PHENOTYPIC DIFFERENCES IN WIND-RESISTANCE TRAITS BETWEEN TWO BIRCH SPECIES IN HEMIBOREAL FORESTS, LATVIA

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ABSTRACT

Birch species have excellent natural regeneration and their share is increasing in hemiborea forests, especially in the Baltic States and western Russia. Thus, it is important to develop recommendations for the management of birch stands to reduce major risk – wind damages. Number of factors are affecting probability of wind damages for a tree. Aim of our study was to assess the potential differences in those traits between silver birch (*Betula pendula* Roth.) and downy birch (*Betula pubescens* Ehrh.) To comprehend if the same recommendations for damage reduction could be used.

Data on above-ground biomass and branch parameters by 1m sections were collected from 16 Silver birch and 12 downy birch trees at the age of 63 years (c.a. 10 years before the final harvest). The height of the mass point of the aboveground part of trees was determined.

The relative height of mass point was not significantly affected by tree diameter (ranging from 15 to 25 cm) or birch species and was ranging from 35.21 to 35.51% of tree height. Also, mean lower border of the green crown or the branch length in the middle of the green crown differed between both birch species. Thus we can conclude, that both birch species will have similar wind resistance based on their above-ground phenotypic traits.

Keywords: *natural disturbances, storm damages, resilience, windfirm trees*

INTRODUCTION

Birch – silver birch (*Betula pendula* Roth.) and downy birch (*Betula pubescens* Ehrh.) – classified as one species in forest inventory and statistics – cover a significant share of forests in the eastern part of the Baltic Sea region. It is a fast-growing tree species with valuable wood, used mainly in veneer industry. Private forest owners prefer it due to good natural regeneration. However, analysis of forest tree breeding trials had demonstrated a clear benefit from planting a selected material that can be increased with every breeding cycle [1], [2]. Considering that and improvements in soil preparation and plant quality, essential to ensure fast growth in fists years after forest regeneration [3], the share of birch planting is gradually increasing. It is the most widely used tree species in afforestation of abandoned agricultural lands. Additional benefit – both in terms of growth as well as in terms on carbon sequestration in above and below-ground biomass (and further in soil) – can be achieved, if also fertilization is used [4], [5], [6]. However, all of these measures of forest regeneration are rather costly and establishment costs of a plantation are gradually rising. Therefore it is important to minimize the damage risk in forest plantations. Birch, in contrast to coniferous trees or aspen, is not often affected by browsing; however, the impact of this type of damages might be severe [7]. Protection against browsing damages is relatively simple. In contrast, protection against damages by abiotic factors might be complicated. The temperature and precipitation regime is changing and predicted to change even further as the Global climate change accelerates. It affects forest trees, shifting the limiting impact on their growth from minimum winter temperatures to summer temperatures and drought [8]. Also for birch, to ensure maximum height growth, faster growth rate (thus – favourable meteorological conditions) at the beginning of vegetation period are essential and genotypes capable to achieve such growth rates form the largest total annual height increment [9]. Birch has relative high phenotypic plasticity and better than other tree species are capable to adjust to an altered summer precipitation regime (prolonged drought periods) [10]. Its phenotypic plasticity has been demonstrated also in geographical provenance trials. This tree species is not resistant to fire, the occurrence of which is affected primarily by increasing drought [11], thus, will be more frequent in the future. However, this can be rather efficiently controlled. In contrast, there are less possibilities to control impact of storms: it can only by minimized while applying silvicultural measures. Storms are changing the forest composition and are predicted to continue to do so [12], [13]. Birch is rather a wind-resistant [14] and therefore its share in forest cover can be increasing in future [13]. The information of wind resistance of birch is based on empirical data – analysis of historical storms [14] and models [13] that have been built on limited number of sample trees. To further elaborate the models, additional empirical data are needed, however, collection of such data are labours. Therefore, to design the study as well as to understand the potential limitation of its results, it is important to know, if there are differences between birch species in traits important to wind resistance. Wind resistance is affected by a set of traits, like wood properties [15], root properties, mass centre of the tree etc. Aim of our study was to assess the differences in above-ground traits between silver birch and downy birch in order to comprehend, if the same recommendations for storm damage reduction for both species could be used.

MATERIAL AND METHODS

Study sites were located in hemiboreal forests, central region (56°N, 25°E) of Latvia (Fig. 1). Climate in this region is maritime, annual sum of precipitation ranges from 700 to 800 mm in accordance to data of Latvian Environment, Geology and Meteorology Centre; mean air temperature in the warmest and coldest month (July and January, respectively) is 18 and -6 °C, respectively.

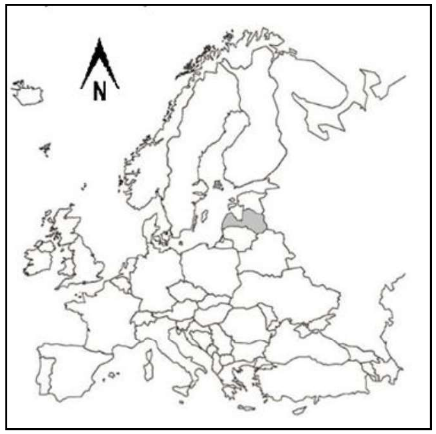


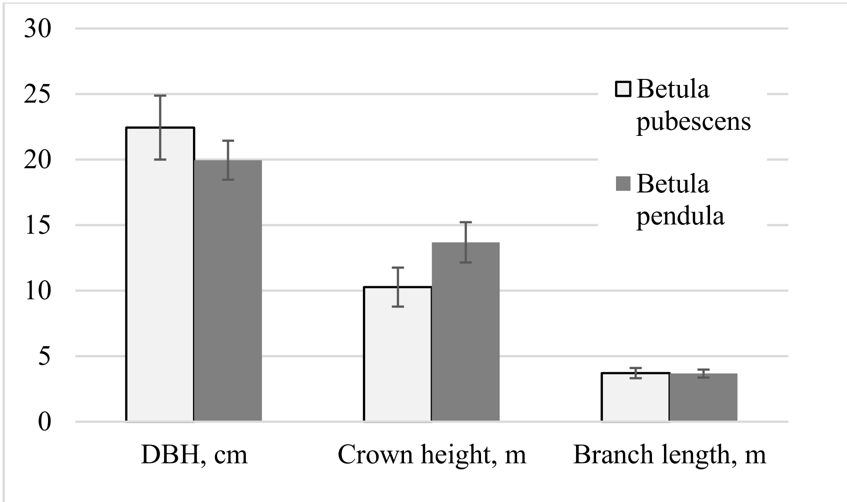
Figure 1. Study area.

Dominant silver and downy birch trees were sampled in stands on fertile mineral soil: with normal moisture regime (*Oxalidosa* forest type) and excess moisture (*Myrtillosoi-polytrichosa* forest type). These conditions are suitable for highly productive birch stands. Random selection of compartments was done from the pool of pure birch stands, determined by: a) age of trees 60-65 years (mean – 63 years), e.g. below the final harvest age, determined by legislation as 71 year, stands; b) density – in range 230-260 trees per ha^{-1}; c) management history – previous thinning not less than 10 years ago. This was done to ensure similar conditions of the growth for both birch species. Dominant trees were sampled in autumn, with leaves – at the state, where they quite likely could be affected by major storms in future. In total 28 trees (12 downy birch and 16 silver birch) were selected, their diameter at breast height, height, height to the crown base measured. Trees were harvested and weight of the branches in each quartile of the green crown length obtained. Also stem was weighted by 1m section. In each of the section branch length was measured. All calculations were based on the fresh weight of the stem and branches, considering, that wind will affect the tree as it stands.

RESULTS AND DISCUSSION

Length of the green crown did not differ significantly between the species and was on average 11.0±1.1 m (here and further in text 95% confidence interval noted to characterize the distribution) for downy birch and 11.9±1.0 m for silver birch. Also the proportion of green crown was similar between birch species – on average 52±5.7% and 47±3.6%. It indicates a rather large green crown and limited impact of competition that is in line with selection of dominant trees in the stand.

Trees of both birch species were of the same size – breast height diameter ranging from 15 to 25 cm with the mean 22±2.5 for downy birch and 20±1.5 for silver birch (Fig. 2); that being only slightly lower, than the average values in birch stands at this age on fertile mineral soils with normal moisture regime based on National forest inventory data.



DBH – diameter at the breast height, cm

Crown height – height of the green crown base, m

Branch length – mean length of branches at the middle part of the green crown, m

Figure 2. Characteristics of the dominant birch trees on fertile mineral soils

The base of the green crown was at 10 to 13 m and length of mean length of branches at the middle section of the crown was 3.7 m. Also the information on the crow shape, as reconstructed from the length of the branches at a different heights in the crown, did not differ notably between both birch species. Results indicate, that similar impact of the wind could be expected for trees of both downy and silver birch with the same dimensions.

Most of the fresh branch biomass was allocated in the lower part of the crown (Fig. 3) – in first quartile 33-35%, in second – 35-40%; in the upper quartile – only 4-7%. Relative large variation between trees in this respect was found and no differences between both birch species. On average lower half of the green crown had 70±6% from the total branch biomass.

There was a relatively large variation between trees in the proportion of the branch biomass in each of the quartiles of the green crown (especially in the lower two), which was partly linked to the tree diameter: link between tree diameter and branch biomass at lower half of green crown was significant, R2=0.43 for downy birch and R2=0.35 for silver birch (Fig. 4). The rest of the variation in crown weight can be explained by number of factors affecting the development of tree, like historic stand density.

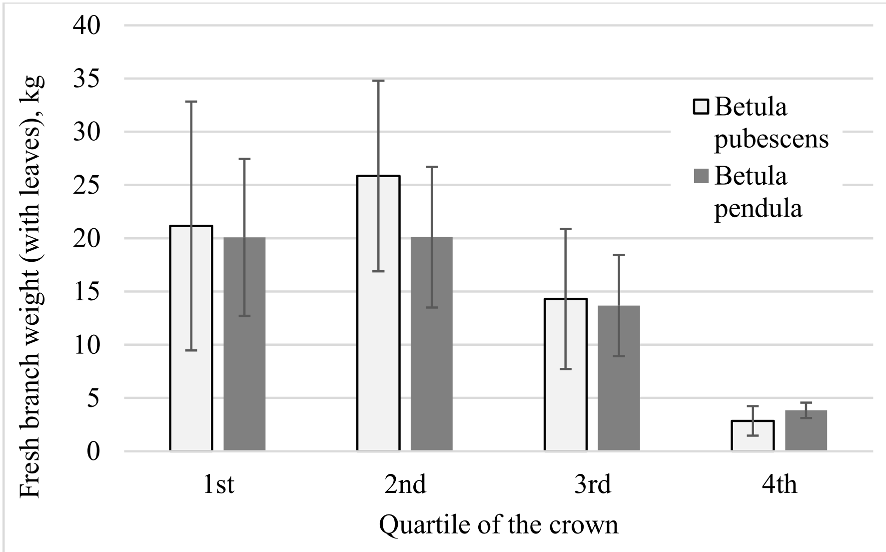


Figure 3. Distribution of branch biomass in the green crown of the birches

Relative height of mass point was not significantly affected by tree diameter or birch species and was ranging from 35.21 to 35.51% of tree height. Thus, the differences in wind damages between birch stands can be expected due to other factors (like the different soils, where each of them is more common, or different growth rates – this different dimensions at the same age) rather than due to species itself.

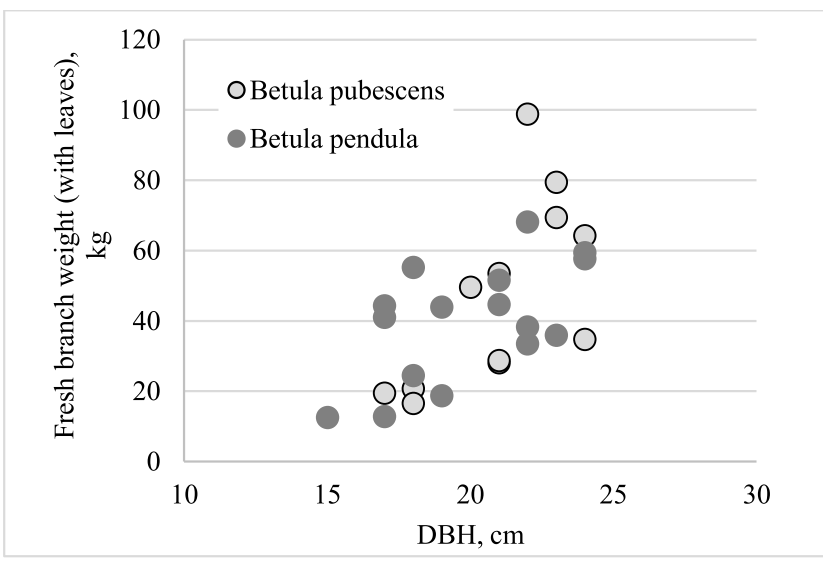


Figure 4. Fresh branch biomass in lower half the green crown depending on breast height diameter (DBH) of birches

CONCLUSION

Birch is economically important tree species with high climatic plasticity. Thus, its share in eastern part Baltic Sea region might continue to rise in future. There are extensive tree breeding programs and planting of Sliver birch is promoted. However, much less attention is paid to regeneration and silviculture of downy birch. Both birch species are noted as one (birch) in the forest inventory. Thus, it is important to assess the potential differences in traits characterizing potential impact of wind (storms) between silver birch (Betula pendula Roth.) and downy birch (Betula pubescens Ehrh.) in order to comprehend, if the same recommendations for damage reduction could be used. It was done, using set of sample trees from upper layer of stands with similar dimensions from both species. Crow characteristics (length and proportion of the green crown, branch length) did not differed significantly between downy and silver birch, thus, creating a similar surface that can be affected by the wind. On average lower half of the green crown had 70±6% from the total branch biomass. The amount of biomass in this part of crown was linked to the tree diameter (R2=0.43 for downy birch and R2=0.35 for silver birch), but not affected by species. Relative height of mass point was not significantly affected by diameter or species and was 35% of tree height. Thus, the differences in wind damages between birch stands can be expected due to other factors rather than due to different birch species in present in the stands. This conclusion is based on phenotypic characteristics of above-ground part of tree. Further studies shall address the potential differences in root characteristics and wood properties to have a complete information on all traits affecting wind resistance.

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REFERENCES

[1] Jansons Ā., Gailis A., Donis J., Profitability of silver birch (Betula pendula Roth.) breeding in Latvia., Proceedings of the 17th international scientific conference Research for Rural Development, Latvia, 2011, pp. 33.-38.

[2] Jansons A., Donis J., Danusevičius D., Baumanis I., Differential analysis for next breeding cycle for Norway spruce in Latvia, Baltic Forestry, Latvia, vol. 21/issue 2, pp 285-297, 2015.

[3] Dumins, K Lazdina, D., Forest regeneration quality - Factors affecting first year survival of planted trees, Proceedings of the 24th international scientific conference Research for Rural Development, Latvia, vol. 1, pp. 53-58, 2018.

[4] Petaja, G., Okmanis, M., Makovskis, K., Lazdiņa, D., Lazdiņš, A., Forest fertilization: economic effect and impact on GHG emissions in Latvia, Baltic Forestry, Latvia, vol. 24/issue 1, pp 9-16, 2018.

[5] Lazdiņa, D., Bebre, I., Dūmiņš, K., Skranda, I., Lazdins, A., Jansons, J., Celma, S., Wood ash – Green energy production side product as fertilizer for vigorous forest plantations, Agronomy Research, Estonia, vol. 15/issue 2, pp 468-477, 2017.

[6] Bardulis A., Jansons A., Bardule A., Zeps M., Lazdins A., Assessment of carbon content in root biomass in Scots pine and silver birch young stands of Latvia, Baltic Forestry, Latvia, vol. 23/issue 2, pp 482-489, 2017.

[7] Sisenis L., Dzerina B., Udris K., Purina L., Luguza S., Katrevics, J., Impact of browsing damages on growth and quality of silver birch plantations in Latvia, Agronomy research, Estonia, vol. 14/issue 1, pp 251–258, 2016.

[8] Luguza S., Jansone D., Jansone B., Kapostins R., Karklina A., Diferences in radial increment of young Norway spruce over a rotation period: case study in Latvia, SGEM2018 Vienna GREEN Conference Proceedings, Austria, vol. 18/issue 1.5, pp 607 – 614, 2018.

[9] Dzerina B., Neimane U., Baumanis I., Kapostins R., Sisenis L., Intra-annual height growth of silver birch (Betula pendula) in Latvia, SGEM2017 Vienna GREEN Conference Proceedings, Austria, vol. 17/issue 33, pp 593-600, 2017.

[10] Krišāns O., Kalniņš J., Puriņš M., Kāpostiņš R., Jansons Ā., Influence of altered precipitation regime on morphology of saplings of Scots pine and silver birch, Proceedings of the 22th international scientific conference Research for Rural Development, Latvia, vol. 2, pp. 14-20, 2016.

[11] Donis J., Kitenberga M., Snepsts G., Matisons R., Zarins J., Jansons A., The forest fire regime in Latvia during 1922–2014, Silva Fennica, Finalnd, vol. 51/issue 5, pp 1-15, 2017.

[12] Dubrovskis E., Jansone B., Kapostins R., Racenis E., Sisenis L., Influence of wind-storm on forest composition: case study in north- western Latvia, SGEM2018 Vienna GREEN Conference Proceedings, vol. 18/issue 1.5, pp 703 – 710, 2018.

[13] Peltola, H., Ikonen, V. P., Gregow, H., Strandman, H., Kilpeläinen, A., Venäläinen, A., Kellomäki, S., Impacts of climate change on timber production and regional risks of wind-induced damage to forests in Finland, Forest Ecology and Management, The Netherlands, vol. 260/issue 5, pp 833-845, 2010.

[14] Donis J., Kitenberga M., Snepsts G., Dubrovskis E., Jansons A., Factors affecting windstorm damage at the stand level in hemiboreal forests in Latvia: case study of 2005 winter storm, Silva Fennica, Finland, vol. 52/issue 4, pp 1-8, 2018.

[15] Liepiņš, J., Liepiņš, K., Mean basic density and its axial variation in Scots pine, Norway spruce and birch stems, Proceedings of the 23th international scientific conference Research for Rural Development, Latvia, vol. 1, pp. 21-27, 2017.