IMPACT OF NEEDLE CAST DAMAGE ON SANITARY CONDITION IN YOUNG *PINUS SYLVESTRIS* STANDS IN CENTRAL LATVIA

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Abstract
Recent studies have demonstrated the occurrence of different needle cast (*Lophodermium spp*.) species in young Scots pine *Pinus sylvestris* L. stands in different regions of Latvia. The impact of these fungi has been known also historically, but is predicted to increase in future due to climate changes that are forecasted to have a positive impact on presence and vigour of various species of fungi. The aim of the study was to characterize the needle cast damage in young Scots pine stands in central Latvia. Material was collected in 12 Scots pine stands at the age of 3 to 26 years in 28 plots with a total area of 8.1 ha in the middle of two consecutive growing seasons (years 2012 and 2013). The impact of disease was visually assessed using a 5 grade scale, depending on the proportion of damaged (brown) one-year old needles. Incidence of damaged trees (P, %) and damage intensity (R, %) was calculated and used to characterize the occurrence and severity of the infection in the stands as well as its link to other stand parameters. Damage incidence (ranging from 20 to 100%), as well as the intensity (from 4 to 35%) was slightly (incidence-also significantly) higher in 2013 in comparison to 2012; correlation between those two parameters was strong in both years ($r = 0.94$ and $r = 0.84$, respectively). The stand age, density (ranging from 1200 to 6900 trees ha^{-1}) and tree height did not significantly correlate with the damage incidence or intensity. Forest type (*Hylocomiosa* or *Myrtillosa mel.*) was not a significant factor, too.
Key words: Scots pine, young stand, resistance, fungi infection.

Introduction

Coniferous forests have considerable economic importance in the Baltic countries, demonstrated both by the share of forestry sector in GDP and share of wood and wood products in total export value. Therefore, it is important to address any threats that might negatively affect vitality and growth of trees. Currently, most of such threats are associated with rapidly progressing climate changes (Edenhofer *et al*., 2014). Relation between meteorological factors and increment (both height and radial) of Scots pine has been well studied and results mainly demonstrate a slightly positive influence of the predicted changes on tree growth (Jansons *et al*., 2013a, b, 2015). However, genetics too plays an important role in determining the tree-climate interaction and, therefore, survival and vitality of trees (Jansons 2005; Jansons *et al*., 2006). For example, the results of provenance trial series analysis revealed that some provenances from different geographic origins planted together might have a very similar yield while others – very different, therefore climatic conditions of the place of origin need to be considered in discussion of the potential suitability of a particular forest reproductive material for a specific site (Rieksts-Riekstins *et al*., 2014).

Climatic changes are predicted to affect productivity of forest stands not only due to changes in stress levels of trees (Voronova *et al*., 2014) and impact on their growth, but also due to changes in patterns in natural disturbances, the most important among them being wind-storms (Seidl *et al*., 2014). Differences in allocation of biomass in trees, related to both genetics and environmental factors, might affect their resistance against the impact of wind (Bārdulis, Jansons, & Liepa, 2011, 2012; Jansons *et al.*, 2014). Climatic changes might also alter the impact of the diseases on trees. For Scots pine in nurseries and young stands (up to 25 years) needle cast is one of the most important diseases (Drenkhan, 2011). In Latvia, needle cast disease is caused by 4 different pathogenic fungi – *Phacidium infestans* Karst., *Lophodermium seditiosum* Minter, Staley & Millar, *Hypodermella sulcigena* (Karst.) Tub. and *Lophodermium pinastri* Chev. (Bankina *et al*., 2003). In recent years, in the Northern Baltics (Estonia) other diseases significantly affecting needles are identified: *Diplodia pinea* (Desmo.) J. Kickx and *Dothistroma septosporum* (Drenkhan & Hanso, 2009). The most important from above-mentioned needle pathogen is *Lophodermium seditiosum* (Minter, Staley & Millar), characterized by a high genetic diversity in territory of Latvia (Moročko-Bičevska *et al*., 2010) and a single year development cycle (Ortiz-García *et al*., 2003). The opportunity to select toughest (both – the least damaged and best recovering from the damages of the needle cast) genotypes and provenances had been proven by different tree breeding experiments (Jansons, Neimane, & Baumanis, 2008; 2016, Neimane *et al*., 2016). Weather conditions favourable for this disease have been observed during recent decades – humid and warm autumn (as well as the end of summer) and mild winters (Martinsson, 1979; Diwani & Millar, 1990; Stenström & Arvidsson, 2001; Hanso & Drenkhan, 2007), making this time period

Table 1

Location and parameters of studied stands

Object location		Area, ha	Forest type	Age, years	Stand average H, m	Stand average DBH, cm	Stand density, trees ha^{-1}	Area of sample plot, m^2
Latitude	Longitude							
56°43'N	23°44'E	0.5	As	3	0.3	1.0	2667	50
56°43'N	23°44'E	0.4	As	3	0.5	0.9	2533	50
56°43'N	23°45'E	0.6	As	3	0.7	1.3	3500	50
56°43'N	23°45'E	0.3	As	3	0.7	1.6	3900	50
56°43'N	23°45'E	0.3	As	3	0.6	1.3	6900	50
56°43'N	23°44'E	0.4	As	4	0.6	1.0	6000	50
56°43'N	23°44'E	0.4	As	15	6.8	7.6	2600	50
56°43'N	23°44'E	0.5	As	15	6.5	8.2	2100	50
56°43'N	23°46'E	0.4	As	16	7.4	8.2	2700	50
56°43'N	23°45'E	1.1	Dm	23	13.7	14.5	1300	200
56°43'N	23°45'E	1.8	Dm	23	12.4	14.0	1483	200
56°43'N	23°43'E	1.4	As	26	12.4	15.5	1200	200

suitable for the studies of occurrence and impact of this disease. The aim of the study was to characterize damages of the needle cast in young stands of Scots pine in the central part of Latvia.

Materials and Methods

Twelve young Scots pine stands were randomly selected for the study in Zemgale regional forestry (Jelgava and Ozolnieki district). The empirical material was collected during the growing season of 2012 and repeatedly in 2013 in 28 sample plots. The total surveyed area of young stands was 8.1 ha (Table 1). Plots were placed on the diagonal of each compartment in equal distances. The plot area depended on the mean height of the trees in the stand: if it was smaller than 12 m, area of sample plots was 50 m^2 (radius 3.99 m), but if it was 12 m or larger the area of sample plot was 200 m^2 (radius 7.98 m). Height and diameter of every tree was measured. Diameter measurements were done with caliper with 1 mm precision at the breast height (1.3 m) for trees higher than 1.3 m and at the root collar for trees smaller than 1.3 m. Height measurements were made with a measuring stick for up to 5 m tall trees and with the ultra sound height measuring device VERTEX IV for taller trees, in both cases with precision of 0.1 m.

Forest types were determined in accordance with the Latvian national forest classification system (Bush, 1981). Plots were placed in stands of two forest types: *Hylocomiosa* (Dm) and *Myrtillosa mel.* (As) is a forest type on drained soils (Sarma, 1948), characterised by the mesotrophic (average fertility) soil (Laiviņš, 2014).

Needle cast was visually assessed for every tree in 5 grade scale, depending on the proportion of damaged (brown) one-year old needles: 1st grade – 0.1 - 5%; 2nd grade – 6 - 35%; 3rd grade – 36 - 65%; 4th grade – 66 to 95% and 5th grade – 96 - 100% of damaged needles. To characterize the health status of young stands, the damage incidence (needle cast grade 2 - 5) (Formula 1) and damage intensity (Formula 2) (Miezite *et al.*, 2013) were calculated:

$$P = \frac{n \cdot 100}{N} \quad , \tag{1}$$

where P – damage incidence (%);
n – number of damaged trees (trees ha^{-1});
N – total number of trees counted (trees ha^{-1}).

$$R = \frac{\sum (n_i \cdot b_i)}{N \cdot k} \cdot 100 \tag{2}$$

where R – damage intensity (%);
n_i – number of damaged trees (trees ha^{-1});
b_i – level of damage (in grades);
N – total number of trees counted (trees ha^{-1});
k – highest level of damage (in grades).

Single factor analysis of variance and correlation analysis were used to evaluate the influence of various factors on analysed traits and relationship between these traits (Liepa, 1974; Liepa, 1996; Arhipova & Bāliņa, 2003).

Results and Discussion

The incidence of the needle cast damage and intensity of the damage impact was analysed in *Hylocomiosa* and *Myrtillosa mel.* forest types. Overall,

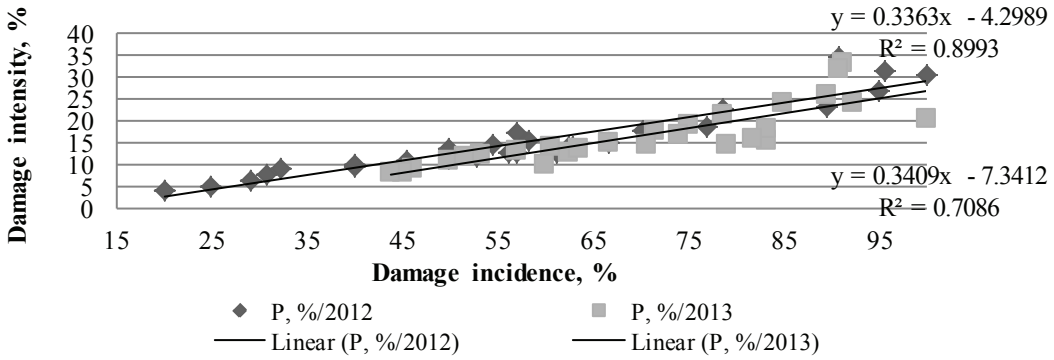

Figure 1. The relationship between the incidence of needle cast damage and damage intensity in young Scots pine stands in 2012 and 2013.

in Jelgava district 6 Scots pine stands in *Myrtillosa mel.* forest type were surveyed. In Ozolnieku forest district 6 Scots pine young stands – 4 of them representing *Myrtillosa mel.* and 2 *Hylocomiosa* forest type - were surveyed. The results demonstrated that the incidence of the needle cast ($p = 0.13$; $\alpha = 0.05$) and intensity of damage ($p = 0.11$; $\alpha = 0.05$) were not significantly different between the forest types. Presumably, it is due to similar conditions for the fungi in both forest types: for successful development of *Lophodermium spp.* acidity of the O horizon or litter layer needs to be pH 3.5 - 4.0 (Шевченко & Чилюзик, 1986) and it was close to these limits both in *Hylocomiosa* (3.4 - 5.5) and *Myrtillosa mel.* (3.7 - 5.4) (Bārdule *et al*., 2009).

Incidence of needle cast damage was significantly ($p = 0.03$; $\alpha = 0.05$) higher in 2013 in comparison to 2012 (70.8% vs. 58.9%, respectively), however intensity of the needle cast damage was not significantly ($p = 0.54$; $\alpha = 0.05$) different and reached 16.7% and 15.5%, respectively (Fig. 1). The incidence of the needle cast damage and damage intensity were strongly linked, suggesting that higher occurrence of the infection will not only affect more trees, but will affect a larger share of proportion of trees to a higher extent.

Dendrometric parameters, such as tree diameter (D) and tree height (H) might be affected by the impact of the infection both as the cause and the effect i.e. there might be lower resistance for weaker (smaller) trees in the stand and the impact of the disease might weaken the trees causing their growth to lag behind that of not affected trees. The impact might differ also in different stands of different age due to the mean size of the tree (and thus the amount of available nutrients). Such relationship had been observed in analysis of impact of pests. For example, the study in Estonia demonstrated, that severe defoliations by sawflies *Bupalus piniaria* occurred in 1930 - 1932, 1980 - 1981 and 1990 - 1992; by *Neodiprion sertifer* – in 1938 - 1939, 1948 - 1950, 1958 - 1960, 1962, 1965 - 1966, and 2007; and by *Diprion pini* – in 1981 - 1982. The result of outbreaks of these pests was a significant reduction of radial increment of younger pines (age of 3 - 11 years) during 2 years following the insect defoliation. Height increment decreased significantly already during the calamity year as well as during the next 2 years. For older pines (age of 25 - 33 years), both radial and height increment was significantly reduced in the year of the calamity, but growth reduction during 2 following years was insignificant (Hanso & Drenkhan, 2012).

The age of our study stands ranged from 3 to 26 years and the mean height – from 0.2 m to 13.8 m. Allocation of the studied stands in 2 age groups (age up to 15 years and older) demonstrates very similar average needle cast incidence in both groups, 59.2% and 58.4%, respectively; difference was not significant ($p = 0.41$; $\alpha = 0.05$.). Analysis of all stands as a single group did not reveal any significant age-related trend in incidence (Fig. 2) or intensity of damages. It indicates the needle cast disease is capable of infecting Scots pines at different age. However, the impact on growth might be different depending on the tree age, as demonstrated by the study in Estonia, where in the younger Scots pines (3-11 years), the radial growth of trees decreased (in comparison to the long-term mean) significantly in the year of *Lophodermium* epidemic and 2 years after the epidemics by 12 and 18%, respectively. Similar decrease in height growth was observed – 18% and 17%, respectively. No significant growth reduction was registered for older pines (22 - 33 years) during the first years after the *Lophodermium* needle cast epidemics (Hanso & Drenkhan, 2012). Similarly, a study in Denmark showed that another fungus *Chalara fraxinea* has a significant negative impact on the growth of common ash (*Fraxinus excelsior*) in up to 15 years old stands (Skovsgaard *et al*., 2010).

Similar to age, the tree height (mean of the stand) was not a significant factor affecting incidence of the disease, as demonstrated by correlation analysis (Fig. 3), as well as analysis of variance carried out

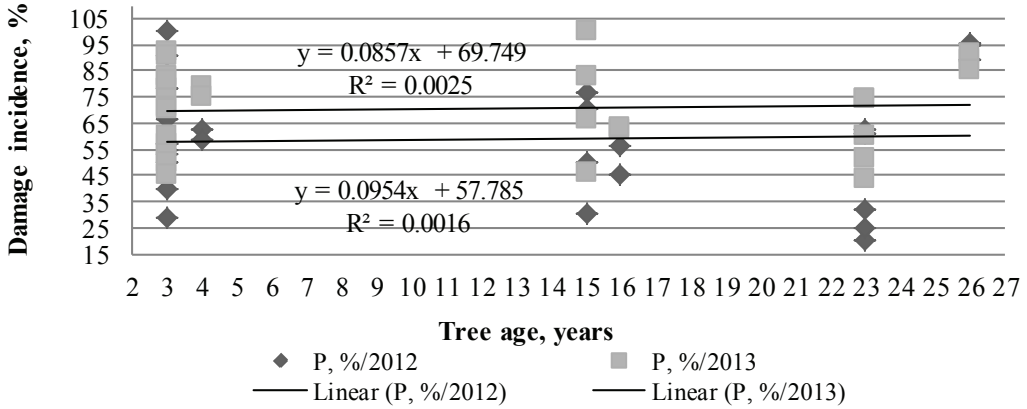

Figure 2. Needle cast damage incidence in Scots pine stands at different age.

between 2 height groups of trees and the incidence of disease ($p = 0.53$; $\alpha = 0.05$) or intensity of damage ($p = 0.41$; $\alpha = 0.05$). Analysis at a single-tree level demonstrated, that there is a link between the tree height and needle cast damage grade: damage intensity affected the height increment of 3 and 4 year old Scots pines ($\alpha = 0.001$). Lower height increment of more damaged trees resulted in a smaller total height (Jansons, Neimane, & Baumanis, 2008).

Density ranged from 1200 to 6900 trees ha^{-1} in the surveyed young stands. The study proved that there is no significant difference ($p = 0.51$; $\alpha = 0.05$) between the damage incidence in different stand density groups or a visible trend linking incidence or intensity of the needle cast damages to the stand density (Fig. 4). This finding contrasts with earlier studies, concluding that trees damaged by the needle cast occur more frequently with increase of the stand density (Voroncovs & Semenkova, 1982). In opposition to that a study in Sweden showed that not only growth of each individual tree, but also its resistance to various diseases had been boosted in plantation with lower density (Lundqvist & Elfving, 2010). Presumably, the differences in results between our findings and the results of other studies might be due to different range of stand densities analysed.

The results indicate, that further studies should address other factors presumably responsible for the differences in Scots pine resistance against the needle cast disease, namely, genetics (at provenance or family level) and tree position in the stand (plantation), as well as the effect of admixture of other tree species that has been demonstrated to be linked to another disease – pine twisting rust (*Melampsora pinitorqua* (Braun) Rostrum.) in Scots pine stands in Finland (Mattilaa, Jalkanenb, & Nikulab, 2001). Similarly, the assessment of genetic correlations between intensity of the disease and parameters of trees might be of importance for elaboration of recommendations for the tree breeding, as well as for the development of the most appropriate (cost-efficient) method to increase resistance in the areas most of all affected by the disease.

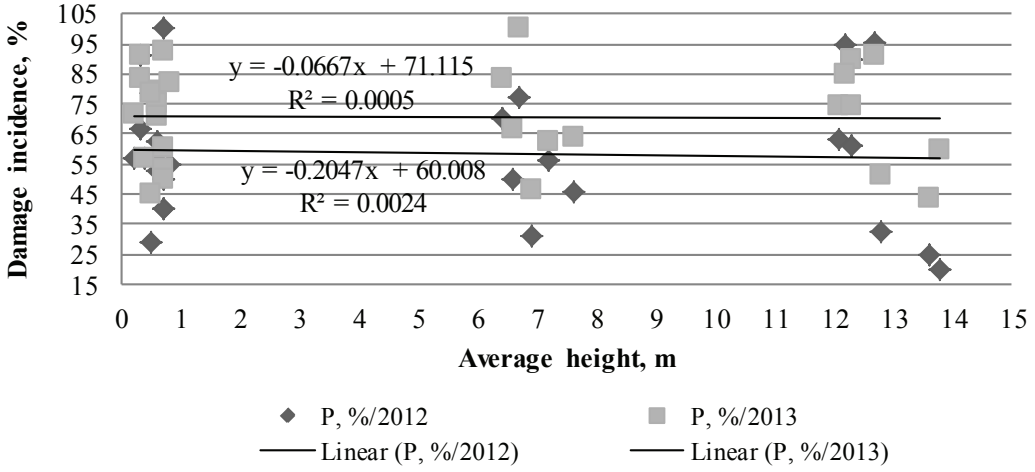

Figure 3. Needle cast damage incidence in Scots pine stands with different tree height**.**

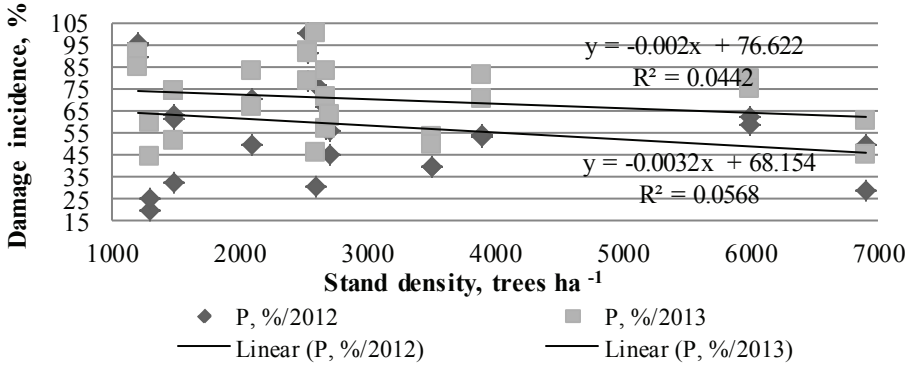

Figure 4. Needle cast damage incidence in Scots pine stands with different density.

Conclusions

1. Mean incidence and intensity of the needle cast damage in the studied sites in 2012 was 58.9% and 15.5%, respectively; while in 2013 – 70.8% and 16.7%, respectively. Difference between the years for the incidence was significant ($p = 0.02$; $\alpha = 0.05$), while for the intensity – not significant.
2. The needle cast disease was found in different age (from 3 to 26 years), height (from 0.2 to 13.8 m) and density (from 1200 to 6900 trees ha^{-1}) Scots pine stands; neither of those factors had a significant impact on the occurrence (incidence) or intensity of the disease.
3. The occurrence and severity of the needle cast disease was not significantly different between plots in *Hylocomiosa* and *Myrtillosa mel*. forest types.

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