat, Ministry of Agriculture of Estonia, Statistics Lithuania and authors' calculations.

The weight of GVA created at dairy sector primary level in total dairy sector GVA in 2004 - 2006 time period decreased in all three Baltic States. In Estonia this decrease was by 13%, in Lithuania by 6%, however in Latvia only by 3%. It is necessary to note that in all three Baltic States the weight of dairy sector primary level is approximately 80% of all value added in dairy sector.

Relation of each Baltic State's dairy sector GVA at factor cost to its GDP at current prices allows to conclude that dairy sector is the most significant in Lithuania where it is 2.6-3% of the GDP. Latvia is next with approximately 2% and in Estonia this sector is relatively smaller – 1.2-1.6% of the GDP. The weight of dairy sector in structure of economies decreased in 2004-2006 period, but is still significant.

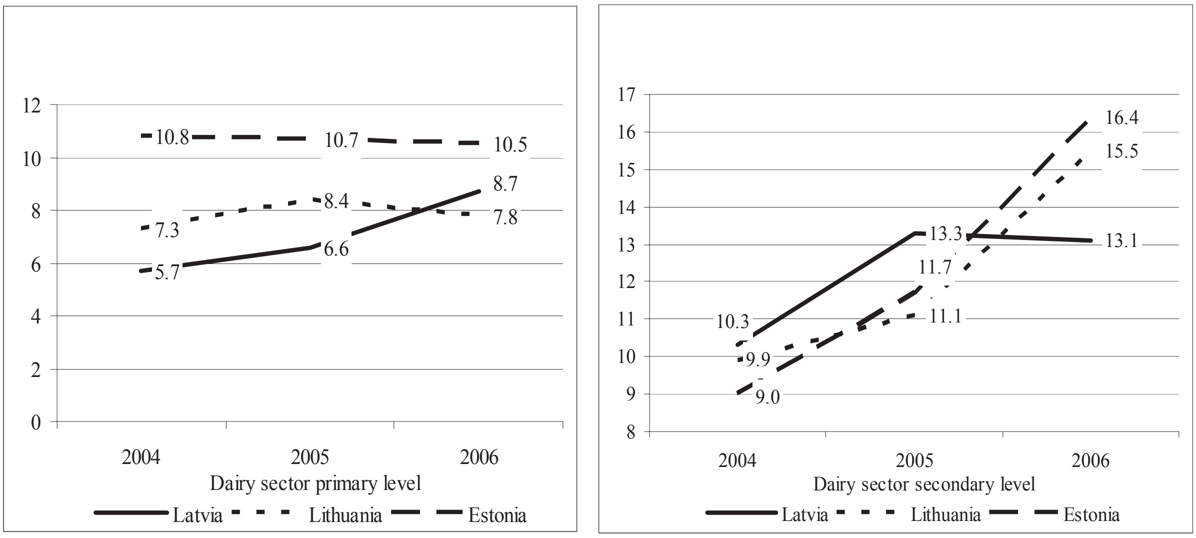

Figure 1. GVA at factor cost per used full time equivalent labour unit in the Baltic States, 2004-2006, thousand EUR year^{-1}.

Sources: FADN, Eurostat, Ministry of Agriculture of Republic of Estonia annual reviews on agriculture and rural development, Statistics Lithuania and authors' calculations.

Note: Primary sector data represent FADN sample.

An important indicator characterising effectiveness is GVA per labour unit. In this respect a positive trend is substantial increase at Latvian primary level (Figure 1), exceeding the Lithuanian indicator. However, an opposite trend can be observed in the milk processing, where Latvian GVA level was the highest in the Baltic States until 2005 and notably lost its relative position in 2006.

GVA at factor cost per utilised labour in full time equivalent units at dairy sector secondary level in 2006 over 2004 increased by 82% in Lithuania, 56% in Estonia and only 27% in Latvia. This allows to make an assumption that current dairy sector problems are to a significant extent caused by insufficient efficiency at the dairy sector secondary level.

Conclusions

1. The role of dairy sector in the Latvian economy evaluated by its GVA at factor cost is significant; moreover, it shows an upward trend over the 7 years period from the year 2000.
2. The dynamics of Latvian dairy sector economic effect in GVA at factor cost was to a large extent determined by external factors' influence at the primary level – increase in state and EU support payments as well as higher milk purchase price. At dairy sector secondary level GVA at factor cost increase trend has been insignificant.
3. Dairy sector evaluated by created GVA at factor cost related to each state's GDP is significant in all Baltic States. In absolute evaluation Lithuanian sector's GVA at factor cost substantially exceeds the sum of respective indicators of Latvia and Estonia.
4. Latvian dairy sector has a decreasing but still important role in ensuring work opportunities. Since 2005, labour use at primary level has stabilised at approximately 40 thousand full time equivalent unit level, at secondary level – at approximately 4 thousand labour units which forms 5.5% of all labour utilised in the economy. In addition, Latvian dairy sector primary level efficiency evaluated by created GVA at

factor cost per used labour at the start of the period was lower than average in agriculture; however, it increased and at the end of the period significantly exceeded it. Latvian dairy sector secondary level efficiency expressed in GVA at factor cost per used labour has increased slower than the average indicator in manufacturing.
5. Results of GVA and labour use analyses in the Latvian dairy sector provide evidence that allows authors to state that the main hypothesis of the paper is true, i.e. the dairy sector is an important part of the Latvian economy. As it is true, support to the Latvian dairy sector is not only a political problem, but also an important issue to the economy.
6. Estonian dairy sector primary level efficiency evaluated by created GVA at factor cost per used labour is the highest; however, Latvian indicator gradually approaches the relatively stable Estonian level. At secondary level the rate of labour use efficiency growth significantly exceeds that of the primary level. Still in this respect Lithuanian and Estonian processing companies have been more successful than the Latvian ones.
7. Research results indicate GVA growth reserves per used labour unit at the secondary level in all Baltic States. Primary level data suggest smaller growth opportunities indicated by even a slight fall in indicators of the relatively more effective Estonian producer structure. Therefore, it can be expected that the weight of secondary level in sector's GVA will increase.
8. Authors draw a conclusion that the additional paper hypothesis, i.e. that Estonian and Lithuanian dairy sectors, while being in similar conditions, have produced better results than the corresponding Latvian sector is true only partly. At dairy sector secondary level Latvian indicators indeed point to inferior results compared to the other Baltic States. However, at primary level analysis rather indicates comparable or even better performance of the Latvian dairy sector.
9. On the whole, the analysis shows that the dairy sector since 2000, especially at primary level, has successfully developed as holdings have made significant investments in production modernisation and it has resulted in value added growth. Analysis allows to conclude that inadequate development of processing is a significant cause of primary level producers not being able to receive adequate price for their product.
10. Period not covered by the paper due to the lack of full set of statistics since 2007 was characterised by a considerable increase and subsequent decrease in milk product prices on the world market. Authors believe that the Latvian producers' structure that is subject to slow restructuring process is unable to provide adequate cushioning effect at such periods of market volatility.
11. EU experience indicates that one of the factors that promote successful operation of the dairy sector is unity in purposeful action of all stakeholders. Unfortunately in case of Latvia natural conflicting issues between primary and secondary level entities often are resolved by overpowering the weakest, and it harms development of the sector on the whole. One of the solutions is ownership rights of primary level producers and producer groups in the secondary level enterprises. Such a model successfully operates in certain EU-15 countries but has not developed enough in Latvia and in the Baltic States in general.
12. At the current dairy sector economic effect conditions and sharply decreasing economic growth rate, the need to provide support to the dairy sector is mostly determined by its significant role in providing work opportunities. As approximately 90% of labour is utilised at the primary level, it is necessary in current conditions to try to maintain work possibilities at the primary level while promoting more efficient use of capacity in processing.

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EMOTIONAL INTELLIGENCE – AN INTEGRAL PART OF MODERN MANAGERS' PROFESSIOGRAMM

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Abstract

The paper expounds the results of a theoretical and practical research on the significance of presence of emotional intelligence in the manager's professiogram. The research aim is to ascertain the role of emotional intelligence in the manager's professiogram in the 21st century. To foster economic development and global competiveness in Latvia, it is necessary to promote quantitative and qualitative growth of innovative enterprises. To make an innovative enterprise perform successfully, the modern management theory and practice have set forth new requirements for enterprise managers – to develop an ability to be a manager-leader themselves. The manager-leader professiogram has to include competencies forming emotional intelligence. The results of a pilot research revealed that students studying the speciality of management and business (at Latvia University of Agriculture) have a quite low self-evaluation for several competencies of their emotional intelligence; besides, an even lower evaluation is awarded by study fellows and group members. Along with studying theoretical aspects of communication, self-cognition, and self-management, the study process for new specialists of management and business has to be arranged in a way that it promotes practical development and use of EI competencies.

Key words: Emotional intelligence; competencies of a manager, leader.

Introduction

One of the main economic features of the 21st century is intellectual capital that is significant in forming value added and competition advantages for organisations, as contradicted to the main traditional factors of production of the 20th century. Innovative enterprises and their most valuable resources – human resources and human capital – are the values on which business has to be based in a period of fast changes. That is why the statement that the most important task for the 21st century management theory and practise is to achieve an increase in intellectual labour productivity is true.

According to S. Babris, statistical data show that the category of employees performing intellectual jobs has become the fastest growing group of employees in any developed country (Babris, 2007). In Latvia, too, it accounts for 38.4% of the total labour force. At the same time, data provided by the Central Statistical Bureau for the period of 2002-2006 show that in Latvia, compared to Europe, the proportion of innovative enterprises is relatively low. Besides, this indicator has decreased from 17.4% in 2004 to 14.7% in 2006 in the sector of manufacturing. In the sector of services, too, an increase from 17.6% (2004) to 17.8% (2006) is insufficient (Data of Central Statistical Bureau of Latvia). Therefore, the economic development and global competitiveness of Latvia are seriously endangered. A solution of how to stimulate any increase in the proportion of innovative enterprises (also in agricultural sector), to develop and fully use human resources and human capital, is education of existing and new managers in which new management methods, including social and psychological ones, for intellectual employees and innovative enterprises are emphasised.

In her previous papers, V.Kūlupa has justified a need for changing the content of the manager professiogram to manage human resources in the 21st century more efficiently. The author made an inference that, under circumstances of fast changes, the manager professiogram has to include the leader's features and functions and came to a conclusion that any study program or course, in which new business and management specialists are prepared, has to contain a study course about leadership, leader ability development in oneself and others, as well as the theory and practise of communication psychology, group sociology, and self-cognition.

D. Goleman's Emotional Intelligence Theory is recognised as one of the most topical approaches in management regarding improving the manager-leader professiogram. Besides, studies of several authors prove a strong relationship between the use of emotional intelligence in business and the efficiency of an organisation, laying stress on the professiogram of a manager and leader (McClelland et al., 1958; McClelland, 1973; Bray et al., 1974; Boyatzis, 1982; Luthans et al., 1988; Kotter, 1982; Thornton and Byham, 1982; Spencer and Spencer, 1993). Emotional intelligence is an ability to feel, use, find, remember, describe, identify, learn, manage, understand, and explain one's own emotions and those of other people and groups of people. This is an ability that has to be intensively developed along with traditional competencies of a manager, so that human resources can be efficiently used in the manager's enterprise.

Within the Ph.D. paper, the author researched not only a real professiogram of practising managers, but also wished to identify the features of a new manager's professiogram, thinking of development perspectives for practical training in management in Latvia. Therefore, the author of the present paper chose to research the features of emotional intelligence in professiograms of students studying business and management at Latvia University of Agriculture.

The research aim is to determine the role of emotional intelligence in the managers professiogram in the 21st century.

To achieve the aim, the research tasks are to:

- Theoretically discuss the nature and role of emotional intelligence in the managers professiogram in the 21st century.
- Identify and characterise the presence of emotional intelligence in professiograms of new specialists in business and management in Latvia.

The research object: new Latvian specialists in business and management – full-time and part-time students from the 1st and 2nd level higher education programs associated with business and management at Latvia University of Agriculture (LUA).

The research subject: emotional intelligence in the managers professiogram.

Materials and Methods

Materials and methods used in the research: the monographic method, the survey method, statistical analysis, descriptive statistics. The information basis of the research consists of publications by D. Goleman, E.R. Boyatzis, P. Salovey, J.D. Mayer, T. Bradberry, J. Greaves and practical research results by the author of the paper.

Results and Discussion

Growing number of scientists working on management theories, e.g. M. Birss, E. Purser, S. Kabana, I. Kalve a.o., point out that the 20th century principles and methods of management do not meet the modern requirements for management practise (Kalve, 2005). A great deal of managers still relies on Theory X, developed by Douglas McGregor in 1960ies, in their performance to stimulate employees. According to this theory, employees do not want to work and they are taken away any ambition, and therefore they have to be forced to work (Mc.Gregor et al., 2000). If a manager assumes that his/her employees lack initiatives, they are not able to make decisions independently and take responsibilities, then there is no chance to transform his/her enterprise into an innovative one. At the same time, when describing the approach of his Theory Y to employees, McGregor pointed out that 'under modern circumstances of production, an average individual's intellectual abilities are not fully used' (Mc. Gregor et al., 2000). And that is why, as the founder of the theory pointed out, any manager - through challenging goals, cooperation, and promotion - has to create such an environment that would stimulate employees to take initiatives themselves, to act as driven by internal wishes etc. Almost 50 years later – managers still choose the easiest way – the X approach because implementing the Y approach requires recognising management not only a science and practise, but also an art. An art that makes possible to understand needs and wishes driven by employees' minds and emotions, to skilfully use managers' emotions in accordance with employees' emotions for creating an environment in which human resources, driven by their wishes, use their human capital for achieving their organisation goals.

By researching the history and development of human brain, it is discovered that emotions and feelings have existed a long time ago before mind (Goulmens, 2001). It is based on the biology of psyche and the structure of human brains, which regulate two different types of mind – emotional and logical – and make them interact. Employees' actions might be motivated both by their minds and emotions. For a manager, too, according to I.Spruģeviča, 'emotions might be a sufficiently good criterion, along with other 'more tangible' indicators, in making decisions or solving daily situations' (Gavare, 2001). An expression created by Latvian writer R.Blaumanis - 'Emotions get easily over a fence that is created by mind' – is unfortunately typical for management. Therefore, there is a need for stressing a category of abilities called emotional intelligence in the manager professiogram.

In studies about intelligence, particular emotional intelligence aspects have been mentioned by scientists a long time ago, for instance, Darvin; R. Thomdike, D. Wechsler. (Wechsler, 1958). By researching multiple intelligences, H. Gardner pointed out that inter-personal intelligence is as much significant as intellectual intelligence that can be measured by IQ tests (Gardner, 1999).

However, the term 'emotional intelligence', hereinafter in the text EI, is quite a new term like the term 'emotional quotient' – EQ that is used for its quantitative measurement.

It is believed that the first who introduced the EI term in theory was P. Salovey and J. D. Mayer. In the beginning of 1990ies, the authors defined emotional intelligence as a 'type of social intelligence that includes abilities and skills to perceive, evaluate one's own feelings and emotions and those of others, so that this information is used for managing one's thoughts and activities' (Bradberry, Greaves, 2005). However, by developing further this theory, D.Goleman (1995) analysed the common features of abilities of prominent and talented individuals and came to a conclusion that they, first of all, are united by self-cognition. It means an ability to control one's own emotions and to understand feelings of other people, an ability to create preconditions for synergy and to solve conflicts in a way that nobody suffers, courage to take responsibility for solving tough problems and to predict hidden consequences, an ability to develop business contacts etc. (Hein, 2007)

S.Heins improved the EI definition by supplementing it and stressing that emotional intelligence is a 'natural, inherent ability to feel, use, discover, remember, describe, identify, learn, manage, understand, and explain emotions' (Hein, 2007). One can conclude that these abilities are inherited by any manager; a difference lies in an extent to which they were developed. And even Goleman points out that the respective abilities have to be developed in childhood; however, there is a chance to master them during the next stages of life.

For her further research, the author of the paper has chosen Goleman's approach in which he, the same way as Salovey, defined 5 clusters of competencies that form EI, but later they were transformed into four clusters. Four clusters contain 19 competencies, as shown in Table 1.

Table 1

Emotional Intelligence Competencies According to D. Goleman

Clusters of Competencies	Competencies
Self-Awareness - concerns knowing one's internal states, preferences, resources, and intuitions	Emotional Awareness: Recognizing one's emotions and their effects Accurate Self-Assessment: Knowing one's strengths and limits Self-Confidence: A strong sense of one's self-worth and capabilities
Self-Management refers to managing ones' internal states, impulses and resources	Emotional Self-Control: Keeping disruptive emotions and impulses in check Transparency: Maintaining integrity, acting congruently with one's values Adaptability: Flexibility in handling change Achievement: Striving to improve or meeting a standard of excellence Initiative: Readiness to act on opportunities Optimism: Persistence in pursuing goals despite obstacles and setbacks
Social Awareness - refers to how people handle relationships and awareness of other people feelings, needs, and concerns	Empathy: Sensing other people feelings and perspectives, and taking an active interest in their concerns Organizational Awareness: Reading a group's emotional currents and power relationships Service Orientation: Anticipating, recognizing, and meeting customers needs
Relationship Management - concerns the skill or adeptness at inducing desirable responses in others	Developing Others: Sensing other people development needs and bolstering their abilities Inspirational Leadership: Inspiring and guiding individuals and groups Change Catalyst: Initiating or managing change Influence: Wielding effective tactics for persuasion Conflict Management: Negotiating and resolving disagreements Teamwork & Collaboration: Working with others toward shared goals. Creating group synergy in pursuing collective goals. Building bonds

Source: developed by the author according to D. Goleman.

The colleagues of Goleman (Hay Group) supplemented two clusters by adding conscientiousness to the cluster of Self-Management and communication to the cluster of Relationship Management. Emotional intelligence is not a single, large, and indivisible term; therefore, tests used for measuring EQ are quite complicated. For instance, in the Bar-On EQ-i which has 133 questions, 15 competencies that are included in emotional intelligence – among which are self-awareness, independence, empathy, social responsibility, flexibility and stress tolerance, impulse control, optimism, etc. were examined (Bar-On, 1997). However, the Multifactor Emotional Intelligence Scale (MEIS) is a test that is made of complicated tasks allowing us to measure an ability to feel, identify, understand, and work with one's own emotions (Mayer et al., 2003). The Emotional Competence Inventory (ECI) is an instrument, offered by Goleman and Hay Group, which allows us to measure both the EQ of every individual and that of a group or a whole enterprise after evaluating competency scores submitted both by employees and auditors (Goulmens, 2001). The tests enable us to compare the EQ scores. Yet one has to keep in mind that these scores might be used together with IQ measurements. 'Emotional intelligence without intellect or intellect without emotional intelligence is just a partial solution' (Gavare, 2001). However, an evaluation of the presence and development level of EI competencies in an individual's professiogram allows us to see opportunities and threats that can be caused by it.

The author of the paper has researched the EI of students studying business and management at LLA in 2008-2009. In the research, data about 79 fulltime and part-time students of the 1st and 2nd higher education levels were compiled. The students were aged 20-46. The sampled population was selected randomly from all students. Only those student groups from the 1st and 2nd higher education levels who studied Management Theory with the author of the paper during this research period were engaged in the research. As a basis of the research, Goleman's model of 21 competencies was developed. A test offered to students does not allow them to determine the emotional quotient (EQ according to Goleman), but it allows them to evaluate – to what extent students notice a developed EI in themselves and to what extent it just matches an evaluation of other people. And also, which competencies are less developed, which ones are better developed. On a 10-point scale, the students evaluated to what extent they have inherited any of 21 competencies; it was assumed that '0' means that a student lacks a respective competency, whereas '10' means a well developed competency. According to a similar principle, any student was evaluated by 3 randomly selected his/her study fellows. The scores were summarised in Table 2.

Table 2

Evaluation of Emotional Intelligence (on a 0-10 point scale) in Professiograms of New Business and Management Specialists at Latvia University of Agriculture, 2008-2009

Competencies		Self-evaluation	Evaluation from the group	Deviation (PV-GV)
1. Self-Awareness		6.7	5.5	1.2
1.	Emotional Awareness: Recognizing one's emotions and their effects	7.3	6.1	1.2
2.	Accurate Self-Assessment: Knowing one's strengths and limits	6.0	5.0	1.0
3.	Self-Confidence: A strong sense of one's self-worth and capabilities	6.8	5.5	1.3
2. Self-Management		6.7	5.2	1.6
4.	Emotional Self-Control: Keeping disruptive emotions and impulses in check	5.7	4.3	1.4
5.	Transparency: Maintaining integrity, acting congruently with one's values	7.1	4.2	2.9
6.	Adaptability: Flexibility in handling change	6.7	5.4	1.3
7.	Achievement: Striving to improve or meeting the standard of excellence	7.2	5.1	2.1
8.	Initiative: Readiness to act on opportunities	7.8	6.6	1.2
9.	Optimism: Persistence in pursuing goals despite obstacles and setbacks	6.6	5.3	1.3
10.	Conscientiousness - diligence and persistence in performing everything in accordance with "conscience"	6.0	5.2	0.8

Table 2 continued

Competencies		Self-evaluation	Evaluation from the group	Deviation (PV-GV)
3. Social Awareness		7.1	4.0	3.1
11.	Empathy: Sensing others' feelings and perspectives, and taking an active interest in their concerns	7.9	4.3	3.6
12.	Organizational Awareness: Reading group's emotional currents and power relationships	7.1	4.4	2.7
13.	Service Orientation: Anticipating, recognizing, and meeting customers' needs	6.2	3.2	3.0
4. Relationship Management		6.0	4.8	1.2
14.	Developing Others: Sensing other people development needs and bolstering their abilities	5.1	4.1	1.0
15.	Inspirational Leadership: Inspiring and guiding individuals and groups	4.9	4.1	0.8
16.	Change Catalyst: Initiating or managing change	5.5	5.1	0.4
17.	Influence: Wielding effective tactics for persuasion	6.8	5.2	1.6
18.	Conflict Management: Negotiating and resolving disagreements	6.3	4.9	1.4
19.	Teamwork & Collaboration: Working with others toward shared goals. Creating group synergy in pursuing collective goals.	5.9	5.1	0.8
20.	Building bonds	6.3	4.9	1.4
21.	Communication	7.1	5.2	1.9

Source: developed by the author according to V.Kūlupa's studies

The compiled research results showed that any individual's self-evaluation is higher than an evaluation of the group in all cases (an average value calculated for the group of respondents). It implies that any individual's evaluation in relation to his/her EI is more positive than his/her image in the view of his/her colleagues.

The respondent group's average value in relation to an individual's self-evaluation is above the average – 6.5. At the same time, attention has to be paid to the scores of particular competencies. The lowest average score (6.0) was observed for Cluster No.4 that is formed of the competencies of relationship management. Besides, the competency 'inspiring and guiding individuals and groups' gets the lowest score – it is below the average value (4.9). It implies that even according to students' self-evaluation, their leadership is poorly developed. As to the author's previous publications in change management and management of innovative enterprises, the features of leader have to be included in the manager's professiogram. As one can see, the presence of this competency is not sufficient in the professiogram of new specialists. The respective score is low in the evaluation from the group – 4.1. And the second significant competency that is necessary for establishing an innovative enterprise – 'initiating or managing change' evaluated both by individuals and the group gains scores just slightly above the average level – 5.5 and 5.1. The evaluation of the competencies of Cluster 4 (the group) fluctuates within a range of 4.1-5.2, i.e. below or slightly above the average value. It is a symptom that it is necessary, within the study process, to review a possibility to stimulate those competencies that develop an ability to cooperate in a team, to unite the team and direct it towards the goal, as well as an ability strengthening personal authority, skills to convince, and communication skills. Besides, the competency 'communication' is evaluated high by individuals in their self-evaluation (7.1), but at the same time in the view of their colleagues it is quite low – 5.2. It might be related to such an endangered of the manager's efficiency as an inability and reluctance to listen to others, paying the most attention to him/herself, his/her needs, and not to a colleague during communication. The low score for Cluster 3 - the social awareness competencies from the group's point of view (an average value for the cluster is 4.0) - proves it. Besides, exactly in this cluster the largest differences between the evaluations of any individual and the group are observed – the group's evaluation is on average 3.1 points lower than any individual's self-evaluation. In this group, the lowest score was gained by 'anticipating, recognizing, and meeting customers' needs' – 3.2. Let's return to the nature of a manager-leader: 'First of all leaders make a contribution themselves and only then expect to receive anything in return from others' (Khan, 2005). The score for empathy draws attention because a self-evaluation is high, but the group's evaluation is low, thus creating a difference of 3.6 points. Egocentrism, an inability and reluctance to understand needs of people and their state of mind significantly endanger the transformation of a manager into a leader and teamwork. Goleman points out that an efficient leader is in harmony with feelings of other people (like a musical instrument when tuned) and, therefore, directs them to positive emotions. Such a manager speaks authentically about his/her own values, priorities, and goal-orientation and resonates with emotions of surrounding people. Under the guidance of such an efficient leader, people feel mutual comfort (Goleman, 2002).

As to Cluster 2 - the evaluations of self-management competencies, the group's evaluation of an individual's ability to be open regarding his/her emotions, work, and values has to be taken into account. It is not in harmony again with the feature of a leader – 'an ability to keep one's word, not to make contradiction between words and deeds' (Khan, 2005). A low score is given to an ability to control one's emotions. Although self-management themes are included in several study courses, yet it is unlikely that practical skills are developed like it is with communication skills, an ability to cooperate in a team etc.

During the research, several symptoms were identified, which makes it necessary to prove their correctness in further researches. Taking into account the relatively small number of respondents in the pilot research (experimental research) and the uneven division of the respondents by age, gender, study form, and group size, presently it is not possible to conduct a correct verification for the assumptions mentioned further.

1. The longer and closer is an interaction period among individuals, the smaller is a difference between the subjective EI evaluation of any individual and that of the group. A trend was observed that differences between the self-evaluations and the group's evaluations are relatively smaller for senior students, as compared to junior students. And a similar trend exists for the study form – fulltime and part-time studies, as well as bigger and smaller groups. The verification of this assumption would allow us to stress again a need not to allow labour turnover at an organisation; and an assumption that it is better to choose a direct manager from inside the organisation in order to get more objective EI evaluations both from the point of view of employees and a manager.
2. There is a relationship between individuals' EI development level and their age and gender.
3. Individuals having a hobby for a long time that is related to regular physical and emotional activities which include a need for cooperation in a team – e.g. a choir, dancing band, sport team (basketball, football etc.) – have a greater possibility for increasing their own EI level.

Taking into account the results of the pilot research, more extended researches have to be conducted, which would allow us to evaluate the development level of EI competencies for new business and management specialists and to identify factors favourably influencing EI development.

Conclusions

1. To make the modern managers professiogram perfect both in theory and practise, it has to include the competencies forming emotional intelligence.
2. An evaluation of the presence of emotional intelligence competencies in an individual's professiogram allows us to assess the opportunities and threats for the manager's efficiency.
3. According to the evaluations of their colleagues, the new business and management specialists have quite poor competencies forming emotional intelligence, especially those related to social awareness and relationship management.
4. Along with studying theoretical aspects of communication, self-cognition, and self-management, the study process for new specialists of management and business has to be arranged in a way that it promotes the practical development and use of EI competencies.
5. It is necessary to conduct further researches to verify relationships between:
   - the length and tightness of interaction periods among individuals and the difference between the subjective EI evaluation of any individual and that of the group;
   - the EI development level and the age and gender;
   - any individual's relation to a hobby which includes a need for cooperation and has a greater possibility for increasing his/her own EI level.

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IMPACT OF CAPITAL INVESTMENTS ON VALUE ADDED IN DAIRY SECTOR

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Abstract

The paper deals with the evaluation of the impact of capital investments on the value added in Latvian dairy specialization farms on the basis of FADN data. The evaluation is carried out through analysing the current level of capital investments in Latvia and the link between capital and the net value added and its main components, based on the comparison with the EU leading milk producing countries. The analysis shows that the current level of capital investments is low in Latvia, especially in buildings and fixed equipment. Insufficient capital investments result in high intermediate costs, lower labour productivity due to large labour contribution in the total output, and also in considerably lower level of the value added, especially per AWU in Latvia.

Key words: capital investments, fixed assets, milk production, intermediate consumption, the value added.

Introduction

Milk production has traditionally been one of the main agricultural sectors in Latvia, accounting for about ¼ of total agricultural goods output in recent years. The share of milk production dropped to 21.4% in 2007 that was caused by very favourable production and price developments in cereal sector (Vēveris and Krieviņa, 2008). The share of milk in final agricultural production in Latvia is higher than in the European Union (EU) on average, where it according to Eurostat equalled to 14.9% in 2007.

Despite the importance of the sector, FADN (Farm Data Accountancy Network) data indicate on a very low level of the net value added created by the sector in Latvia. The net value added per AWU (annual work unit – 1,840 hours within a year) in Latvian dairy specialization farms is 3.6 times lower than in the EU on average.

The study on formation of the value added in Latvian agri-food sector (Miglavs et al., 2007) reveals that the competitiveness of Latvian dairy products has been mainly driven by comparatively cheap production resources in recent years. There was rapid increase in resource prices after accession to the EU; though, milk purchase prices also rose significantly allowing to compensate growing production costs. As there is no milk price growth expected as a part of price convergence process at the present quality and delivery volume per farm any more, the still existing gap in resource prices presents a major threat for the future sector competitiveness. The fading low cost competitive advantage has to be replaced by more efficient production and the sector has to move forward to the next phase that is investment driven competitiveness. Farms with more efficient production have also better preconditions for facing high milk price volatility risk that has been marked by recent developments on the global market.

The maintenance of sector competitiveness is a precondition for the creation of the value added because only competitive products can ensure appropriate demand, which is basis for the production. At the same time, increase in the level of capital investments on the farms (the present level of capital endowment is very low in the sector if compared to other EU countries) could diminish the existing gap between the levels of the value added in Latvia and other EU countries by the overall increase in production efficiency.

The role of the capital to increase the production efficiency has been widely studied (for example, Špoģis and Radžele, 2007; Latvietis and Priekulis, 2006; Zujs, 2005); however, the author has not come across studies where the overall effect relating to the creation of the value added is analysed.

The object of the study is dairy farms in Latvia and other EU countries, and the subject – the net value added.

The objective of the paper is to evaluate the impact of the level of capital investments on the value added created by farms in Latvian dairy sector, based on the comparison with other EU countries. In order to reach the objective, the following tasks were set – 1) to evaluate the current level of capital investments in Latvia compared to the leading milk producing countries; 2) to evaluate the link between capital investments and production volumes, and prices; 3) to examine the level of production costs; 4) to evaluate the overall impact of capital on the value added.

Materials and Methods

Analysis and comparison have been carried out using FADN (Farm Data Accountancy Network) data on dairy specialization farms. The EU average corresponds to the average level observed in countries covered by FADN database (EU-25 countries, except Cyprus). To make comparison among countries, 10 leading EU-25 milk producing countries (EC, 2008) and 3 Baltic States were selected. The latest comparative data cover year 2006.

Capital investments are assumed to be money transformed in fixed assets, what represents both the formation process of capital on yearly and also longer period basis. The level of capital investments on farm is measured by fixed assets. Having regard of considerable difference in land prices (according to the latest available data, land is almost 20 times more expensive in Belgium than in Latvia (EC, 2008)), the value of fixed assets in land, permanent crops and quotas available at FADN database as a single sum is disregarded.

In the context of this paper, the value added is defined as additional value, which is created (added to the intermediate product) in milk production stage and which is distributed among the owners of factors of production (land, capital and labour). In terms of value, the net value added in FADN is calculated as the difference between production value and intermediate consumption, minus depreciation and plus balance of current subsidies and taxes (LSIAE, 2008). For analytical reasons, to evaluate the economic efficiency achieved without public support, the net value added as the difference between production value and intermediate consumption less balance of current subsidies and taxes is also calculated.

Theoretical assumption envisages that the value added can be increased via increasing the volume of production, by increasing output prices and reducing production costs.

As the additional value created by the production factors is distributed among the owners of production factors, the net value added per AWU as the main indicator is used.

Methods of statistical analysis and logically constructive analysis were employed in data analysis.

Results and Discussion

The current level of capital investments on Latvian dairy farms is comparatively low. According to FADN data, the average value of fixed assets on dairy specialization farm was LVL 21.1 thsd. in 2007 (without land), and that is considerably lower than in the EU on average.

Comparative FADN data of 2006 indicate on more than 5.5 times lower level of capital investments in Latvia than in other EU countries (see Table 1). Compared to Denmark that has the highest level of capital investments, the difference is even 36 times. There is comparatively better endowment with machinery in Latvia (2.8 lower level than average), the difference in breeding animals amounts to 5.2 times, but the worst endowment is with buildings and fixed equipment. The considerable difference between Latvia and other EU countries is due to a large number of small dairy farms in Latvia, which lag behind the average indicator considerably.

Table 1

Value of Fixed Assets and Depreciation in Dairy Specialization Farms in Selected EU Countries in 2006

	Dairy cows per farm	Utilized agricultural area (UAA) per farm, ha	Fixed assets per farm, thsd. EUR	including			Depreciation per farm, thsd.EUR
				Machine-ry per farm, thsd.EUR	Buildings and fixed equipment per farm, thsd.EUR	Breeding livestock per farm, thsd.EUR	
Latvia	16.6	55.6	35.2	18.8	7.8	8.5	4.1
Lithuania	13.2	36.5	36.4	20.9	8.5	6.9	2.5
Estonia	55.2	181.1	191.2	64.4	91.5	35.4	12.4
Poland	12.6	17.1	58.2	18.5	31.1	8.6	3.0
Spain	39.3	21.9	107.0	21.3	39.6	46.1	5.8
Italy	48.3	30.3	223.0	56.9	104.6	61.6	15.4
Ireland	47.6	49.7	162.0	31.9	76.6	53.5	14.2
The United Kingdom	100.3	96.7	257.9	82.7	68.8	106.4	25.2
France	42.4	70.2	186.8	54.5	78.7	53.6	24.1

Table 1 continued

	Dairy cows per farm	Utilized agricultural area (UAA) per farm, ha	Fixed assets per farm, thsd. EUR	including			Depreciation per farm, thsd.EUR
				Machine-ry per farm, thsd.EUR	Buildings and fixed equipment per farm, thsd.EUR	Breeding livestock per farm, thsd.EUR	
Belgium	44.5	42.7	176.2	45.3	72.9	58.1	15.6
Germany	44.6	55.0	208.4	70.6	88.4	49.5	21.2
The Netherlands	70.6	46.1	314.0	86.1	158.7	69.2	27.3
Denmark	100.5	99.5	1 273.1	170.5	1 019.9	82.6	41.1
EU on average	41.0	48.2	194.0	53.5	95.9	44.6	17.1

Source: FADN public database.

Latvian milk production is very fragmented – according to the Central Statistical Bureau of Latvia, 90.6% of all farms with dairy cows have less than 10 animals (CSB of Latvia, 2008) and the average economic size of Latvian FADN dairy farm is 9.3 ESU (European Size Unit - the size of the farm business measurement, where 1 ESU = 1,200 Euro of Standard Gross Margin), compared to 54.9 ESU in the EU on average. Available data on dairy specialization farms in some leading milk producing countries (the Netherlands, the United Kingdom, France, Germany, Denmark and Belgium) show that there are farms only starting from 16 ESU or even 40 ESU (Denmark and Belgium) operating in the sector. The author thinks that it can be explained by the fact that most modern technologies are economically approvable if there is at least 50 to 100 dairy cows on the farm, the use of feeding programmes and specific feed and feed supplements also pays off in large and productivity-oriented farms with highly productive animals. In order to ensure compensation of invested money that can be achieved through revenues gained from competitive product supply to the market, the scale is necessary to distribute and diminish the fixed capital cost burden per production volume. At the same time, not only technologies require scale to be profitable, but generally also considerable increase in production volume is not possible without technologies, because, in order to ensure demand for larger sales to the market, increase in product competitiveness should be achieved, and technologies help to achieve it by increasing productivity.

At comparative average UAA on farms in Latvia and the EU on average (also Germany, the Netherlands, Belgium and Ireland) there is 6.4 times lower level of fixed assets per ha in Latvia (see Table 2). There is also less intensive utilization of land that is characterized by 0.50 livestock units (LU) per ha, compared to 1.45 LU per ha in the EU on average. Having regard of the fact that land resources in Latvia are still comparatively available and cheap, the current extensive utilization of land does not cause direct threats to the competitiveness at the present; though, more efficient utilization would diminish fixed costs associated with land per produced unit. If the current livestock density is maintained, the level of capital investments should be increased by 2.2 times to reach the current average level of capital investments per hectar observed in the EU on average. Though, the comparison of farms based on the indicator of fixed capital per hectar is influenced by the farm production structure and resource utilization efficiency (to compare farms with different livestock density).

Table 2

Indicators of the Level of Capital Investments in Dairy Specialization Farms in Selected EU Countries in 2006

	Fixed assets per UAA, thsd.EUR	Fixed assets per AWU, thsd.EUR	including: Machinery per AWU, thsd.EUR	including: Buildings and fixed equipment per AWU, thsd.EUR	including: Breeding livestock per AWU, thsd.EUR	Depreciation per AWU, thsd.EUR
Latvia	0.6	25.1	7.7	3.2	14.3	1.7
Lithuania	1.0	34.0	10.8	4.4	18.8	1.3
Estonia	1.1	60.1	11.2	15.8	33.1	2.2
Poland	3.4	27.3	11.5	10.9	4.9	1.7
Spain	4.9	65.8	13.1	24.3	28.3	3.6
Italy	7.4	105.0	26.8	49.3	29.0	7.2
Ireland	3.3	105.6	20.8	49.9	34.9	9.3
The United Kingdom	2.7	177.8	35.9	29.9	112.0	11.0
France	2.7	188.4	32.1	46.3	109.9	14.2
Belgium	4.1	194.1	29.9	48.0	116.2	10.3
Germany	3.8	209.5	40.2	50.4	118.8	12.1
The Netherlands	6,8	342.2	52.7	97.2	192.3	16.7
Denmark	12.8	1,251.1	86.6	517.9	646.5	20.9
EU on average	4.0	183.8	28.7	51.3	103.8	9.2

Source: author's calculations based on data at FADN public database.

As generally capital and labour can be replaced by each other (Koschel, 2000), and the created value added by agricultural activity is distributed between the owners of the capital, in the context of this paper, the author thinks that better measurement of the level of capital investments on farms is fixed assets per AWU. The level of total fixed assets per AWU in Latvia is significantly lower than in the EU on average (7.3 times).

Total fixed assets per AWU in Latvia are also lower than in other Baltic States. Estonia has high absolute value of fixed assets per farm that is very close to the EU average, but it does not show reduction in labour contribution that can be explained by different evaluation methodology of fixed assets in Estonia. The fixed assets are evaluated by replacement value that gives increased value.

Indicators of the level of capital investments in the Baltic States and Poland are significantly lower than the average level. Obtained results show that there can also be distinguished countries with very high capital endowment (Denmark, the Netherlands). The rest of the countries provide the results that are close to the average level in the EU, with exception of Spain, Italy and Ireland, for which the data show lower capital endowment level that could be also due to methodological differences.

As, according to the explanation given by the author before, capital investments and production volumes are interconnected, the increase of the value added at the farm level is by no means connected with improvement of technological level as part of farm concentration.

Investing in farm and increasing of production volume can also ensure better price received for produced milk. FADN data show that economically larger farms receive higher price for the milk produced. The difference in received milk price between the smallest and the largest farms was 27.8% in 2007 in Latvia. The average received milk price by the smallest farms was by 13.6% lower, but in the largest farms – by 12.5% higher than the average observed milk price for the sector. The author thinks that the difference in milk price between farms of different size can be explained by higher milk quality due to better technological equipment (milking, milk cooling and animal keeping conditions) and balanced feeding on larger farms, as well as by larger deliveries that lower transportation costs per production unit. However, having regard of almost perfect competitive conditions on the milk market, the main role of capital investments is in maximization of farm margins through minimization of production costs.

In the value adding process, intermediate consumption accounted for 73% of the revenues generated by production volumes and prices in Latvia in 2007, the share of depreciation was 14%, and the remaining 13% corresponded to the additional value created by the production factors (labour, land and capital), that is the amount available for compensation of the production factors. In general, compensation paid for production factors in the production process should equal the additional value created by these factors; however, the previous analysis carried out by the author shows that the average net value added (output minus intermediate consumption and depreciation) per AWU in dairy specialization farms was LVL 1,417.9 in Latvia in 2007, which is very small result, because it does not allow to provide the labour force for the remuneration equivalent to the average compensation for labour in the sector (LVL 2,746.1). Again, only in farms with economic size starting from 16 ESU the created value by the production factors could cover labour costs and also rents, but the value was still insufficient to cover interest paid. Balance of current subsidies and taxes on average farm increased the net value added more than 3 times to reach LVL 4,713.4 in 2007, and, except very small farms, it was sufficient to cover all factor costs. Data on the EU average show that the share of intermediate consumption costs can be decreased considerably (62%) to increase the share of the value added (23%).

Table 3

Intermediate Consumption, Depreciation and the Value Added per Output Value in Dairy Specialization Farms in Selected EU Countries in 2006, EUR

	The net value added	Depreciation	Intermediate consumption	including			
				Feed	Energy	Con-tract work	Machinery and building maintenance
Latvia	0.12	0.12	0.76	0.39	0.12	0.02	0.08
Lithuania	0.32	0.11	0.57	0.30	0.08	0.01	0.05
Estonia	0.18	0.10	0.72	0.38	0.10	0.02	0.05
Poland	0.34	0.15	0.51	0.19	0.08	0.02	0.06
Spain	0.40	0.06	0.54	0.37	0.03	0.02	0.03
Italy	0.39	0.10	0.52	0.36	0.05	0.01	0.02
Ireland	0.25	0.16	0.59	0.22	0.04	0.05	0.07
the United Kingdom	0.19	0.11	0.71	0.29	0.05	0.05	0.07
France	0.13	0.22	0.65	0.17	0.05	0.10	0.07
Belgium	0.34	0.14	0.52	0.18	0.05	0.06	0.06
Germany	0.21	0.16	0.63	0.20	0.08	0.05	0.08
the Netherlands	0.31	0.13	0.56	0.18	0.05	0.06	0.08
Denmark	0.22	0.11	0.67	0.35	0.03	0.07	0.06
EU average	0.23	0.15	0.62	0.25	0.06	0.05	0.07

Source: author's calculations based on data at FADN public database

Feed is the main intermediate cost position that accounts for about the half of the total intermediate consumption in Latvia, the corresponding indicator is about 30% in France, Germany and the Netherlands, being 41% in the EU on average.

Analysis of feed costs per production value shows that Latvia has by 54% higher cost level than in the EU on average. The obtained results of the countries do not allow to make direct conclusion regarding link of capital to lower feed costs (see Table 3). Poland that is among the countries with the lowest capital investments achieves cost level similar to the Netherlands that has one of the best capital endowment. Though, when compared Latvia and leading countries, by providing higher nutrition value that is characterized by larger yields and also considerably higher livestock density, the countries can achieve lower feed costs than Latvia. The author thinks that this indicates on the efficiency that can be attained by reducing feed losses (including optimal servings) and having more productive animals. In the case of Poland, the low feed costs can be explained by the use of low nutrition feed shown by the lowest milk yield among the EU countries. There are comparatively high feed costs in Denmark, at the same time, the country has the highest milk yield among the countries.

Farming overheads account for 27% of the total intermediate consumption in Latvia as compared to 39% in the EU on average. In some countries like the Netherlands, France and Germany the share of these costs is about 50% that can mainly be attributed to higher capital investments that require higher absolute costs for building and machinery maintenance and energy consumption. There is also higher share of contract works on larger farms because larger production volumes generally require higher specialization, the absolute value of other costs are also higher in these farms. Larger value of fixed assets also results in higher absolute consumption of capital.

Despite lower absolute value of maintenance and energy costs, the relative costs per production value in Latvia are even higher than in the EU on average, and that is due to the direct scale and capital effect in other countries. Furthermore, technologies and scale allow to compensate comparatively higher prices of energy in leading milk producing countries. The level of maintenance costs in Latvia could also be higher due to old buildings and machines in small farms.

The level of contract work costs, other costs and depreciation per production value is lower in Latvia than in the EU on average. However, the total intermediate costs per production value in Latvia are still considerably higher than in the EU on average. In some leading countries the total level of intermediate consumption per output value is also higher than the average level. As capital mainly replaces labour, the more distinctive impact of capital can be observed in the net value added per AWU, which in these countries (except France) is higher than the average indicator.

The average additional value created by production factors (output minus intermediate consumption and depreciation) on a dairy farm was LVL 2.8 thsd. in Latvia in 2007. If balance of current subsidies and taxes is regarded, the net value added per dairy farm was LVL 9.2 thsd. The result ranks Latvia in one of the last places among the EU countries (together with Slovakia, Poland and Lithuania). Latvia has also the lowest level of capital investments per farm, though the differences in the net value added per farm is less explicit – 2.7 times lower value (see Table 4). Without contribution of subsidies, the difference would amount to 6.7 times, because in larger and market oriented farms the importance of subsidies in the value added decreases. Having regard of the dominance of small dairy farms, Latvian dairy sector almost fully relies on subsidies (balance of current subsidies and taxes constituted 70% of the net value added in 2007).

Obtained data on labour productivity as well as share of labour costs in the total output confirm that labour is substituted by capital. The countries with the lowest capital endowment have dramatically lower labour productivity that is due to large labour contribution (both paid and also unpaid) in the total output.

Table 4

Labour Productivity, the Share of Labour Costs and the Net Value Added Indicators in Dairy Specialization Farms in Selected EU Countries in 2006, EUR

	Output per AWU, thsd. EUR	Share of labour costs in output, %	Share of labour costs in output, % (corrected to the average salary in the EU)	Farm net value added, thsd.EUR	Net value added per AWU, thsd. EUR	Net value added per AWU, thsd.EUR (disregarding balance of subsidies and taxes)
Latvia	13.4	25%	118%	17.4	7.1	1.6
Lithuania	11.7	21%	135%	12.6	6.5	3.7
Estonia	21.4	29%	74%	48.1	8.3	3.9
Poland	11.4	36%	138%	12.0	6.8	3.9
Spain	62.6	25%	25%	50.9	31.3	25.2
Italy	76.1	22%	21%	79.3	37.4	29.3
Ireland	59.3	33%	26%	43.4	28.3	15.0
The United Kingdom	102.5	25%	15%	78.9	34.3	19.1
France	65.1	24%	24%	38.5	22.7	8.4

Table 4 continued

	Output per AWU, thsd. EUR	Share of labour costs in output, %	Share of labour costs in output, % (corrected to the average salary in the EU)	Farm net value added, thsd.EUR	Net value added per AWU, thsd. EUR	Net value added per AWU, thsd.EUR (disregarding balance of subsidies and taxes)
Belgium	75.0	18%	21%	59.9	39.5	25.5
Germany	76.9	26%	20%	58.3	33.2	16.5
The Netherlands	128.3	19%	12%	90.2	55.2	40.3
Denmark	191.8	17%	8%	134.2	68.2	42.1
EU on average	60.7	26%	26%	47.7	25.6	13.7

Source: author's calculations based on data at FADN public database.

Productivity on Latvian farms is 4.5 lower than in the EU on average. At the present productivity, the compensation level for labour force is also significantly lower resulting in the share in the total output that is close to the average. When the average salary in the EU is used to evaluate labour input, the obtained results indicate on the large labour contribution very explicitly. According to the calculated results, the labour costs would even exceed the value of output by 18% if the salary was at the average EU level. This also clearly indicates that the increase in compensation for labour should be balanced with growth in productivity. The data of 2006 show that there was balance between productivity and compensation level, because the average salary was 4.7 times lower in Latvia than in the EU on average. Though, during 2007 and also part of 2008, there was considerable increase in compensation for labour that was not accompanied by equal rise in productivity thus worsening the comparative competitiveness of Latvian farms.

The net value added per AWU lags behind the average indicator more considerable – disregarding subsidies, the level in Latvia is 8.8 times lower than in the EU on average. According to the FADN calculation method, the net value added per employee in Latvia is 3.6 times lower.

The capital helps to increase resource utilization efficiency, but not results in lower than the average intermediate costs in all cases (the United Kingdom, Denmark and France). When analysed in terms of the value added per AWU, Denmark, which has the best endowment with capital, achieves the highest level, as well as both indicators in the United Kingdom are also above the average. There is comparatively low value added per employee in France, in terms of labour productivity the output value is slightly above the EU average level, but there is high depreciation value per production value that could indicate on not fully efficient utilization of capital, because capital alone as such cannot ensure efficiency. There is also comparatively high level of cost relating to contract work in France. Furthermore, dairy farms in France have comparatively high dependency on subsidies that allows to achieve the average level, but, in general, is not stimulating to efficiency.

The obtained results for the two extreme country groups - countries with comparatively very poor capital endowment (including Latvia) and countries with the best capital endowment indicate on a direct link between capital investments and the net value added per AWU. Countries with the capital endowment considerably below the average level achieve the net value added per AWU that is also considerably below the average level. Like the countries with considerably higher level of capital investments create the net value added significantly above the average level. The results for the rest of countries show some differences indicating that capital alone does not determine the total amount of the value added. There are some other factors including differences in the price levels, production structure, capital utilization efficiency and other factors that require to be examined in a more detailed study. Though, the obtained results explicitly indicate on the significant role of capital in substitution of labour force that in turn helps to achieve a higher net value added per AWU.

Conclusions

1. There is a very low level of capital investments in Latvia, which is characterized by 5.5 times lower level per farm, 6.4 times - per hectar, and 7.3 times lower level per AWU compared to the EU on average.

2. There is comparatively better endowment with machinery, followed by breeding livestock and finally buildings and fixed equipment in Latvia.
3. Data on the EU leading milk producing countries reveal that scale and capital are connected, because only farms starting from 16 ESU are operating in the sector in most analysed EU-15 countries.
4. Investing in farm and increasing of production volume can also ensure better price received for produced milk, because observed data show that economically larger farms receive higher price for the milk produced.
5. There is high share of intermediate consumption in Latvia that can be decreased considerably (from 76% to 62%) to increase the share of the value added (from 12% to 23%) observed in the EU on average.
6. At higher nutrition value that is characterized by larger yields and also considerably higher livestock density the selected EU-15 countries can achieve lower feed costs than Latvia, indicating on higher efficiency there.
7. The net value added per farm in Latvia is 2.7 times lower than in the EU on average; the difference in the net value added per AWU is more explicit – 3.6 times, if disregarding subsidies – 8.8 times.
8. Lower level of capital investments results in significantly lower labour productivity (4.5 times) due to large labour contribution in Latvia.
9. Observed countries with the capital endowment considerably below the average level achieve the net value added per AWU that is also considerably below the average level. Like the countries with considerably higher level of capital investments create the net value added significantly above the average level.

Though, there are also other factors to be considered, by no means increase in capital has to be ensured in Latvia to reach the average level of the net value added per AWU observed in the EU. Furthermore, the increase in capital investments is necessary to ensure competitiveness on the market, because by no increase in labour productivity, the potential growth in compensation level causes direct threat to the competitive positions that has already caused problems in the sector. At the same time investing in farm modernization should be reasonable and coupled with the exploration of the possible price trends and demand patterns. The author thinks that cooperation is one of the possible means to facilitate the availability of capital by farms and the increase in production efficiency in Latvia.

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THE IMPACT OF CONTROLLED DRAINAGE ON WATER QUALITY

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Abstract

Eight-year (2000-2007) field studies on the effectiveness of controlled drainage in loam sandy soil were carried out in the Lowland of Middle Lithuania. The plot, which has existing subsurface water removal systems operated as conventional drainage was readjusted for the water table management. Two separate systems - 4.9 hectares free drainage (FD) and 5.4 hectares controlled drainage (CD) were arranged. A water level control structure with a riser column and hand operated rigid flap door was installed in the outlet of drainage collector in the manhole at the junction of two collectors. The water table level was allowed to rise to the maximum of 68 cm above the drains. Measurements to record the water table depth, drain outflow quantity and quality were performed. It was determined that in the CD system the annual drainage outflow lasted shorter by 40-62%, at the same time it was reduced by 25% and nitrate leaching – by 20-28% lower in comparison with the drainage operating in an ordinary regime. These indicators varied depending on weather conditions. The water table control in single-acting drainage systems is feasible and has a positive hydrological and environmental impact.

Key words: controlled drainage; water table management; drainage water quality; inorganic nitrogen.

Introduction

A subsurface drainage is an important component of the land management. However, the drainage intensity required for the agricultural production is not the same in all years or all periods of the year. While wetness is the major concern, weather conditions vary so that crops periodically suffer from the drought stress. Intensive drainage systems, necessary to provide trafficability during extreme wet periods, often remove more water than necessary during drier periods, leading to temporary overdrainage (Doty et al., 1986). Problems with drought on drained soils have resulted in a transition from conventional drainage methods to water table management systems (Evans et al., 1995; Thomas et al., 1995). Especially the controlled drainage and subirrigation was developed in the USA, where it has been widely applied over the last 20 years because of its environmental benefits and increased yields (Skaggs, 1999). Such systems have a control structure that can be opened or closed according to the need. Most existing subsurface drainage systems can be retrofitted for the controlled drainage (Brown et al., 1997).

Controlled drainage systems provide the combined effect on the environment (Mejia and Madramootoo, 1998). Firstly, they reduce the volume of drainage water leaving a field from 20–30% on average; however, the outflow varies widely depending on the soil type, rainfall, a type of drainage system and management intensity. During dry years, the controlled drainage may totally eliminate the outflow. In wet years, the control may have little or no effect on the total outflow (Gilliam et al., 1979; Deal et al., 1986; Evans et al., 1991). Secondly, the controlled drainage provides a higher field water table level, which promotes denitrification within the soil profile. It results in significant reduction of nitrate concentration in drainage water (by 58.7% and 65.3% in the drain flow with the 0.25 and 0.50 m water table above the drain level respectively) (Lalonde et al., 1996). In numerous field studies (Gilliam et al., 1978, 1979; Deal et al., 1986; Evans and Skaggs, 1989; Belcher and D'Itri, 1994; Cooke et al., 2006), the drainage control reduced the annual transport of total nitrogen at the field edge by 45% and total phosphorus by 35% on the average. The reductions at individual sites were influenced by locality conditions. Despite some inconsistencies, the primary benefit of the controlled drainage is a reduction of the total outflow and nutrient loading.

The possibilities for applying controlled drainage are strictly limited by soil texture and topography (Evans and Skaggs, 1989). It is best suited for flat or gently sloping lands (less than 1% slope) as it is much easier to maintain the water table at a uniform depth. A field with considerable surface undulation could result in excessive variation of the depth to the water table within the field. For this case, a proper water table management may require more water control structures. This will increase the cost of the system installation.

In Lithuania such drainage practice, with the exception of several research and demonstration sites, was not applied because there are practical limitations on a portion of suitable areas. Many existing drainage systems were not designed for the drainage water management making retrofitting expensive, and that the practice is economically challenging on slopes greater than 1%. However, on the plains with intensive farming and high pollution levels the drainage control shows promise by reducing the influence of agricultural activities on the environment. Surface water quality problems are of great concern in EU (Council…, 1991). Therefore, the studies on feasibility of controlled drainage as one of the means to reduce the non-point source pollution from the drained agricultural areas are relevant to such circumstances.

The aim of the studies was to research drainage control possibilities and the effectiveness from the point of view of hydrology and the environmental protection. The factors determining the effect of the water table management on the water quality were investigated.

Materials and Methods

The field studies on the effectiveness of controlled drainage were carried out through the period 2000-2007. The experimental site represents a region of intensively developed agriculture in the Middle Lithuania Lowland with typical soils and topography. An area, which has existing subsurface water removal systems operated as conventional drainage, was chosen for the research. Tiles with a radius of 40 mm were laid at a depth of 0.9-1.1 m and spacing at 20-24 m. Having installed a drainage manhole at the junction of two collectors, two separate systems – 4.9 ha free conventional drainage (FD) and 5.4 ha controlled drainage (CD) were arranged (Figure 1). A water level control device with a riser column and a hand operated rigid flap door was installed in the outlet of the drainage collector in the manhole. The elevation of the outlet allowed to raise the water table to a maximum of 68 cm above the drains. This level was chosen in consideration of the site relief (the slope 0.2-0.9%) and the required water table depth favourable to crop growth – 0.60-0.70 m below the soil surface. The area impacted by the water table management covered 2.8 ha, or 52% of the CD treatment plot. The results of eight-year studies (2000-2007) are analysed in the paper.

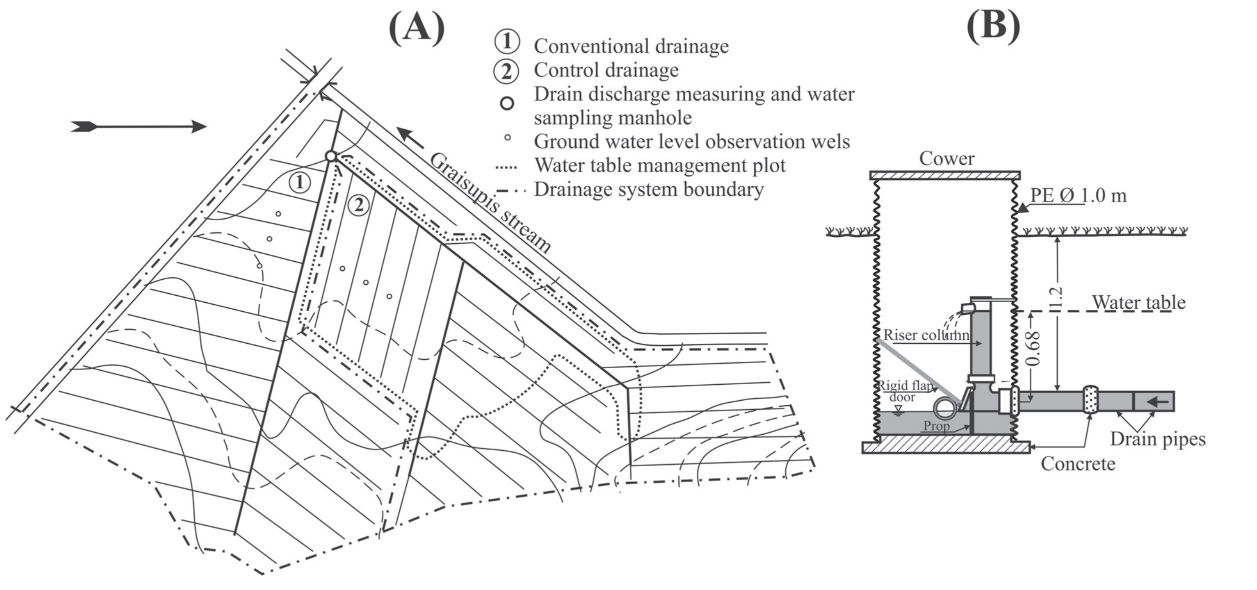

Figure 1. Layout of the experimental site (A) and water table management structure (B).

Endocalcari-Endohipogleyic cambisols (CMg-n-w-can) according to the FAO soil classification system are prevailing in the site (Buivydaitė et al., 2001). Sandy loam soil texture was defined according to the clay, silt and sand fraction composition throughout the soil profile up to the drains in both treatments. Beneath the drainage depth of the CD treatment, there is a sandy clay loam. Such a combination of soil horizons is favourable for the water table management, as water seepage into deeper soil layers is limited. Steady-state infiltration method using a ring infiltrometer was applied to determine saturated hydraulic conductivity of the soil. The statistical mean value of saturated hydraulic conductivity equalled 1.7±0.56 m day^{-1}. In the subsoil these values were more than four times lower - 0.40 ± 0.15 m day^{-1} on the average. At a depth of 1.4 m in CD system it reaches only 0.01 ± 0.01 m day^{-1}. The organic matter content in the topsoil was 20±2.64 g kg^{-1}, and 1.63±0.28 g kg^{-1} in the subsoil. Soil porosity was 47.08±0.88 and 33.68±1.82% respectively. Mineral nitrogen content determined before the treatment was 1.52±0.08 g kg^{-1} in the topsoil layer and 0.51±0.07 g kg^{-1} in deeper layers on the average.

The data of meteorological station, located approximately 5 km from the experimental site were used to characterize weather conditions (Lithuanian…, 1991). The average annual precipitation for the study period was 3–29% lower than the long-term average, except the year of 2007, when the total precipitation amount reached 668 mm, which was higher than the norm by 78 mm (13%) (Table 1). According to the total rainfall the years of 2002, 2003, 2005 and 2006 were dry, 2000, 2001 and 2004 – moderate, 2007 – humid, with a precipitation likelihood of 86-95%, 53-68% and 24% respectively. The years under the study were drier and warmer than usual: the total precipitation was 12% less than the long-term average value and the air temperature was +1.4 °C higher than the annual mean.

Table 1

Rainfall and Air Temperature Recorded at the Meteorological Station, Located Nearby the Experimental Site

Index	Year							
	2000	2001	2002	2003	2004	2005	2006	2007
Annual precipitation, mm	563	571	465	456	564	418	465	668
Percentage of the norm[a]	95	97	79	77	96	71	79	113
Annual air temperature, °C	8.2	7.8	8.0	7.1	7.0	7.0	7.7	7.9
Temperature deviation, °C[b]	+2.0	+1.6	+1.8	+0.9	+0.8	+0.8	+1.5	+1.7

[a] the long-term average of the annual precipitation for the period of 1961-1999 was 590 mm;
[b] the annual mean temperature for the same period was +6.2 °C

The similarity in hydraulic parameters of both systems was verified before the treatment in spring (February - March) of 2000. The results confirm that the drainage systems chosen for the research were similar in their characteristics: drainage coefficients were 1.14±0.29 and 1.19±0.37 mm d^{-1} respectively. Statistical analysis showed that they were not significantly different at $p \leq 0.05$.

The drain discharge and the water table depth were measured every 1-5 days, depending on the drainage intensity during the main drainage season in both systems. The water table depth was measured in three observation wells (PVC Ø50 mm) installed at the midpoint between the parallel laterals to a depth of 1.1 m. Discharges of FD and CD treatments were measured in a volumetric way in the drainage manhole simultaneously. Samples of the drainage water were collected for analysis once a week, or twice a month, subject to the drainage intensity. The water was analysed for inorganic nitrogen (NO_3-N and NH_4-N). Concentrations were determined by the spectrometric method, using an FIA Star 5012 analyser, according to the water quality investigation standards (LST EN ISO 13395:2000; LAND 38:2000). The runoff of nitrate nitrogen was calculated on the basis of the linear interpolation method (Guidelines…, 1994).

A conventional cropping rotation and land cultivation were applied in the site. The beginning of the drainage outflow control in spring was chosen taking into account plants and climatic conditions. The control device was opened in case when the water level had risen close to the soil surface during spring melting. The drainage outflow was withheld when the water table depth in the site dropped to 0.70 m below soil surface. The reliability of the results was determined by processing them using MS Excel for Descriptive Statistics (mean values, standard deviation) and for Correlation and Regression Analysis. Differences of drainage treatments were tested applying *t*-test at the significance level $p \leq 0.05$.

Results and Discussion

The water table management resulted in marginal short-term increase on the water table depth in between the drains in the experimental site. The designed (0.68 m) water level in the CD treatment was reached in the years of 2002, 2003, 2006 and 2007. That is partly related to drainage parameters and the climatic conditions of the research period. Due to relatively small diameter of laterals (40 mm) and a considerable spacing between drains (20-24 m), the lateral seepage was insufficient to elevate the water table. The water table level fluctuated in response to seasonal precipitation events. When there was a lack of precipitation in spring (monthly amount 8-28 mm), a steady rise of th air temperature stimulated evaporation, and there was no sufficient supply of the drainage water to maintain the designed water level. In such conditions (2000 and 2004) the abatement of the water table level was faster in comparison to other investigated years. The declining water table level raised up by 0.24-0.60 m for short periods of time in case of heavy rainfall (25-36 mm) late in spring (2001, 2005 and 2007). Ephemeral rainfall of 5–7 mm had no impact on the water level elevation. The total length of time the water table persisted above the drains level ranges between 28 and 75 days.

According to the data, under the climatic conditions of Middle Lithuania 0.5 to 8.0 mm drainage outflow was retained by controlling water level in the drainage outlet. The retained quantity of water only partially depended on the continuance of the water table management throughout the year ($R^2 = 0.29$). Such climatic factors as precipitation and the mean air temperature have a much greater influence on the retained outflow ($R^2 = 0.76$-0.96). The water table persistence at its highest level (0.40-0.68 m above the drains) correlates with the precipitation more significantly, while the overall persistence (in the range of 0.0-0.68 m) more significantly correlates with mean daily temperature (as with increased total evaporation less precipitation passes into the drains and due to that the water level drops gradually). The strongest logarithmic relationship ($R^2 = 0.74$) is obtained between the water table persistence above the drains and precipitation likelihood (Figure 2). In the case of dry or moderate spring (above 25% likelihood) the water table above the drains must be retained for 30-40 days, in the wet period (below 25% likelihood) - up to two and a half months.

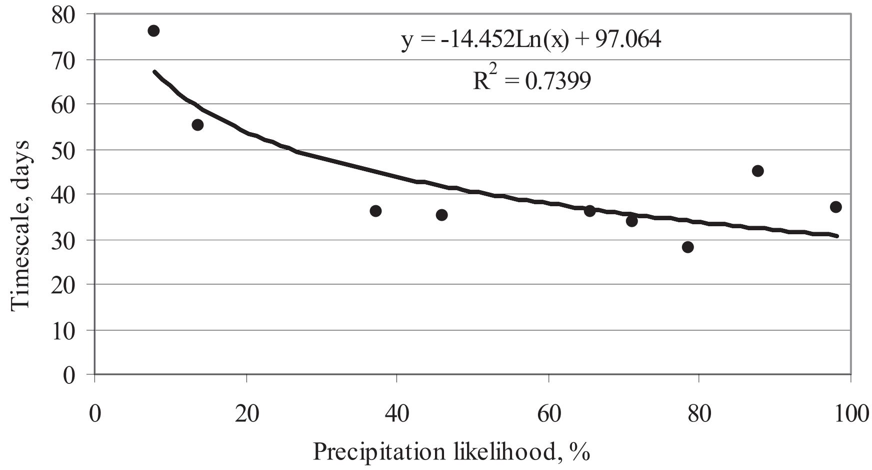

Figure 2. Dependence of the water table persistence above the drains (y) on precipitation likelihood (x).

During the spring peak the drainage outflow in CD system was 8-17% lower compared with FD area. In the summer drainage the outflow occurred only twice during the studies: in August 2001 and July 2007, when the rainfall exceeded 2.4-1.7 times long-term average (173-118 mm) (outflow from CD area was by 7.0-7.5 mm lower compared with FD area). In remaining years the summer drainage outflow did not occur, as precipitation only re-supplied the soil humidity. In autumn drainage the outflow started in September – October after 230-330 mm of precipitation had fallen since the ending of the spring outflow. The drainage outflow in CD system started three – seven weeks later and was 11-27% lower compared with FD area. The water accumulating in the drains was absorbed by the soil dried out during the summer period; therefore, more time was required to reach the designed water level in CD system. In the case when wet autumn coincided with the winter warmer than usual (2003-2004 and 2006-2008), long lasting (146-220 days) drainage functioning periods occurred in CD system. In autumn similarly to the spring peak values of drainage coefficients in CD area were 8-20% lower than in FD area.

While analysing the drainage activity, it was found out that free conventional drainage functioned nearly two times longer than the controlled one – 1423 and 725 days respectively (Table 2). In a dry year the activity time of the controlled drainage was 2.6 times (by three months on average) in a moderate year – 1.6 times shorter. The statistical evaluation showed that these differences are significant. Accordingly, a statistically significant difference of the annual drainage outflow between treatments was established: it was 25% (184.2 mm) lower in CD area on the average compared with FD area.

Table 2

Drainage Outflow Characteristics During the Study Period

Year	Flow duration, days			Annual outflow, mm		
	FD	CD	Δ, days(%)	FD	CD	Δ, mm (%)
2001	232	141	91 (39)	173.2	131.3	41.9 (24)
2002	140	54	86 (61)	63.1	45.8	17.3 (27)
2003	159	43	116 (73)	46.4	26.5	19.9 (43)
2004	262	166	96 (37)	153.6	105.2	48.4 (32)
2005	127	51	76 (60)	64.1	59.4	4.7 (7)
2006	167	77	90 (54)	37.3	26.0	11.3 (30)
2007	336	193	143 (43)	192.3	151.6	40.7 (21)
Total sum	1423	725	698 (49)	730	545.8	184.2 (25)

Δ – difference between treatments.

One of the targets of the drainage outflow management is raising the groundwater level in a drained area. However, according to the research results, it is not always possible to achieve that (Morkūnas ir Ramoška, 2001). The water table depth in between the drains of FD and CD systems differed significantly only during five months of the entire period: it was significantly higher in April 2002, February and March 2004 and April 2006, while in November 2006 it was significantly lower than in the conventional drainage treatment. There were no significant differences between drainage treatments during all the other periods.

The differences of the drainage outflow formation had an impact on the variation of nitrogen concentration in the drainage water. From the beginning of the research till the end of 2005, the mean annual NO_3-N concentration in the drainage water of CD system was 5-13% lower compared with the water of free drainage system (Figure 3). These results correspond to a common impact of the control drainage – an elevated water table level creates anaerobic conditions that promote denitrification and decrease in nitrate concentration, herewith nitrate nitrogen leaching is reduced (Gambrell et al., 1975; Twitty and Rice, 2001; Evans and Skaggs, 1989).

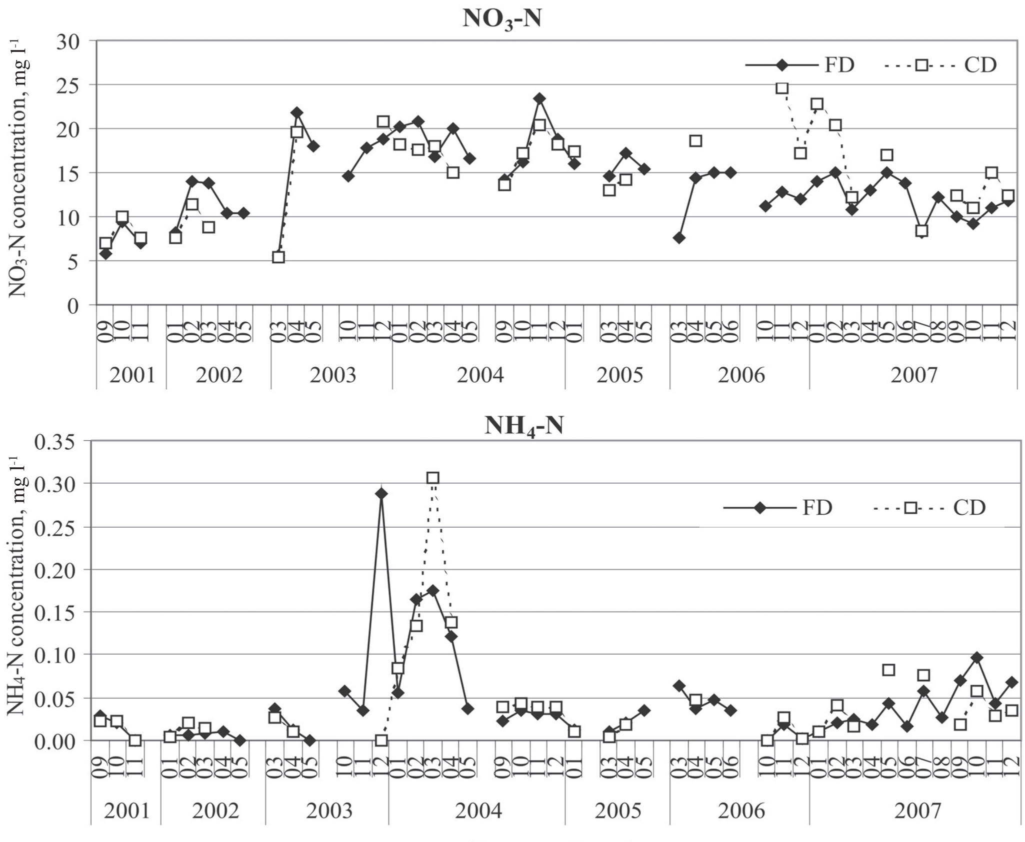

Figure 3. Dynamics of nitrate and ammonium nitrogen concentration in drainage water.

Extreme values of nitrate nitrogen in controlled drainage water were found in the years of 2006-2007. NO_3-N concentration of this period in the controlled drainage water was 29-72% higher in comparison to the free drainage (extreme value reached 24.7 mg l^{-1} and was 7% higher than MAC. According to Lithuanian standards the maximum allowable concentration (MAC) of NO_3-N into the natural environment is 23 mg l^{-1}, MAC of NH_4-N – 5 mg l^{-1}.

The reason for such high NO_3-N concentrations was a dry summer-autumn season in 2005 and the lack of precipitation in the beginning of summer 2006, when only 35% of the precipitation norm fell. Because of a lack of moisture in the soil, plants used fertilizers inefficiently. When the drainage outflow started, better conditions for leaching existed in CD area. Meanwhile, the water in FD system flowed to the drains from deeper layers where less nitrogen compounds accumulated. Due to the impact of meteorological factors a higher NO_3-N concentration in CD drainage water lasted even for 11 months.

The concentration of ammonium nitrogen in FD and CD water varied differently. Extreme values of NH_4-N concentration were related to heavy melting of certain periods, when the water level rose to the cultivated layer rich in mineral nitrogen. However, they were lower than MAC. In December 2003, the highest concentration of NH_4-N in FD and CD area reached 0.29-0.94 mg l^{-1} and in March 2004 – 0.18-0.32 mg l^{-1} respectively. The concentrations of ammonium nitrogen determined in standing water of the control device were 0.63-1.43 mg l^{-1}. Meanwhile, there was only 0.01-0.034 mg l^{-1} NH_4-N in the water flowing out of FD system in May 2003-2005. Such quantitative changes originate from intense biochemical processes occurring in standing and warming water (Suzuki, 1974). During autumn 2006 and winter 2007, when a pronounced increase of NO_3-N concentration was recorded in CD drainage water, NH_4-N concentration did not differ significantly: FD – 0.013 mg l^{-1}, CD – 0.038 mg l^{-1}.

In recent studies, no statistically significant differences in nitrate concentrations have been found in the conventional and the water table management systems. The reductions in nitrate nitrogen loads determined in the controlled drainage system are conditioned by reduction in the drain outflow. Some authors propose that up to 70-90% of the drainage outflow can be retained by controlling the water level (Wesström et al., 2003). R.O. Evans et al. (1995) stated that the total drainage outflow may be reduced by 30%. Similar results were obtained by other researches (Belcher and D'Itri, 1994). They concluded that controlled drainage reduced nitrogen transport at the field edge, primarily because of the reduction in the outflow volume. There is less water leaving the field through the drainpipe, and therefore, less nitrate flowing out of the drain, even if there is no change in the nitrate concentration.

The data suggest that the amount of 4.4 to 29.5 kg ha^{-1} of NO_3-N and 5 to 135 g ha^{-1} of NH_4-N was leached together with drainage water in FD area annually. In CD area it was from 4.4 to 23.8 kg ha^{-1} of NO_3-N and from 6 to 167 g ha^{-1} of NH_4-N respectively (Table 3). Similar amount (30 kg ha^{-1}) of NO_3-N lost per year was determined while calculating the balance of mineral nitrogen, which had been carried out earlier in the same area (Aksomaitienė et al., 1999).

Table 3

The Amount of Nitrate and Ammonium Nitrogen Leached from FD and CD Systems n the Experimental ite. Retention '–' and Loss '+' Presented as Difference (Δ),%

Year	characterization	Crop	NO_3-N, kg ha^{-1}			NH_4-N, g ha^{-1}		
			FD	CD	Δ, %	FD	CD	Δ, %
2001	moderate	Barley	16.7	14.4	-13.8	90	22	-75.6
2002	dry	Winter wheat	8.9	4.4	-50.6	5	8	+60.0
2003	dry	Winter wheat	7.9	4.6	-41.8	90	167	+85.6
2004	moderate	Barley	29.5	17.9	-39.3	135	116	-14.1
2005	dry	Winter wheat	10.2	9.0	-11.8	10	9	-10.0
2006	dry	Summer rape	4.4	4.5	+2.3	8	6	-25.0
2007	humid	Summer wheat	23.5	23.8	+1.3	78	31	-60.3
Total sum			101.1	78.6	-22.3	416	359	-13.7
Average of dry years			7.8	5.6	-28.3	28	48	+68.1
Average of moderate years			23.2	18.7	-19.5	101	53	-44.2

The nitrate and ammonium nitrogen losses n the experimental site were related to the drain outflow variation depending on the amount of precipitation. Compared with FD, the annual reduction of NO_3-N in dry years in CD was 28%. In moderate years, the corresponding reduction was about 20%. However, statistically these differences are not significant. Contradictory data were found in 2006 and 2007, when despite the decrease of the annual drainage outflow of 30 and 21% in CD area, NO_3–N loses increased slightly compared to FD system. That was related with greater NO_3-N concentration in the drainage water in CD treatment. The total nitrate nitrogen losses from CD area were 22% lower compared with FD treatment during the investigations (2001–2007). However, on the basis of t-test these differences cannot be regarded as statistically significant at $p \leq 0.05$. On the subject of NH_4-N leaching it is difficult to identify any consistent pattern. The values of the ammonium nitrogen loss in particular years changed widely in both treatments (variation coefficient CV=87-125%). Calculating the leached amount of NH_4-N within the entire study period there was a statistically insignificant difference of 14% between the treatments.

Conclusions

1. In the controlled drainage system that was not adapted for the subirrigation, the total length of time the water table persists above the drain tubing depended on the beginning of the drainage outflow control and the period's meteorological conditions. This time is related to the seasonal rainfall, air temperature (R^2 = 0.76-0.96) as well as to the precipitation likelihood (R^2 = 0.74).
2. When controlling the water level in the drainage outlet, the annual drainage outflow lasted shorter by 40-62%; at the same time it was reduced by 25% and nitrate leaching – by 20-28% in comparison with drainage operating in an ordinary regime. These indices varied depending on the weather conditions: in dry years the difference between treatments was higher, but in moderate years it was lower.
3. In the drainage systems adapted only for water removing, the maintenance of the optimal water table depth for vegetation of agricultural crops is complicated. However, the water table control can minimize the negative environmental impact of the drainage, make more effective use of the rainfall and soil moisture supplies and improve the water quality.

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THE CHANGES OF WATER QUALITY IN THE RIVER BELOW THE LARGE PIG-BREEDING ENTERPRISE

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Abstract

The researches were carried out from 2002-2007 in the upper reaches of the Šušvė river, a Nevėžis tributary, at the pig enterprise Limited company (LTD) 'Litpirma' breeding near the township of Šiaulėnai. LTD 'Litpirma' has been operating since 1978 and produces 25 thousand fattening pigs per year, along with an associated 56 thousand m^3 organic fertilizers (liquid manure, slurry and solid manure), which are spread on surrounding agricultural fields. This article presents the impact of a large pig breeding company on the river water quality and quantifies the leaching of nitrogen, phosphorus and potassium (NPK). It is based on the water quality research data collected from an 11.6 km section of the Šušvė river, both upstream and downstream of Šiaulėnai, regarding the drainage water outflow from the fertilized fields and from Šiaulėnai domestic wastewater.

Drainage water from 728 ha of fields that have been fertilized with organic fertilizers carry an average of 11.4 tons of nitrogen, 0.073 tons of phosphorus and 5.53 tons of potassium.

Changes in NPK quantities carried by this section of the Šušvė were calculated as follows: total nitrogen increased by an average of 83 tons yr^{-1} (58%), potassium by 51 tons yr^{-1} (54%) and the smallest increase, for total phosphorus, by 1.2 tons yr^{-1} (48%). All of these pollutants leached into the river during the cold season (to 60% total phosphorus and to 88% total nitrogen) when there was no vegetative growth. A wet year affects the quantities of leached NPK.

Key words: NPK, concentration, runoff, manure, fertilization rate.

Introduction

Since the year of 2002 large pig-breeding enterprises with the support of EU structural funds have been applying more advanced and modern technologies for animal husbandry raising. Although large-scale animal farms with high animal concentration in one location cause a greater risk to the environment than the small ones, the development of animal husbandry/raising enterprises has been recently orientated towards the increase of capacity. Large animal husbandry enterprises are more successful in implementing more productive and cost-efficient equipment, automation of technological processes and reduction of costs. After the scientific evaluation of the environmental problems in Lithuania related to animal husbandry raising in pig farming complexes it was suggested that these complexes are reconstructed by equipping them with the waterless manure removal technology.

Modernized pig farming complexes fractionate the produced liquid manure into thick fraction and slurry. These organic fertilizers of both kinds are overspread onto agricultural fields according to the fertilizing programmes in agreement with the institutions of environmental protection.

Lithuania gives priority to ecological agriculture, countryside tourism, regular and well-balanced development of agriculture/rural economy. All that raises the importance of balancing the rate of fertilization with the amount of fertilizers exported together with the yield in order to reduce leaching into the environment (Pažangaus…, 2000). The effect of field fertilization with manure upon the bodies of the surface water is generally considered as spill/spread pollution the scale of which is determined by the kind of fertilizers, their amount, time of their insertion, type of soil and its granulometric composition, climatic conditions and cultivated plants (Misevičienė, …2002).

A Finnish scientist S.Vuorenmaa (Vuorenmaa et al., 2002) claims that the condition of the surface water bodies is getting worse because of the spilled pollution, especially from the sources of agriculture. By analysing the pollution of small rivers, the researcher indicates that namely weather conditions not the effect of the agriculture change occur as the main reason for the pollution. Due to the conditions of our climate the run-off of the rivers of Middle Lithuania constitutes the following percentage of the annual run-off: in spring (March-May) 48-77%, in summer (June-September) 6-13%, in autumn (October–November.) – 5-15%, in winter (December–February) – 12-25% (Gailiušis et al., 2001). In spring, as soon as the weather gets warmer, nutrients come into rivers as the mineralization product of organic substances and as mineral fertilizer untaken by plants. In autumn their amount in water increases due to autumn soil fertilization and mineralization of dead plants. Lithuanian scientists A.S. Šileika, K. Gaigalis and G. Kutra determined that the amounts of nitrogen in the river are the lowest during the period of plant vegetation, which requires an extensive use of nutrients. (Šileika et al., 2005; Kutra et al., 2002).

The aim of the work is to determine the effect of a large pig breeding enterprise Limited company (LTD) 'Litpirma' upon the quality of the Šušvė river water (pollution by ammonium nitrogen, total nitrogen, total phosphorus and potassium). The work was performed on the basis of the observations from 2002 to 2007 upon the water quality of the river itself and its received drainage water.

Materials and Methods

The water quality investigations were performed in the Šušvė river, covering the sector of 11.6 km above and below the area of the pig complex activity, in locations Š1 and Š2 (Fig.1). Šiaulėnai gauging station has been working since 1956. The width of the river basin up to this place is 162.4 km^2. There are a lot of swamps (15.8%) and forests (20.5%) in the basin. Large areas with thin peat layer of low lying marshy land were drained and turned into landed property of rural economy. Certain areas constitute 53.7% of the minimal part of the basin. The present part of the Šušvė basin does not contain any ponds or lakes as well as large industrial objects and towns affecting the quality of the river water.

The farmland covers only 26% of the river basin area. The quality of the water is determined by natural conditions of the basin and agricultural activity. The biologically treated waste water from Šiaulėnai town is released into the Šušvė (on the average 130 m^3 d^{-1}). A pig complex LTD 'Litpirma' is situated near the town and has been developing its activity since 1978.

Before the beginning of the reconstruction (modernization) (in 2000) the annual capacity of the enterprise was 12.0 thousand fattening pigs weighing 105–115 kg per year. In 2001–2006 average annual capacity reached 25 thousand fattening pigs per year. The enterprises of certain capacity keep about 1200 sows, 3200 piglets up to 20 kg and 7600 fattening pigs weighing from 20 to 115 kg. The pollution of this kept group of animals may be defined as the pollution of 1212 LU (livestock units). Situational scheme of the location with indicated fertilized areas and places of water sampling is presented in figure 1.

Accumulated organic fertilizers of the pig breeding enterprise are kept in open containers. Each year the enterprise stores 58 thousand m^3 of organic fertilizers – 25 thousand m^3 of slurry, 31 thousand m^3 liquid sludge and about 2 thousand tones of thick manure fraction. These resources of organic fertilizers annually contain 80.2 t of nitrogen, 9 t of phosphorus and 47.2 t of potassium. Total nitrogen on the average constitutes 0.657 kg in 1 m^3 of slurry, 1.6 kg – in liquid sludge, 4.4 kg – in thick manure fraction.

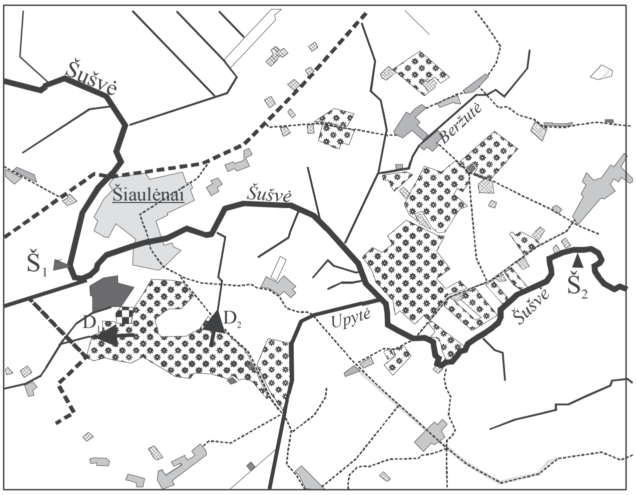

Figure 1. The location of the areas of 'Litpirma', Ltd fertilized with organic fertilizers:

1 2 3 4 D_1 D_2 5 D_1 D_2 6

1-location of production of 'Litpirma', Ltd; 2- fertilized area; 3- villages and small-towns; 4- sampling places in the river; 5- drainage water outlet; 6 – rivers and canals.

Organic fertilizers are used for field fertilization in accordance with the fertilization program. Slurry is applied to 156 ha area twice a year – in spring and before an autumn sowing not exceeding 100 m^3 ha^{-1} of dissemination loads. Liquid sludge is also applied two times with the loads up to 50 m^3 ha^{-1} and thick manure fraction is used for autumn field fertilization. (dissemination loads up to 18 t ha^{-1}).

Annually 131.4 kg ha^{-1} of total nitrogen, 38.9 kg ha^{-1} of phosphorus and 97.2 kg ha^{-1} of potassium on the average get into the slurry applied 156 ha field. 572 ha of farmland fertilized with liquid sludge and thick manure fraction receive on the average 105.2 kg ha^{-1} of total nitrogen, 21.8 kg ha^{-1} of phosphorus and 28.8 kg ha^{-1} of potassium every year. These fields are planted with barley, beans and peas which are later used as feed. All organically fertilized areas are drained. The drainage water of the slurry applied 156 ha field is released through 2 drainage outlets (D_1 and D_2). D_1 releases drainage water from the area of 102 ha and D_2 from the area of 54 ha. The quality of the drainage water revealed the amount of fertilizers coming into the river from the fertilized agricultural fields.

The data of the Šušvė hydrological schedule were collected from the annual reports of Šiaulėnai Hydrometeorological station of Lithuanian Hydrometeorological Service (Hidrologijos…, 2002-2007). Sampling places of the Šušvė did not coincide with the measurement place of discharges. Accordingly the discharges in the sampling taking places were calculated by evaluating the difference of the basin area. In the drainage outlets the discharges were measured by volumetric method during the process of water sampling.

The variation of chemical substances was estimated according to the average weighted concentration (Helsinki Commission (HELCOM), 1996).

NH_4-N – by a spectrometric method;

N_{total} – by a titrometric way having burnt the material (Kjeldal method);

P_{total} – photo colorometric method, having burnt the substance;

Potassium – by a flame photometric method.

Reliable limits of 5% significance level were calculated in order to evaluate the reliability of factual variation of water pollution. The coefficient of variation and Stiudent criterion were calculated for the evaluation of the variation of the pollution dynamics.

Pollutant in water was identified in the Chemical analytical laboratory at the Water Management Institute of LUA certified by the Ministry of Environment of the Republic of Lithuania.

The presence of pollution is determined when higher than maximum permissible concentration of chemical substances is found in the river or drainage water samples. The water quality of the river and drainage was analysed due to years (January-December) and seasons: warm or plant vegetation (May-October) and cold (November–April).

Results and Discussion

According to the data from the nearest meteorological station, the year of 2005 was the driest year of the research when the annual amount of precipitation reached only 401 mm, i.e. 69% of the norm. The wettest and warmest period was recorded in 2007 when the annual amount of precipitation exceeded the norm (115%, or 733 mm.) The distribution of precipitation during 2007 was very uneven: spring was dry, summer was wet, especially in July with 159 mm of precipitation.

The same year respectively provided the highest wateriness of the river: the average annual river discharge around Šiaulėnai reached 1.84 m^3 s^{-1}, when the long-term norm is 1.3 m^3 s^{-1} (figure 2). The average discharge in July was very high (1.59 m^3 s^{-1}) and equalled the flood of January. Five years of all the observation period were drier than long-term norms. The year of 2005 was especially distinctive with only 69% of long-term precipitation norm. However, the least wateriness of the investigated river was in 2005 and 2006. The average annual discharge of that period was only 0.56–0.59 m^3 s^{-1}. The average annual weather temperature of some years was either equal to the norm (the norm +6.0 °C) or higher than the norm up to 1.5 °C.

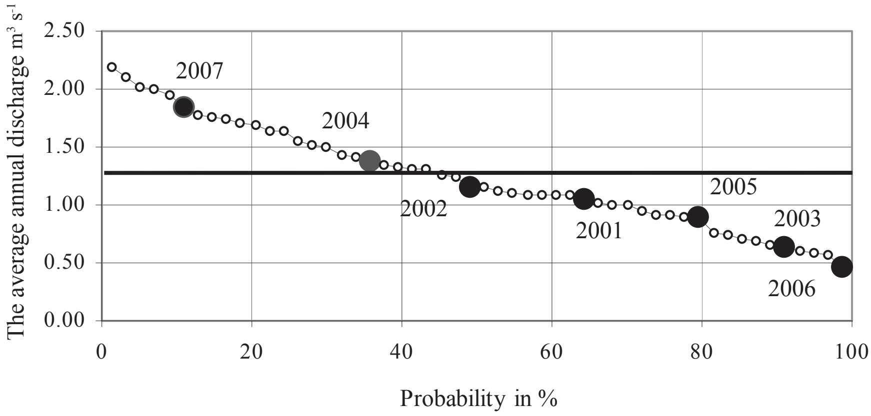

Figure 2. The average annual discharge of the Šušvė river around Šiaulėnai.
——— long term norm.

The quality of drained water of organically fertilized agricultural fields and NPK run-off. Substance leaching from the fertilized agricultural fields was investigated during the cold (November-April) period characterized by the absence of the plant vegetation and a considerable amount of water getting into the river from the basin (together with chemical substances) and during the warm period (May-October) with the process of active plant vegetation and the use of biogenic substances for the growth.

The amount of NPK coming into the river from the territory fertilized with organic fertilizers (728 ha) was determined according to the data of two drainage outlets D_1 and D_2. The comparison of drainage water quality from both outlets revealed that the concentration of ammonium nitrogen, phosphorus and potassium in drainage water was higher in the outlet collecting water from the larger area (102 ha). The concentration of total nitrogen appeared to be converse – both annual and seasonal concentrations were higher from the smaller area (54 ha) (table 1). While comparing average seasonal concentrations of the studied elements, it was determined that the concentration of ammonium nitrogen in drainage water was 47% higher during the warm period whereas the concentration of total nitrogen and potassium increased during the cold one (23 and 15% respectively). The concentration of total phosphorus remained almost the same during both seasons.

Table 1

The Indices of Drainage Quality and Run-off (2002-2007)

Indice	The period of the observation	Concentration, mg l^{-1}							Run-off kg ha^{-1}	Run-off t $year^{-1}$
		D_1 (102 ha)			D_2 (54 ha)			D_1; D_2		
		Ave-rage	Hig-hest	Low-est	Ave-rage	Hig-hest	Low-est	Aver-age	Ave-rage D_1; D_2	Out 728 ha areal
NH_4-N	Year (01–12)*	0.32	2.30	0.03	0.28	2.10	0.02	0.30	0.40	0.29
	Warm (05–10)	0.36	3.16	0.03	0.39	2.10	0.03	0.38	0.20	0.14
	Cold (11–04)	0.26	4.10	0.04	0.13	0.42	0.02	0.20	0.20	0.14
N_{total}	Year (01–12)	8.97	2.40	1.73	15.70	24.00	9.90	12.30	15.60	11.40
	Warm (05–10)	5.63	15.59	1.73	16.05	24.00	10.48	10.80	4.90	3.60
	Cold (11–04)	12.61	3.83	3.40	15.32	20.80	9.90	14.00	10.70	7.80

Table 1 continued

Indice	The period of the observation	Concentration, mg l^{-1}							Run-off kg ha^{-1}	Run-off t $year^{-1}$
		D_1 (102 ha)			D_2 (54 ha)			D_1; D_2		
		Ave-rage	Hig-hest	Low-est	Ave-rage	Hig-hest	Low-est	Aver-age	Ave-rage D_1; D_2	Out 728 ha areal
P_{total}	Year(01–12)	0.11	5.60	0.03	0.04	0.12	0.01	0.07	0.10	0.07
	Warm (05–10)	0.11	2.30	0.06	0.05	0.12	0.01	0.08	0.04	0.03
	Cold (11–04)	0.12	3.52	0.03	0.03	0.08	0.01	0.07	0.06	0.04
Potassium	Year (01–12)	6.82	5.60	3.20	5.16	6.70	3.80	6.00	7.60	5.53
	Warm (05–10)	6.00	2.30	3.20	4.99	6.00	3.80	5.49	2.60	1.89
	Cold (11–04)	7.54	12.10	3.50	5.33	6.70	3.90	6.43	5.00	3.64

*01-12- Janv-Dec; 05-10 May-Oct; 11-04-Nov-Apr.

Each year 11.4 t of nitrogen, 0.07 t of phosphorus and 5.53 t of potassium on the average were discharged into the Šušvė river by the drainage from all fertilized 728 ha area. Biologically treated waste water from Šiaulėnai town was discharged into the investigated Šušvė section between the measurements Š1 and Š2. The calculation in quantities (t $year^{-1}$) revealed that during the investigated period on the average 13.6 t $year^{-1}$ of total nitrogen came into the Šušvė basin from the enterprise and the town. The main part of the pollution was constituted of the pollutant from the pig breeding enterprise (84% or 11.4 t $year^{-1}$). Only 2.2 t $year^{-1}$ of total nitrogen together with the biologically treated waste water came into the river from the town.

During the research period the average river discharge of the warm period around Šiaulėnai ranged from 0.17–0.45, except the wet period of 2007 when it increased up to 2.28 $m^3 s^{-1}$. The river discharges of the cold period ranged greatly from 0.75 (2006) to 2.29 (2004) $m^3 s^{-1}$ (Figure 3).

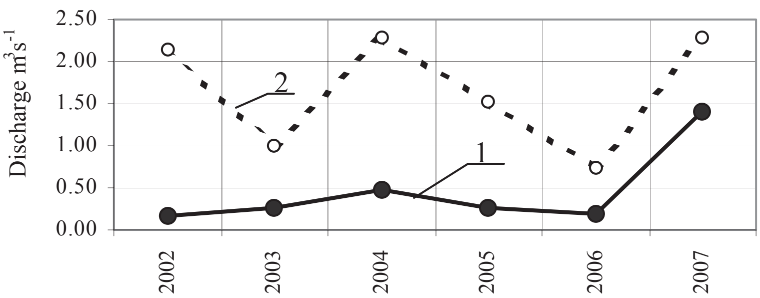

Figure 3. The average discharges of the Šušvė river during warm and cold periods in 2002-2007
1– may-october-month; 2 – april-november month.

The comparison of the average concentrations of the investigated substances during cold and warm periods revealed that the concentration of total nitrogen during the cold period is 2.1 times higher than during the warm period. The concentrations of potassium and phosphorus were similar. However, the calculation of the run-off of the substances indicated that during both warm and cold periods the run-off of nitrogen, phosphorus and potassium increased by 57-74% in the investigated section of the river (Table 2).

Table 2

The Average NPK Concentrations and Run-off During Warm and Cold Periods

Season of the year	The investigated substance	Concentration mg l^{-1}			Discharge t $year^{-1}$			Percentage Š$_1$
		Š$_1$	Š$_2$	Š$_2$-Š$_1$	Š$_1$	Š$_2$	Š$_2$-Š$_1$	
Warm period (May-October)	N_{total}	2.79	2.95	0.16	20.0	34.0	13.0	66.0
	P_{total}	0.09	0.10	0.01	0.7	1.1	0.4	61.0
	Potassium	3.06	3.25	0.19	22.0	37.0	15.0	66.0
Cold period (November-April)	N_{total}	5.64	6.25	0.61	147.0	256.0	109.0	74.0
	P_{total}	0.07	0.07	0.00	2.0	3.0	1.0	57.0
	Potassium	2.93	3.13	0.20	77.0	128.0	52.0	68.0

Meteorological conditions of the year have great impact upon the quality of the river water and the amounts of leached pollutants of the fertilized fields. The investigated period dealt with very dry years, like 2003 and 2006 with the probability of 90-99% and wet and extremely wet years (2004-2007) with the probability of 36 and 11% respectively. The concentrations of NPK and the leach varied each year. The highest concentration of these elements was determined during drier years. However, clear dependence upon the wetness of the year was absent (Table 3). The average NPK concentration and the run-off during the year of different wetness ranges up to 2-4 times. However, a close connection between these values was not found.

Table 3

The Average Annual NPK Concentration During the Years of Different Wetness

Year	Probability in percent	The discharge of the river, $m^3 s^{-1}$		$N_{total,}$ mg l^{-1}		$P_{total,}$ mg l^{-1}		Potassium mg l^{-1}	
		Š$_1$	Š$_2$	Š$_1$	Š$_2$	Š$_1$	Š$_2$	Š$_1$	Š$_2$
2007	11	1.84	2.89	5.72	5.78	0.05	0.05	1.90	2.40
2004	36	1.38	2.17	3.69	3.91	0.11	0.11	2.75	2.92
2002	49	1.16	1.82	3.00	3.27	0.09	0.10	3.90	3.97
2005	80	0.89	1.40	3.75	4.70	0.10	0.08	3.18	3.18
2003	91	0.64	1.00	3.98	4.00	0.06	0.07	3.38	3.73
2006	99	0.47	0.73	7.55	7.65	0.06	0.06	2.90	2.80
Max	-	1.84	2.89	7.55	7.65	0.11	0.11	3.9	3.97
Min	-	0.47	0.73	3	3.27	0.05	0.05	1.9	2.4

The run-off of NPK (t $year^{-1}$) varies greatly due to the wetness of the years. Their interdependence is best represented by the polynomial equation (Figure 4).

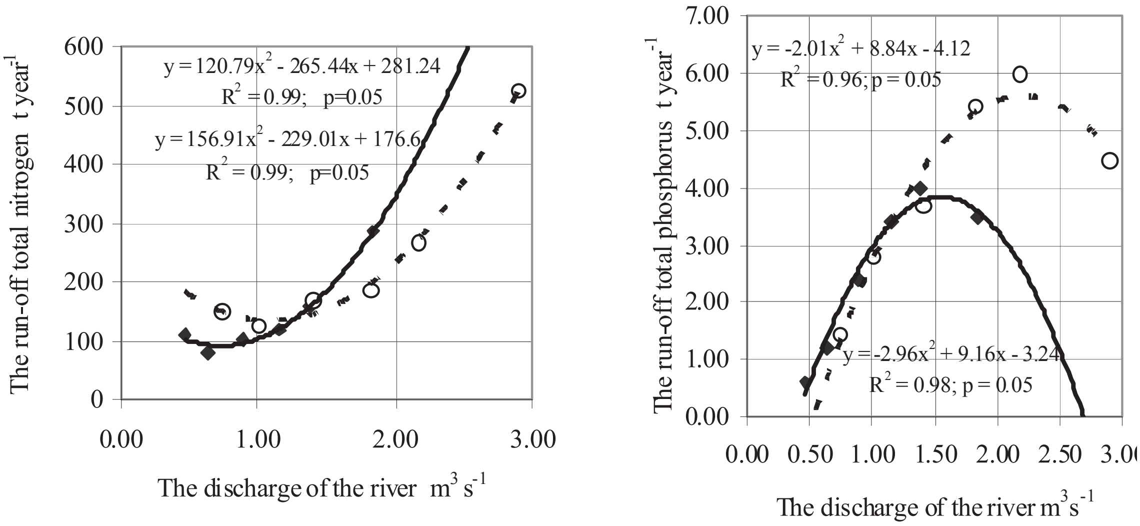

Figure 4. The dependence of the run-off of total nitrogen and total phosphorus on the discharge of the Šušvė above ($Š_1$) and below ($Š_2$) Šiaulėnai.

$Š_1$ $Š_2$

The possession of the discharge data of the river water quality allowed calculating the increase in the run-off of N and P pollutants in the section between Š1 and Š2 due to the wateriness of the river. Mathematical dependences of the run-off are presented in Figure 5.

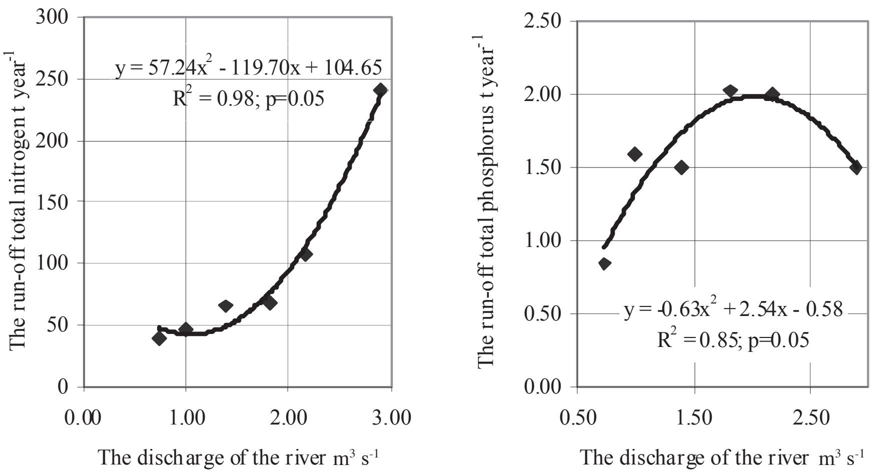

Figure 5. The increase in the run-off of total nitrogen and phosphorus due to the discharge of the river.

The greatest increase in the run-off of total phosphorus was determined when the wateriness of the river corresponded to 25-30%. Further increase in the wateriness causes less variation of the run-off of this pollutant, because of the achieved limit of the amount leached from the fields. Total nitrogen does not have such a limit. The run-off of this element increases from 50 t to 200 t year^{-1} due to the increase in the wateriness. The highest run-off was recorded during the wettest years (probability 11%) (Figure 5).

Table 4 presents the dependence equations of NPK run-off.

Table 4

The Equations of the Dependences of NPK Run-off Increase in the Investigated Basin on the River Wateriness

The equations	Run-off t $year^{-1}$			The chaffer	The coefficient of correlation
	Average	Max	Min		
N_{total}	99	195	46	y = 5.7245x2 – 119.7x + 104.65	k = 0.94
P_{total}	1.4	2.0	0.8	y = -0.6753x2 + 2.671x – 0.6603	k = 0.93
Potassium	66	109	22	y= -21.142x2 + 100.88x – 39.02	k = 0.96

Conclusions

1. Every year 11.4 t of nitrogen. 0.073 t of phosphorus and 5.5 t of potassium on the average come by the drainage into the river from the organically fertilized area of 728.0 ha of the pig-breeding enterprise.
2. The average concentration of NPK in the Šušvė river below the agricultural fields fertilized with the organic fertilizers increased slightly: total nitrogen – 0.007, total phosphorus – 0.010 and potassium 0.180 mg l^{-1}.
3. The greatest amount of pollutants (NPK) come into the river together with the drainage water from the agricultural fields fertilized with organic fertilizers during the cold period when plants do not vegetate: nitrogen – 68.6, phosphorus – 60.0 and potassium – 66.0% of the annual amount.
4. The NPK concentration during the year of different wetness ranges 2-4 times. However, a close connection between the discharge of the river and average annual concentration was not found. The dependence of the run-off of NPK and the discharges of the river may be presented by the polynomial equation.

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RESEARCH OF OPEN INLETS FOR SURFACE WATER OF DRAINAGE SYSTEMS

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Abstract

The research of the draining surface water from drained areas has become relevant with an increase of drainage system areas. In order to maintain a sufficient drainage efficiency by the draining surface water from the drained fields the density of open inlets for the surface water had to be increased to 5.5 u 100 ha^{-1}. That was determined by the density decline of the open ditches. The observations of the technical condition of open inlets for the surface water in the drained fields of the country have been performed since 1986. It was established that prevalent type of the inlets is F-5 design. Such inlets amounts over 90% of all tested ones. The article discusses the condition of the inlets of such type, evaluates the selection of the installation location, conditions of surface water running to an inlet and the condition of water inlet openings.

The research demonstrated some disadvantages of inlet designs, quite a few mistakes of installation and breakdowns during operation. A clear increasing tendency of water inlet openings being blocked by the ground and vegetation was established: in 1986 11.1% of water inlet openings were completely blocked, in 1996 the percentage was 20.8% and in 2007 it was 42.9%. On the basis of this it can be stated that the inlets with halfway blocked openings will stop functioning soon as well if the maintenance work is not carried out in good time and an appropriate way.

Key words: drainage maintenance, open inlets for the surface water, wetland.

Introduction

Open inlets for the surface water are designed for draining larger amounts of the surface water from lower relief locations to the drainage network and for regulating surface runoff while protecting fields from erosion (Brown and Ward, 1997). Draining of the surface water is more relevant during wetter years and especially in spring; besides, the water draining problem is the more relevant the heavier drained soils are. The average areas of close depressions in the ground, which collect surface water, are not large compared with the entire drained land area; however, farmers suffer considerable losses in such fields: crops soak in hollows, it is not possible to sow in time and harvesting is complicated. Uncluttered, well maintained open inlets for the surface water facilitate avoiding harvest losses and performing a timely draining of surface waters. They can be open and blind type.

In foreign countries open inlets for the surface water are not popular due to the risks of silting up and polluting surface waters with different pollutants coming from the agricultural land (Christopher, 1999). Most often establishing flat slope watercourses or excavating ditches solves the problems of the surface water; sometimes blind inlets for the surface water are recommended (Stuyt et al., 2005). Farmers into intensive agricultural activities are recommended by environmentalists to change the existing open inlets with blind inlets of bulk materials (stones, rubble, and gravel). In such a way drainage failures due to silting up are avoided as well as the pollution of open water bodies with biogenic materials and chemicals used in agriculture is reduced (Ginting et al., 2000; Moncrief and Hansen, 2002).

In Lithuania draining of the surface water by open type inlets is rather common. In 1959 there were 350 units of them installed, and the density in drained areas was only 0.32 u 100 ha^{-1}. Year by year with an increase of the scale of drainage areas the number of open inlets for the surface water in the drainage systems increased as well. On 1 January 2007 their number was over 142.2 thou u and the density increased up to 5.5 u 100 ha^{-1} (Melioruota …, 2007).

Serial production of different design inlets (Šaulys, 1999; 2001; Šaulys and Bastiene, 2007) from the built in sections of ferroconcrete and recently – from plastic components (PN–42) and easy assembling in installation location determined the spread of these land reclamation installations. Some of them are really popular, others are not so numerous and some can only be found at experimental sites. Inlets prevent the land cultivation, and though the average density of them in drained areas is 5.5 u 100 ha^{-1}, in the arable land they are not numerous – one inlet per 200 ha on average. Most often inlets are installed near the edges of permanent arable fields.

The investigations of the drainage system condition carried out in Kėdainiai district showed that the most common drainage breakdowns are related to the drain silting with ground particles (21%) and deformations of open inlets for the surface water (13%) (Buožis and Bastiene, 1998). The breakdowns of open inlets for the surface water are clearly seen on the contrary to the drainage ones. Their cause and the required amount of repairing works can be easily identified. It is more difficult to identify the extent of hidden drainage breakdowns. Such breakdowns include drain silting with ground particles. Beside other reasons of such a breakdown occurrence it is as well the result of breakdowns of open inlets for the surface water.

The research objective is to establish the maintenance efficiency of open inlets for the surface water, their breakdowns and the dynamics of deformations in order to ensure timely surface water drainage from the drained areas.

Materials and Methods

The investigations of the technical condition of open inlets for the surface water in the drained fields of the whole country were carried out in the years of 1986, 1996 and 2007. In analysing the technical condition of open inlets for the surface water and their maintenance the inlets of various types (F–7, F–5, F–5–1, PVN–3 and PN–42) were observed using the expedition method. The observation data were registered in a specially designed card, in which the data of inlet installation and technical condition were written down. The condition of the inlet lid and the amount of silt in inlets (drain junction spot was uncovered, if needed) were recorded, the selection of the inlet installation location and the conditions of surface water inflow/run to the inlet, the condition of water inlet openings, etc. were assessed.

Now the most common inlets in Lithuania are those of F–5 design (Fig. 1). They consist of 90 cm diameter lid (1), 58 cm diameter well ring with a bottom (6) with an opening for a drain (4) to attach (Šaulys and Bastiene, 2007).

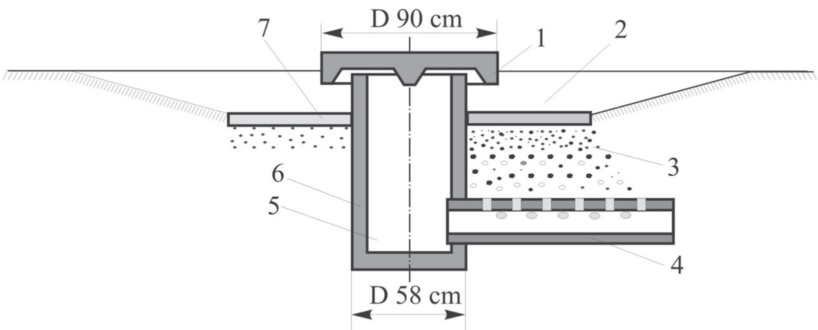


Figure 1. Open inlet for the surface water F–5.

A drain starts with a perforated tube made of asbestos cement. Above the tube a blind inlet of sand and gravel mixture (3) is installed to have water faster drained from a sediment trap (2). The trap base around the inlet is paved with concrete slabs (7). A space for sediment to settle (5) is left inside the inlet F–5.

The following numbers of F–5 design inlets were observed: in 1986 – 72, 1996 – 125, 2007 – 84 u. The observations of open inlets for the surface water during different seasons revealed some drawbacks of their designs, considerable faults during installation and breakdowns during the operation period.

The data collected were processed using mathematic-statistical methods (descriptive statistics, frequency and correlation analysis); indicator variation tendencies describing the condition of inlets were established.

Results and Discussion

The Melioration Cadastre registers quantitative changes of reclaimed land areas. The analysis of the cadastre data allows the evaluation of tendencies, condition and actual state of the reclaimed land and installing land reclamation facilities in natural indicators. With an increase of drainage area the length of open ditches increased as well. The dependence between drainage area and open ditches length can be expressed by linear regression equation (correlation coefficient $r = 0.98$):

$$L=16.91\,A+10.02, \qquad (1)$$

here L – length of open ditches km;
A – drainage area thou ha.

In 1957–1958 when only 48.1–68.6 thou ha were drained in Lithuania, the length of open ditches per hectare of drainage area was 196–141 m. During the next decade, when drainage area increased 10 times (in 1967 617.6 thou ha had been already drained), the length of open ditches decreased to 25.0 m ha^{-1}, i.e.

7.8 times. During the later period of drainage system installation the length of ditches remained stable (in 1977 – 24.4, in 1986 – 20.6, in 1997 – 20.3 and in 2007 – 20.3 m ha^{-1} respectively) (Melioruota …, 2007).

According to the data of the Melioration Cadastre the number of open inlets for the surface water increased by exponential dependence (correlation coefficient r = 0.99) with an increase of the drainage area:

$$N=1.14\ e^{1.88\ A}, \tag{2}$$

here N – number of open inlets for the surface water thou u;
A – drainage area thou ha.

In analyzing installation dynamics of open ditches and open inlets for the surface water three stages can be distinguished. At the first (I) stage (1957–1970) with an increase of the length of open ditches per drainage area hectare the number of open inlets for the surface water was slightly increasing as well (Fig. 2). 28.7 ha were drained additionally and 0.36 of open inlets for surface water installed per each additionally excavated kilometre of open ditches. At the second (II) stage, 1970–1990 the situation changed. For example, in 1978–1988 86.3 ha were drained additionally and 9.88 of open inlets for the surface water installed per each additionally excavated kilometre of open ditches. These figures clearly indicate that in the seventies when installing drainage systems the greatest attention was paid to the efficiency of drainage, especially to draining the surface water from the drained areas.

During the independence period (stage III) starting from 1990 the extent of new drainage system installation and renovation of the existing ones has been decreasing due to known reasons (Šaulys, 2001). It is natural that the density of open ditches (20.3 m ha^{-1}) and open inlets for the surface water (5.5 u 100 ha^{-1}) has remained stable (Smilgevičius, 2001).

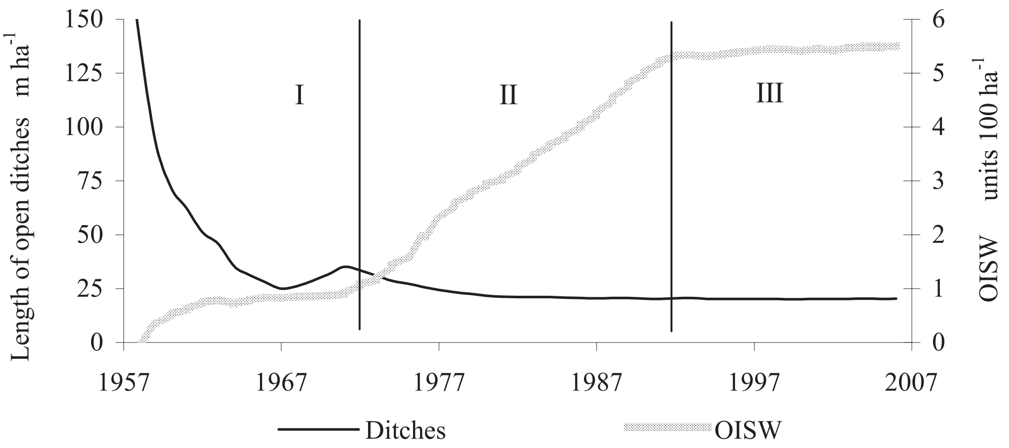


Figure 2. Density of open ditches and open inlets for the surface water (OISW) in drained areas.

During the research there was no special searching for the inlets of certain design; therefore, it can be stated that the data collected was random. Having summarized the results it was established that over 90% of inlets were of F–5 design. The inspection data on the inlets of this design are presented in Table 1.

Table 1

Dynamics of the technical condition of F–5 open inlets for the surface water (OISW) in the country's fields

Indicator of technical condition		1986	1996	2007
Lid	in place	64 / 0.889	102 / 0.816	72 / 0.857
	thrown down	8 / 0.111	17 / 0.136	10 / 0.119
	none	– / –	6 / 0.048	2 / 0.024
Location of OISW installation selected	well	68 / 0.944	119 / 0.952	80 / 0.952
	bad	4 / 0.056	6 / 0.048	4 / 0.048
Water inflow conditions	good	54 / 0.750	81 / 0.648	64 / 0.762
	bad	18 / 0.250	44 / 0.352	20 / 0.238
Inlet openings blocked with ground or covered with vegetation	clean	42 / 0.583	44 / 0.352	20 / 0.238
	50 % blocked	22 / 0.306	55 / 0.440	28 / 0.333
	completely blocked	8 / 0.111	26 / 0.208	36 / 0.429
Soil surface damaged by ploughing	yes	19 / 0.264	28 / 0.224	14 / 0.167
	no	53 / 0.736	97 / 0.776	70 / 0.833
Inlet damaged mechanically	yes	8 / 0.111	9 / 0.072	10 / 0.119
	no	64 / 0.889	116 / 0.928	74 / 0.881

Note. Number of observed inlets / frequency of indicator repetition.

According to the data of 2007 the inlets with lids in place made 85.7 %, the ones with thrown down lids made 11.9 % and the ones without lids at all – 2.4%. Before that (data of 1986 and 1996) the percentage of inlets of this design with thrown down lids and without lids was 11.1 and 18.4% respectively (Šaulys, 1999) and now it is 14.3%. This shows that the situation is nearly the same. The most common reason for lid throwing down is the operation of broad land cultivation machinery.

A tractor operator is not always to blame for damaging open inlets for the surface water during the land tillage. Often these land reclamation installations are difficult to notice as there are no columns marking spots of inlet installations or they are turned over on numerous occasions. The operators do not know the sites of installations, cannot see them; thus, the inlets are covered with soil or just damaged.

There are more numerous cases that the lids of F–5–1 design inlets are thrown down more often. Their lids are easier thrown down due to the design peculiarities as well (twofold, poorly attached).

Speaking about installation locations of open inlets for the surface water it can be stated, that they were not selected in the best way all the time. Four to six inlets from one hundred were installed in wrong locations. This indicator does not vary year by year. However, it is worthwhile mentioning that now the locations of open inlets for the surface water prepared now are most often selected incorrectly.

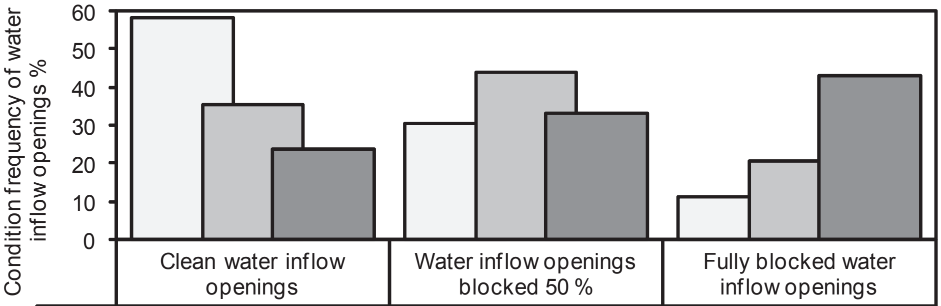
When the conditions of the water inflow to an inlet are poor, during spring melting or in summer after the rainfall the inlet surrounding area is dry and nearby pools of water can be observed. Such faults of installation can be seen quite often. In 2007 about 23.8% of such inlets were found – mainly in arable land. Previously badly managed soil surface near inlets F–5 made 25.0 (1986) and in 1996 it was 35.2% (Šaulys, 1999). Such frequency is related with the selection of installation location of an open inlet for the surface water.

As inlets prevent from performing land tillage operations, they are often installed near the edges of permanently tilled fields, i.e. not in the lowest spot of the surrounding area. In such cases flat sloped beds are shaped or the soil surface is formed in a way to facilitate surface water inflowing to an inlet without obstacles. When preparing drainage, good conditions for the water inflow to an inlet are created; the problem is that they worsen later under inappropriate tillage of drained land.

While inspecting, it was established that due to inappropriate ploughing, the conditions of the surface water inflow had been worsened in the case of 65% of inlets. In the case of nearly one third of inlets installed on the arable land the soil surface around was damaged by other tillage equipment. As yet only a small number of land users level down the soil surface around inlets: on numerous occasions people do not think about the way the surface water flows to an inlet.

The most common deformation of F–5 design inlets is silting of the water inflow openings with ground and overgrowing with vegetation. According to this failure inlets are divided into three groups: I – inlet water inflow openings are clean, II – water inflow openings are semi-blocked (50%) and III – openings are completely blocked. Having summed up the research results of 2007 (Fig. 3), it was established that in the case of 23.8% of inlets the water inflow openings were completely clean, 42.9% of inlets were found with completely blocked water inflow openings; the water inflow openings of the remaining 33.3% of inlets were half blocked.

The percentage of the inlets with completely blocked openings in the arable land was over 80% and in pastures – only 33%. The more numerous cases in pastures were the inlets with halfway blocked, mainly overgrown water inflow openings (56%). These figures prove that sediment traps perform their function. Each year during the spring flood and heavy rainfalls sediment is retained by them. When the sediment is not cleaned, turf is formed which reduces the size of the inlet water inflow openings as well as permeability.



	Clean water inflow openings	Water inflow openings blocked 50 %	Fully blocked water inflow openings
1986	58.4	30.4	11.2
1996	35.2	44.0	20.8
2007	23.8	33.3	42.9

Figure 3. Blockage variations of the inlet water inflow openings.

According to the data of 1986 F–5 design inlets with completely blocked water inflow openings made 11.1% and in 1996 the percentage was 20.8%. Now this failure can be observed more often (during the last decade it became double and in 2007 it was 42.9%). Thus, there is a clear increasing tendency of water inflow openings blocked with ground and overgrowing with vegetation and – which is really saddening – a clear decreasing tendency of inlets with clean water inflow openings. Whereas in 1986 such inlets accounted for more than a half (58.3%), today they make less than a quarter (23.8%).

Due to such a change of opening condition of the inlets, the water inflow openings of which are halfway blocked will soon become dead, if their sediment traps are not cleaned. It seemed that with the change of approach towards ownership farmers and members of agricultural companies will pay enough attention to the maintenance of inlets. However, although a lot of discussions have been carried out regarding the necessity to maintain and clean open inlets for the surface water, during the research period few cleaned inlets were found.

The data on mechanically damaged inlets show that the number of such failures is not decreasing (it is still over 10 %). If a tractor with agricultural machinery runs over inlets, inlet lids are thrown down or broken, a well ring is tumbled. Such inlets are difficult to repair; in many occasions they have to be installed anew.

The discharge of open inlet for the surface water Q is calculated by the formula:

$$Q = \mu_{PVN} A \sqrt{2gH_0} \tag{3}$$

here μ_{PVN} – discharge coefficient of an open inlet for the surface water;

A – area of drain for water draining;

H_0 – reduced pressure elevation – difference in water levels in front of and beyond the inlet having evaluated rate elevation.

Inlet experiments carried out in the stand of hydraulic investigations showed that discharge coefficients of inlets F–5 and F–5–1 were 0.66 and 0.67 (Fig. 4) respectively, when the diameter of the drain attached to the inlet was 150 mm. These discharge coefficients assess all inlets of a system – resistances at draining by a drain, when the inlet water inflow openings are clean (Rimkus and Šaulys, 1998). When the water inflow openings are halfway blocked, the discharge coefficient is lower respectively and when the water inflow openings are completely blocked, μ_{PVN} =0.

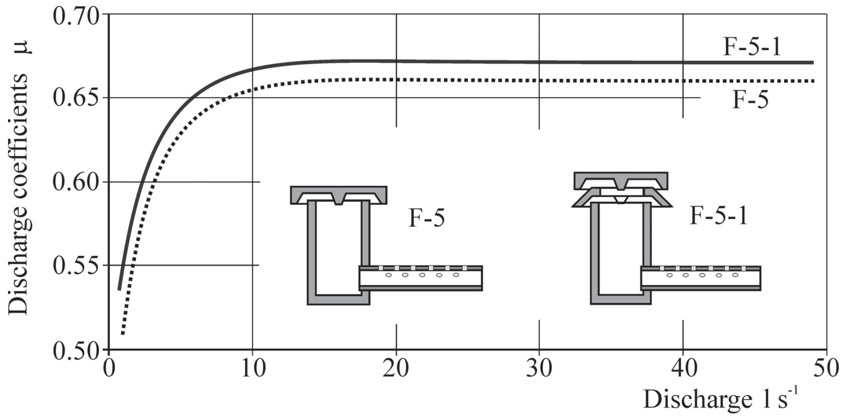


Figure 4. Discharge coefficients of water inlets F–5 and F–5–1 design.

The measurements of water inflow velocities carried out in the stand of hydraulic investigations showed that they did not exceed critical limits of washing rates, even if inlets could be installed on weak grounds in terms of washing. Velocity distribution diagrams according to depth near inlets F–5 and F–5–1 (Fig. 5) show that bottom velocities (measured at 8, 20 and 35 cm distance from the edge of inlet lid, when the maximum discharge is passed) do not exceed 10 cm s^{-1}. Therefore, paving with concrete slabs around an inlet is justified more in terms of maintenance (the ground precipitated in the sediment trap can be easier removed from concrete slabs) than ground washing.

The advantage of open inlets installed in drained areas over other means (blind inlets, multiplexed drain network, increasing permeability of drainage ditches) of draining surface water is the capability of open inlets to drain larger amounts of water accumulated in lower parts of the relief. Disadvantages include regular maintenance and contamination of main canals as the polluted water coming from drained areas pass into ditches, streams and lakes directly.

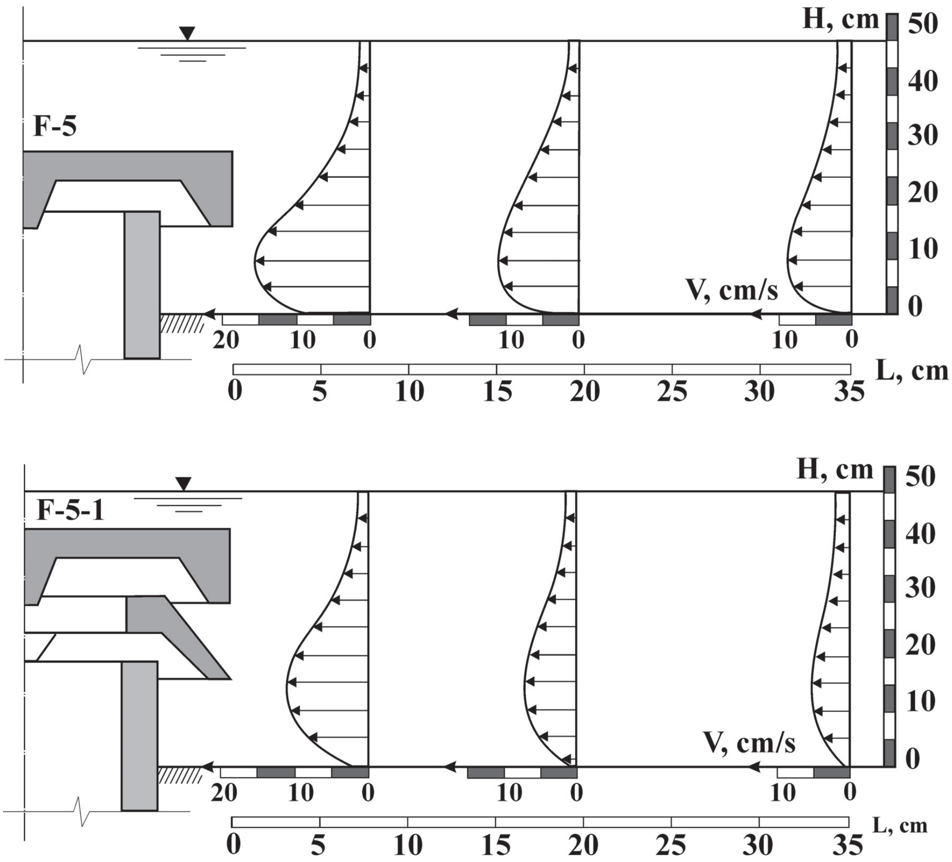


Figure 5. Velocity distribution diagrams according to the depth near inlets F–5 and F–5–1 design.

Contamination reduction measures could be the installation of bank protection strips of sufficient width or retention of the surface water runoff. When there is a close hollow of considerable size on drained land and it has to be tilled later in spring due to uneven area drying, this area would be better remained untouched instead of installing additional drainage means. In terms of environmental protection wetland would be more useful to set up in such a place; it would collect the surface water. A protection strip for water bodies could be set up around it; the strip would prevent biogenic materials and other pollutants from entering drainage as well as the main canal (Fig. 6). According to foreign scientists (Puustinen et al., 2001; Reinhardt et al., 2005) such artificial wetlands are an effective means to reduce nonpoint source pollution. According to the data by G.W. Raisin (1996) wetlands can retain up to 23% of nitrogen and 38% of phosphorus coming from the drained watershed.

In order to drain surplus water from a wetland an open inlet for the surface water should be installed. While planning such operations it is necessary to remember that tree roots can block drains; therefore, trees should be at least 10 m away from drainage lines or drainage lines should be made of imperforated plastic tubes.

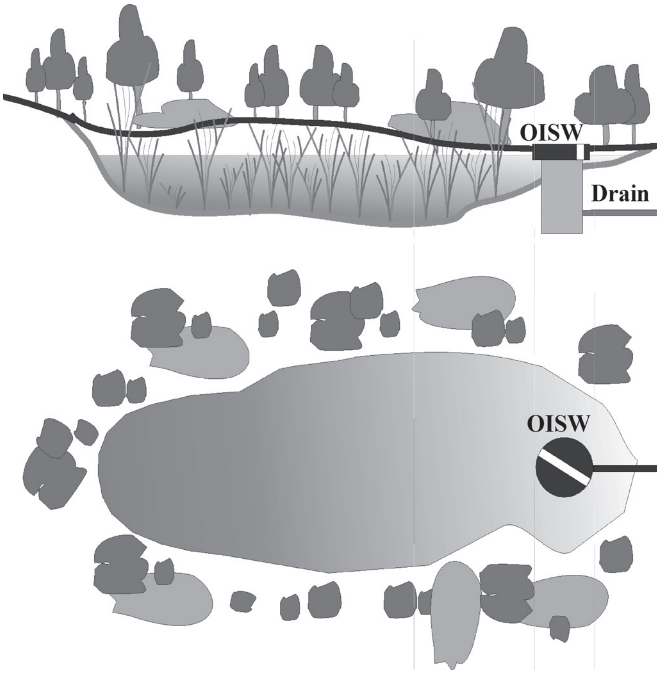


Figure 6. Scheme of wetland set up.

Today the works of maintenance, repair or reconstruction of open inlets for the surface water within a land parcel are organized and financed by the landowner. We would like to believe that now, when the Melioration Law legitimized private ownership of land reclamation facilities (all land reclamation facilities belong to a land parcel and are in the ownership of the parcel owner), farmers will pay appropriate attention towards the maintenance of open inlets for the surface water to avoid expensive repair works of both inlets and systems of drainage.

Conclusions

1. In order to maintain sufficient drainage efficiency while draining surface water from drained fields, the decrease in the density of open ditches (down to 20.3 m ha^{-1}) determined the increase in the density of open inlets for the surface water up to 5.5 u 100 ha^{-1}.
2. During the research period (1986, 1996 and 2007) the number of inlets of good technical condition (with lids of good condition in place) was 88.9, 81.6 and 85.7% respectively. There was a clear increasing tendency of water inflow openings in these inlets blocked with ground and overgrowing with vegetation. The number of inlets with completely blocked water inflow openings made 11.1% in 1986, 20.8% in 1996 and in 2007 it was already 42.9%. The data of mechanically damaged inlets show that the number of such failures is not decreasing (it is still over 10%).
3. Polluted water coming from drained areas passes directly into ditches, streams and lakes via water inlets; therefore, contamination reduction measures could provide installation of bank protection strips of required width or retention of surface water runoff by setting up wetlands.

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IMPACT OF ANGIRIAI HYDRO - POWER STATION ON THE ECOSYSTEM OF THE RIVER ŠUŠVĖ

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Abstract

After a 16-m high dam was constructed and a 297-ha pond was arranged in the river Šušvė nearby Angiriai in 1980, the previous natural flow regime of the river has changed: 15500000 m^3 of water accumulated above the dam is not discharged via a natural bed, but through two 1.5x1.5 m bottom orifices, and flood discharges (up to $Q_{1\%}$ = 296 $m^3 s^{-1}$) are directed into the lower reach through a 16-m high shaft spillway of floods. Such arrangement of the Angiriai dam ensured it to become an essential obstacle for migrating fish. In 2000, after the arrangement and operation of Angiriai hydro-electric power station, the water regime downstream the dam has been changed and new hydrological pulses as well as ecosystem biodiversity are to be adapted. Thus, the operation of Angiriai HPS on the river Šušvė generating hydroelectric power can have adverse effect on the river habitats and hydro ecological connectivity. To evaluate the effect, the eco-hydraulic water regime measurements in 2005 in a lower stretch with and without turbines operating were made. The study results showed that artificial water levels fluctuation (≈ 4 m hr^{-1}) induced by Angiriai hydro-electric power station as well as the discharge flowing through the bottom orifices due to high velocities (13–14 m s^{-1}) and temperature differences could create stressful situations for young fish in the lower bank.

According to the data of soil texture of the Šušvė river, the bed armoring process is going on below the Angiriai HPS is quasi-stable and no impact of HPS operation is found.

Key words: river below the dam, artificial hydro pikes, impact on ecosystems.

Introduction

The hydro-electric power station located on the river Šušvė is a typical example of the operation of small and mid-sized HPS in the plains of Middle Lithuania. After a 16-m high dam was constructed and a 297-ha pond was arranged in the river Šušvė nearby Angiriai in 1980, the previous natural flow regime of the river has been changed: a 15500000 m^3 pond has been formed, from which the water is discharged into the lower bank not by a natural bed, but through a 16-m high shaft flood spillway arranged in the pond. During the flood this spillway is able to release a flood discharge of $Q_{1\%}$ = 296 $m^3 s^{-1}$, which means that the highest water levels and flow discharges have not changed. However, the transforming effect of the turbines may be significant for the lowest river discharges and velocities of the dry period of the year when the water may flow into the lower stretch only through two 1.5x1.5 m orifices and the environment protection discharge (0.340 $m^3 s^{-1}$) is taken from the bottom of the pond. According to S.J. Peake (2004), critical swimming speeds of a small mount bass (Micropterus dolomieu) range from 65 to 98 cm s^{-1} and are positively correlated to fish length. The investigations of the habitat density distribution in the Austria river Drau show that about 80% of fish select water flow velocities 0.2 – 0.5 m s^{-1} and the depth till 0.5 m. Spanish researchers (Alonso-Gonzalez et al., 2004) have determined that frequent unnatural floods occurring during the incubation period may significantly reduce the amount of young fish. (Spina, 2001). Frequent artificial floods may also result in a negative effect to aquatic vegetation (phytoplankton). However, a contrary effect is also possible, when the flood water improves the conditions for the fish spawn survival in reed in drought. Other researchers (Bustamante et al., 2004) confirm that low dams (up to 3-m high) make no negative effect on the development of macrophytes and the movement of plankton, although higher N concentrations have been observed in small ponds, and comparatively short residence time of nutrients does not ensure favorable conditions for denitrifying bacteria. Speaking about medium or large dams (h>10 m), their effect is significant – large ponds act as bioreactors transforming nutrients into the plankton mass, and results in more stratified less oxygen saturated and colder water outflow from bottom orifices of such dams (Navarro et al., 2004). Changes in the hydraulic regime also affect the development and spread of mollusca and larvae populations, as well as the distribution of algae mass and growth of macrophytes (Medvedeva, 2004; Breugnot et al., 2004; Franklin et al., 2004). The erection of a dam on a river and an increment of water depth in the pool cause the decrement of water velocity and increased sedimentation of sand and silt there. Dams of hydroelectric power stations (HPS) can change significantly the connection and existence conditions of ecosystems (Alonso-Gonzalez et al., 2004). As the researcher G. Sabas has concluded (2005), rapid water level fluctuation pulse below the dams of Lithuanian HPS significantly effect on the natural regime of rivers and must be regulated in respect of standards of Lithuanian ecosystem (0.2 m h^{-1}). Recent research, however, suggests that fish react to locally environmental factors that operate at a fine-scale (Kemp et al., 2004). The direct observation of their behavior revealed that individuals elicit strong avoidance when they encounter areas where hydraulic conditions change rapidly.

On the basis of the data obtained, a hypothesis has been made that artificial flooding due to the operation of HP station can create a stressful situation for aquatic ecosystems of the Šušvė during the dry period in lower reaches of the river. The objective of the study was to evaluate the impact of the operation of turbines on the existing conditions of ecosystems of the river Šušvė below the Angiriai dam during the dry period of the year.

Materials and Methods

To evaluate the effect of Angiriai dam on the eco-hydraulic water regime of the river Šušvė, water flow velocities were measured and the environment protection discharge was calculated in three profiles of the lower reach during the dry period of the year on 14 July of 2005 (Figure 1).

Figure 1. Location of study places below Angiriai dam in the river Šušvė:
① In the pond; ② 300 m below the dam; ③ 1500 m below the dam; ④ 3000 m below the dam

Measurements of water flow were made with the help of a micro-propeller flow meter with micro-computer calculation system. Moreover, samples of water and bottom bed-armored soil were also taken; their turbidity, the oxygen saturation degree, grain-size composition of river bed, water temperature regime and nutrient ($N\text{-}NO_3$, P, O_2) pollution were determined under the laboratory conditions. Concentrations were determined by the spectrometric method, using an FIA star 5012 analyzer, according to the water quality investigation standards (LST EN ISO 13395:2000; LAND 38:2000). Measurements were replicated having started operating one turbine with the nominal power of 500 kW (discharge 5.5 $m^3 s^{-1}$). The material and data of previous investigations were also analyzed (Vaikasas and Poškus, 2006)

Results and Discussion

During the investigations the stones of the bottom were covered with algae film saturated with nutrients. With minimal discharges, water visually seemed to be clean; a 2.0–2.5-m wide flow was meandering at the depth of 0.3–0.5 m. In some places the flow developed till the whole width of the riverbed. Changing flow velocities depended on barriers of vegetation (rushes) and large stone islets (0.3–0.4 m). Below the dam, banks of the river Šušvė were overgrown with willows and bushes. However, a 100–200 m long strip of the bank situated below the dam is less overgrown with vegetation due to a continuous gradient fluctuation; therefore, there were almost no shadows on the riverbed. As the determined runoff modules of September and October of 2002 show that the river discharge below Angiriai was not lower than the environmental discharge – 340 l s^{-1} (Pauliukevičius, 2004).

During the dry period of the year on 14 July of 2005 in the upper part of the pond extreme measured water temperature was 27.5 °C, i.e. it exceeded the air temperature (t_{air} = 25.5 °C). Slopes of the pond in the upper bank of HPS were also overgrown with bushes and rushes, and smaller than 0.01 mm particles (clay and silt) made up even 97.8% in the soil of the bottom. As one can see, these are typical examples of the bed of the pond and a lower bank. No erosion of slopes was detected in the pond.

Considering the environment protection requirements, the intensity of the water level lowering should not exceed 0.2 m per day in the pond. But below the Angiriai dam the intensity of fluctuation significantly exceeded the 0.2 m value (Figure 2).

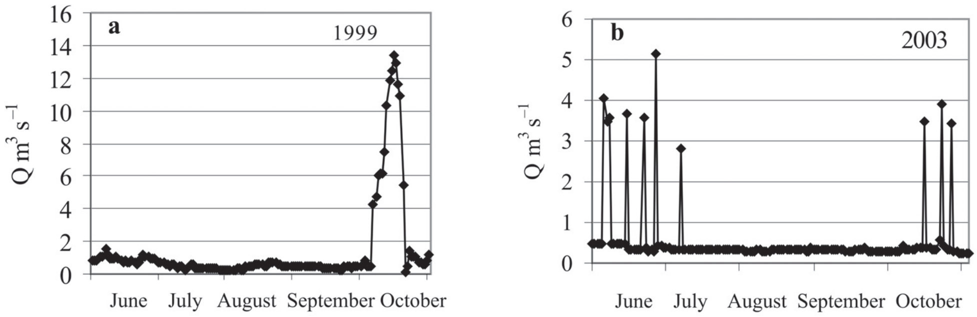

Figure 2. Everyday discharges at Josvainiai water measurement post before (a) and after (b) the construction of hydro-electric power station in 2003.

These sudden and frequent fluctuations of runoff indices may have a negative effect on the ecological conditions of the coast. However, although the fluctuations are more intensive during the cold period of the year, their negative effect on the ecosystems of coasts is less significant. This is because the vitality is less active in winter. Those are the reasons why the stress experienced by the ecosystems in summer is more influential (Kesminas and Virbickis, 1999).

The changes of everyday discharges due to the HP station may also be evaluated having compared the discharges of different years (Fig. 3). As one can see, after the construction of the Angiriai dam in 1980 the spring peak discharges of the Šušvė decrease on 25-30 %.

Having started operating the hydroelectric power station, periods of the smallest discharges from the pond became longer (Figure 4). Longer duration of small discharges ensures more intensive growth of macrophytes.

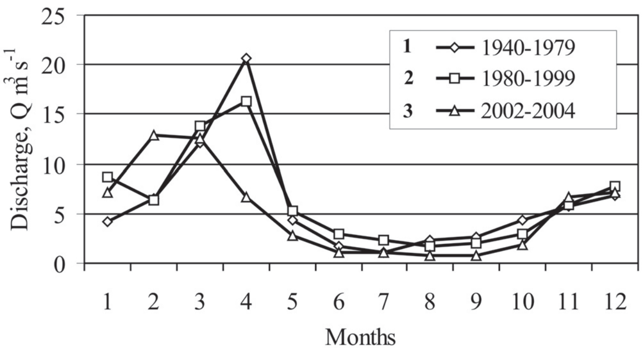

Figure 3. Data of annual hydrograph in Josvainiai post (before the construction of Angiriai dam (1) after the construction of Angiriai dam (2) and during the operation of hydro-electric power station) (3).

However, there is no data available about the overgrowth of the bed before the construction of the electric power station.

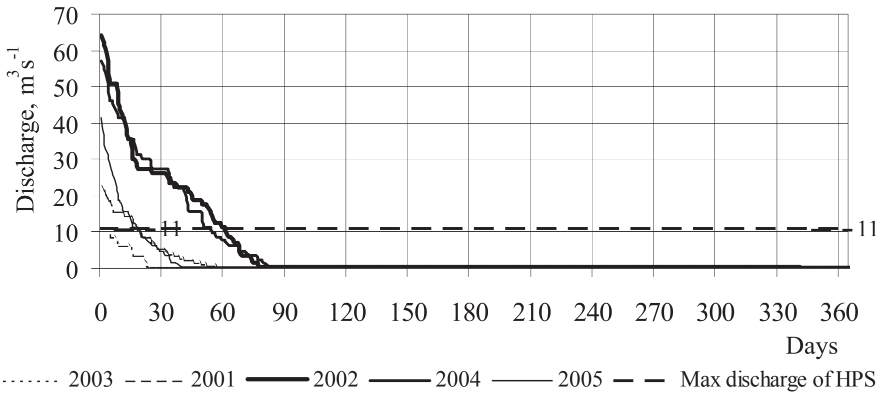

Figure 4. Duration of discharges released through the shaft spillway of the dam in different years.

The smallest discharge and velocities distribution during the dry period was measured in 2005 in 3 bed cross-section profiles at 200 m and 300 m below the dam. In all profiles the water depth did not reach 30 cm during the measurement, and the water flow did not occupy the whole width of the bed. The distribution of flow velocities differs significantly from the shape of the cross-section; actually, it depends on the grass cover of the bed.

After the hydroelectric power station is turned on, the discharge suddenly increases from the measured minimal 372 $l\ s^{-1}$ to 5800 $l\ s^{-1}$ (when one aggregate is operated) or even to 10800 $l\ s^{-1}$. Water at 200 m below the dam (at profile 1 of minimal discharge measurements) rose by 0.7 m on the average, and maximal flow velocity increased from 0.36 to 0.98 $m\ s^{-1}$. During the artificial flood induced by the hydroelectric power station water level rose by 0.45–0.7 m within 5–10 minutes, and the highest flow velocities increased up to 0.6–0.85 $m\ s^{-1}$ at the coast and 0.93–0.98 $m\ s^{-1}$ in the middle of the river channel. Therefore, particularly during summer and autumn months when the base flow varies around 0.35 $m^3\ s^{-1}$, the riparian areas of river are severely affected by continuous water pressure and flow velocity fluctuations.

The intensity of the water level fluctuation was 4.2 $m\ h^{-1}$. It is the largest intensity of the measured fluctuation compared with other Lithuanian HPS (Sabas, 2005). Values of velocities distributed more evenly, water inundated shallow places and lay down the macrophytes. Visually, water became more turbid and similar to the floodwater. Turbulence of water released from the turbine into the retention pond also increased, which resulted in higher concentrations of dissolved oxygen (11.78 mg l^{-1}). It showed that the flow discharges and velocity fluctuations due to the electric power station action are significant and similar to velocities caused by storms and spring floods.

During the measurements, the average $N\text{-}NO_3$ concentration on the surface of Angiriai pond was 3.4 mg l^{-1}. Bottom orifices are arranged in the lowest silt spot; therefore, the released ground water contained larger amounts of nutrients $N\text{-}NO_3$ concentration reached 4.2–4.9 mg l^{-1} below the dam. However, in the reach of the river near Josvainiai, at 4 km from the dam $N\text{-}NO_3$ concentration decreased and was only 3–3.7 mg l^{-1}.

During the investigations the bed of the lower bank and fish community was observed visually. Despite the favorable conditions, no units of fish were observed below the dam in 14 July of 2005. On the contrary, in 2000, i.e. 5 years ago, an ecologists V. Kesminas and T. Virbickis (1999) found a lot individuals and biomass of fish in the lower bay of Angiriai.

It was determined that a rather stable 0.10-0.15 m deep layer of stones (diameter – 1.2–1.4 cm) was formed on the sandy bottom. This was also confirmed by the data of the analysis of the soil mechanical composition – sand particles make up to 28.2–97.1% here. According to the grain-size composition, the bed armoring process below the dam of HPS Angiriai is going on.

Particularly significant differences were observed between the temperatures of flowing water: on the surface of the pond water temperature was 27.5 °C, while the temperature of the water flowing from bed orifices reached only 13.5 °C. Differences in temperatures were also observed in water flowing 0.5–1.0 km below the dam – it was 15.3–15.6 °C, and only at 4 km from Josvainiai the temperature of the surface water reached 24.5 °C. Amounts of oxygen O_2 dissolved in water were: in the pond - 9.2 mg l^{-1}, below the dam - 8.67–10.52 mg l^{-1}

Having suddenly turned on one turbine of the hydro-electric power station, the flow discharge increased from 0.37 to 5.8 $m^3\ s^{-1}$, which resulted in the increased turbulence of water and increased O_2 amounts (up to

11.23–11.78 mg l^{-1}). The temperature of stream water became 25–25.5 °C. This implies that warmer water from the surface layers of the pond was released.

Conclusions

Artificial floods induced by the Angiriai HPS operation during the dry period of the year is the main reason creating stressful situations for younger fish and invertebrates in the lower bay. This is due to the following facts: in summer the environment protection discharge released through the bed orifices is distinct for low temperatures and increased biogenic pollution; when the turbines are activated the flow velocities and water levels increase suddenly. Angiriai HPS hidropiking water levels fluctuation speed is 400 cm h^{-1}, which is about 100 times more than natural water level fluctuation during the natural excessive rain fall or flood. In the lower bank the velocities suddenly increase till 0.98-1.1m s^{-1}, and it is more than the acceptable critical swimming speed for juveniles. However, the highest flow velocities may reach even 13-14 m s^{-1} (in the orifices). Small fish caught by such flow is carried to the lower stretch where it experiences stress. In the present situation the artificial floods induced by the turbines can be mitigated, by prolonging the starting time of turbines and choose the turbines to enable operation through out the year (Zdankus and Sabas, 2005; Rintamaki, 2001). According to the data of the Šušvė river soil texture, the bed armoring process is still going on below the Angiriai HPS. No visible impact of HPS operation on this process is found.

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SEASONAL NITROGEN LEACHING FROM FIELDS APPLIED BY SLURRY

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Abstract

The article analyses the seasonal nitrogen variation in drainage water, when the plants in the field crop rotation are fertilized with slurry during different seasons. The investigations were carried out in 2001-2003 in Juodkiškis experimental site of the Lithuanian Water Management Institute.

The investigations established that the largest amounts of nitrogen are leached out in spring and in winter. In the autumn fertilized variant 38.8% more of this element was leached out in winter and spring compared with the variant fertilized in spring. During autumn nitrogen leaching was also 21% higher from the variant fertilized in autumn.

It was established that the fertilization rate and dissolved inorganic nitrogen (DIN) supply in soil have influence on the concentrations of this element. During the cold season nitrogen concentrations in drainage water, when plants had been fertilized with slurry in spring, were more affected by the supply of dissolved inorganic nitrogen in soil more compared with the rate of fertilization; and if fertilization had been performed in autumn – the concentrations were more affected by the fertilization rate. In warm season both the fertilization rate and the supply of dissolved inorganic nitrogen in soil had similar influence on the concentrations of nitrogen in the drainage water in both treatments.

Meteorological conditions affect nitrogen leaching a lot. During the cold season a greater amount of nitrogen is leached out when the air temperature is higher and during the warm season – when more precipitation falls.

Key words: concentration, drainage water, nitrogen, seasonal leaching.

Introduction

Nutrient leaching is typical for all Baltic states of oceanic climate, including Lithuania. In Lithuania, the main source of nutrient input into the Baltic Sea is the river Nemunas and its smaller tributaries. As it was determined, the largest amounts of mineral nutrients enter the sea in winter, while in summer the inflowing amounts of the elements are significantly less. The second largest values of inorganic nitrogen due to the effect of the flood water were observed in spring (Dubra et al., 1999). During the later research it was established that in Lithuania the largest amounts of mineral nitrogen were transported during autumn-winter season. 51.7% of the annual flow amount on average were transported in the rivers of Southern Lithuania, 51.9% – in the rivers of Central Lithuania and 65.4% – in the rivers of Western Lithuania (Bagdžiūnaitė – Litvinaitienė, 2005).

In Lithuania there are quite favorable conditions for the development of cattle-breeding, including favorable natural conditions, sufficient forage resources, deep traditions and long-term experience of cattle breeding activities and well-developed meat producing industry. Therefore in the future, dairy and meat-processing industries will remain the principle direction of cattle-breeding activities in Lithuania. Specialized and concentrated cattle-breeding industry, well-developed technologies of industrial cattle keeping often result in the increased amounts of slurry. Consequently, accumulating large amounts of slurry may cause the problem of its accurate handling so that no adverse effect would be made on the environment.

One of the most advanced ways of slurry handling is to apply it on fields as a fertilizer. However, the application process of organic and inorganic fertilizers on agricultural fields is not always sustainable enough due to the ignorance of fertilization rates and time. Nitrogen is a particularly labile chemical element; therefore, it may be easily leached into the environment, which on its turn may result in the increased pollution of water in wells, rivers and lakes up to lethal concentrations as well as in the intensive overgrowth of various water bodies (Rutkovienė et al., 1997). In Lithuania the water in more than 1/3 of all shaft wells is polluted with nitrates the concentration of which is sometimes 100 times higher than nitrate concentrations contained in drainage water outflow from agricultural fields (Šileika, 2001).

The Marine Research Center of the Ministry of Environment of Lithuania has determined a rather high eutrophication level in the Curonian Lagoon (Olenina, 1998). As the researches carried out at the Lithuanian Institute of Water Management have shown, recently the agricultural production processes and the usage of different fertilizers has been significantly reduced; however, the pollution of water in most rivers has still increased (Šileika, 2000 b).

Worse quality of drainage water is observed in the territories of intensive agricultural activities (Jordan et al., 1997). In the territories with large areas of woods and less intensive agricultural activity, N leaching is on the average 5.6 kg ha^{-1} per year, while in the fields with intensive farming the leached amounts of N are 2.5 times higher (Dumbrauskas and Tumas, 1994).

In 2000, intensive N fertilization resulted in 16 kg ha^{-1} of N leached in the Graisupis river basin in the Middle Lithuania Plain, which 2.6 times more than in the Vardas river basin in the Baltic Highland region and even 4 times more than in the Lyžena river basin in the Žemaičiai Highland (Kutra and Račkauskaitė, 2001). Due to intensive farming activity the average annual 14.4 kg ha^{-1} N leaching in the streams of Middle Lithuanian Plain mostly depended on high nitrogen concentrations (5.9 mg l^{-1}) (Gaigalis and Račkauskaitė, 2001).

In order to reduce the eutrophication in the Curonian Lagoon, the Government of the Republic of Lithuania has approved several important documents: the Code of Good Agriculture (according to this document, nitrate pollution is to be reduced and the annual amount of slurry applied on fields in each farm should not exceed 170 kg N for 1 ha of agricultural land (Šileika, 2000 a); the Program of water protection against the pollution with N-compounds from agriculture; National Sustainable Development Strategies (this document commits Lithuania to the reduced environmental pollution until the year 2020 so that the allowable normative requirements approved by the European Union would be followed (Lietuvos…, 2003).

To reduce N leaching from the fields where slurry is applied, researchers of foreign countries suggest applying slurry in spring and having intermediate crops cultivated (Skyggeson et al., 1990; Tortensson and Aronsson, 1998; Durkowski and Wesolowski, 1990).

The objective of the studies was to determine the changes of nitrogen amount contained in drainage water in different seasons of the year.

Materials and Methods

In 2001-2003, the investigations were carried out in Juodkiškis study object of Water Management Institute of Lithuanian University of Agriculture.

The experimental scheme comprises treatments I - II in three replications (Fig. 1).

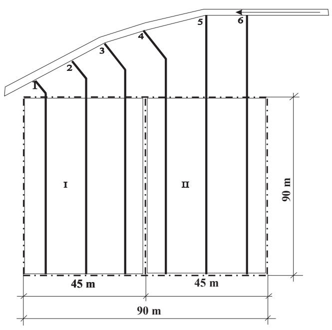

Figure 1. Experimental scheme:
treatment I – slurry applied in spring; treatment II – slurry applied in autumn;1 – 6 – number of drainage outlet.

The area of the study object (0.81 ha) is drained with drainage, drain spacing is 15 m, draining depth is 1.2 m. Three replications of each treatment are arranged on separate drains. In-between two adjacent drains there are polythene screens arranged in order to separate one drain from the other and avoid nutrient leaching from one drainage system into the other. Each separate drainage system covers the area of 0.135 ha.

The following crops were grown in the test field:

1. Red clover, 2nd year (slurry in spring $N_{88}P_{43}K_{97}$ and slurry in autumn $N_{60}P_{20}K_{63}$);
2. Sugar beet (slurry in spring $N_{190}P_{76}K_{271}$ and slurry in autumn $N_{206}P_{73}K_{206}$);
3. Spring rape (slurry in spring $N_{75}P_{32}K_{98}$ and slurry in autumn $N_{60}P_{80}K_{20}$).

Soil grain-size composition was determined by Kačinskis pipette method. The soil of the study object is calcareous gley brown soil (RDg4-k2) (Buivydaitė et al., 2001). According to the grain-size composition the soil is attributed to sandy loam soils. In treatments I and II sandy loam soils are prevailing.

The soil is of alkaline reaction (pH>7), low in humus content (on the average 18.2-19.0 g kg^{-1} of humus in the arable layer), contains low nitrogen concentrations (36 kg ha^{-1} dissolved inorganic nitrogen (DIN) at a 0-40 cm deep layer).

Soil samples for agrochemical investigations were taken from 0-40 – cm deep soil layers after the harvest of background crops in autumn, before the sowing time in spring, and after the total harvest in autumn. Plant available nutrients contained in the soil were determined by the following methods: ammonia nitrogen ($N-NH_4$) – colorimetric with Nesler reagent in KCl extract; Nitrate nitrogen ($N-NO_3$) – potentiometric with selective electrode, soil reaction – potenciometric with glass electrode in KCl extract, humus was studied by Tiurin's method.

Samples for the determination of drainage water chemical composition were taken once a month. N_{total} of water samples was determined according to methods approved by the Ministry of Environment of Lithuania (Unifikuoti…, 1994) – photocolometric with analyser 'FIA star 5012' system.

The drainage runoff was measured every five days. During the periods of spring and autumn floods, the runoff measurements were taken every day in a volumetric way. Discharges were calculated on the basis of linear interpolation, drainage runoff heights were estimated according to everyday discharges.

Results and Discussion

The average air temperature during every year's seasons was higher than the perennial one except for the autumn of 2002 and winter of 2002-2003, when it was lower by 1.1 and 1.9 °C. Precipitation distributed very unevenly during the year. Precipitation exceeded the perennial rate in the winter of 2000-2001 (105%) in the spring, summer and autumn of 2001, the winter of 2001-2002 and the autumn of 2002 – it was 108, 120, 115 and 141, and 103% respectively. Precipitation was lower compared to the perennial rate in the spring and summer of 2002, the winter of 2002-2003, and the spring and summer of 2003 – it was 56, 59 and 54, 57 and 88% respectively (Table 1).

Table 1

Meteorological Conditions of the Study Periods

Study year	Study season	Indicies			
		Precipitation, mm	% from perennial rate	Average air temperature, °C	Deviation from perennial rate
2000-2001	Winter (XII-II)	108.1	105	-0.8	3.4
	Spring (III-V)	145.3	108	7.0	1.3
	Summer (VI-VIII)	239.5	120	17.6	1.2
	Autumn (IX-XI)	176.6	115	7.6	0.8
2001-2002	Winter (XII-II)	145.1	141	-1.7	2.5
	Spring (III-V)	75.9	56	8.7	3.0
	Summer (VI-VIII)	117.1	59	20.6	4.2
	Autumn (IX-XI)	158.0	103	5.7	-1.1
2002-2003	Winter (XII-II)	55.3	54	-6.1	-1.9
	Spring (III-V)	76.6	57	6.6	0.9
	Summer (VI-VIII)	176.0	88	17.8	1.4

During the research period in cold season there were 468.1 mm of precipitation and the average air temperature was –1.4 °C. On average 208.7 mm of water went down the drains, i.e. 44.6% of the precipitation amount. During the warm season there were 46.6% more precipitation (1005.4 mm) and the average air temperature was 14.1 °C. During this period only 3% of the fallen precipitation went down the drainage.

Data of drainage runoff distribution in different seasons of the year is presented in Figure 2.

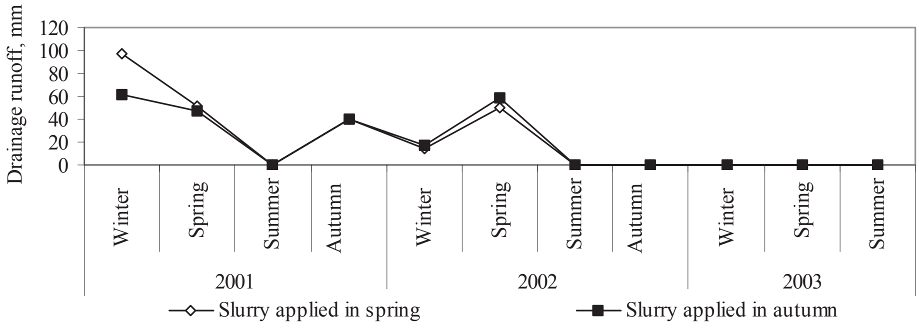

Figure 2. Drainage runoff distribution (mm) in different seasons of the year.

The highest concentrations of total nitrogen were recorded in the spring of 2002: in the treatment I fertilized with slurry in spring it was 31.9 and in the treatment II fertilized in autumn it was 35.8 mg l^{-1} (Fig. 3).

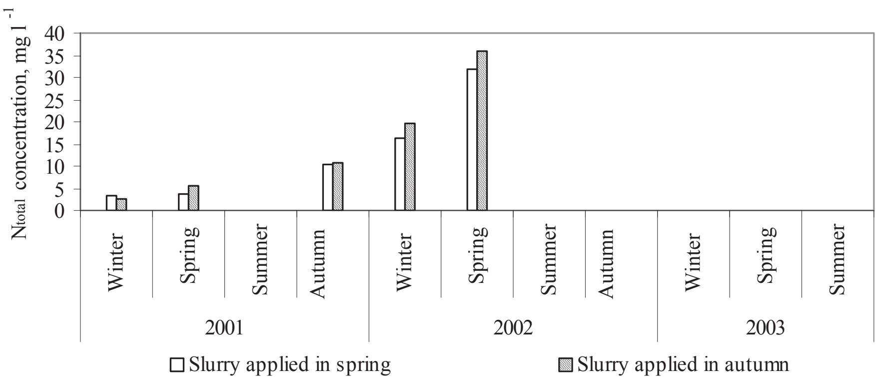

Figure 3. Fluctuations N_{total} concentrations in drainage water (mg l^{-1}).

In 2001, the drainage runoff lasted for three seasons: winter, spring and autumn. Nitrogen concentrations in the drainage water were not high in both treatments due to growing red clover which used it to grow green mass. In the treatment I fertilized with slurry in spring the concentrations in winter were 3.4, in spring – 3.6 and in autumn – 10.3 mg l^{-1}. In the treatment II fertilized with slurry in autumn they were 2.7, 5.5 and 10.9 mg l^{-1} respectively. Though nitrogen concentrations were lower than maximum permissible concentration (MPC), however, in autumn after the clover had been ploughed the concentrations of this element increased notably, and during the winter season of 2001-2002 they were already 16.3 and 19.6 mg l^{-1} respectively. In the spring of 2002 (March – May) with slurry spring fertilization it was 31.9 and with autumn fertilization it was 35.8 mg l^{-1}. It could be explained by the fact that nitrification processes in the soil are quite intensive, when air temperature is slightly positive (Tripolskaja, 2005).

The research established that the increase of nitrogen concentrations in the drainage water depended much on a fertilization rate and the supply of dissolved inorganic nitrogen in soil. The impact of fertilization rates with slurry and the supply of dissolved inorganic nitrogen on the quality of drainage water is proved by the dependence between fertilization rates per year (x), the supply of dissolved inorganic nitrogen in the soil (y) and the concentrations of this element in the drainage water (z) (Table 2).

Table 2

Dependence of Nitrogen Concentrations in Drainage Water on Fertilization Rates and Mineral Nitrogen Content in the Soil

Cold period of the year (XI - III months)					Warm period of the year (IV - X months)				
Form of relation	R^2	n	F_{actual}	$F_{theor95\%}$	Form of relation	R^2	n	F_{actual}	$F_{theor95\%}$
Treatment I									
z =4.39-0.11x+0.16y	0.76*	8	8.1	4.7	z =-22.10+0.28x+0.02y	0.98*	4	35.2	19.2
Treatment II									
z =-5.02+0.15x-0.05y	0.77*	7	8.5	4.7	z =-12.32+0.21x+0.10y	0.98*	4	35.8	19.2

Note. Correlation connection values reliable according to the criterion F (F_{actual}>$F_{theor95\%}$) are signed with stars.

In cold season N_{total} concentrations in the drainage water in the treatment I fertilized with slurry in spring were determined by the amount of dissolved inorganic nitrogen in soil (r=0.74) and in the treatment II fertilized with slurry in autumn – by fertilization rate (r=0.72). In warm season in both variants the concentrations were more determined by the fertilization rate – r=0.99 and r=0.98 respectively; however, the supply of dissolved inorganic nitrogen in the soil had also considerable importance – r=0.59 and r=0.85 respectively.

The largest amounts of nitrogen are transferred from the crop rotation fields into drainage in winter and spring (Fig. 4.).

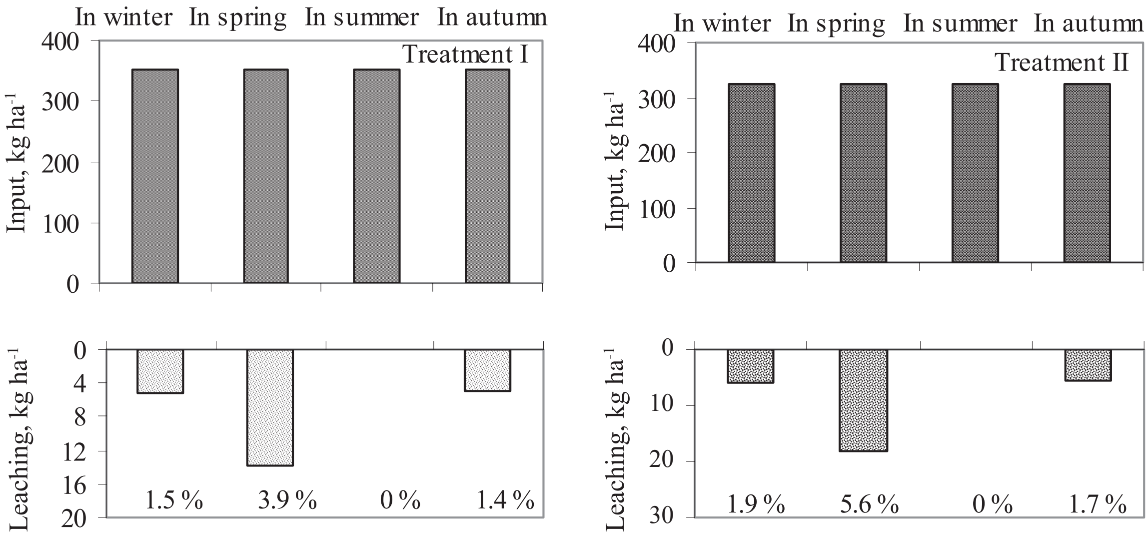

Figure 4. Seasonal variation of nitrogen leaching amounts.

Of all the amount of nitrogen applied with manure 1.5% of nitrogen from the treatment I and 1.9% from the treatment II were leached in winter. The largest amounts of this element were leached out in spring – 3.9% from the treatment I and 5.6% from the treatment II. In summer without the drainage runoff there was no nitrogen leaching. In autumn the following nitrogen leaching was recorded: 1.4% from the treatment I and 1.7% from the treatment II of all nitrogen amount applied with slurry.

Seasonal nitrogen variations mainly depend on meteorological conditions. As it was established, the highest leaching is usually recorded at the start of drainage operations and during the spring flood. As 2001 was a rainier year than usual, due to the drainage runoff nitrogen was leached in autumn as well.

The binary correlation analysis established that the nitrogen leaching is heavily influenced by meteorological conditions. The largest N_{total} amounts are leached out during the cold season, when the air temperature is positive, and in the warm season – at more abundant precipitation.

Conclusions

1. The largest nitrogen amounts are leached out in spring (treatment I – 3.9%, II – 5.6%) and winter (treatment I – 1.5%, II – 1.9%). In autumn the leaching of this element is slightly less compared with winter – 1.4 and 1.7% respectively of the nitrogen amount applied with slurry.
2. During the cold season, when plants had been fertilized with slurry in spring, the nitrogen concentrations in the drainage water depended more on higher amount of dissolved inorganic nitrogen in the soil and if the fertilization with slurry had been performed in autumn – on the fertilization rate. In the warm season both the fertilization rate and the supply of dissolved inorganic nitrogen in the soil had similar influence on the nitrogen concentrations in the drainage water in both treatments.
3. In the cold season more N_{total} is leached out when the air temperature is higher and in the warm season – at higher rates of precipitation.

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RESEARCH OF LIQUID SLURRY PROCESSING IN PIG COMPLEX

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Abstract

The traditional way of dealing with manure - storage, transportation, spreading in the fields - is currently applied very successfully, but is economically very expensive. People complain about very unpleasant smells, which are caused by gasses (indole, merkaptanas, hydrogen sulphide, ammonia) being released from the manure. Scientists are searching for other ways of handling manure which try to convert it to less harmful substances, reduce its odour and at the same time make it thicker by extracting its water content.

The aim of our work was to evaluate the composition of slurry after processing it mechanically, and to test the effectiveness of the application of new coagulants and flocculants on its clarification.

Fresh liquid manure from 'Sajas' pig complex (Kelmė district) and the liquid manure treated in biogas reactors from Lekėčiai pig complex (Šakiai district) was used for research (2006-2008).

Anionic coagulants such as aluminium chloride (Al_2Cl), ferrous chloride (Fe_2Cl) and pollycrilamide cationic flocculant 'Magnofloc 1011' were applied to clarify manure.

40-44% of organic pollutants can be removed from the aerated sewage under constant processing by coagulants and flocculants. The best result in pollutant removal from sewage is achieved when it is processed with 1.5 kg m^{-3} norm of aluminium saline (AlCl) and 3.0 g m^{-3} norm of flocculant 'Magnofloc 1011'.

Key words: slurry, coagulants, flocculants, pollutants, wastewater.

Introduction

Animal husbandry enterprise produces a side product – manure. Environmentally, this product is considered as waste improving soil features.

Traditional manure management – collection, transportation and application in fields is rather successful today, however, economically it is quite expensive and besides it often causes complaints by inhabitants due to unpleasant odours which are generated by manure produced gases – indole, mercaptan, sulphuretted hydrogen and ammonia.

Researchers are looking for the ways to process manure in order to decontaminate it and reduce odours as well as to solidify manure by removing water out of it.

Researchers J.Beck and C.Burton (Beck and Burton, 1998) analysed all manure processing technologies that are recently used in the European Union. They include: mechanical separation, centrifuging, aerating, anaerobic lagoons (long-term 4-5 year storages); anaerobic mesophyllic fermentation; anaerobic thermophilic fermentation; treatment with acids; dilution; draining-evaporation; osmosis.

All these technologies differ in treatment efficiency and cost. The lowest manure treatment cost is achieved when manure is separated mechanically, treated with acids and diluted with water, and the highest cost is achieved when liquid manure is evaporated.

In Russian military and civil ships human excrements are collected from toilets and processed into solid mass and sewage by using inductive turbulent devices. With the help of these devices liquid organic materials are dispersed and organic colloids separate from water easier (spontaneous separation).

In 2003 company 'Miniboat' in Russia started to apply these devices to purify sewage contaminated with oil products and heavy metals, later they were used to separate distilleries' grains into sewage and solid materials (New Method…, 2005).

The processing of liquid manure into solid fertilizer and sewage is aggravated by the fact that huge amounts of dissolved compounds can pollute the environment: the amount of dissolved ammonia nitrogen can reach 4000-5500 mg l^{-1} (about 75-85% of the total nitrogen amount), the amount of chlorides can be from 3500 to 5600 mg l^{-1} (Kutera, 1994).

The investigations to separate liquid manure into solid manure and sewage mechanically carried out in different countries are suggesting tangible results; however, so far they are only in the stage of experiments (Fugere et al., 2005; Appel and Mengel, 1990; Meers et al., 2006; Meers et al., 2008).

The use of traditional membrane filters is problematic due to early clogging. A conceptual technology of processing liquid manure into solid manure and sewage is described in a technical report by researchers G. Johnson, B. Culkin and L. Stowell (Johnson et al., 2004). They had evaluated the experience of different researchers and especially practical technological achievements in Japan and Korea and came to a conclusion that the first stages of liquid manure processing have to be the separation of solid particles by using centrifuges, filtpresses, etc. And the soluble compounds can be separated from liquid by using modern membrane filters: microfiltration at 0.1-0.5 micron holes can retain molecule compounds larger than 500000 daltons, ultrafiltration at 0.01-0.1 micron holes can retain molecule compounds larger than 1000 daltons, nanofiltration 0.001-0.01 micron holes can retain soluble molecule compounds larger than 100 daltons and reverse osmosis at holes lesser than 0.001 microns can retain molecule compounds smaller than 100 daltons (Johnson et al., 2004).

In Holland due to intensive animal husbandry development and shortage of land area for manure spreading researchers E. Meers, F.M. Tach and others are trying different physical and chemical ways of processing liquid manure into solid fertilizer and sewage under laboratory conditions and in pilot objects (Meers et al., 2005). The liquid manure is processed in three-stage installations, the solid manure is produced and the remaining sewage is purified to such a level that they can be emitted into surface water bodies – according to the average data of four years pollution of the sewage after purification is as follows: biochemical oxygen demand (BOD_7) – 15.0 mg O_2 l^{-1}, total phosphorus (P_{total}) – 2.0 mg l^{-1} and chemical oxygen demand (COD_{Cr}) – 125 mg O_2 l^{-1}.

In the first decade of this century in Lithuania, the large-scale animal husbandry complexes, benefiting from the EU financial support, have modernized animal husbandry technologies. They have reduced water consumption 3-5 times, the liquid manure produced is of high concentration and it is separated into solid fraction and slurry by using mechanical separators (Rupinskai and Šalnaičiai pig complexes) or before the separation the liquid manure is treated in biogas reactors (Lekėčiai pig complex). These technologies have had stable operation for several years.

The objective of our work is to assess the composition of the slurry obtained after mechanical liquid manure processing and to test the efficiency of their purification by applying modern coagulants and flocculants.

Materials and Methods

Fresh liquid manure from 'Sajas' pig complex (Kelmė district) and the liquid manure treated in biogas reactors from Lekėčiai pig complex (Šakiai district) was used for research (2006-2008).

Before the mechanical treatment biochemical indicators of liquid manure composition were established: pH, $COD_{Cr,}$ dry matter (DM), total nitrogen (N_{total}), its compounds N-NH_{4}, N-NO_3 and phosphorus (P_{total}).

The following biochemical indicators were established in the slurry obtained after the mechanical treatment and purification: pH, COD, BOD_7, suspended solids (SS), total nitrogen (N_{total}) its compounds (N-NH_4, N-NO_3) and phosphorus (P_{total}). The following indices have been determined:

- ph – be a potenciometric method using a glass electrode;
- BOD_5 – by a titrometric method (Vincler), LAND 47-1-2002;
- Suspended solids (SS) – by a gravimetric method, having filtered the substance through a mid-thickness filter, LAND 46-2002;
- N_{total} – be a titrometric way, having burnt the material (Kjeldal method), LST EN 25663:2000;
- N-NH_4 – by a spectrometric method, ISO 5664-1984(E);
- N-NO_2 – by a spectrometric method, LST EN ISO 13395:2000;
- P_{total} – photo colorimetric method, having burnt the substance, LAND 58:2003;
- PO_4-P – by a colorimetric method, with ammonia molybdate and ascorbic acid, LAND 58:2003;
- COD_{Cr} – by an oxidation method, with potassium bichromate and sulphur acid, LST ISO 6060:2003.

These indicators were established in a certified laboratory of chemical analyses of the Water Management Institute of Lithuanian University of Agriculture applying certified methods (Certificate No. 1AT-97, 2005).

Anion coagulants were used for the slurry purification: aluminium chloride, Al_2Cl, ferric chloride Fe_2Cl and cationic polyacrylamid flocculant '*Magnofloc 1011*'.

Coagulant rates were selected as follows: 0.5, 1.0, 1.5 and 3.0 kg m^{-3}. Flocculant rates: 1.0, 1.5, 3.0 and 5.0 g m^{-3}.

The flocculant is of a very high concentration and it dissolves for a long time (6-8 hrs), therefore, 0.01% flocculant solution was made (0.1 kg m^{-3}). The slurry coagulation and flocculation processes were carried out using a laboratory model.

This model scheme is presented in Figure 1. 32 experiment variants. A mechanical mixer (household mixer) is installed in a mixing chamber (10 l capacity). Coagulants and flocculants were poured into the mentioned vessel.

Having switched on the mixer in the beginning coagulants were poured in, after that the flocculant solution was added. The mixer was on for 0.5 hr. After 0.5 hr from the beginning of the experiments 5 l of sewage were sucked out of the vessel (without switching off the mixer) and left to settle. Settlement duration – 24 hrs. After 24 hrs 0.5 l of sewage were sucked out for analysis. The analyses were made with different fractions of manure: fresh liquid manure (FM); liquid manure treated in biogas reservoirs (BM); slurry obtained after mechanical separation – fresh manure slurry (FS); slurry treated in biogas reservoirs (BS); sewage after chemical treatment.

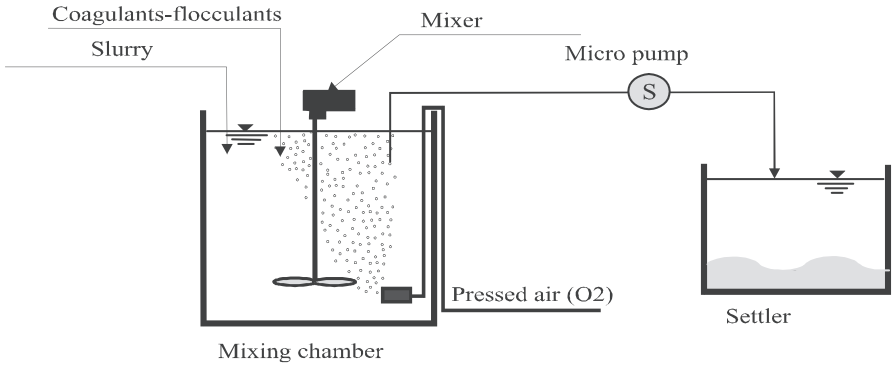

Figure 1. Laboratory experiment scheme.

The data of investigations and calculations was analysed with the help of correlation analysis.

Results and Discussion

At the beginning of the experiments the composition of fresh liquid manure (FM) and liquid manure treated in biogas reservoirs (BM) was established: dry materials 43-56 g kg^{-1}, of which organic materials 29-36 g kg^{-1}; N_{total} 6600-7100 mg l^{-1}; N-NH_4 4700-5500 mg l^{-1}; P_{total} 420-508 mg l^{-1}; Ca 326-307 mg l^{-1}; Mg 48-37 mg l^{-1}; Cl 3250-5600 mg l^{-1}; SO_4 767-478 mg l^{-1}; Na 469-720 mg l^{-1}; K 1700-1250 mg l^{-1}, HCO_3 1142-07383 mg l^{-1}; cadmium (Cd) 0.4-0.48 mg kg^{-1} DM; chromium (Cr) 7-10 mg kg^{-1} DM; nickel (Ni) 18.4-14.6 mg kg^{-1} DM; lead (Pb) 5.6-7 mg kg^{-1}DM; copper (Cu) 720-760 mg kg^{-1}DM; zinc (Zn) 1180-1500 mg kg^{-1} DM; cobalt 4.8-4 mg kg^{-1} DM; manganese (Mn) 284-410 mg kg^{-1}DM; molybdenum (Mo) 12.14-18.62 mg kg^{-1}DM; mercury (Hg) 0.08-0.099 mg kg^{-1} DM; boron (B) 484-440 mg kg^{-1} DM; magnesium (Mg) 7150-14500 mg kg^{-1} DM; detergents 53-32 mg kg^{-1} DM.

According to the presented composition of liquid manure we can make a conclusion that by the amounts of organic materials and nitrogen it is about 110 times more contaminated compared with the household sewage and according to the amount of phosphorus – about 50 times; the amount of heavy metals in the manure is lower compared with the sewage sludge (Nuotekų dumblo…, 2005).

While carrying out mechanical separation of liquid manure, the solid manure fraction and slurry are produced. The amount of solid manure fraction accounts for 10% of all liquid manure amount and the slurry makes the remaining 90%.

The main indicators of the solid manure fraction and slurry composition are given in Table 1. We can see from the table data that during the separation process 38-49% of dry materials and phosphorus and 10-14% of nitrogen and potassium are removed from the liquid manure. Only 8.9-9.1% of chlorides are removed from the liquid manure with solid fraction. We did not identify substantial differences comparing the fractioning efficiency of the fresh liquid manure and the manure treated in the bioreactor.

Table 1

Composition of Slurry and Solid Manure Fraction After Liquid Manure Fractioning

Research object	Dry materials	N_{total}	N-NH_4	P_{total}	K	Cl
	g kg^{-1}	mg l^{-1}(mg kg^{-1})				
Slurry after fresh manure separation	236.0	5230.0	4575.0	244.0	1010.0	5380.0
Solid fraction after fresh manure separation	2166.0	9270.0	4480.0	1920.0	2690.0	3020.0
Slurry after separation of manure treated in bioreactor	386.0	7000.0	5180.0	410.0	960.0	5620.0
Solid fraction after separation of manure treated in bioreactor	2124.0	7180.0	5040.0	1860.0	2275.0	5260.0

The slurry obtained after separation was treated with coagulants and flocculants in aerated mixing chamber.

The best theoretically achievable result is to decompose the contaminants present in slurry to carbon dioxide and to emit only pure water into the environment. This is practically impossible to achieve as one part of the contaminants dissolves fast – volatile carbonic acids, products of protein, carbohydrate and fat fermentation (amino acids, glycerol, monosacharides, etc.), which can make from 10 to 56% of total COD, and the other part of the contaminants (cellulose, lignin, etc.) dissolves badly and more time is required to remove them (Dauknys, 2000).

The more contaminated the liquid, the more problematic is its purification.

Non-complex volatile acids, e.g. carbonic acid and sodium acetate, decompose during aeration (in oxygen environment) (Henze et al., 1995).

When aeration is not carried out (in anaerobic environment) while organic nitrogen compounds are decomposing, ammonia is produced and, when polyphosphates decompose – orthophosphates are produced. Orthophosphates are emitted to the environment from cells in order to maintain osmotic pressure in a cell (Dauknys, 2000).

In oxygen environment carbonic acid combines with ammonia and orthophosphates; decompose nitroacetate, hydrophosphate and carbon oxide (Henze et al., 1995).

The need for air and aeration duration to maintain complicated oxidation processes highly depends on the chemical composition and concentration of contaminants. While carrying out a huge scope of experiments with different rates of coagulants and flocculants, it was established that coagulants – ferric and aluminium salts had nearly similar effect. We also established that the rates of these coagulants lower than 1.0 kg m^{-3} had an unsubstantial influence of contaminate removal. The most effective removal of contaminants from the slurry was achieved, when 1.5 kg m^{-3} of ferric or aluminium salts were added into it. Coagulant rate 3.0 kg m^{-3} did not increase the contaminant removal from the slurry and was rejected.

Different rates of flocculant for the contaminate removal from the slurry performed differently. The influence of flocculant rates on the removal of certain contaminants from slurry, e.g. BOD_7, N_{total} and P_{total}, showed in Figures 2, 3 and 4.

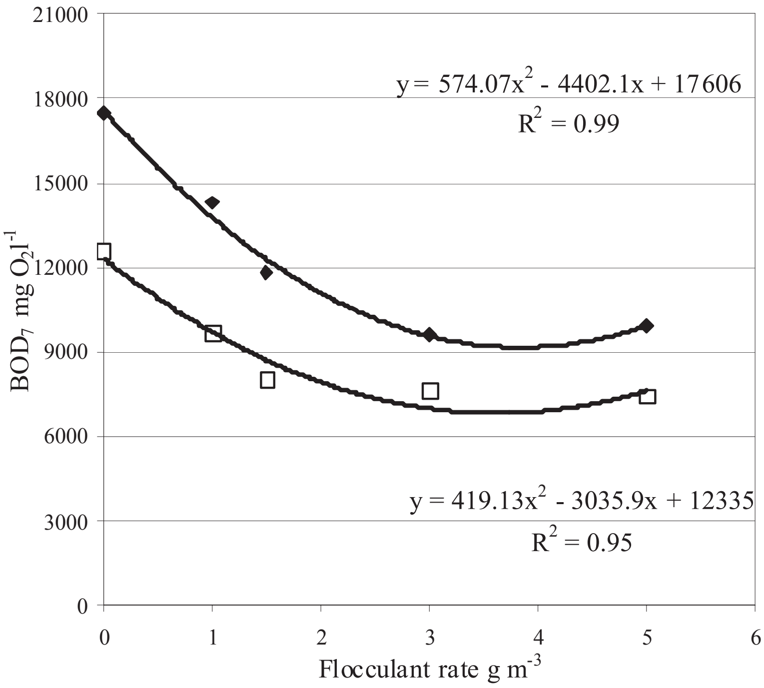

Figure 2. Efficiency dependence of organic contaminant BOD7 removal from FS slurry on and BS flocculant rate.

—◆—FS —□—BS

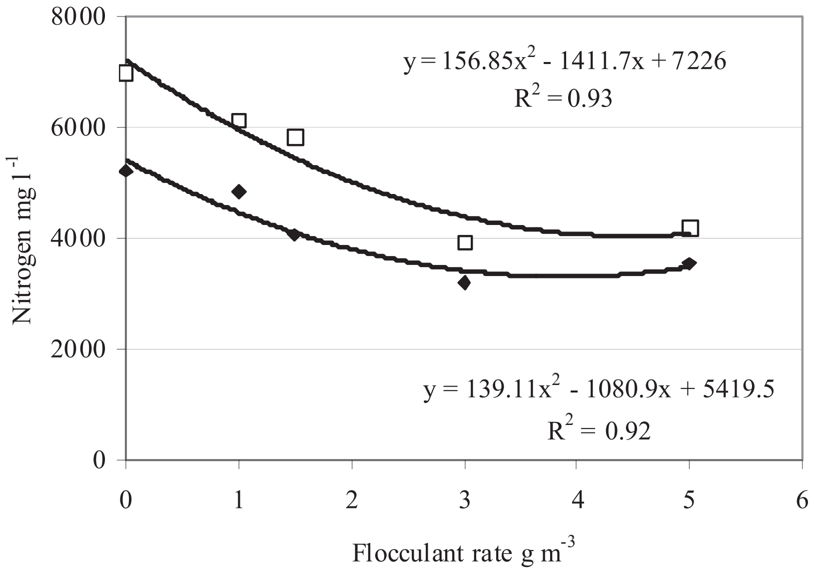

Figure 3. Efficiency dependence of nitrogen removal from FS and BS slurry on flocculant rate.

—◆—FS —□—BS

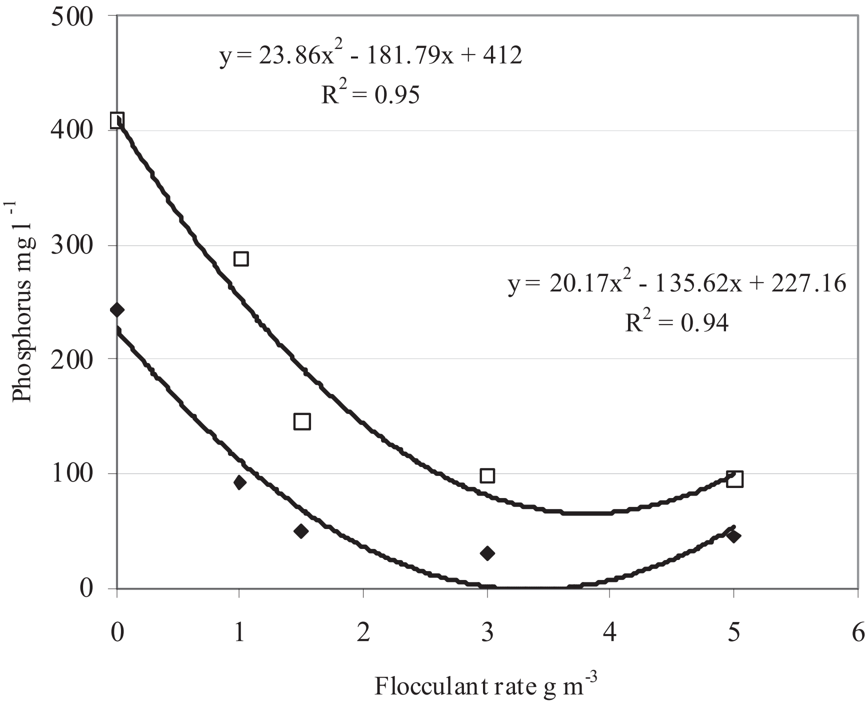

Figure 4. Efficiency dependence of phosphorus removal from FS and BS slurry on flocculant rate.

We can see from these dependences that the most efficient removal of contaminants from the slurry happens when 3.0 g m^{-3} or close to that rate of flocculant is used. At this flocculant rate 40-44% of organic contaminants BOD_7, 38-43% of nitrogen and 76-87% of phosphorus are removed. After coagulation-flocculation process the contaminants are removed from the slurry in the form of sediment.

After the chemical reaction the purified slurry becomes similar to sewage by its composition. The composition of such slurry is given in Table 2.

Table 2

Slurry Obtained after Treating with 1.5 kg m^{-3} Coagulant Rate and 3.0 g m^{-3} Flocculant Rate

Research object	pH	BOD_7	COD_{Cr}	N_{total}	$N\text{-}NH_4$	P_{total}	$P\text{-}PO_4$	Cl	SO_4
		mg O_2 l^{-1}		mg l^{-1}					
Sewage after chemical treatment of FS slurry	8.02	9650.0	13600.0	3210.0	3905.0	31.3	18.8	2810.0	329.0
Sewage after chemical treatment of BS slurry	8.07	7630.0	15590.0	3950.0	2910.0	99.0	52.0	5310.0	624.0

This sewage is close to the sewage from slaughterhouses according to the main indicators (Strusevičienė and Strusevičius, 2006), except for chlorides, the concentration of which is 2.8-5.3 higher compared with maximum permissible concentration (MPC).

Conclusions

1. In a pig farm while separating the liquid manure mechanically, solid fraction and slurry are produced. 38-49% of dry materials and phosphorus and 10-14% of nitrogen are removed from the liquid manure into the solid fraction.
2. When the aerated slurry is consistently treated

with coagulants and flocculants, 40-44% of organic contaminants can be removed from it. The best results of removing contaminants from the slurry were achieved while treating it with aluminium salt at 1.5 kg m^{-3} rate and flocculant '*Magnoflocion*' at 3.0 g m^{-3} rate.

3. After the slurry treatment with chemicals the sewage is produced, which is close to the animal slaughtering sewage by composition. It has 7630-9650 mg O_2 l^{-1} of organic contaminants BOD_7, nitrogen compounds 3210-3950 mg l^{-1} and phosphorus compounds 31.3-99.0 mg l^{-1}. Chloride concentration in the sewage exceeds MPC 2.8-5.3 times.

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CALCULATION METHOD OF RAINFALL FLOW RATE

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Abstract

The aim of this research is to work out the graphic method for the calculation of the maximum rain intensity with a different guarantee in Riga. In order to develop this method analysis as regards the rainfall rates having a different probability was carried out. The measurement data of maximum rainfall minute intensity (mm min $^{-1}$) 3 and 9 hours as well as daily common rainfall from the accessible archive materials in the period 1954-2006 have been studied in this research and treated with the mathematical statistics methods. After the data collection and calculations, the final results are shown in a graphical way in which it is easy to determine which guarantee percent and repetition probability the rain intensity in Riga may be foreseen. In order to determine which module of one factor regression is the most accurate, five different modules were investigated. From the modules studied the most adequate one for data analyses was the logarithmic module having the accuracy up to 92%.

The analysis of the rainfall data as well as the research of the situation of the location place can help to choose the system of rain accumulation and infiltration for each building location thus improving the operation of the total sewerage system. The calculations may be useful in practice to calculate the runoff rates from the areas of different covering. If necessary, using the graphic, it is possible to work out a mathematical expression for the calculation of the maximum rain intensity having any necessary probability. The accessibility and application of a wide range of materials for modern surfaces or infiltration buildings in the world present a wider range of their practical use for separate modern solutions in Riga.

Key words: rainfall duration, infiltration cartridge box, waste water.

Introduction

One of the most obvious problems during heavy rain especially in the period from April till October is that separate territories and streets overflow in Riga and the amount of waste water increase dramatically in the total sewerage system (Rainfall intensity measurements report charts of pluviograph TM-14, 1954-1979). Then unpurified or partly purified waste water gets into fresh water bodies. In order to determine the waste water rate, it is necessary to find out the rainfall rate as well as the rain intensity in detail and to compare it with the infiltration coefficients of the areas of surface runoff. Therefore the managers of Riga waste water are to take into consideration the possibility of unpurified waste water to get into water bodies after heavy and durable rains as well as the frequency of this probability over the years. If it is not possible in some places to join to the gravity flow collectors of rainwater drainage, to ditches and other gutters, the possible amount of rain should be known which should be pumped to the pumping stations and what would be the electro consumption.

The solution of the problem is the rainfall infiltration and accumulation which should be used at the net of the total system for the load decrease during the rain. For the present the rainfall infiltration and the runoff regulation of Latvia towns take place slowly. The modern solution for runoff decrease could be best management practice with the runoff regulation by use of different surface under-covering and underground infiltration cartridge boxes in the water infiltration ground. The surface coverings are clearly shown in Table 1 for the calculation of different runoff rates. The table presents the coefficients of surface runoff for different coverings and shows great possibilities for the decrease of runoff.

Table 1

Coefficients of surface runoff

Kind of under-covering surface area	Coefficient of surface runoff Ψ
Covering of asphalt or concrete street, pavement	0.70-0.95
Covering of concrete space	0.80-0.95
Covering of cobble stones	0.70-0.80
Pedestrian pavement and driving part	0.75-0.85
Covering of house roof(depending of material)	0.75-0.95
Grassland covering with sandy soil content	
Sandy soil with decline of 2% or less	0.05-0.10
Sandy soil with decline of 2%-8%	0.10-0.16
Sandy soil with decline of 8% and more (precipice, slope)	0.16-0.20
Grassland covering with clayey soil content	
Decline of 2% or less	0.10 - 0.16
Decline of 2%-8%	0.17 - 0.25
Decline of 8% and more (precipice, slope)	0.26 - 0.36

Source: Computer applications…, 2004.

At present there are wide possibilities to work out simple and complicated solutions of the town total system for the accumulation of surface runoff depending on the intensity of the rainfall rate. The versions for the management of each town are to be chosen according to the conception of town development and management. The more expensive offers are to be connected with a wide development of the town in a long term. The simplest infiltration solutions will cost less but can be good solution.

The high comfort requirements and the necessity of modern society in urban environment are to drain the rainfall as fast as possible in the sewerage by means of engineering. Such a solution of the problem with the present total system do not give positive results, but a contrary effect – the chain reaction by flooding the outputs of pumping station as well as those of break-down. The optimization of the system should be carried out with balancing in general. It means the combination of the hard covering area of different kinds with the water infiltration in the ground. In foreign literature this idea of 'green thinking' in urban environment is called „rain gardens" or retention, and is known as The Best Management Practice – BMP (Mancl, 1996). These are measures which may be carried out in the local place of the confluence basin in order to decrease the rainfall flow rate and their pollution. Depending on the particular solution, these measures need less capital investments, but more exploitation works. The rainfall flow control with the accumulation of the surface runoff includes:

1) accumulation outside the sewerage net in reservoir (artificial underground built accumulation reservoirs);
2) accumulation in rain outlet system or co-system of waste water system (in collectors, tunnels);
3) accumulation on the ground surface – artificial surface basins for collection for rain accumulation;
4) use of ground or grass covering for water drainage;
5) infiltration in plastic cartridge systems.

Green zones are used for some local regions for rainfall filtration and decrease of flow rate. Reservoirs of artistic design may be built in some existing territories and the territories of new towns. Such a system would demand to build surface collecting areas preventing the flow rate. Of course, this kind of surface buildings demands supplementary costs both in the process of investment and exploitation. One of such a model town is Malmo (Sweden) having many modern solutions of

BMP (Economy and ecology…, 2006). The most often used solution is a surface or subsurface (underground) accumulation basin accumulating a certain amount of rain water having a possible overflow in the total system or in the rain water system during a heavy rain. The water accumulation helps to ensure a pleasant humidity after the rain in urban environment for a longer time in the hot season as shown in Figure 1.

Figure 1. Rain water accumulation basin in town park Placa de les corts, Barcelona (Photo: R.Ziemelnieks, 2008).

It is indispensable to modernize the rain water accumulation system in Riga taking into account the BMP. The problem largely arises because at present Latvian Building Normative provides to calculate rainstorm with repetition probability once, twice and three times a year. But, in order to precisely calculate rain water drainage and pumping station parameters, it is necessary to know maximum rain intensity with repetition probability at least once in five or ten years. To do so, it is necessary to analyze the rainfall rates having a different probability and based on the data gathered to work out the graphic method for the calculation of the maximum rain intensity with a different guarantee in Riga. Working out this specific model for Riga is the aim of the research.

Materials and Methods

The measurement data of maximum rainfall minute intensity (mm min^{-1}) 3 and 9 hours as well as daily common rainfall from the accessible archive materials of the Latvian Environment, Geology, and Meteorology Agency in the period 1954-2006 have been studied (Ziemelnieks and Tilgalis, 2008). They have been treated with the mathematical statistics methods in hydrology and meteorology by use of hydrological values (Zīverts and Strūbergs, 2000). The hydrological values have been calculated with a given excess probability guarantee using the data of long-term empirical observations. For the analyses of these data the Pirson III, Gumbel and Gamma have been used. For the calculation of distribution several algorithmic language programs in FORTRAN77 environment have been used in order to get different calculations of rainfall probability repetition. The computer programs Statppir or Statpir 3 used for Pirson III distribution calculation perform the calculation of static parameter and coordinates of guarantee curve according to data collected in one file. The formation of calculation data base consists of the following principal stages:

- transformation of long-term data in digital/computer format
- arrangement and edition of observation data in EXCEL files
- formation of data treatment in the files according to the observation time (mm time-units^{-1})
- arrangement of observation rows in diminishing sequence, selecting the necessary values
- formation of auxiliary files for starting the calculation in data (prn) and text (txt) format files
- determination of principal calculation values with different distribution methods
- collection of results in tables and graphics
- analyses of results, proposals and recommendations.

After the data collection and calculations, the final results are shown in a graphical way in which it is easy to determine which guarantee percent and repetition probability the rain intensity in Riga may be foreseen. The calculations may be useful in practice to calculate the runoff rates from the areas of different covering.

For determining the approximate division of rainfall it is possible to use the medium rainfall map of A. Pastors from 1987 accessible in Latvia (Kļaviņš and Sudārs, 2002).

Results and Discussion

After the data treatment in the algorithmic program, it was possible to draw up the graphics (see Figure 2) of rain intensity that have different probability. While using the curves it is possible to analyze which probability is to determine the maximum possible rain intensity to ensure the protection of streets and territories from flooding during the rain.

By calculating the data in the algorithmic programs from the auxiliary files, they automatically make the necessary module coefficient files in text (txt) format, as a result the calculation data with variation coefficients Cv from 0.05 to 1.7 with a step 0.01 and the probability p from 1% to 99% with a step 1% may be seen.

As the rainfall is valued and foreseen from one factor (from probability), in the situation estimates one factor regression is used. In order to determine which module of one factor regression is the most accurate, five different modules were investigated. They are the following: module of linear regression, scale module, exponential module, logarithmic and hyperbolic module. In these modules the following things were evaluated:

1) Determination coefficient (R^2);
2) F test was carried out in order to determine whether the module was significant at all;
3) Evaluations (estimation) of the significance of modules and "p" tests (significance tests);
4) Standard errors and "T" values were determined for the modules studied.

From the modules studied the most adequate one for data analyses was the logarithmic module having the accuracy up to 92%. When the guarantee value p increases for 1%, the intensity I value decreases for 1.1 mm min^{-1}.

For example, while using Figure 2, it is possible to determine, that the rain intensity of 20 minutes with the repetition frequency every year is 20 mm min^{-1}, but with the repetition once in 10 years – 65 mm min^{-1}.

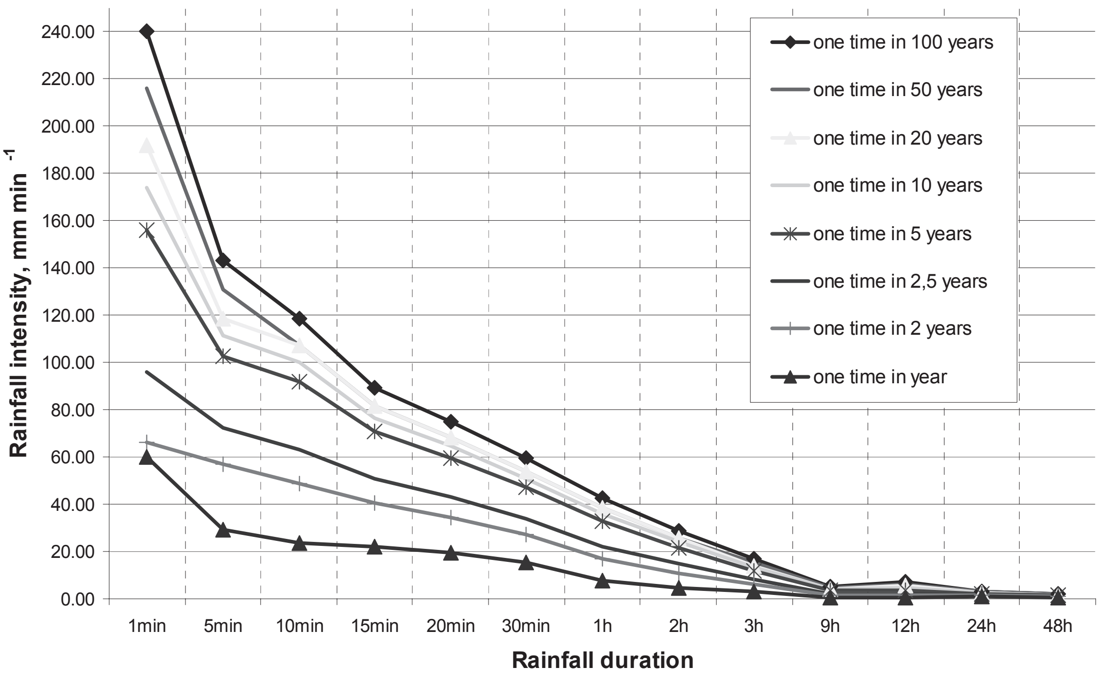

Figure 2. Determination of rain intensity in definite time interval with the necessary probability.

While treating the obtained data, we got the graphic method for the calculation of the maximum rain intensity with a different guarantee. If necessary, using the graphic, it is possible to work out a mathematical expression for the calculation of the maximum rain intensity having any necessary probability. It has been proven that after filling of co-system most often during the rain first 20 min of maximum rain intensity and rain intensity up to three hours has to be taken into account. Results achieved provide explanation for overflow of streets and areas during intensive rain and provides with a possibility to project and justify necessity to open incident release during intensive rainfalls.

Graphic interpretation provides possibility to take fast and advised decision for designers of rain canalization systems as is allows to examine the most optimal precipitation probability case depending on amount of a rain and covering material in any given district of Riga.

Conclusions

BMP is used to prevent problems created by a fast flow and large discharge in different countries. Infiltration and different accumulation systems as well as the rain water infiltration boxes, ensuring the water purification are just some of the examples. This is not the case in Riga where separate territories and streets overflow frequently during heavy rain periods and as a result the amount of waste water increase dramatically in the total sewerage system letting unpurified or partly purified waste water to get into fresh water bodies. The problem largely arises because Latvian Building Normative does not provide to calculate rainstorm with repetition probability at least once in five or ten years. Specific model - graphic method for the calculation of the maximum rain intensity with a different guarantee in Riga worked out as a result of this research that is elaborated on the basis of long-term rainfall observations now can be used for the determination of the rainfall intensity having a different probability in different time intervals. It can also serve as a foundation for modern solution to the ever existent problem of overflow in Riga. Calculations provided may be useful in practice to calculate the runoff rates from the areas of different covering and to take profound steps to come closer to implementation of BMP solutions in Riga.

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NEURAL NETWORK APPROACH IN RISK ASSESSMENT OF PHOSPHORUS LOSS

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Abstract

The main objective of this study is to demonstrate the use of artificial neural network (ANN) modeling tool to predict the risk of phosphorus (P) loss from the fields to nearest water body. The attention is drawn to ANN as an alternative approach to the P index calculation for prediction of the P losses. The specific tasks of this study were to determine risk classes of P loss by linking together source and transport factors that accelerate P losses and to evaluate ANN model performance for predicting risk classes via nutrient transport. ANN was trained with a Levenberg-Marquardt algorithm, and Scaled Conjugate Gradient algorithm was used to estimate the possible risk of P losses from agricultural land. Two small agricultural watersheds in Auce and Bauska were chosen to determine field parameters, and expert's evaluation was used for description of the risk classes' of P loss. Finally these values were used as inputs for the neural network model. The model was trained and validated by assessing its predictive performance on a testing set of data excluded from the training set. The research results highlight the capabilities of ANN to predict risk for a particular field and suggest that future research on application of other algorithms is required.

Key words: neural network, P loss prediction, risk assessment.

Introduction

The problem of phosphorus (P) loss in environmental science is well studied (Buczko and Kuchenbuch, 2007). Widely used approach for control of the P loss is designation of Phosphorus Index (P Index). The P Index (Sharpley et al., 2003; Heathwaite et al., 2000) is a tool that combines indicators of P source and of P transport as well as management factors to get qualitative risk characteristics of the site. P Index ranks fields according to risk of P loss in categories such as low, medium, high, and very high risk. General approach of P Index is to access the potential risk of P transport to surface waters from various fields by weighted parameters that promote risk of the P movement. Parameters values usually are rated (low = 0, medium = 2, high = 4, very high = 8) and rates for each level are summed. The original P Index uses a technique, which multiplies the site characteristics weighting factor with the phosphorus loss rating value to calculate the vulnerability of each site, but a numerous of modified techniques have been derived from the original version (Buczko and Kuchenbuch, 2007). Full understanding of the nutrient transport process is still difficult. Development of advanced tools is often restricted by large data input requirements and this limits the accuracy and reliability of many models. However, it is essential for good index to get appropriate index parameters ranks or weights and scale range boundaries for P index outcome in specific region (Kim et al., 2008). Since the estimation of nutrient losses fills an evident part of environmental studies, a number of computer-based models have been developed to enhance prediction of nutrient losses. Examples of computer-based techniques for studying of the water-quality-management systems include artificial intelligence, expert systems, neural networks, genetic algorithms, and other (Huang and Xia, 2001). Recently, one of the more popular and widely applied computational approaches is the artificial neural network approach. In comparison to traditional statistical methods, ANN is presented as a powerful data-modelling tool that is able to capture and represent complex input-output relationships (Govindaraju and Rao, 2000). Basically, the advantages of neural networks are ability to represent both linear and non linear relationships and to learn these relationships directly from data. For example, comparing ANNs with traditional multiple regression, ANN is found more flexible, hence more suitable and accurate for prediction (Talib et al., 2008). A set of inputs and output responses, representing a variety of simulation scenarios is sampled at random, and a particulate technique to allocate this set into training and testing subsets, is developed to obtain the best performance of network for the smallest error between observed and calculated data sets (Kim et al., 2006). Like biological neurons, ANN models contain multiple layers of simple computing nodes (neurons) that operate as summing devices. Weighted links interconnect these nodes. Each weight is adjusted when measured data are presented to the network during a 'training' process. The artificial neuron which is given in Figure 1 has *N* input denoted as *uj*, for *j* = 1...N and each line connecting these inputs to the neuron is assigned a weight, which are denoted as *wj* respectively and corresponds to the connection between neurons. While a single artificial neuron may not be able to implement some functions, the problem is solved by connecting the outputs of some neurons as input to the others, so constituting a neural network (Gümrah et al., 2000). Successful training can result in an ANN model that performs tasks such as predicting an output value, classifying an object, approximating a function, and others (Kim, Gilley, 2008). Regarding variable prediction as one of the artificial neural network technology broad categories, it comes useful to test how accurately ANN learns to predict the value of an output variable (P loss risk class for a field) by giving input variable information (evaluation of P source and P transport factors that promote P loss from a field).

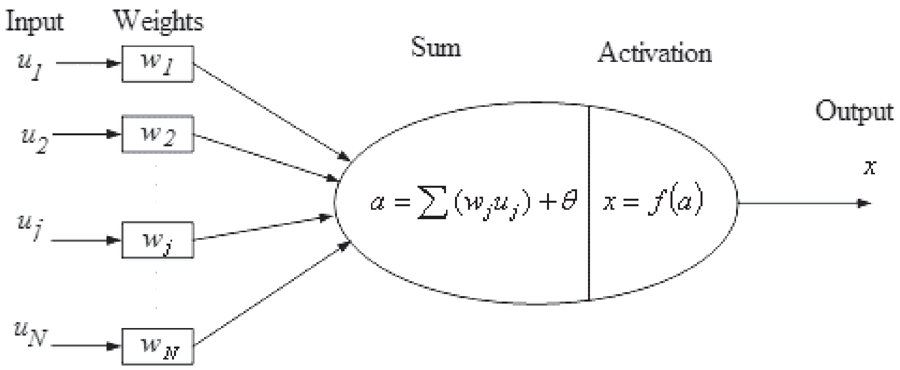

Figure 1. Artificial neuron and its structure (Gümrah et al., 2000).

The most widespread ANN design consists of an input layer, hidden layer(s), and an output layer of processing units (neurons). These are key components of artificial neural network models. The input layer introduces inputs to the network, or in other words, serves as an interface between the input variable data and the ANN model. Most of models also contain one, two or more hidden layers that transform inputs by adding them and applying linear or non-linear activation function(s) thus performing most of the calculations within the network (Nour et al., 2006). The output layer represents the response of the network. The goal of artificial neural network learning is to minimize the error between the models predicted value and the actual value of the output variable(s). According to Nour et al. (2006), the error minimization takes place by modifying the weights between neurons by a learning rule. As training progresses, the mean squared error (MSE) between the target output and the network output is calculated, and the weights are updated systematically. Weight adjustments are made based on an objective function that reduces MSE. Training proceeds until the prediction error is sufficiently small or until a maximum number of iterations have been reached (Nour et al., 2006; Baxter et al., 2002).

ANN modeling suggests that subject to data should be divided into three sets in the ratio 3:1:1 for training, testing, and validating the model, respectively. The training data set is used to adjust the connection weights. The validation data set measures network generalization to halt training when generalization stops improving, but testing data set measures of network performance during and after training, but does not affect the training. Advantages of artificial neural network modeling include handling of nonlinear relationships and providing of output variables in response to simultaneous and independent fluctuations of the values of model input variables Also data patterns with missing values of input variables can be incorporated into model building (Govindaraju and Rao, 2000). Besides, ANN does not require complicated programming, several user-friendly ANN software packages exist. Challenges of artificial neural network modeling show that model predictions are more accurate if only large and complete training data sets are used and extremes of possible values are present. Consequently, ANNs will almost never perfectly predict all values, so a reasonable error must be used for training and testing of networks (Govindaraju and Rao, 2000). The key to a good network is the appropriate training data; consequently artificial neural network models can be developed only where sufficient historical data for each of the process variables exists (Baxter et al., 2002).

Artificial neural networks (ANNs) have found wide applications in recent years. ANNs capabilities have been successfully used and proved through many water resource applications (Govindaraju and Rao, 2000). Studies of ANN include chemical composition of surface waters and water quality prediction (Maier, Dandy, 1996), water quality modeling (Gümrah et al., 2000), prediction of eutrophication (Kuo et al., 2007), estimation of soil erosion and nutrient concentrations in runoff (Kim and Gilley, 2008), prediction of nutrient transport in runoff (Kim et al., 2006), phosphorus dynamics in small streams (Nour et al., 2006), and others (Talib et al., 2008). This study aims to test an ANN modeling tool that can predict agriculture field vulnerability to P loss risk.

Materials and Methods

Field tests for experimental data of P loss risk were conducted at Auce and Bauska (central part of Latvia). The individual risk indices were evaluated for 30 fields in Vecauce farm and 41 fields in Bauska farm. The following information was available for index calculation: soil P contents, land use (crop rotation), inputs of P in fertilizers and manures, soil type, field slope, and drainage. Data on land use and inputs of P were collected from farmers and field observations. Soil types, field slopes and location of drainage were derived from land amelioration maps developed by Department of Environment and Water Management (Latvia University of Agriculture). Knowledge on P input time and methods made the greatest uncertainty. Uncertainty in fertilizer application rates consequently contributed most to the output uncertainty.

The MathLab software was used to create neural network. The architecture of network is organized as a set of interconnected layers of artificial neurons – input, hidden and output layers (Fig. 2) – trained by Levenberg-Marquardt algorithm. Levenberg-Marquardt learning algorithm as improved Guass-Newton method is mentioned as one of the popular methods to speed up the learning process; other characteristic of this method is to deal with the small residual problems in learning (Chan, 1996). Detailed information about the algorithm is covered by R.M. Hristev (1998) and A.A. Suratgar et al. (2005).

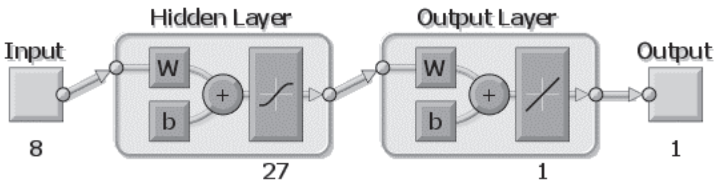

Figure 2. Arhitecture of the neural network used for P loss risk estimation.

Eight variables were selected as the inputs: results of soil P test, P fertilizer rate and P transport factors – erosion, runoff, leaching, drainage, surface run-off inlets and buffers for training of the neural network. All transport factors were calculated based on soil properties and evaluated by direct observations of fields. Details about P loss identification variables are covered by L. Berzina and A. Zujevs, 2008. P loss risk class was provided as an output variable. The input and output process elements (PEs) are fixed by the particular user application, but the number of hidden PEs must be specified. Hidden layer includes 27 hidden neurons that gave the best results. The weights (w) and biases (b) are iteratively adjusted during training to minimize network error. Networks were trained with experimental data that represent the characteristics of the process of risk of P loss identification. 71 data point was used in this study. For this dataset, each data points of P loss risks parameters were randomly divided into three subsets: a training set (70% of the total), a validation set (15% of the total), and a test set (15% of the total). Training data set was used for ANN prediction model development, validation set – for ANN performance evaluation, but the test set was used to guide the fitting of ANN.

Mean squared error algorithm was used for performance, and random algorithm was used for data division. The ANN modeling approach conducted in this study can be divided into three phases: data pre-processing, model building, and model evaluation.

Basically, the four main steps were taken in this forecasting study:

1) model design: choose a suitable model;
2) training: estimate the parameters of the model;
3) validation: test the model on data sets to determine its validity;
4) interpretation: explain results.

Results and Discussion

ANN was trained in 7 epochs that gave the best overall results for prediction of P loss. Model evaluation was based on the correlation coefficient and graphical examination of both measured and predicted values; however, residuals analysis and model stability also are suggested and can be used in further analysis of the results (Nour et al., 2006). The training process is plotted in Figure 3. It shows on logarithmic scale the precision of response of the network to validation and test data sets explicated by mean square error. The graph displays that neural network is able to predict targets from training set with reasonable accuracy already at epochs 4 to 5. At epochs 6 to 7, the accuracy of prediction tends to be almost absolutely correct. Meanwhile the response to validation and test data sets reached a stable unchanging level of mean square error of 0.75 for validation and 1.20 for testing data sets, which is number of times greater in comparison to training samples. It can be explained with over-learning characteristic of AAN's, when the network adopts to all input vectors of training data only, while improvement in response to other data cannot be observed.

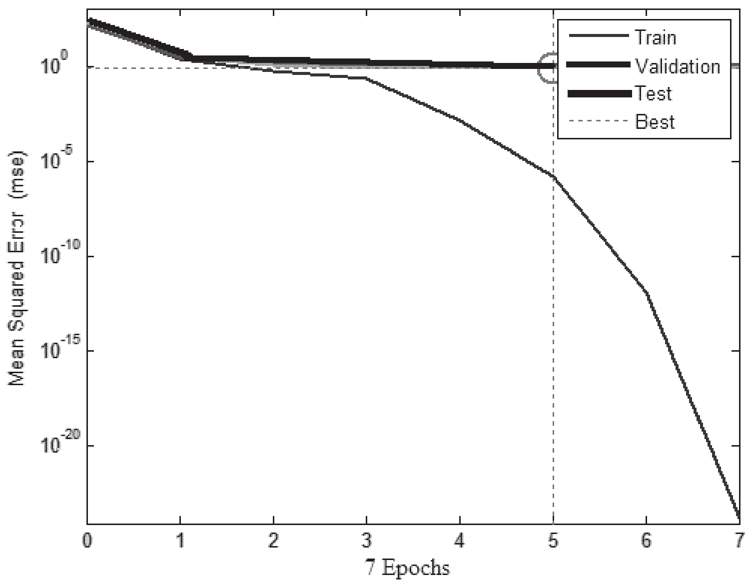

Figure 3. Training process of ANN.

The correlation of AAN response with expert evaluations in all data sets is shown in Figure 4. It also highlights that AAN used and trained in the study shows the strongest correlation with training data (R = 1). The correlation with validating and test data sets is also strong, respectively 0.96 and 0.89, but considering the mean square error for each data set mentioned above, the architecture and learning parameters of the network should be adjusted in order to lower it.

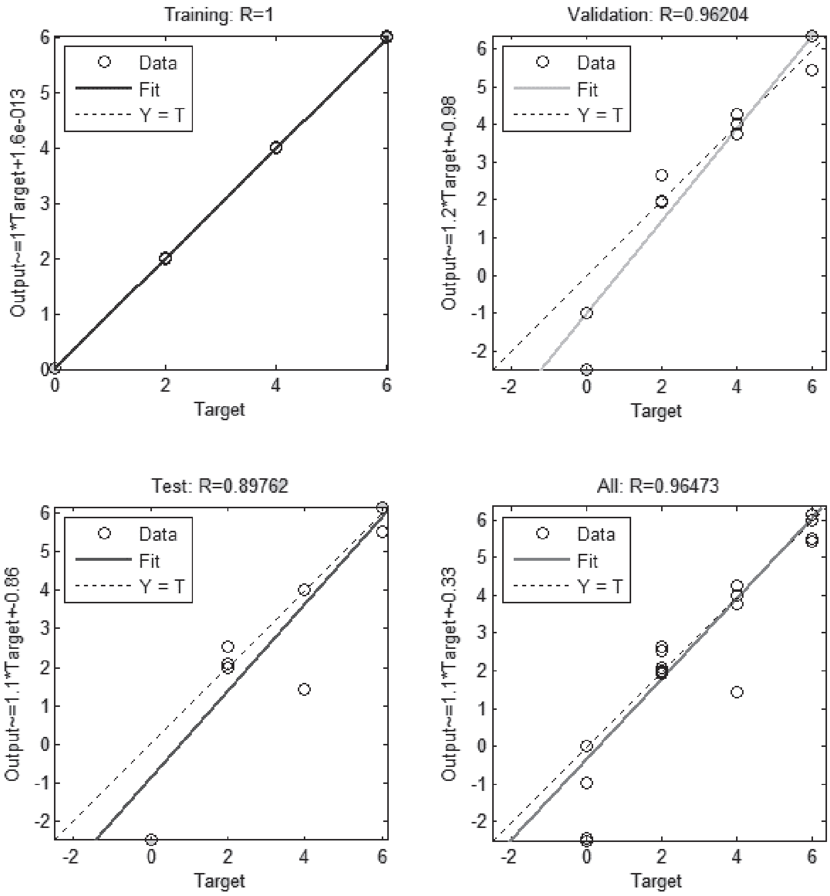

Figure 4. Correlation of expert's evaluations to AAN's predictions.

Studies have shown that a neural network with one hidden layer is capable with very high accuracy (Kim and Gilley, 2008) and this is consistent with the present study. Typically, the increased number of neurons enhanced the training-set performance. The testing-set performance increased whilst the additional neurons help to correctly predict outputs from inputs, and decreased when the network started to memorize the data due to too many neurons. However results indicate potential of network to predict P loss risk class, the truth of results still depends on expert judgment about output variable.

The network with two hidden layers was also trained with Scaled Conjugate Gradient algorithm described by M.T. Hagan and others (1996). The architecture of the network is shown in Figure 5: first layer includes 20 neurons, seconds 45 neurons. Input layer consists of 8 neurons, and output layer of one neuron. Consequently, the network structure is 8-20-45-1.

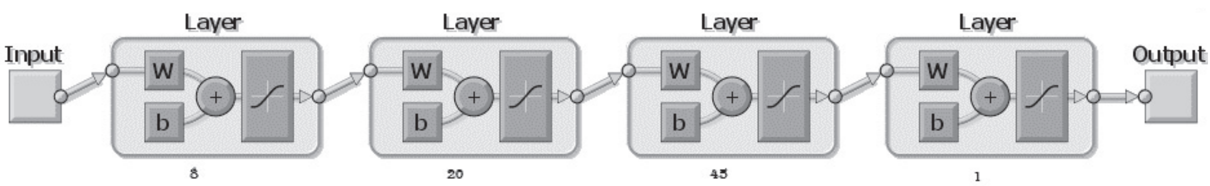

Figure 5. Comparing architecture of the neural network used for P loss risk estimation.

Conjugate Gradient algorithm network gave the best results from other 23 experimental networks and was chosen for ANN training. ANN was trained in 5 epochs, and Figure 6 displays that neural network is able to predict targets from training set with reasonable accuracy already at epoch 0.

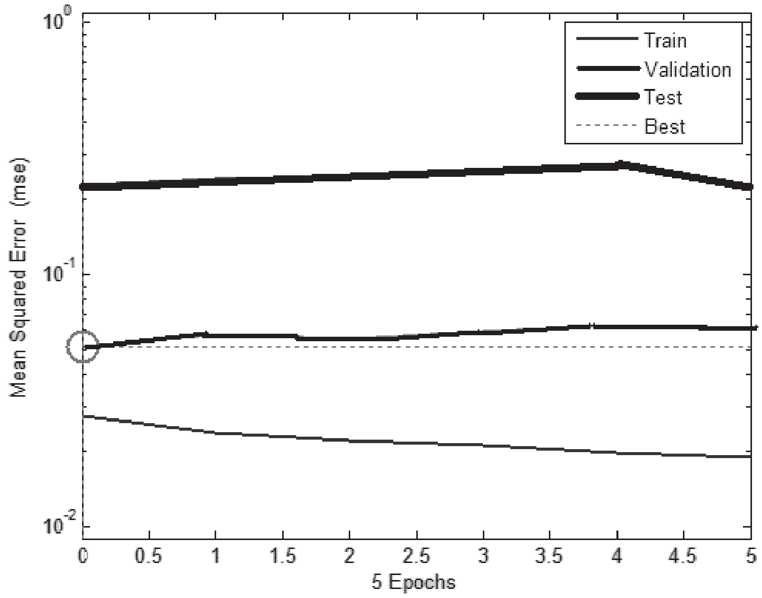

Figure 6. Training process of ANN with Conjugate Gradient algorithm.

In validation and testing of ANN, measured correlation coefficients between observed and predicted P loss risk classes were more than 0.99 for validation data and 0.97 for testing data. The maximum mean squared error for validation data set observed was 0.0276. Also several statistical methods can be used to solve a range of problems in forecasting and data classification. Since each statistical method uses different data assumptions, relationship between the variables being forecasted and the variables used to produce the forecast, as well as the distribution of forecast errors must be considered before applying statistical methods. As a result, there are certain instances where traditional statistical methods are unsuitable. ANN training algorithms help learn the structure of the data, consequently neural networks learn by example, witch is very useful when there is no idea of the functional relationship between the dependent and independent variables. The most evident advantage of ANN is the use of very sophisticated modelling techniques capable of modelling extremely complex functions, at the same time ANN requires fewer statistical assumptions. This is also reason why ANN could be valuable alternative approach to P Index modelling by considering assumption that P loss is extremely difficult to predict via complicated relationships intermediary factors that accelerate P loss. The basis of the power of the neural networks in P Index calculation is to let to define the input-output relationship functional form using training data.

Conclusions

ANN model with Levenberg-Marquardt training algorithm was developed and used for forecasting the risk class of P loss for agriculture fields. In all, 70% of data observed in field experiments in the central part of Latvia have been used for training, and 30% of data have been used for validation and testing of ANN performance. In validation and testing of ANN measured correlation coefficient between observed and predicted P loss risk classes was more than 0.96 for validation data and 0.89 for testing data, which shows the ability of ANN in acceptable forecasting of risk class for selected fields. The maximum mean squared error for validation data set was 0.75, and for testing data set was 1.2, witch is still acceptable for P risk classes' prediction that varies from 0 to 8 corresponding to good model performance. However, future research on the application of other algorithms is required by considering the amount of squared mean error, for example, the use of Conjugate Gradient algorithm that gave correlation coefficients between observed and predicted P loss risk classes with values 0.99 for validation data and 0.97 for testing data. The survey results confirm high capabilities of ANN to predict risk of P loss and suggest future research on application of other algorithms.

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NITRATE MONITORING RESULTS IN AGRICULTURAL CATCHMENTS

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Abstract

The paper deals with monitoring results of nitrate nitrogen (NO_3^--N) run-off in three small agricultural catchments in Latvia (Berze, Mellupite, and Vienziemite) during the period of 1995 - 2007. Continuous flow measurements and water sampling were carried out in two scales – catchment and drainage field. Water quality data was analyzed statistically to identify outliers at various intensity agricultural production systems. The results indicated that with increase of agriculture intensity outlying values are higher and scattered from the rest of the data set thereby the risk of NO_3^--N leaching is higher. It can be explained by application of different rates of organic and inorganic fertilization. To analyze water discharge data, cumulative distribution was used. The results show that main part of the water discharge is observed from late autumn to spring, whereas in summer period it is low and stable. The dependence of NO_3^--N concentrations on the discharge is expressed by Spearman's correlation coefficient - at catchment scale it is 0.37 in Vienziemite site, 0.39 - in Berze, and 0.44 in Mellupite. Calculated correlation coefficients are statistically reliable.

Key words: nitrate nitrogen concentration, agricultural catchments, discharge.

Introduction

Agriculture is one of the major sources of nitrogen that contributes to the eutrophication of the inland waters and the Baltic Sea (Jansons et al., 2003; Kyllmar, 2004; Šileika et al., 2006).

Other consequence of nitrogen losses from agriculture could be the increase of nitrate concentration in the surface and groundwater. This can result in the poor water quality from both private wells and municipal water sources that are used for water supply. EC Directive 91/676/EEC (Nitrate Directive) aims to protect waters against pollution caused by nitrates from agricultural sources and prevent further such pollution. Member States which apply the action programmes throughout their national territory shall monitor the nitrate content of waters (surface water and groundwater) at selected measuring points which make it possible to establish the extent of nitrate pollution from agricultural sources. Monitoring to control the effectiveness of action programmes means assessment of the impact of changes in agricultural practices on nitrate losses to surface and ground waters firstly at the whole catchment, secondly at the micro-catchment, and thirdly at the field level (Draft guidelines for..., 2003).

For the assessment of agricultural pollution to water bodies, an agricultural run-off monitoring programme in Latvia was implemented in three small agricultural catchments (Berze, Mellupite, and Vienziemite). Measures of the action programmes to reduce NO_3^--N pollution are not yet implemented in monitoring catchments.

Surface water quality in agricultural catchments depends on both natural conditions and human impact. Therefore the hydrologic and weather conditions, spatial and temporal variability, differences in land use and land management practices should be taken into account when analysis of water quality data is carried out (Iital, 2005).

Materials and Methods

Study areas represent different geographical regions in the western (Mellupite), central (Berze), and north-eastern (Vienziemite) parts of Latvia. In study areas are varied soils and agricultural practices. Continuous flow measurements and water sampling were carried out in two levels – catchment and drainage field. Composite water samples based on flow proportional procedure and manual samples were collected monthly. Water analyses of NO_3^--N were carried out in Latvian Institute of Aquatic Ecology according to standard method (LVS 339:2001). Main characteristics of monitoring sites are presented in Table 1.

Table 1

Main characteristics of monitoring sites

Monitoring site / Scale	Area, ha (% arable land)	Soil	Flow measurement sampling method	Intensity of agricultural system
Berze Small catchment Drainage field	 368 (98) 77 (100)	 Silty clay loam	 Modified Crump V-weir, data logger Flow prop. sampling Triangular weir, data logger Flow prop. sampling	 Intensive
Mellupite Small catchment Drainage field	 960 (69) 12 (100)	 Loam, clay loam	 Crump weir, data logger Flow prop. sampling Triangular weir, data logger Flow prop. sampling	 Moderate intensive
Vienziemite Small catchment Drainage field	 592 (78) 67 (100)	 Sandy loam	 Combined profile weir, data logger Manual sampling Triangular weir, data logger Manual sampling	 Low input farming

The Berze catchment is characterized by relatively intensive crop production as compared to the present farming conditions in Latvia. The landscape is flat lowland and 98% of the catchment soils are cultivated. Due to high natural soil fertility, winter wheat and rape have become the main crops in the Berze catchment. The share of arable crops has increased up to 80-90%. Farmers use modern equipment, and rather intensive technology for Baltic conditions, e.g. a fertilizer application in some fields has reached 160 kg N ha^{-1} $year^{-1}$.

The Mellupite catchment represents average farming conditions and can be considered as typical for the present agriculture in Latvia. Several large farms are using intensive agricultural technology, whereas a few farms are producing only for self-consumption with low fertilization rates and without pesticides. The average use of mineral fertilizers ranges from 10 to 40 kg N ha^{-1} $year^{-1}$.

The landscape in the Vienziemite catchment is rather hilly for Baltic conditions. Soil, slopes, and market conditions are less favorable for agriculture and only two farms in the catchment are producing something for market. Almost no fertilizers (only 4 –5 kg N ha^{-1} $year^{-1}$) are applied in Vienziemite. Most of the farmland was abandoned land or low productivity grassland during the measurement period. The Vienziemite catchment is a typical example of low - input agricultural land use, and can be used as a reference site for diffuse pollution (Jansons et al., 1999).

Two different types of graphs and two tests are used to visualize and evaluate water quality and quantity data. Box plots (Figure 1) are used for graphical presentations of the NO_3^--N concentration data. The box plots represent the rank-sum test results and show the 25th, 50th, and 75th percentiles as calculated using robust log-probability regression. Side-by-side box plots are convenient for determining differences in medians and similarity in spreads (Warner, 2000). As well as box plots could be used to calculate and show outliers of monitored data set. These are observations which values are quite different from the others in the data set, and often cause concern or alarm. Outliers can have one of three causes: (i) a measurement or recording error; (ii) an observation from a population not similar to that of most of the data, e.g. a flood caused by a dam break rather than by precipitation; (iii) a rare event from a single population that is quite skewed (Helsel and Hirsch, 2002).

The statistical properties of water quality data (concentrations of nutrient) are usually not normally distributed, and they often reflect a seasonal pattern because they are influenced by water discharge (Iital, 2005). Therefore to test normality of water quality and discharge data, the Kolmogorov–Smirnov test (K–S test) was used.

Spearman's rank correlation procedure was used to identify monotonic (but not necessarily linear) correlations among constituents, providing a measure of the intensity of association between two variables. Spearman's correlation coefficient is the linear correlation coefficient computed on the ranks of data instead of actual values. This coefficient ranges from -1 to +1; a negative coefficient indicates that the higher ranks of one variable are related to the lower ranks of the other variable. The closer the absolute value of r_s is to 1, the greater is the correlation between the two variables. A small r_s value, however, can still be significant, depending on the associated *p* value. If this *p* value is less than the significance level ($p<0.05$), then the null hypothesis of no correlation (or $r_s=0$) is rejected, and the correlation coefficient computed is considered statistically significant (Warner, 2000).

A cumulative distribution curve of the monthly mean values was used to show high and low water discharge periods.

Results and Discussion

The observed concentrations of NO_3^--N have rather remarkable variability in all monitoring sites, as well as in monitoring scales (Figure 1). High mean and maximum NO_3^--N values in the Berze catchment (mean – 6.8 mg l^{-1}) and drainage field (mean – 10 mg l^{-1}) levels can be explained by the intensity of agricultural production, and increased use of fertilizers. Compared to Berze in Mellupite monitoring catchment less fertilizers are used therefore NO_3^--N concentrations (mean 2.7 mg l^{-1} in the catchment and mean 6.5 mg l^{-1} in the drainage field) are fairly stable and close to mean value. In the Vienziemite site, NO_3^--N concentrations are low and can be assumed to be close to the natural levels, and there are no difference in the concentration in drainage field (mean - 0.83 mg l^{-1}) and catchment (mean - 0.86 mg l^{-1}) scales. NO_3^--N mean concentrations in the studied catchments do not exceed the levels established by the Nitrate Directive (i.e., 11.3 mg NO_3^--N l^{-1}).

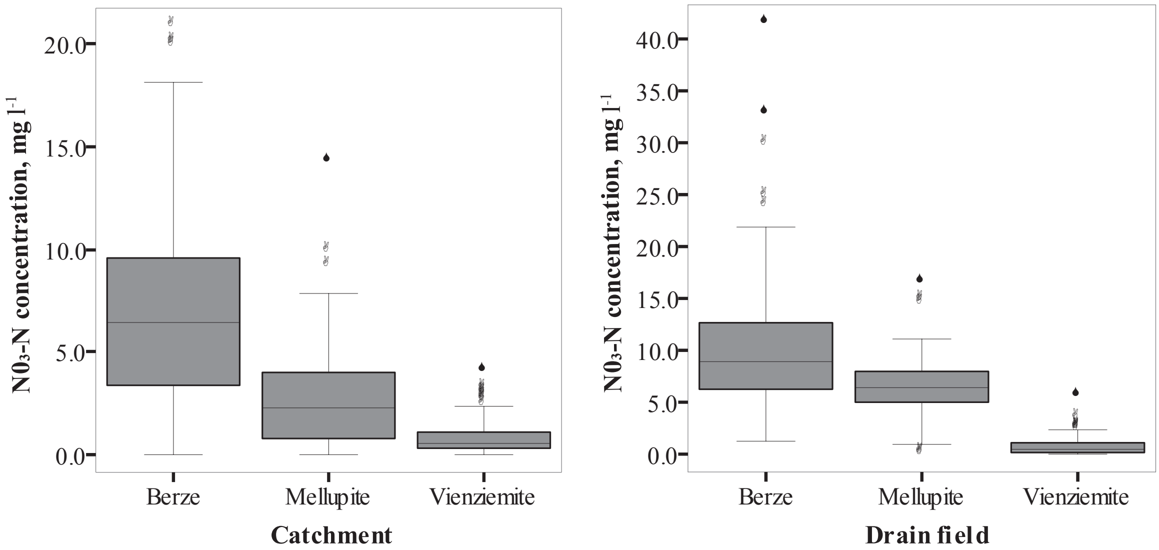

Figure 1. Concentrations of NO_3^--N in the catchment and drainage field scales: minimum, mean, maximum, and outlying values.

The observed NO_3^--N concentrations were higher in the drainage field outlets compared with concentrations in the streams. The drainage water as it moves from the root zone to the underlying drainage pipes has higher nutrient concentrations, and nitrogen removal / retention started there due to aeration, intake, and mixing with the surface run-off. Relatively slow flow processes and more favorable conditions for retention can contribute to the nutrient decrease in streams (Jansons et al., 1999).

It should also be noted that some values of the observed concentrations can be considered as extreme values, which are statistically different from the other data set. They are most likely due to extreme natural conditions such as intense rainfall over a short period, fast snow melting, etc. In fact, outliers are the maximum values that have been fixed during the study period, and it is obvious that these values have an impact not only on the instantaneous concentration in water, but also on the calculated total NO_3^--N losses.

Cumulative distribution of discharge shows the time periods of intensive water flow, which also affects the NO_3^--N losses. Similar trends can be seen in all monitoring sites and in both field and catchments' monitoring scales. Most of the water discharge occurred during spring flood, snowmelt in winter, and rainy period in the fall (Jansons et al., 2003; Deelstra et al., 2004; Kutra, 2006). The results show that main water discharge occurs during the period from October to May, while during the summer months, discharge is low and stable. Highest water discharge is measured in Vienziemite monitoring site, while the lowest is in Berze. Differences in discharged volumes are associated with the regional distribution of rainfall and local water balance. In the study period, the average rainfall in Vienziemite catchment area was 702 mm, in Mellupite 636 mm, and in Berze 581 mm.

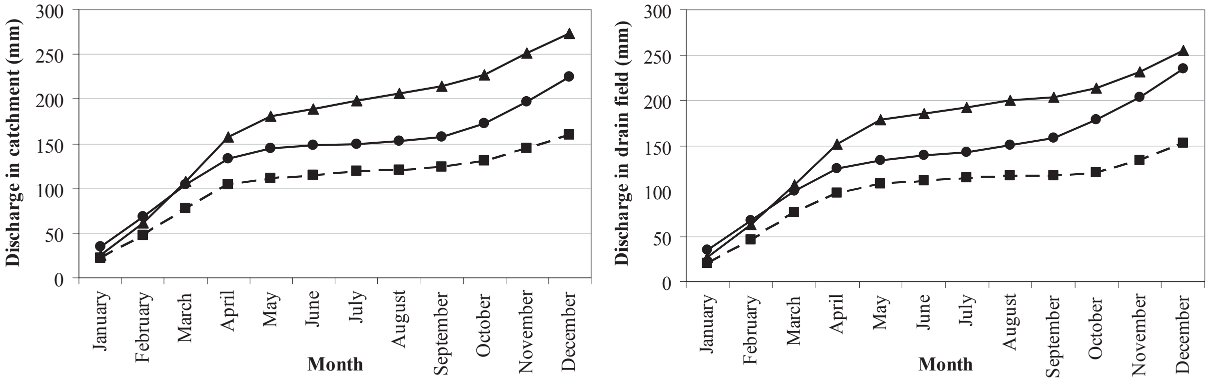

Figure 2. Cumulative distribution of discharge (mm) in different monitoring scales:
■ - Berze, ● - Mellupite, ▲ - Vienziemite.

In general, nitrogen losses from arable land have a good correlation with water discharge from the catchment area and main losses occur with surface and drainage runoff during the high runoff periods (Iital, 2005). Monthly concentrations of NO_3^--N in Berze catchment support the above - mentioned statement (Figure 3). Mean values are higher during spring flood and rainy period in the fall. Extreme values in summer can be explained by rainfall that follows dry periods.

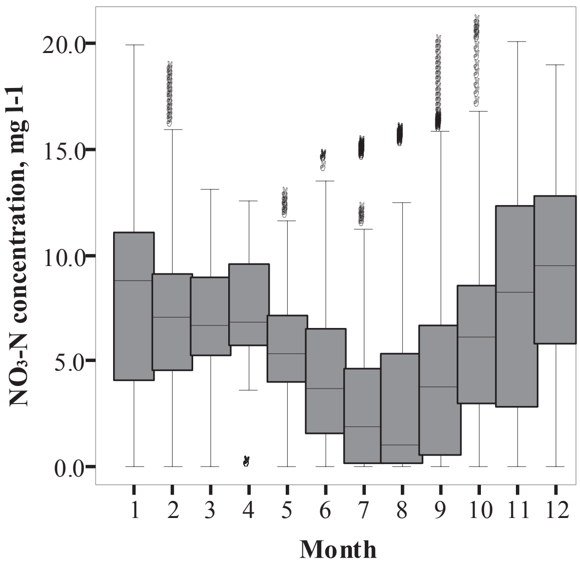

Figure 3. Minimum, mean, maximum, and outlying monthly concentrations of NO_3^--N in Berze catchment scale:
1 – January, 2 – February, 3 – March, 4 – April, 5 – May, 6 – June, 7 – July, 8 – August, 9 – September, 10 – October, 11 – November, 12 – December.

Also Spearman's correlation coefficients (r_s) between NO_3^--N concentrations and discharge show rather close relationship. In the small catchment scale in Berze monitoring site, $r_s = 0.39$ ($p = 0.00$), in Mellupite - $r_s = 0.44$ ($p = 0.00$), and in Vienziemite - $r_s = 0.37$ ($p = 0.00$); p value indicates that the given correlation coefficients are statistically reliable.

Conclusions

The results of the study show large variations in NO_3^--N concentration depending on land use and management practices. With increase of agriculture intensity, resulting in increase of nitrogen inputs in the catchments' area, mean and maximum NO_3^--N concentrations are higher in Berze and Mellupite monitoring sites.

Water discharge in all study catchments mainly occurs during the period from October to May, while during the summer months discharge is low and stable. Higher water discharge usually determines higher NO_3^--N losses, because more water infiltrates through the soil profile, resulting in a higher nitrate leakage, especially in drainage systems. Thus, specific agricultural practices and mitigation measures should be implemented to decrease the pollution risk caused by the meteorological conditions that are prevailing during the autumn/winter period.

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REVIEW OF INDUSTRIAL COMMUNICATION NETWORKS IN THE CONTROL OF SMALL-SCALE AUTONOMOUS POWER SUPPLY SYSTEMS

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Abstract

This article gives a review of modern networking technologies and standards used in the development of distributed control systems. Study of related scientific and professional literature has been performed, and basing on it a multi-level model of digital network structure in the field of small-scale autonomous combined power systems has been proposed. Necessity of integration of autonomous powering into SmartHouse systems and related distributed computing and networking issues are reflected as well.

As there is a wide variety of industrial networking standards used, this review covers and groups more frequently used protocols and stacks from the view of OSI (Open Systems Interconnection) reference model and layers of industrial automation. The aim of this article is to give a reference-point in the development of distributed control systems in the field of small-scale autonomous power supply and integration of them in SmartHouse systems.

Key words: industrial communication network, autonomous combined power system, SmartHouse.

Introduction

With increased expansion of dwellings and small farming facilities in rural regions with undeveloped energetic infrastructure, a problem of inaccessibility of energy resources arises and various autonomous solutions can be considered as the only solution. It can be referred to both heat energy supply and electrical energy supply to power miscellaneous household appliances, electronics, lighting and for use in farming and water supply needs. In a number of cases in rural regions of Latvia, setting up of an individual autonomous power supply system that uses one or more renewable energy sources, battery bank and a back-up generator is a reasonable solution, because of expenses of connection to public electrical power network. For example, in accordance to 'Methodology of calculation of connection fee to public power network' (approved by the council of Public Utilities Commission, document No.145, 11.12.2002.) installation costs of a power line depending on its parameters vary from 3000 to 20000 LVL per kilometer.

The purpose of an autonomous combined power supply system is to provide electrical power independently from public network by combining several mutually complementary sources of energy. In practice, systems with wind generators, solar cell panels and, in some cases, small water-power plants are used. Integral parts of such systems are also a battery bank for voltage stabilization and temporal power supply and a reliable back-up generator with combustion engine driving. It can be used for long-term powering if wind and solar energy is unenviable and batteries are depleted, and also if additional power is needed, e.g. for washing machine operation. All of this equipment should be supervised by a centralized automatic control system to provide the consumer with electrical power of good quality and ensure normal mutual interconnection of all components of the system (Osadčuks and Galiņš, 2007a; 2007b; 2008).

However, the costs per kilowatt hour (i.e. costs of exploitation) of autonomous electrical power system using today's technologies are still higher than energy provided by public electrical grid although the difference has tendency to go down. Therefore the key of use of self-produced energy is the economy and effectiveness. It is calculated that investments in effectiveness of use of energy save five times of expenses of generating equipment. It is true for both electricity and heat usage (Kemp, 2005). Energy effectiveness of buildings is studied by another area of science and technology: SmartHouse. It unites energy metering solutions as economy of resources is connected to precise accounting of them, technological solutions (economical lighting, heating, ventilation, air conditioning, heat insulation, etc.), security systems and use of optimal automatic control algorithms to improve the overall level of comfort. SmartHouse covers also communications: 'triple play' services (Internet, telephone and cable TV). Detailed researches have been performed and numerous technologies and end-user devices have been developed in this area. By integration of all of these technologies a new concept of an universal high-level centralized home interface, automation and monitoring solution – 'residential gateway' – has been proposed (Намиот and Шнепс-Шнеппе, 2008).

In order to increase the effectiveness of both producing party (the autonomous combined power supply) and consuming party (home automation systems) it is purposeful to integrate them on one of higher levels of automation and implement a centralized control.

Due to advances in microprocessor systems (integrity of chips, power consumption and manufacturing costs) it becomes economically justified to embed cheap microprocessor units, which can perform both control and digital interface (to other processors and human user) functions in a major part of sensors and executive devices. Thus it is possible to create a complicated multi-level distributed control system based on digital communication networks. Most of modern industrial automatic control systems are implemented using this distributed approach replacing legacy centralized control solutions based on analog signal networks (Кругляк, 2002; Vince and Kovacova, 2007).

There are several hundreds of digital communication network open and closed (commercial) standards, which are used in implementation of distributed control in various levels of automation. Unlike home and office networking, these standards provide higher level of determinism, specialized data structures and high reliability when used in stress environments.

The aim of this article is to present a review of industrial digital communication network standards, which could give a reference point in selection of optimal solution in the implementation of autonomous combined power supply systems and integration of them to SmartHouse for the system level and for the developer of end-user equipment.

Materials and Methods

Every terminal device (node) connected to the digital communication network can be taken for an intellectual unit, which unites necessarily functions to control the given technological process and interface to other devices on the network. The following functionality of a common terminal device in an industrial application can be defined (Кругляк, 2002):

- receiving commands and data from other terminal devices;
- reading values of connected analog transducers and switches;
- processing of control algorithm accordingly to technological process;
- delivering control impacts to connected actuators accordingly to technological process and/or commands obtained from other terminal devices;
- sending the collected information to other terminal devices on the network.

As in conventional computer networks, data interchange in industrial networks can be described using OSI (Open Systems Interconnection) reference model, which structures the data exchange functionality between nodes of a network into seven layers: physical, data link, network, transport, session, presentation, and application layer. Above the application layer, the actual user application comes. A number of industrial network standards implements only selected layers. For example, there are standards that define functionality only in physical layer describing prerequisites of networking in industrial applications with electromagnetic interference, thermal and corrosive stress environments, etc. Examples are RS-485, RS-422, Meter-Bus.

The communications in different layers can also be structured by ranks of the nodes. There are master-slave, server-client, and subscribing models in higher layers, and peer-to-peer and also master-slave (differently ranked) models in physical layers. In opposite to conventional computer networks, industrial applications make a heavy use of differently ranked node devices in the physical layer as in order to be economically reasonable, the network architecture should be chosen with taking into account of tasking, self-independence and complexity of terminal devices that can differ significantly in a single application.

The number of network standards that are used together in industry can be explained with essentially different requirements to networks. All the standards can be grouped by these requirements into hierarchical layers of automation. A version of common layer structure in industrial applications is given by K. Кругляк (2002). There are four layers of hierarchical automation (begging with the lowest): transducer and actuator layer, low level automation, segment automation of a technological process, and production level automation (Fig. 1.).

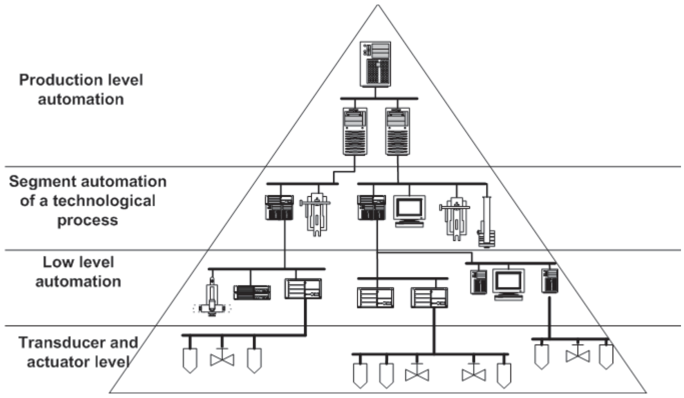

Figure 1. The hierarchy of automation and control networking.

It should be pointed out that all the data communication equipment (hubs, switches, repeaters, interfacing devices, etc.) is considered as an integral part of a network and therefore lies in corresponding layers of the hierarchy.

The distribution by layers also allows to minimize problems of compatibility of various networks used. For this purpose the bus masters and interface converters should be grouped at the boundaries of the layers.

At the lowest layer of transducers and actuators, several to tens of data bytes per frame are enough for communications between the terminal devices. Common devices of this layer are various subsystems of analogous and digital transducers, networks of intelligent digital transducers, data logging devices, electrical drives for motor control, valve, positioners, relay modules, etc. The basic characteristic requirements for networking in transducer and actuator level are deterministic operation in real time mode, simplicity of implementation of OSI model, minimal wiring (number of wires in a transmission line; it is a pair mostly), in certain cases the ability of powering network devices from the communication line and requirements for hazardous industrial environment.

For sensor arrays e.g. in temperature or gas composition sensors for measurement in larger areas the maximum number of nodes and radius of network is also important. As the end nodes of network due to number of them and conditions of operation (sensor arrays, actuators) should be as simple, power-economical and cheap as possible, the master-slave network architecture is mostly used in this layer of automation.

Examples of standards in this layer are AS (Actuator/ Sensor) interface (Половинкин, 2002), Meter-Bus, CAN (Controller Area Network), ModBus, Wake, LIN (Local Interconnect Network), X10 (network over mains power lines), wireless ZigBee, Z-wave, and MiWi.

In the layer of low-level automation, the length of data frames may vary from tens to hundreds of bytes as both amounts of user data and service information (headers, length fields, checksums, etc.) are increased, more complex addresation can be used, and OSI layers can be used more widely. Characteristic devices are controllers of machines and master nodes of transducer and actuator layer networks. Data interchange consists of technological commands from higher layer and data acquired from sensor systems. Therefore data throughput requirements are increased in comparison to lower layer. The examples of network standards in this layer are: Profibus-DP, Profibus-PA, CAN, Interbus, Foundation Fieldbus, DeviceNet. In a number of situations, industrial Ethernet can also be used (Кругляк, 2003).

In the layer of segment automation of technological process, the coordination of machines in automatic and manual mode has been performed. Operating modes of discrete machines and segments of a system (e.g. production facility) are organized and fault elimination, monitoring of operation, data logging and delivery to higher level are managed as well. The terminal devices used are industrial computers, high-end PLC (Programmable Logic Controllers) and HMI (Human Machine Interface) terminals, and other manual controls. Data transmitted consists of complex control commands, comparatively larger data arrays of monitoring and statistical information, updates of control equipment firmware, and HMI related data (drawings, agendas, user instructions, etc.).

Network specifications used in this layer: Profibus-FMSand industrial Ethernet. Peer-to-peer communication architecture is mainly used.

Production level automation layer groups personal computers and servers, which display the operation parameters of technological process, provide the lower layers with various informative services, archives and stores statistical data, maintains databases, creates reports, interfaces to the Internet, and performs administrative functions. The real-time requirements in contrast to lower layers are decreased and are limited to requirements of common local area network. Conventional home and office Ethernet equipment can be used in this layer.

The boundaries of automation layers described above are not strictly regulated and the layers can overlap, if it is economically reasonable. For example, the performance of CAN interface is relatively high (throughput of up to 1 Mbit s^{-1}, deterministic operation, and low latency) and it is available as a hardware module in a number of middle range microcontrollers (e.g. PIC18F4XX, dsPIC33FJ256GP, AT90CANXX). Therefore it is possible to use CAN in interfacing to transducers and sensors and in data interchange between more sophisticated controllers in low-level automation layer. The same situation is with Ethernet networks. Hardware solutions on a single chip for interfacing Ethernet networks in physical and data link layers of OSI model have become available recently, e.g. ENC28J60/SP chip, which is supplied in 28-pin dual inline package and implements Ethernet to UART (Unified Asynchronous Receiver and Transmitter) conversion. Manufacturers of microcontrollers also support Ethernet networking by providing full implementation of TCP/IP stack as freely available software library. It allows to integrate this type of networks to the lowest level of automation. There is also an extension developed: Ethernet/IP (Industrial Protocol). It works in session-presentation-application layer as object-oriented CIP (Control and Information Protocol) in order to achieve real-time functionality of Ethernet networks. But due to activity of lower OSI layers, actual determinism cannot be fully achieved.

Results and Discussion

Theoretical literature, a number of application notes and specific developments have been studied, and the digital communication networking hierarhchic structure of autonomous combined power supply system with integration in SmartHouse applications has been developed (Fig. 2.).

The lowest layer contains transducers and actuators of autonomous power system and SmartHouse installations: sensors of parameters of autonomous power grid (voltage, current, energy consumption metering), associated transducers of certain generators and power converters (anemometer, pyrometer, fuel level, operating temperature, etc.), and SmartHouse equipment (outside and indoors visible light sensors, thermometers, motion detectors and other security devices, remotely controlled dimmers and relays, blind controllers, etc.).

At the layer of low-level automation there are controllers of more sophisticated devices that use in their operation data from the sensor layer below: wind generators, solar cell panels, complex lighting control of rooms, simple HMI, like lamp switches and gauges of autonomous powering conditions, access control systems, etc.

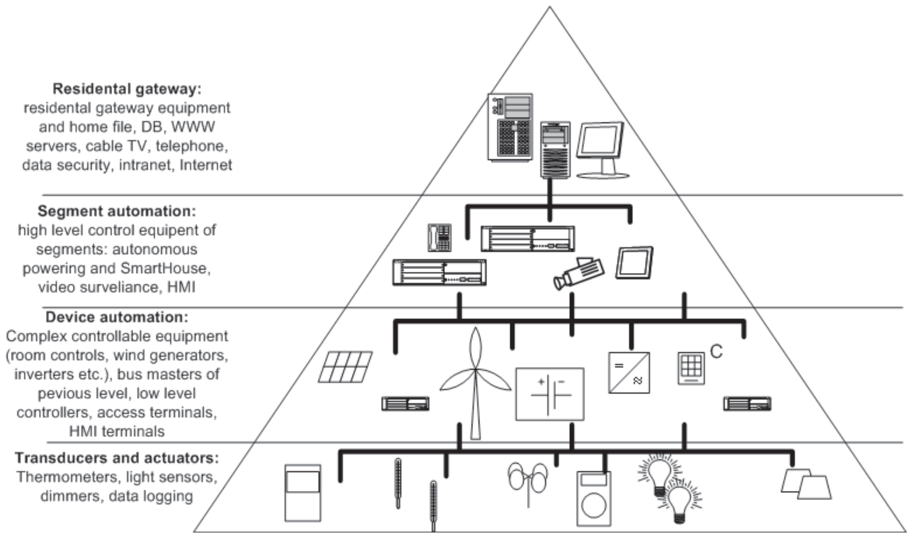

Figure 2. The hierarchy of automation and control networking in autonomous combined power supply and SmartHouse.

At the layer of segment automation, high level control of discrete segments can be implemented. In this case, the segments are autonomous powering and SmartHouse. This level also contains HMI points (touch panels with graphical user interface) and video surveillance system.

The highest layer is formed by local intranet, central node of home automation – residential gateway, triple play services, and data security equipment.

Figure 3 summarizes and groups by layers of hierarchical automation and OSI reference model the networking standards and technologies listed in this article and used by authors in projects connected to room automation.

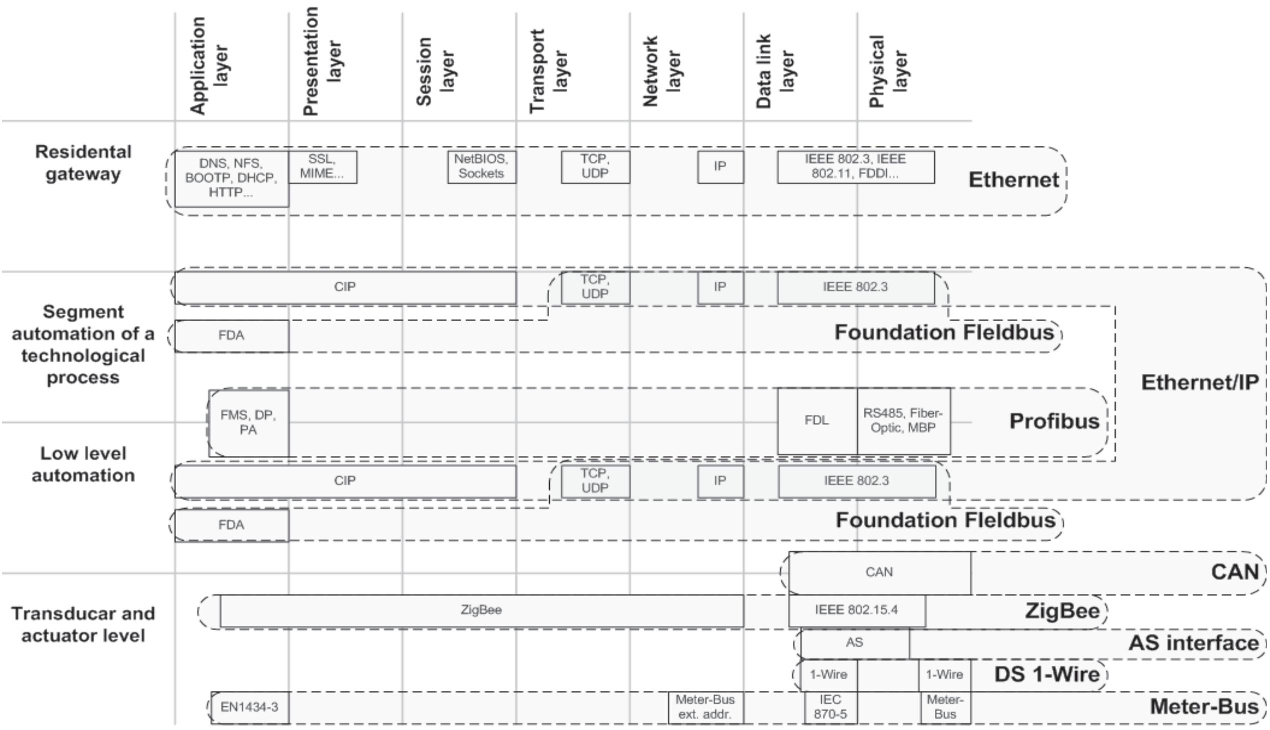

Figure 3. Grouping by layers of hierarchical automation and OSI reference model of several more frequently used industrial networking standards.

Conclusions

The common hierarchical multi-layer model of distributed industrial automation and networking and the particular model for autonomous combined power supply and home automation allows to structure overall system by using groups of industrial network requirements and accordingly select specific standard or technology of industrial networking. It can help in selection of optimal communication interface for particular project of both discrete device development and implementation of overall system.

The distribution by industrial network requirements allows also to minimize problems of compatibility of various network used in a single project, if bus masters and interface converters are grouped at the boundaries of the layers.

The idea of integration of autonomous combined power supply system and SmartHouse installations can help in increase of effectiveness of both of them as these actually are deeply linked systems by functionality. One part is a producer and the other one – a consumer.

This article gives only a review of mostly used industrial networking standards and only general recommendations in selection of optimal networking solution for particular project, and more sophisticated methodology is to be developed.

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GLOBALIZATION, MIGRATION AND CULTURE DIVERSITY

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Abstract

The aim of the study is to analyse society`s attitude towards globalization, increased immigration and multicultural dialogue emphasizing the importance of multicultural education. The investigation is based on the EU Comenius school partnership project *'Richness in Diversity'* (No.: 07-LVA01-CO06-00167-2) where five EU countries (Latvia, Slovakia, Portugal, the Netherlands and Ireland) are involved. During investigation, a qualitative research has been done. The EU Comenius school partnership project *'Richness in Diversity'* coordinators (teachers experts) were interviewed to discover their own experience and attitude towards globalization, migration, intercultural dialogue as well as their observations of their students' (aged 12-15) attitude and knowledge at the beginning of the project and dynamics - how changes their attitude when they have a possibility to visit a particular country and meet its inhabitants. The results show a positive progress of the teachers` and students` knowledge about the EU Comenius school partnership project *'Richness in Diversity'* involved countries. During the project, mobilities students live in host families which gives them an excellent opportunity to get introduced with the particular EU country`s family, their everyday life, traditions and habits. It helps them better understand people from different cultures and learn to appreciate the culture diversity.

Key words: migration, radicalism, intercultural dialogue, culture, integration.

Introduction

During globalization when increases immigration and many people go to work and study abroad in other cultures, difficulties of intercultural communication (intercultural communication occurs whenever a message produced in one culture must be processed in other culture and the message must be understood (Kim, 1998)) may arise as well as racial discrimination and race-hatred. The role of multicultural education is to reduce radicalism, racial discrimination and promote integration processes in society emphasizing multicultural dialogue and culture diversity. Many scientists from all over the world, like P.S. Adler, I. Apine, J.A. Banks, Y.Y. Kim have done investigations proving the fact that multicultural education reduces society`s radicalism and discrimination among nations. Studies of different cultures and traditions help to improve international relationships and the multicultural dialogue and to avoid some degree of culture shock that may happen when first time live abroad, especially in a very different culture. 'The ability to communicate effectively with people from diverse cultures and co cultures benefits each of us as individuals and has the potential to benefit the other 5.5 billion people with whom we share this planet' (Samovar and Porter, 1991).

The aim of the study was to discover their own experience and attitude towards globalization, migration and intercultural dialogue. The teachers experts' observations of their students' attitude and knowledge were estimated and dynamics when they have a possibility to visit a particular country and meet its inhabitants. The results show a positive progress of the teachers` and students` attitude and knowledge about the EU Comenius school partnership project *'Richness in Diversity'* involved countries.

Materials and Methods

The investigation described in this article is based on the EU Comenius school partnership project *'Richness in Diversity'* where five EU countries are involved (Latvia, Slovakia, Portugal, the Netherlands and Ireland) and was done in spring 2008. This is a continuing research, on which basis the author will work out the doctor thesis.

The data were obtained using a qualitative research - interviews. The coordinators (teachers experts) from all five countries involved in the EU Comenius school partnership project *'Richness in Diversity'* were interviewed. The interviews were made according to A. Kroplijs and M. Račevska 'Methods of Qualitative Research in Social Sciences' (Kroplijs and Račevska, 2004). It was partly structured interviews, according to A. Geske and A. Grīnfelds 'Educational Research' (Geske and Grīnfelds, 2006).

The aim of the investigation was to analyse the teachers experts` from all five EU countries involved in the Comenius school partnership project *'Richness in Diversity'*:

1) own experience and attitude towards globalization,

migration, intercultural dialogue;

2) observations of their students' attitude and knowledge at the beginning of the project and dynamics - how changes their attitude when they have a possibility to visit a particular country and meet its inhabitants.

The research basis – coordinators (teachers experts) from participating countries (Latvia, Slovakia, Portugal, the Netherlands and Ireland) in the EU Comenius school partnership project *'Richness in Diversity'*. The teachers experts` were selected on their high-level education basis (12 Masters` and 3 Doctors` degrees in Pedagogy) as well as on their long working experience - more than 10 years in pedagogy and project coordination (55). This factor is essential for getting valid information.

Schools and countries from where teachers experts participated in the investigation were:

1) Satini Primary School, Saldus region, Latvia (there work 23 teachers and it has 130 students, in the research participated 10 teachers experts);
2) CJC Riga Pupils` Palace, Riga, Latvia (there work 95 teachers and it has 3956 students, in the research participated 15 teachers experts);
3) Zakladna School, Kezhmarok, Slovakia (there work 50 teachers and it has 867 students, in the research participated 12 teachers experts);
4) Agrupament de Escolas da Guia, Portugal (there work 125 teachers and it has 917 students, in the research participated12 teachers experts);
5) Montessori College, Nijmegen, the Netherlands (there work 57 teachers and it has 597 students, in the research participated 11 teachers experts);
6) Merci College, Sligo, Ireland (there work 57 teachers and it has 597 students, in the research participated 10 teachers experts).

Most of the interviews were made during the project mobilities in 2008 when all project partners met each other in a particular country (in February, 2008, meeting in Portugal; in May, 2008, meeting in Latvia; in October, 2008, meeting in Ireland). The rest of the interviews and additional information were gained using telephones and e-mails from February till December 2008.

Results and Discussion

Respondents` opinion on Globalization

Gained results show different attitudes towards globalization. Summarizing the answers we can divide respondents in two parts. One part of respondents (75%) acknowledges globalization and has a positive attitude towards globalization, while others (25%) has a negative attitude towards globalization.

Most of the respondents (87%) recognize globalization as a fact of life, which is here to stay. They say that it brings problems like the rise of Transnational Corporations which have become more powerful than national governments but which are not responsible to anyone except their shareholders. Also, while governments seem to want free movement of goods and services they wish to restrict the free movement of people. People sometime say - we are creating 'Fortress Europe', for example in an attempt to keep out poor people from other countries. Respondents from the Eastern part of Europe (65%) (Latvia and Slovakia) confess that they meet globalization in very limited fields of human activities. They agree with globalization in communications and telecommunication sector, transport, science, statistics and life saving and warming systems but not in the fields of culture, traditions and ways of lives. Respondents from Slovakia (98%) say that after joining the European Union in May 2004, there have been a lot of discussions about keeping up their national, economic and cultural identity in common Europe. They agree that the possible way to reach it is keeping of own traditions, habits and culture in every detail. The task of the future is finding margins between integration (globalization) and national identity and originality.

Respondents` opinion on Migration

Speaking about migration in general, respondents (56%) say that migration brings many positive benefits and also some challenges. They acknowledge that it is good to be enriched by other cultures and other ideas and point out that migration has always happened though not on the same scale as at present. Saying that countries need new life, new blood, and new ideas, respondents (71%) support migration but at the same time emphasize the fact of challenge that arises because change is not always easy and learning to accommodate diverse cultures, languages and religions takes time. Irish respondents (98%) say that Irish people have a history of migration and now it is their turn to receive migrants from many countries. Respondents from Latvia and Slovakia (74%) say that in general migration can contribute to understanding of different nations, learning of languages, gaining of useful working experience. Respondents from Slovakia (87%) say that at the moment they feel a huge impact of the brain drain in Slovakia. Highly educated people and especially young people leave the country because of earning much more money abroad. They are worried that it might have really devastating effect on their society. The same happens in Latvia.

Respondents form the Netherlands and Portugal (57%) have quite negative attitude towards migration in their country. They explain that immigrants bring negative changes in their country. Respondents from Latvia and Slovakia (7 respondents) have noticed that there is no such problem in their country because these countries do not attract a lot of immigrants at the moment. In general they think that countries should provide political asylum and help people in need, but as it is seen in some European countries too many economy immigrants can cause tension in the society. All respondents from Ireland (10 respondents) welcome the diversity and variety but at the same time says that not everyone does. If immigrants are seen to bring down the price of labour and native people lose jobs because immigrants are willing to work for less that can cause resentment. The solution they give is not to ban immigration but to make sure that labour laws are minimum wage holidays, etc. should be enforced.

All respondents (100%) from all countries agree that immigrants in their host country must have a possibility of keeping their native language, traditions, and lifestyles but at the same time they must learn the language, traditions and lifestyle of the host country as well as respect its legislation. Irish respondents (96%) admit that a lot of immigrants can be a danger for the host country if immigrants do not become integrated within the host society. The given example about America shows that this country is made up of waves and waves of immigrants but America is a very patriotic society. Second and third generation immigrants will see themselves as Irish and American or Latvian and Irish or whatever. The type of patriotism, which depends on a monolithic culture, is not good. Irish respondents (89%) also say that Northern Ireland is probably an example of a place, which is not united and where to one half of the population being patriotic means being Irish and to the other half it means being British. It could be said that the Ulster Unionists were immigrants for several hundred years that displaced the local population so immigration cannot be forced by governments.

In all interviewed countries respondents say that there is a possibility for immigrants to get a citizenship when they pass exams but at the same time they confess that integration work is not enough done. Irish respondents (10 respondents) say that there are also some diversity and tolerance programmes but there is not enough funding available. In Ireland immigrants are welcomed as workers but not enough has been done to welcome them as human beings.

It is also an interesting fact that all respondents admit a possibility of going abroad for a while for studies and gaining new experience but very few of them (3%) admit a possibility of working abroad.

Respondents` opinion on Culture Heritage

Speaking about the knowledge of different countries, cultures and traditions as provided at schools, all respondents (100%) say that it is not enough. Respondents from Latvia and Slovakia (95%) say that geographical knowledge given at their schools is sufficient but they should improve education in tolerance and respect to other nations. Respondents from the Netherlands and Portugal (87%) admit that they have a very poor knowledge about the Eastern Europe countries, like Slovakia and Latvia. Respondents from Ireland (79%) say that schools can impact knowledge through History, Language teaching, European studies, etc. and it is difficult to pass on a positive attitude to other cultures as attitudes at home and in the wider community are more influential on students. All respondents say (100%) that curriculum has not been adapted to help learn about other cultures. Irish respondents (6 respondents) give an example that the junior history syllabus gives a choice to learn about ancient Greece or Rome as examples of another civilization but there is no choice to do Chinese Civilization instead even though they have Chinese students. Also the history course teaches about the Renaissance but gives no information about the Muslim contribution to European civilization. Language students do learn about the culture of France, Germany or Spain.

All respondents (100%) say that there is a big difference between knowledge given at schools and gained abroad. Direct contact with country and its people is invaluable. The most important 'human dimension' is missing in school education and this can be given to students through the exchanges during project mobilities when students visit a particular country. Slovak respondents (58%) say that understanding each other is not only the matter of knowledge but mainly it is about our communication and feelings of friendship and cooperation. Irish respondents (87%) admit that it depends on how the knowledge is gained abroad. If one gets an opportunity to live with a family, go to school or work, meet local people then the knowledge is worthwhile, but if one is a tourist staying in a hotel and only seeing touristy things one may not get much knowledge. There it should be explained that in our EU Comenius school project *'Richness in Diversity'* mobilities students live with host families, go to school, attend lessons and meet local people.

Respondents` answers (100%) showed the discrepancy between a tourist visit and project mobility. They say that tourist visit can be more superficial and the emphasis is on seeing sights and spending time with family or friends one travelled with. However, they admit the fact that if one is interested as a tourist one can discover a lot about the culture of the country but if one does not know the language of the host country it is not possible to meet local people in any meaningful way. Slovak respondents (86%) also agree that there is a wide gap between being in the country as a tourist or as a participant of the project. You can see buildings, towns, fine arts and many other valuable things as a tourist but you do not usually have a chance to meet people, to know their real lives, their feelings and opinions. The best guide is a service provider only, but your project partner is a friend and a colleague who gives you informal personal information and it is extremely valuable and important. One Irish respondent gives an example that she had a very interesting visit to Cordoba in Spain where she got a lot of information about the Islamic, Roman and Jewish cultures, which helped to shape it but she did not speak Spanish and even the wonderful Roman museum she could not follow all the information signs about the exhibits. At the same time when she visited Kempten, Sligo`s Twin Town in Bavaria and stayed with exchange hosts of her daughter, the families showed her around and share their culture. This is similar to that we have in our project. All respondents (100%) appreciate the project mobilities and say that during these mobilities they can improve their knowledge about the particular country, use foreign language learnt at school and understand that learning languages is really important for their future lives. They can gain greater motivation in learning languages as well. The students` foreign language knowledge improves and this progress is evaluated in marks during the foreign language lessons when returning home. At the same time improves students and teachers` knowledge about culture diversity, traditions and they get new friends. Students` attitude has changed – at the beginning of the project they were quite worried about using languages and staying in a strange family. After their first experience, they become more confident in communication and they even love those members of the families who did not speak English at all. They appreciate meeting new friends and people and they consider this aspect of the exchange the most valuable in their reports. First they used to be a bit shy but later they started to be aware of their abilities. They all emphasized their positive experience and warm welcome provided by the host families. It could give them a chance to be real European citizenships in the long term.

Most of the respondents (96%) admit that they are sure that the language barrier can cause difference in foreigners` attitude. Speaking in partners` native language is the best way to understand each other, but using another foreign language, which all know, is a good alternative as well.

Speaking about multicultural understanding whether it has changed during such projects, 76% of respondents say that despite the differences among cultures, religions and experiences, all countries want to live in peace, play a role on the world political stage, improve their living and working conditions and strive for greater justice in the world. Respondents think that every nation with its culture, traditions, customs and other specifies represents the huge human creative power and the richness of mind. Loosing whichever of them they consider spiritual impoverishment of the mankind.

During the mobilities, respondents (98%) notice that students have no problems to communicate and they want to understand each other. They could not feel any national or ethnic barriers between them and they behaved very friendly. Seven Slovak respondents say that students are very curious about their host families` life style and they have no difficulties in respecting the existing differences. While 30% of Irish respondents have noticed that most students are not very curious about or interested in other cultures, but in general Irish students do not show any overt racism or hostility towards students from other cultures but in general, they do not go out of their way to include them or make them welcome. This applies equally to the migrant students. If there are a number of them they tend to associate with their own peer group. Language difficulties on both sides partly explain this but the respondents think that it is also because teenagers tend to be very wrapped up in their own peer group and are not very curious about other groups. This does not apply just to other cultures but also to urban versus rural or sporty versus non sporty within the same culture. These respondents also think that younger students, i.e. primary school age seem to be more open to diversity but the teenage years are a time for the dominance of the peer group.

Discussing activities that should be carried out at school and during project mobilities to teach students appreciate all nations, all respondents (100%) point out different group works, creative works, working together and sport activities. Also different cultural practices need to be explained to students, e.g. fasting during Ramadan, etc. There needs to be a debate about where the boundaries between respect for another culture and insisting on the basic human rights understanding of one`s own culture lie. An Irish respondent gives an example that one can respect some cultural practices but not all, e.g. corporal punishment, gender discrimination, etc. Irish respondents (87%) admit that a lot needs to be done to impress on Irish students that not being able to speak English is not a sign of a lack of intelligence and activities need to be fostered which are not language dependent, e.g. games, art, crafts, etc.

Six Irish respondents give an interesting comment on migration. They say that Ireland now has a very large immigrant population especially form Eastern Europe. This is a very new experience for us as up to the 1980's Irish people needed to emigrate to find work themselves and there are millions of people of Irish descent all over the world. Attitudes to immigration were shaped to a great extent by the large numbers of asylum seekers who arrived in Ireland from 1999 onwards. They were not allowed to work and it took years to process their applications, so, to a great extent, they were seen as 'scroungers' who were exploiting the Irish people. Making education provision for the children of asylum seekers was the first experience the Irish government had of accommodating diversity. Since the government did not regard the asylum seekers as long - term residents it was reluctant to invest too much in providing for them. The accession of the new EU countries brought large numbers of migrants from Eastern Europe. People came because of the growth in the economy and many brought their families with them. This has huge implications for education but while language teachers have been appointed and Intercultural Guidelines produced nothing has been done at an official level to train teachers for the new situation or to adapt the curriculum. The government has not done enough to help society as a whole adapt to the change. Immigrants have been viewed as workers and all their other needs to a great extent ignored. They admit that this is changing a little now. Ireland has a Minister for Integration, and various area partnerships are working on diversity projects but it needs to be more mainstream.

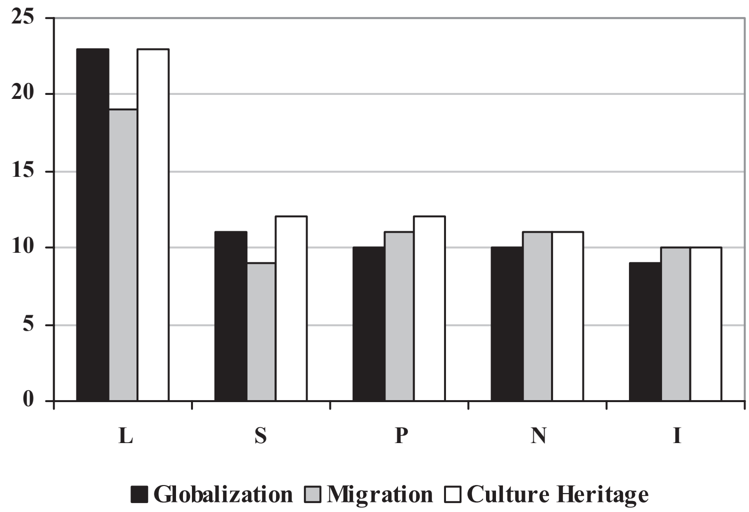

Figure 1. The importance of globalization, migration and culture heritage:
L – Latvia, S – Slovakia, P – Portugal, N – The Netherlands, I – Ireland.

Figure 1 shows teachers experts` attitude and importance of globalization, migration and preservation of the culture heritage in their own country as well as in the European Union.

Having studied scientific works about immigration and integration the author came across with many examples of negative attitude towards immigrants. Because of the different history there is a big discrepancy between Eastern and Western EU countries, and the common tendencies show that. People from the Eastern countries migrate to the Western countries as there they find better living conditions. It is also observed in Latvia and Slovakia when their inhabitants emigrate to the Western EU countries for better job and living conditions (Krūma and Indāns, 2007). People`s negative attitude and attacks towards immigrants show their fears about their national identity, their culture values as well as they are afraid of terrorism threats in their countries (Krūma and Indāns, 2007). Radicalism is considered as the main influencing factor of terrorism, e.g. a separate social group – new Muslims - men who are not integrated in Western societies and therefore foster radicalism processes in society (Reire, 2007). In democratic societies, names 'extreme' and 'radical' usually describe groups which do not recognize common values (Rostoks, 2007). It is impossible to think about radicalism in different ethnical groups` relationships, attitude towards immigrants, religion and cultural minorities without definite political context. To avoid this it is important for the host country to solve immigrants' problems (Ijabs, 2007). Speaking about social or culture identity it is important to understand that every individual has a need to belong to a particular group – to be a part of the social group which has common values. Different social groups that have to live together have the same question of mutual relations and the result is social world – society as it is now. Every social group has its own norms, values and means of expression and experiences, which characterizes and differs from other groups (Vasariņa, 2007). The basic idea of understanding and successful multicultural dialogue is connected with the presumption of the objectivity of moral norms – there exists something that everybody should recognize (Muižniece, 2007). To influence society`s consolidation it is important for the public governance to choose people from different social groups, for instance, in educational, demographical, ethnical, political structures. It is also considered to be more democratic model (Reinholde, 2007) and it fosters integration processes in society. We have to confess that EU partner countries can get a lot of economical and other benefits from immigrants. Therefore it is important to integrate immigrants in their host country`s society (Krūma and Indāns, 2007).

Conclusions

1. Teachers and students who participate in the EU Comenius school partnership project *'Richness in Diversity'* and during the project mobilities visit the particular country and get acquainted with its inhabitants, culture, traditions and habits become more tolerant towards culture diversity.
2. The fact that during the project mobilities when students are assimilated into the local society and they live in the host families provide optimal conditions for a particular country`s culture studies.
3. Going abroad as a tourist and living in the hotel without knowing the local language is more difficult to understand the local culture and traditions.
4. During the project activities students have an opportunity practically to use the foreign languages taught at school as well they can study languages which they do not cover at schools.
5. During globalization when we all have to live together it is important to be tolerant to the diversity, avoid radicalism and intolerance. Therefore it is important for the new generation to provide multicultural education at school and promote participation in the EU projects in order to get to know other cultures better.

Acknowledgments

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ENSEMBLE WORK FOR PUPILS' SELF-REGULATED LEARNING

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Abstract

Music schools in Latvia provide pupils with musical education both in the towns and rural areas of Latvia. Studies include instrumental playing, history of music, and music theory lessons. An actual pedagogical problem at the time is activation of pupils' learning. Self-regulated learning acquires significant meaning for pupils' future life. A way of helping pupils' self-regulation in learning is differentiation of learning methods and forms. The aim of the paper is to research the meaning of music schools' ensemble work (collective performance) for enhancing pupils' self-regulated learning. Learning is a process where an individual inherits accumulated experience of the society, acquires skills, knowledge, attitudes, enhances his experience, individually and responsibly working and discovering himself, nature and society. Learning as an activity is based on learning experience. According to L.S. Vygotsky's theory of learning, the cultural development depends upon social interaction. The use of ensemble work (collective performance) in school as a form of learning activity and method observes a reciprocal movement towards didactic goal, includes the components of due learning contents (knowledge, skills, instrumental playing experience, attitudes), the results of learning process and its evaluation. Analysis of the obtained data shows that music teachers choose ensemble work as method and form of teaching to indirectly influence the self-regulated learning of pupils, whereas the pupils do not fully understand the significance of ensemble work for enhancing self-regulated learning techniques.

Key words: ensemble work, self-regulated learning.

Introduction

Learning is a specific activity which implies experience and skills as personal qualities that allow or do not allow an achievement of learning goals set by the self or a teacher (Žogla, 2001). Actual pedagogical problem at the time is activation of pupils' cognition. How to help pupils learning to learn, foster the independence and self-regulation in learning by observing individual approach? A way of helping pupils' self-regulation in learning is differentiation of learning methods and forms (Andersone, 2007).

Music schools in Latvia provide pupils with musical education both in the towns and rural areas of Latvia. Studies include instrumental playing, history of music, and music theory lessons. The aim of the paper is to research the meaning of music schools' ensemble work (collective performance) for enhancing pupils' self-regulated learning.

Materials and Methods

As stated by pedagogue I. Žogla, learning as didactic notion includes two aspects – pedagogical and psychological. Pedagogical aspect's learning content is variable and its separate components are significantly apart of each other which considerably increases the significance of learning approach choice (Žogla, 2001).

Learning is a process where an individual inherits accumulated experience of the society, acquires skills, knowledge, attitudes, enhances his experience, individually and responsibly working and discovering himself, nature and society, as defined in the Glossary of Pedagogical Terms (Pedagoģijas terminu skaidrojošā vārdnīca, 2000). Learning as activity is based on learning experience.

W. Dilthey argued that experience is a starting point of cognition and demonstrates an attitude to the world. He suggested that all human experience divides naturally into two parts: that of the surrounding natural world, and that of inner experience, characterized by responsibility for actions (Dilthey, 2000).

J. Dewey defined two main principles formatting the basis of human experience underlie the basis of the experience-forming:

- the principle of mutual cooperation,
- the principle of perpetuity or legacy (Dewey, 2005).

Hermeneutics offers a new way to understand the experience of arts. Originally devoted to the interpretation of sacred texts, hermeneutics was extended by M. Heidegger. He suggested that human beings are always in the process of interpreting the world and themselves, and saw in hermeneutics a structure of existence (Heidegger, 1962).

According to L.S. Vygotsky's theory of learning, the cultural development depends upon social interaction.

Reflecting that the individual uses the world as instrument for his/her object-orientated actions, author stated that this applies equally to voluntary attention, to logical memory, and to the formation of concepts (Vygotsky, 1978).

L.S. Vygotsky's theory is complementary to the work of A. Bandura on social learning. According to A. Bandura's concept of self-regulated learning, the behaviour depends upon controlling. Reflecting that the individual compares the learning as performance with traditional standards or competing with others/ourselves, he suggested such three steps:

- self-observation,
- judgment,
- self-response (Bandura, 1997).

As stated by pedagogue I. Žogla, learning is a purposeful cognitive activity in order of enhancing experience within a specially organized environment and with the help of another person which actualizes emotions, motives, interests, needs, contact, attitudes, and other individual qualities (Žogla, 2001). Learning activation is a resource which is realized by differentiation of learning forms and choice of appropriate teaching methods to increase the self-regulation in pupils' learning process.

The use of ensemble work (collective performance) in school as a form of learning activity and method observes a reciprocal movement towards didactic goal, includes the components of due learning contents (knowledge, skills, instrumental playing experience, attitudes), the results of learning process and its evaluation. Ensemble work (collective performance) is realized through teacher – pupil co-operation by integration of individual and group practice into the learning process.

Ensemble work at music school is characterized by the involved pupils' united efforts and responsibility for achieving the artistic goals in the piece of music being learned, by including the following tasks:

- playing a musical instrument,
- being able to interpret the visual music notation,
- control dynamics and rhythm in group playing,
- coordinate the way of sound production,
- collectively solve the tasks of ensemble playing,
- be aware of needs for improvement in individual playing.

In order to evaluate the importance of ensemble work (collective performance) at schools for enhancing pupils' self-regulated learning, in 2008/2009 a pedagogical study was conducted involving 18 teachers and pupils of a Vidzeme area music school.

Results and Discussion

The pedagogical premises of ensemble work (collective performance) at music schools are being realised according to the educational standard on professional vocational education program 'Instrumental music' for educational contents' amount and distribution (Educational standard, 2002).

The form of ensemble work in vocational education program is used in the subject 'Collective performance' with contents' acquisition during six academic years (third through eighth grade, 560 lessons in total). Program realization plan includes keyboard and string instruments' divisions as follows:

- piano playing,
- violin, viola, cello playing.

Ensemble work form for subject 'Collective performance' in a shorter period of four academic years (third through sixth grade, total of 420 lessons) is realized in the following divisions:

- accordion, Latvian psaltery, guitar playing,
- double bass, percussion playing,
- flute, oboe, clarinet, bassoon playing,
- saxophone, horn, trumpet, trombone playing,
- tuba, euphonium, other brass instrument playing.

Professional vocational education program 'Instrumental music' contents' realization in practical education process in Latvia rural areas' music schools is dependent on the presence of teachers at the each educational institution. Not all Latvian schools realize each of the program components every year. This is why ensemble work forms and contents in each particular situation are planned according to instrumental teachers' and pupils' presence.

A survey on situation in real pedagogical process in a music school in Vidzeme area was conducted in 2008/2009 with purpose of obtaining data from two independent groups (teachers and pupils). Data was processed with a Mann-Withney U test. The research is based on the data received from the analysis of the situation in the educational practise. During the 2008/2009 academic year, 18 pedagogues and pupils of rural music school in Vidzeme were asked to complete a questionnaire about developing self-regulated learning by using ensemble work (collective performance). A totally 7 pedagogues and 11 pupils took part in the assessing experiment. Respondents were interviewed in two question groups, and set reply data was obtained in six positions:

1) disagree,
2) rather disagree than agree,
3) not sure,
4) rather agree than disagree,

5) agree,
6) no data.

Ensemble work (collective performance) research was done using nonparametric methods, to establish differences between two unconnected sample units (pedagogues and pupils). Data processing and analysis by Mann-Whitney U Test in SPSS environment was applied on two independent data selections (Lasmanis, 2003).

Test results in the first question group on knowledge as resource for self-regulated learning analysed hypothesis that a significant difference in a number of replies between pedagogues and pupils exists:

1.1. Knowledge about ensemble music literature enhances self-regulated learning.

As p-value=0.003<0.05, then with a 95% possibility can be concluded that pedagogues' reply numbers differ significantly from the pupils';

1.2. Knowledge about co-operation in ensemble encourages self-regulated learning.

As p-value=0.039<0.05, then with a 95% possibility can be concluded that pedagogues' reply numbers differ significantly from the pupils' (see Fig. 1).

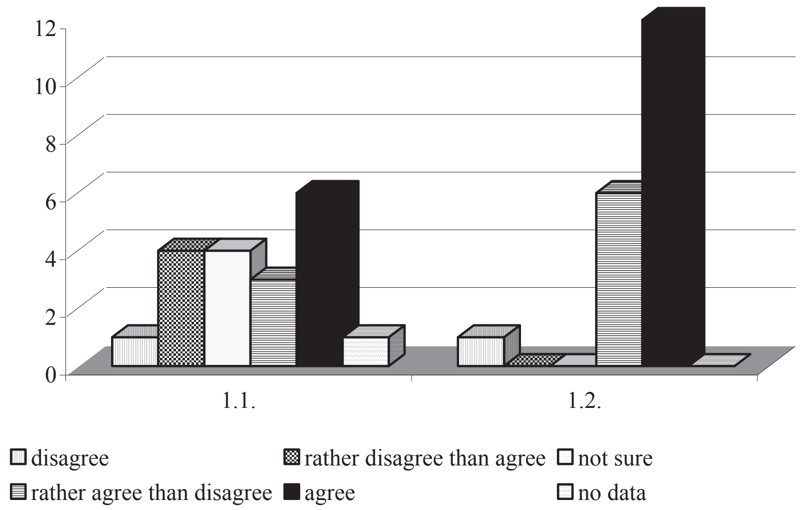

Figure 1. Knowledge as resource for self-regulated learning.

Test results in the second question group on ensemble experience as resource for self-regulated learning analysed hypothesis that a significant difference in a number of replies between pedagogues and pupils exists:

2.1. Obtaining performance skills for solo instrument playing.

As p-value=0.024<0.05, then with a 95% possibility can be concluded that pedagogues' reply numbers differ significantly from the pupils';

2.2. Obtaining responsible attitude for individual practising.

As p-value=0.000<0.05, then with a 95% possibility can be concluded that pedagogues' reply numbers differ significantly from the pupils' (see Fig. 2).

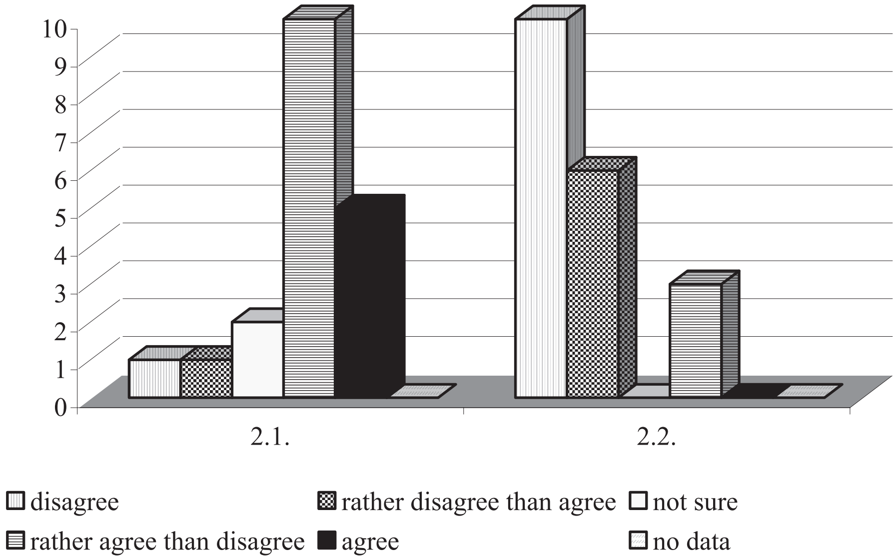

Figure 2. Ensemble experience as resource for self-regulated learning.

Analysis of the obtained data shows that music teachers choose ensemble work as method and form of teaching to indirectly influence the self-regulated learning of pupils, whereas the pupils do not fully understand the significance of ensemble work for learning self-regulated learning techniques.

Significant components for enhancing self-regulated learning are:

- knowledge about ensemble music literature,
- knowledge about co-operation in ensemble work,
- performance skills for playing solo instrument,
- responsible attitude to practising.

Conclusions

1. Ensemble work (collective performance) as form and method of learning at music school satisfies the pupils' need for contact and cooperation in practising.
2. Ensemble work (collective performance) at music school is a pedagogical condition for enhancing pupils' self-regulated learning by obtaining knowledge and experience.

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TEACHER EDUCATION: THE FOCUS ON DOCTORAL STUDIES

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Abstract

The Bologna Process started in 1999, aiming to elaborate an overarching framework of qualifications for the European Higher Education Area. The doctoral level as the third cycle was introduced for promoting closer links between research and higher education. The implementation of doctoral programme of pedagogy has strengthened the area of educational research. The general goal of the doctoral education is to provide doctoral students with an in-depth knowledge of the field of research and the capability to produce novel scientific knowledge independently. The aim of the paper is to characterize the realisation of teachers' education as doctoral training in the context of Bologna Process strategies. The seminar in Salzburg set up ten basic principles concerning doctoral education. Learning outcomes in the field of research training are one of the basic building blocks of European higher education quality. The quality of teachers' education on doctoral studies level is depending on advanced learning outcomes of an individual. The goals of doctoral education are increasing internationalisation, co-operation between academies, promoting academic careers and establishing post-doctoral positions. The investigation about research training was carried out at Riga Teacher Training and Educational Management Academy doctoral study programme in pedagogy. A questionnaire about aspects of doctoral studies was developed for obtaining information for analysis and was given to teachers (doctoral students). Respondents were asked to complete the questionnaire focusing on learning outcomes. The estimation of the results was made summing the answers, and the percentage was calculated. Feedback from doctoral students plays an important role in the further development of the curricula.

Key words: doctoral programme, doctoral students.

Introduction

The Bologna Process started in 1999, aiming to elaborate an overarching framework of qualifications for the European Higher Education Area. In the Berlin Communiqué 2003, the doctoral level as the third cycle in the Bologna Process was introduced for promoting closer links between research and higher education. Two years later, the Bergen Communiqué 2005 emphasised the importance of higher education and the quality of teaching in further enhancing research and vice versa (The European Higher Education Area beyond 2010, 2005). In the London Communiqué 2007, the emphasis again was put on embedding doctoral programmes in higher institutional strategies and policies (Bologna Process: Stocktaking Report 2007, 2007).

The general aim of the doctoral education is to provide doctoral students with an in-depth knowledge of the field of research and the capability to produce novel scientific knowledge independently. Doctoral education in pedagogy in Latvia has a special national goal to support the strengthening of teacher education. Through educating doctoral students there will be more doctors teaching in primary and secondary school teacher education in the future.

The aim of the paper is to characterize the realisation of teachers' education as doctoral training in the context of Bologna Process strategies.

Materials and Methods

Doctoral education in Europe is diverse because of many national differences in national regulations governing higher education. European higher education institutions have the autonomy to develop their own profiles and research priorities. Advancement, development and improvement of knowledge through original research are the key component of the third cycle (Augstskolu likums, 1995).

The main objective of the seminar organised in Salzburg (2005) was to discuss perspectives of doctoral education as the third cycle in the Bologna Process (Bologna Seminar on 'Doctoral Programmes for the European Knowledge Society', 2005).

The seminar in Salzburg set up ten basic principles concerning doctoral education.

1) the core component of doctoral training is the advancement of knowledge through original research;
2) universities as institutions need to assume responsibility for ensuring that the doctoral programmes and research training they offer are designed to meet

new challenges and include appropriate professional career development opportunities;
3) the rich diversity of doctoral programmes in Europe – including joint doctorates – as a strength which should be underpinned by quality and sound practice;
4) doctoral candidates should be recognized as professionals (early stage researchers) – with commensurate rights – who make a key contribution to the creation of new knowledge;
5) in respect of individual doctoral candidates, arrangements for supervision and assessment should be based on a transparent contractual framework of shared responsibilities between doctoral candidates, supervisors and the institution;
6) doctoral programmes should seek to achieve critical mass and should draw on different types of innovative practices being introduced in universities across Europe, bearing in mind that different solutions may be appropriate to different contexts and in particular across larger and smaller European countries;
7) doctoral programmes should operate within appropriate time duration (three to four years full-time as a rule);
8) the promotion of innovative structures to meet the challenge of interdisciplinary training and the development of transferable skills;
9) doctoral programmes should seek to offer geographical as well as interdisciplinary and inter-sectoral mobility and international collaboration within an integrated framework of cooperation between universities and other partners;
10) the development of quality doctoral programmes and the successful completion by doctoral candidates requires appropriate and sustainable funding (Bologna Seminar on 'Doctoral Programmes for the European Knowledge Society', 2005).

The focus on quality in the Bologna Process has raised awareness within higher education institutions of the potential challenges and they must begin to think through the implications of the existence of the European Higher Education Area after 2010. This concern transcends across the boundaries as a change of educational paradigm from a system of teacher-driven provision, and towards a student-centred learning (Reichert and Tauch, 2005). According to the report, doctoral programmes are one of the important elements in the institutional strategies for enhancing internationalisation and mobility of doctoral students and academics (The European Charter for Researchers, 2006).

The Bologna Process elaborated a framework of 'comparable qualifications for comprising three cycles (including, within national contexts, the possibility of intermediate qualifications)' and descriptors for each cycle based on learning outcomes (A Framework for Qualifications of the European Higher Education Area, 2005).

A Framework for Qualifications of the European Higher Education Area emphasized the qualifications that signify completion of the third cycle such as:
1) students have demonstrated a systematic understanding of a field of study and mastery of the skills and methods of research associated with that field;
2) students have demonstrated the ability to conceive, design, implement and adapt a substantial process of research with scholarly integrity;
3) students have made a contribution through original research that extends the frontier of knowledge by developing a substantial body of work, some of which merits national or international refereed publication;
4) students are capable of critical analysis, evaluation and synthesis of new and complex ideas;
5) students can communicate with their peers, the larger scholarly community and with society in general about their areas of expertise;
6) students can be expected to be able to promote, within academic and professional contexts, technological, social or cultural advancement in a knowledge-based society (A Framework for Qualifications of the European Higher Education Area, 2005).

The London Conference prepared a report on the further development of the basic principles for doctoral programmes and stressed the importance of 'transferable skills development as an integral part of first, second and third cycle programmes' (Bologna Process: Stocktaking Report 2007, 2007).

The main goal at the level on the third cycle should be raising awareness among doctoral candidates of the importance of both recognising and enhancing the skills that they develop and acquire through research, as a means of improving their employment prospects both in academia and on the wider labour market (Doctoral Programmes for the European Knowledge Society, 2007).

According to 'The national concept of the development of higher education and the institutions of higher education of the Republic of Latvia till 2010', one of the priorities is altering the curricula towards being based more on research training (The national concept of the development of higher education and the institutions of higher education of the Republic of Latvia, 1998).

Results and Discussion

Higher education in Latvia at the beginning of 2009 was offering a total of six doctoral study programmes in pedagogy with the main goal of assuring the quality of teachers' education. Accreditated doctoral studies in pedagogy are offered at the University of Latvia, Latvia University of Agriculture, Daugavpils University, Liepaja University and Latvian Academy of Sports Education (Accreditated programmes by degree: Doctoral Studies: Pedagogy and Teachers Education, 2009).

Doctoral education at Riga Teacher Training and Educational Management Academy (RTTEMA) as the sixths is steered by doctoral study programme regulations. The creation of doctoral programme in pedagogy was a new stage in the development of strategy of study process at RTTEMA. During the last two years the doctoral programme (licence from 12.05.2008.) involved 24 students.

The aim of the doctoral study program at RTTEMA is ensuring the integration of fundamental and theoretical knowledge of pedagogical sciences into practical pedagogy, fostering the preparation of scientists for research and academic work of international standard, and achieving a doctoral degree in following fields of pedagogy science:

- pre-school pedagogy;
- school pedagogy;
- pedagogy of music, dance, visual art and vocational pedagogy (Riga Teacher Training and Educational Management Academy Doctoral Study Programme, 2008).

The investigation about research training and the organization of teachers' education has been carried out at RTTEMA doctoral programme in pedagogy. A questionnaire about aspects of doctoral studies and learning conditions for professional activity had been developed for getting information for analysis and was given to 10 teachers (doctoral students). Respondents were asked to complete the questionnaire focusing on the goals of the curricula, learning outcomes, supervision and doctoral students' mobility. The estimation of the results was made by summing the answers, and the percentage was calculated.

Learning outcomes in the field of research training are one of the basic building blocks of European higher education quality. In order to guarantee the realisation of the goals of the curricula and students' research progress, an annual attestation of doctoral students is being organised. The student is required to submit an attestation report including an evaluation of learning outcomes. In the first part of the report the student is asked to present data about the progress of the doctoral thesis. The second part requires a detailed analysis of the contribution through original research by participating in the conferences and publication articles. The last part of the report focuses on the fulfilling the curricula.

The results showed that all learning outcomes of doctoral students should be periodically reviewed as a written estimation of the progress of teachers training for:

- academic carrier development – 50%,
- professional development – 50%.

Constructive support from the supervisors is important to sustain the efforts required for research training. The respondents graded the positive collaboration with supervisors as excellent (60%), good (30%), and poor (10%). Respondents considered the help of their supervisor to be the most important in such areas as defining the problems of dissertation, selection of a research method, planning of the empirical research, and participating in the international conferences.

At the level of the theoretical seminars for doctoral students, learning outcomes must be strengthened in the context of credit award:

- planning seminars once a month – 60%,
- planning seminars twice a month – 40%.

Funding of studies on doctoral level should offer more financial instruments facilitating the international short-term mobility and the scholarships during the course of a doctoral programme. The respondents pointed out that increasing international mobility demands increased investment of personal financial resources (10%), self-regulation (10%), and foreign language studies (10%), but 70% of doctoral students were satisfied with the education process.

All respondents are involved in the research guidance process playing a significant role in the attainment of desirable learning outcomes. More attention should be paid to the question of social guarantees offered to doctoral students. Today such guarantees are not enough for them to devote all of their time to the doctoral studies. The starting level of research skills of doctoral students is rather different which may be an obstacle for their engaging in greater joint projects. Feedback from RTTEMA doctoral students plays an important role in the further development of the curricula.

Conclusions

1. Quality of the realisation of teachers' education on doctoral studies level is depending on advanced learning outcomes of an individual. The creation of doctoral study programme of pedagogy according to

Bologna Process strategies has strengthened the area of educational research and the quality of teachers training.

2. The goals of teachers' education as doctoral training are increasing international mobility, collaboration with supervisors, and evaluation of learning outcomes leading to PhD degree.

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