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Effect of Competition and Climatic Conditions on the Growth of beech in the Mixed pine beech Stand: Lithuanian Case Study

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Abstract: Climate change and warming will potentially have profound effect on forest growth and yield, especially for the pure stands in the near future. Thus, more and more attention is given to the mixed stands, for example pine and beech mixtures. Yet, interaction of tree species, growing in mixtures it is still remaining question to be answered. Thus the aim of this study was to investigate the impact of the interspecific and intraspecific competition to diameter, height and crown width of pine and beech trees growing in mixtures and to evaluate the impact of climatic indicators to the beech radial diameter increment.

The data was collected in the mixed mature pine beech double layer stand, located in the western part of Lithuania in 2017. The sample plot of 1.2 hectare was established and tree species, diameter at the breast height, tree height, height to crown base and crown widths as well as position were measured for all 836 trees. Additionally, representative sample of radial diameter increments were estimated only for the beech trees, by taking out core discs at the height of 1 meter, when the stand was partially cut. Competition analysis was based on distance dependent competition index, based on crown parameters. Climatic effect was evaluated by using Classification and Regression Trees (CART) analysis.

It was found almost no interspecific competition effect to diameter, height or crown width for both tree species, growing in the first layer. However, it has an effect to beeches growing in the second layer. The intraspecific competition effect was important for pine as well as for beech trees and had a negative effect for them.

These results show the possible coexistence of these tree species due to niche differentiation.

Analysis of climatic indicators in the period of 1991-2005 revealed that precipitation during February-May of current year as well as mean temperatures from July to September had expressed effect to radial diameter increment of beech trees. Low temperatures during March and April as well as high precipitation during the January, had negative effect to beech radial increment.

In the period of 2006-2016 the highest effect to radial diameter increment had the mean temperatures from July to September and the precipitation in January of the current year.

When all the period 1991-2016 was taken into account, the highest effect to radial diameter increment had temperature from July to September of current year and the precipitation in June of current year.

Generally, cool summers as well as higher precipitation during the June of current year had positive effect to the beech radial increment. It shows its sensitivity to high temperatures as well as droughts during the summer time under Lithuanian growth conditions.

Keywords: Interspecific competition; intraspecific competition; pine and beech mixtures; seasonal effects; climatic indicators; radial growth

1. Introduction

Climate change and forest adaptation to future environmental conditions may significantly alter forestry practices in many parts of the globe [1]. Promotion of mixed forests is also related with an adaptation strategy in forest management to cope with climate change [2]. Recent studies show that mixed stands can reach the same productivity as pure stands, also they can show and higher productivities compare to pure stands [3], [4]. Never the less mixed-species stands may provide many more forest functions and services compared to monocultures [5].

However, management of mixed stands require much more knowledge and skills. It is well known that not all tree species affect each other positively and can coexist together. Only those species, which ecological niche differ, for example light demanding pine and shade tolerant tree species like a beech, provide higher yields compared to pure stands [6].

Since Atlantic distribution range of European beech and the more continental range of Scots pine overlap, mixed stands of pine and beech are of considerable importance in Europe [7]. For example, for more than two decades, Forest conversion from pure pine stands to pine – beech or pine oak mixtures, has been a major objective for planning and management in Germany and the importance of multi-storied stands in forestry practice has increased steadily [8].

Even though remarkable research regarding the pine beech mixtures was done, Pretzsch 2015 [7] highlights the limited knowledge of mixing effects between scots pine and European beech.

Thus the aim of this study was to investigate the impact of the interspecific and intraspecific competition to diameter, height and crown width of pine and beech trees growing in mixtures, and to evaluate the impact of climatic indicators to the beech radial diameter increment.

2. Methods

The experimental plot of 1.2 hectare (length of 200 metres and width of 60 metres) was established and the data was collected in the mixed mature pine beech double layer stand, located in the western part of Lithuania in 2017. The age, recorded in the stand wise forest inventory data, for pine was 115 years and for beech 75 years. Experimental site belongs to *Pinetum Vaccinio–myrtillosa* forest type with moderately dry and comparatively fertile *oligotrophic* mineral soils - *Haplic Arenosol*, where water table is deeper than 5 m and suitable for pine growth.

The tree species, diameter at the breast height, tree height, and height to crown base and crown widths as well as position were measured for all 836 trees. Additionally, representative sample of radial diameter increments were estimated only for the beech trees, by taking out core discs at the height of 1 meter, when the stand was partially cut. In total, core discs were taken for 76 trees, and the radial diameter increments for each sample were measured two times, according to North and East directions, that were marked in the field for each disc. Thus, 152 measurements were available for this study. Measurements were done by using „LINTAB 6“ estimation system and a program package „WinTSAP 0.30“.

The synchronization of annual rings increments was done by using „TSAP-Win“ program. The asynchronous annual rings were tested and re-measured once again.

Competition analysis was based on distance dependent competition index. The competitors for each tree were identified by setting the inverse search cone with opening angle of 80 degrees on the crown base of the target tree [8]. Competition index proposed by Pretsch 1995 [9], that incorporates horizontal crown areas was used to estimate competition values. Combined, interspecific and

intraspecific competition indices were calculated by using the *CroCom* analytical program, developed by TU Dresden scientists.

Interspecific competition was estimated only by taking different tree species that appeared in the search cone of a target tree. Accordingly, intraspecific competition was calculated only by taking the same tree species trees that appeared inside of a search cone.

We investigated the effect of climatic indicators to the beech radial diameter increment from 1991 to 2016 years. For this purpose as climatic indicators: mean monthly temperatures as well as mean monthly precipitations representing current years from period 1991-2016 were used. Climatic data was taken from the closest Jurbarkas meteorology station that belongs to Lithuanian hydrometeorology service. This station is located about 25 kilometres away from the research plot.

In order to eliminate the age impact to radial diameter increment, radial diameter increment indices were estimated by using Stravinskienė (2002) method [10] . According to this method, all analysed period is divided into 5 years intervals. For these intervals mean radial diameter increment is estimated. Finally, the radial diameter increment of current year is divided by the 5 years mean radial diameter increment, respectively to the years' interval that current diameter increment belongs. Analysis of climatic indicators was done by using Classification and Regression Trees (CART) analysis implemented in STATISTICA 10 program.

3. Results and Discussion

Productivity. The main yield characteristics of analysed stand are presented in Table 1. The two layered stand mainly was composed from the pines age of 115 years (about 70%) dominating the first layer and the beeches age of 75 years (30% in the first layer and 100% in the second layer). Also other trees species like birch, oak and spruce was found in the stand, yet their proportion was only minor.

It is important to note that this mixed stand stands out for its productivity. The growing volume of pines was 392 m^3/ha. Yet, the growing volume of beech trees in the first layer was 144 m^3/h and in the second 78 m^3/ha. The total productivity of the stand was 659 m^3/ha.

Table 1. Main yield characteristics of the investigated mixed stand.

Stand													
Layer	**Share%/ Species**	**Age**	**H_{AB}**	**D_{AB}**	**Stocking level**	**H_q, m**	**D_q, cm**	**H_q/D_q**	**BA, m^2**	**N, vnt.**	**N/ha, vnt.**	**V/ha, m^3**	**V, m^3**
1	70/Pine	115	29.2	35.9	1,0	30.4	38.5	0.79	27.89	274	228	392	470
	30/Beech					25.3	28.3	0.89	11.96	212	177	144	173
	Birch					26.0	23.5	1.11	1.23	34	28	13	16
	Oak					24.8	27.2	0.91	0.87	18	15	10	12
	Spruce					26.5	34.9	0.76	0.64	8	7	8	10
In total:										**546**	**455**	**567**	**681**
2	10/Beech	75			0.3	18.5	15.2	1.22	3.6	217	181	78	94
	Oak					20.5	17.4	1.18	0.62	31	26	6	7
	Spruce					19.1	19.8	0.96	0.54	21	18	5	6
	Birch					21.2	14.9	1.42	0.3	21	18	3	3
In total:										**290**	**243**	**92**	**110**
In total:										**836**	**698**	**659**	**791**

*H_{AB}-site index based on the mean height at the base age of 100 year for pine in m, D_{AB}- site index based on the quadratic mean diameter at the base age of 100 year for pine in cm, H_q- mean height in m, D_q-quadratic mean diameter in cm^2, BA- basal area in m^2, N- number of trees, V – growing volume in m^3.

The impact of interspecific and intraspecific competition to diameter height and crown width of the trees. It was found almost no interspecific competition effect to diameter, height or crown width for both tree species growing in the first layer. The R^2 (coefficient of determination values) between interspecific competition and diameter at breast height, tree height and crown width, did not reach

More than 0.2 and the relations were insignificant ($p > 0.05$). However, interspecific competition has an effect to beeches growing in the second layer. The asymmetric competition from pines had a significant negative effect to diameter, height and crown width of the beech trees.

The intraspecific competition had negative significant effect to diameter at breast height, height and crown width of pines and beech trees, growing in the first as well as second layers ($R^2 > 0.33$).

Climatic trends during 1991 to 2016 in Jurbarkas Region. The mean annual temperature from 1991 to 2016 increased approximately by 1 ^{0}C, from 7 to 8 ^{0}C with a yearly increase of approximately by 0.0625 ^{0}C. However, the mean annual precipitation in analysed period remained quite the same and fluctuated around 800 mm per year (Data taken from Jurbarkas meteorology station).

The impact of climatic variables to radial increment of beech trees. Analysis of climatic indicators revealed that in the period of 1991-2005, higher than 48.5 mm precipitation during February-May of current year had very positive effect to radial growth of beech trees as well as mean temperatures from July to September being lover than 16.5 °C. Contrary, temperatures lover than 5.2 °C during March and April as well as high precipitation during the January, more than 62.8 mm had negative effect to beech radial increment.

Analysis of climatic indicators in the period of 2006-2016 revealed that the highest radial increment was achieved when the mean temperatures from July to September was lower than 16.5 °C and the precipitation in January of the current year was higher than 62.8 mm.

When all the period 1991-2016 was taken into account, the highest effect to radial diameter increment was found when the mean temperature from July to September of current year was lower than 16.3 °C and the precipitation in June of current year was lower than 74.7 degrees.

Generally, cool summers as well as higher precipitation during the June of current year had positive effect to the beech radial increment. It shows its sensitivity to high temperatures as well as droughts during the summer time under Lithuanian growth conditions.

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