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Influence of environmental and climatic factors on the radial growth of European ash (*Fraxinus excelsior* L.)

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The aim of the research was to evaluate the influence of various environmental factors on the radial growth of European ash (*Fraxinus excelsior* L.). Six research plots were selected. Two of them were located in parks and others in the natural forest.

The research has shown that the present state of ash and the peculiarities of radial growth depend on different factors such as the lithological composition of the soil, groundwater level and climate conditions in different periods. The radial growth of ash was found to respond differently to the climatic factors of separate periods in each research plot. The reaction of earlywood and latewood is also different.

The response of the earlywood growth of ash to precipitation and air temperature during the winter period was very homogeneous among all research plots, and the correlation coefficients reached +0.40. It is evident that the huge amount of precipitation during winter and higher temperatures lead to a better preparation of ash trees to the next growing season. The latewood growth responds to winter climate conditions similarly. The positive impact of annual precipitation and the negative influence of air temperature in autumn (r = –0.40) are also typical of the earlywood and latewood growth of ash. A positive influence of precipitation and negative effects of air temperature in summer were also established. The research has shown that for a more detailed interpretation of the link between climatic factors and the radial growth of ash, data on soil moisture fluctuations are necessary.

The state of ash is not dependent on the age of trees, meanwhile dryoff of younger ash trees is a typical problem in Lithuania at present. We have found that the rather vital crown with only sporadic dry branches is common for the mature trees. The fact that the earlywood growth begins to exceed the latewood growth for a longer period and more complacent latewood sensitivity are one of the main indicators determining the decline and a high probability of the dryoff of trees. A decrease of ash radial growth every second or third year may be related to a huge amount of precipitation and low temperatures and in some cases even to high temperatures and lower amounts of precipitation.

Key words: European ash, radial growth, climatic factors, habitat, influence

INTRODUCTION

Data of the forest inventory and management presented in 1998 indicate that the area occupied by European ash stands in Lithuania is 2.7% (Brukas et al., 1998). Ash was known as one of the most healthy tree species during 1989–1991 in Lithuania. The latest research points to a decline of ash in Lithuania; forest monitoring in 2000 has revealed that the crown defoliation of ash is 32.4%, and only 9.9% of trees were qualified as healthy (Ozolinčius, Stakėnas, 2001). The Station for Forest Protection in Lithuania has forecasted a considerable increase in the area of the dryoff of European ash in 2002 (Zolubas, 2002).

It is evident that the state of ash has worsened remarkably in 1992. The main features of the decline are the dry top of a tree, dryoff of shoots and branches, a decrease of crown density and increased defoliation. The decline of ash is more common to younger stands. Scientists argue that the decline of ash trees during 1992–1994 was connected to climate extremes, while the reasons for the decline in 1996–1997 are vague until now (Ozolinčius, Stakėnas, 2000). In the opinion of R. Ozolinčius (2002), the causes of the decline are only hypothetical.

For a dendrochronological assessment of the state of ash, six research plots were selected. The state of ash growing in Kaunas Botanical Garden (hereafter KBS) and other forests, *e.g.*, Sausinė (Kaunas forest enterprise), Girelė (Kaišiadorys forest enterprise) and Kelmė (Tytuvėnai forest enterprise) indicates the decline of ash. The state of ash growing in the former Ariogala forestry (Raseiniai forest enterprise) is especially poor. Ash, as compared with other research plots, grows best in the Park of the Pagryžvys estate (Kelmė district). No dryoff of shoots and branches or a decrease of crown density and evidence of defoliation were detected in 2002, while the age of ash here exceeds 100 years.

A huge amount of research has been conducted on ash (Abraitis, 2000; Marigo et al., 2000; Prieditis, 1999; Ubysz, 2001), while research on the radial growth of ash (response to different factors and growth peculiarities) has been investigated only sporadically. Research on the radial growth of ash has not yet been performed in Lithuania.

The aim of the present research was to evaluate the influence of various environmental factors on the radial growth of European ash (*Fraxinus excelsior* L.).

MATERIALS AND METHODS

For the purpose of the research, 23 European ash trees were selected in KBS. According to the growing place the trees were divided into four groups. Five trees belonging to the first group (KBS-1) grow near the former outhouse building (Ž. E. Žilibero 2), the second group (KBS-2) grows at the beginning of Vilties and Ž. E. Žilibero streets, the third group (KBS-3) grows to the north of the Ž. E. Žilibero 4 building, and the fourth group (KBS-4) is located to the west from the Ž. E. Žilibero 6 building. Dendrochronological investigations on ash were also carried out in the Sausinė (SaU) and Girelė (GiU) forests, former Ariogala forestry (ArU), Pagryžuvys Estate Park (PzU) and Kelmė forestry (KeU).

Using an increment borer, samples from more than 10 trees in each research plot were taken. Because of a huge number of ash trees with decayed piths and a small number of trees growing in each group of Kaunas Botanical Garden, samples were taken from the less number of trees. Trees representing the average and normal selection categories were cored, because it has been proven by previous research that such trees better reflect the influence of climate (Êàðïàâè÷þñ, 1986).

Tree ring widths, latewood and earlywood separately, were measured within a 0.05 mm accuracy. For this purpose an MBS-9 stereomicroscope was used. Tree ring width series obtained from individual trees were averaged into local chronologies. The oldest trees (142 years) grow in Kaunas Botanical Garden (KBS-4) and Pagryžuvys Park (116 years). Ash trees from Sausinė forest and Kaunas botanical Garden (KBS-2) are only 48 and 57 years old, respectively. Ash trees in other sites are from 70 to 100 years old.

Investigations on soil texture and groundwater level have been performed in several research plots. A special ground borer or profile digging was used for this purpose. Soil research was performed between KBS-1 and KBS-2 and in the KBS-4 research plots. A thick humus surface horizon (20–40 cm) and rich clay soil with a deeper transition to pure clay was found in both places. The groundwater level between KBS-1 and KBS-2 was found at a depth of 110 cm and clay soil was characterized by thin insertions of moist sand. Soil at the KBS-4 is characterised by a thinner humus layer, clay soil turns into a gleyey layer at a depth of 160 cm, indicating a surplus of water in the soil. The groundwater level was deeper than 180 cm and soil was much drier than in the KBS-1 and KBS-2 research plots.

Soil composition in Sausinė forest: litter 5 cm thick, humus layer 12 cm, greyish and deeper yellowish loam up to 50 cm, and light clay deeper. The soil layers were moist at the time of research (17 07 2001). Ash trees in Pagryžuvys Estate Park grow on the banks of the Gryžuva and Bliukė streams. The humus horizon is 15–20 cm thick; it turns into greyish sandy loam. A 10 cm thick gravel layer with clay addition deeper than 25 cm in some places was observed. The predominant plant species is *Aegopodium podagraria* L. A mixed ash forest with oak and spruce, belonging to Kelmė forestry, grows in the vicinity of the mentioned streams.

Because local ash chronologies have shown pronounced age curves, an indexing procedure was performed. For this purpose, the ITRDB (International Tree Ring Data Bank) CHRONOL 6.00P program (R. L. Holmes, Tucson) was applied. To assess the link between the radial growth of ash and the climatic factors, correlation coefficients were calculated. We used climatic data from the nearest meteorological stations located in Kaunas and Raseiniai. The following data were used: air temperature and amount of precipitation during a hydrological year (ty, py), previous autumn (t9-11, p9-11), winter (t12-2, p12-2), spring (t3-5, p3-5) and summer (t6-8, p6-8). For this calculation, the ITRDB – DPL 6.07 P (Dendrochronology Program Library) TSA program was applied. Calculations were performed in 1961–2000. This period was determined by the age of ash trees, decay of pith and the peculiarities of the radial growth pattern.

The additional indicators such as earlywood / latewood radial growth ratio (e/l) and the average values of radial growth and climatic factors in different periods were also calculated. We analysed the periodicity of the radial growth and the e/l ratio and the determining factors from 1949 to 1972. This period was selected by referring to J. Jablonskis' (1993) results, indicating that the amount of precipitation during 1950–1970 in even years was bigger than in uneven years.

RESULTS AND DISCUSSION

First of all we discuss the link between the ash radial growth and climatic factors as discovered during our research. Data on correlation coefficients (r) demonstrate a different reaction to climate (Figs. 1, 2).

The influence of precipitation during the previous autumn was weak: only in few cases the coefficients are higher than ±0.10. Air temperatures during previous autumn and the radial growth of ash show an inverse link; *e.g.*, in SaU the r reaches –0,4. The only exception is the earlywood growth of ash in Pagryžuvys and KBS-1. This is probably connected to the soil humidity. It has been proven that the moisture deficiency is frequent event during summer months (Bagdonas, 1998). The soil moisture deficiency was probably formed after dry summers of 1961–2000, when the average precipitation was 66.7 mm *versus* the long-term mean 78.1 mm. That is why high temperatures in autumn had an inverse effect on the radial growth due to increased soil evaporation. The positive effect of autumn temperatures was observed only in Pagryžuvys, where the trees grow nearby streams. A different response of ash trees growing in Sausinė and Girelė forests to summer air temperatures and precipitation also points out to the peculiarities mentioned above (Fig. 2). The radial growth of ash in Girelė forest shows a positive link with precipitation and an inverse link with air temperatures, while in Sausinė forest it demonstrates a positive link with air temperatures (no effect of precipitation was observed, r = 0.01). Ash trees in Kaunas Botanical Garden respond to air temperatures and precipitation in summer differently even if located at not long distances; *e.g.*, the link between the latewood radial growth of ash in KBS-1 and KBS-2 and precipitation was positive and with air temperatures negative (Fig. 1), while the response of radial growth of ash in KBS-3 and KBS-4 is inverse if compared to KBS-1 and KBS-2. Links between ash trees growing in Pagryžuvys and Kelmė forestry and precipitation (earlywood to annual and latewood to summer) also differ (Fig. 2). We conclude that the reaction of ash to climatic factors is connected to the seasonal hydrological conditions of the habitat like in oak (Kairaitis, Karpavičius, 1996) and pine (Êàðïàâè÷þñ, 1993).

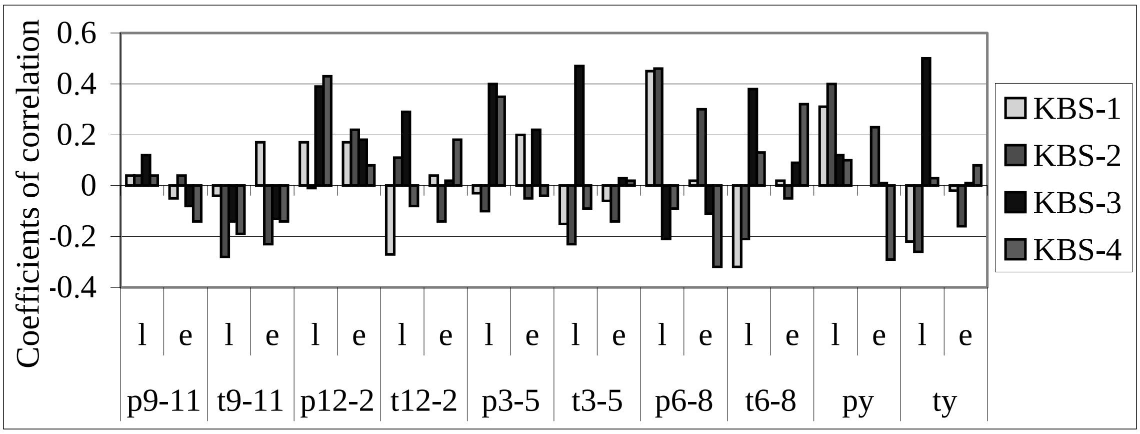

Fig. 1. Coefficients of correlation between earlywood (e) and latewood (l) radial growth of European ash in Kaunas Botanical Garden (KBS) and climate data

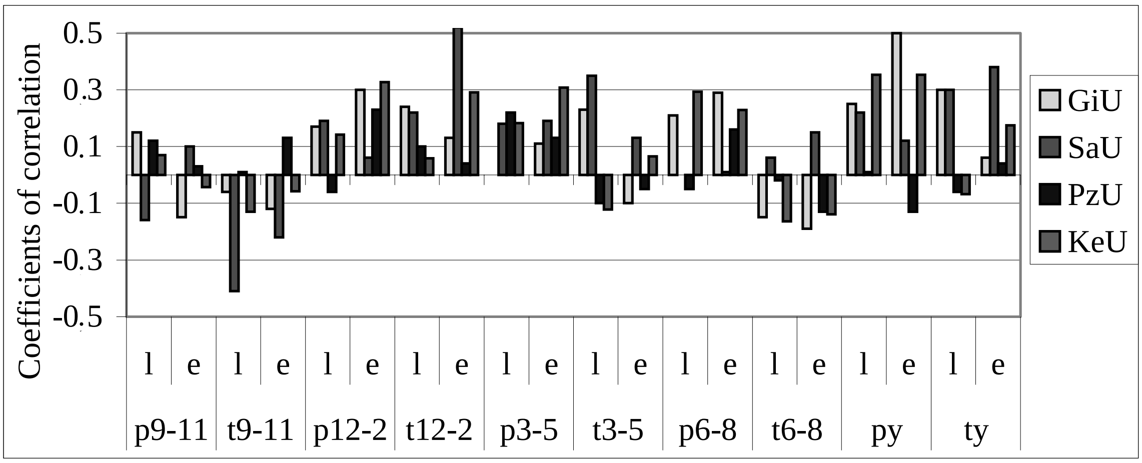

Fig. 2. Coefficients of correlation between earlywood (e) and latewood (l) radial growth of European ash in Girelė (GiU), Sausinė (SaU), Pagryžuvys (PzU), and Kelmė (KeU) and climate data

Several regularities of the response of ash radial growth to climate were established. The earlywood of ash responds positively to air temperatures and precipitation in winter (r reaches +0.40), implying that warmer winters with abundant precipitation are favourable for the next growing season of ash. The annual amount of precipitation has a positive effect on the latewood growth of ash.

Summarising the above data we conclude that the response of ash radial growth to climate is strongly driven by soil texture and groundwater depth. Strong limiting factors only, such as low temperatures during winter, affect identically the radial growth of ash in any site types. A similar response to climate was found also for other tree species (Kairaitis, Karpavičius, 1996; Karpavičius et al., 1996).

Here we will present and discuss the other factors that determine the radial growth patterns of ash and its peculiarities. Our research shows that the age of trees is not the main factor to determine the state of ash. Mature ash trees growing in KBS-4 are characterised by strong and vital crowns with sporadic dead branches only, and their radial growth during the last 10 years exceeded the radial growth rates of younger ash trees (Fig. 3). Meanwhile, only five ash trees were found to have vital crowns in the other groups (KBS-1, KBS-2 and KBS-3) in 2002. Crowns of other ashes are rarefied, with completely dry shoots and partly dead branches. A particularly poor state of ash has been monitored in the former Ariogala forestry, where a lot of young trees are already dried off. Ash stems are not resistant enough against decay: ≈50% of the oldest trees in KBS-4 were found to have rotten stems.

Several factors are responsible for the state and peculiarities of the radial growth of ash in KBS. One of them is difference in site conditions. All ash groups grow on the similar texture fertile soil however, the groundwater depth differs. Trees in KBS-1 and KBS-2 grow near the risalits of the former outhouse building (Ž. E. Žilibero 2) and are additionally fed by the precipitation flow from the roof. This is attributed to the anthropogenic impact after the restoration of the building when two risalits were built in 1959 (Lagunavičius et al., 1991). The groundwater level was raised near the outhouse building during the restoration works as a result of the moulding of a stone way nearby. This have changed the groundwater flow and worsened the aeration conditions of the soil. Root decay was probably provoked by stagnating water during spring melt or a longer-lasting rainy period. The radial growth of ash growing near the risalits (KBS-1) has decreased since 1959. Part of trees are already dead and the remaining are characterised by remarkable features of decline. The radial growth of ash trees growing away from the outhouse (KBS-2) decreased significantly after 1988. The older and the younger ash trees had high radial growth rates and the typical radial growth patterns (the radial growth decreases gradually with tree age) until the risalits were built up (Fig. 3). Earlier results presented by B. Ubysz (2001) revealed that the resistance of ash trees to floods was lower than of oak or alder.

Several statistics on the radial growth of ash have shown that two characteristics are directly connected to the declining status of ash (significant decrease of the radial growth). The first indicator is the earlywood / latewood ratio, the second being the mean sensitivity to the environmental conditions (Tables 1, 2).

A decrease of the radial growth of ash trees is directly connected to the decrease in the latewood widths (Table 1). The earlywood growth decreased only slightly from 1961 to 2000, but in the latewood it has decreased more than twice (KBS-3) or even three times (KBS-1). The latewood growth in KBS-1, KBS-2 and KBS-3 has decreased even more during the last decade, while in KBS-4 the radial growth has increased due to the increase of latewood growth.

The latewood growth is more sensitive than earlywood to the environmental changes. The sensitivity in

Table 1. **Statistical data of European ash radial growth at four research plots of Kaunas Botanical Garden in different periods. e – earlywood, l – latewood, a – annual radial growth**

Group	Period	Radial growth (mm)			Mean sensitivity		
		e	l	a	e	l	a
KBS-1	1921–1960	0.82	1.35	2.17	12	35	24
	1961–2000	0.73	0.45	1.18	8	18	9
	1991–2000	0.74	0.38	1.13	–	–	–
KBS-2	1944–1960	1.18	3.37	4.55	18	26	22
	1961–2000	0.96	1.64	2.60	8	23	16
	1991–2000	0.84	0.94	1.77	–	–	–
KBS-3	1921–1960	1.00	2.64	3.64	12	22	17
	1961–2000	0.89	1.22	2.11	8	20	13
	1991–2000	0.80	0.82	1.62	–	–	–
KBS-4	1921–1960	1.01	0.74	1.75	8	17	9
	1961–2000	0.92	0.70	1.62	8	21	10
	1991–2000	0.98	1.09	2.08	–	–	–

Table 2. **Climate data (in numerator – precipitation, mm, in denominator – air temperature, °C) and the earlywood / latewood ratio (e/l) in the period of decrease of latewood radial growth of European ash (in numerator in the period of decrease, in denominator during all growing period)**

Research plot	Period	Autumn	Winter	Spring	Summer	Ratio of e/l
KBS-1	1961–2000	53.2	38.5	43.7	66.7	1.72
		6.9	–3.5	6.2	16.5	1.07
KBS-2	1988–2000	52.2	43.0	49.5	65.8	0.99
		6.6	–1.8	7.0	16.9	0.59
KBS-3	1986–2000	51.5	42.7	45.3	69.9	0.97
		6.6	–2.4	6.7	16.7	0.58
KBS-4	1993–2000	53.2	45.4	50.9	69.2	0.88
		6.3	–2.5	7.0	16.8	1.20
PzU	1987–2001	61.9	50.9	46.0	72.8	1.19
		6.0	–2.4	6.1	16.2	0.73
KeU	1990–2001	62.6	52.2	46.8	67.6	0.84
		6.0	–2.2	6.3	16.3	0.58
SaU	1996–2000	48.8	40.2	41.8	67.6	0.90
		6.7	–3.1	7.0	17.0	0.41
GiU	1992–2000	51.3	44.6	50.0	66.1	0.89
		6.5	–2.3	6.9	17.0	0.49
ArU	1996–2001	56.8	47.5	41.4	68.7	1.97
		6.2	–3.1	6.2	16.4	0.57

Table 3. **Years with the decrease (+) of the latewood radial growth of European ash during 1949–1972 and climatic data of May–August (p – precipitation, t – temperature) and year (y)**

Years	Research plots									py	ty	p5-8	t5-8
	KBS-1	KBS-2	KBS-3	KBS-4	PzU	KeU	SaU	GiU	ArU				
1949									+	658	7.9	104	15.9
1950										915	6.8	111	16.2
1951	+	+		+						497	6.6	65	17.1
1952					+	+			+	691	5.5	63	16.0
1953		+	+	+				+		423	6.4	67	17.1
1954					+		+			785	5.8	143	16.9
1955						+		+	+	493	5.9	35	17.0
1956										604	4.6	88	16.0
1957					+	+				592	7.0	92	16.3
1958	+		+					+	+	717	6.0	99	15.4
1959				+						608	7.0	102	18.0
1960	+	+	+		+			+	+	750	6.3	125	16.7
1961						+	+			586	7.3	77	16.2
1962			+	+						658	5.7	68	14.6
1963					+	+			+	548	5.7	68	17.5
1964	+	+		+			+	+		442	6.0	28	17.3
1965			+							511	5.5	58	15.2
1966					+	+		+	+	468	6.5	30	17.3
1967	+		+	+						631	7.2	48	16.6
1968							+			632	6,1	76	17.1
1969					+	+		+	+	516	4.9	40	16.3
1970	+	+	+	+						784	5.7	74	16.6
1971					+	+		+		527	7.1	44	17.0
1972				+					+	629	7.1	74	18.8

Table 4. **Periods of increase and decreace of the earlywood/latewoos (E/L) ratio of European ash in KBS-4 research plot and climate data (in numerator – precipitation, mm and in denominator – air temperature, ˚C)**

Period	Autumn	Winter	Spring	Summer	E/L
1893–2002	50.3 / 6.9	35.7 / –3.7	42.2 / 6.1	78.1 / 16.6	1.20
1920–1925	42.8 / 6.2	31.6 / –3.6	40.8 / 7.2	98.0 / 15.8	1.70
1926–1936	56.9 / 7.4	23.2 / –4.4	47.2 / 5.9	81.0 / 16.5	1.17
1937–1947	43.5 / 6.9	27.9 / –5.1	38.2 / 5.6	79.8 / 17.3	1.45
1948–1956	50.3 / 7.3	36.7 / –3.9	40.5 / 5.5	83.5 / 16.5	1.42
1957–1977	52.8 / 7.3	35.4 / –3.7	41.0 / 5.8	70.0 / 16.5	1.90
1978–1992	53.5 / 7.4	42.2 / –3.8	43.0 / 6.6	76.8 / 17.4	1.40
1993–2000	53.2 / 6.3	45.3 / –2.5	50.9 / 7.0	96.2 / 16.8	0.88
Long–term mean	50.4 / 6.9	35.9 / –3.9	42.2 / 6.1	77.9 / 16.6	–

the KBS-3 latewood changed only slightly, while in KBS-1 it has decreased almost by half. A sudden decrease in the latewood widths and its sensitivity, especially when the earlywood exceeds the latewood growth rates, is one of the indicators of decline and a higher dryoff probability of ash trees.

A negative impact of moisture deficiency on the radial growth of ash is also observed as a decrease of the radial growth of ash in Kaunas Botanical Garden during 1990–1992. The average annual precipitation rate during this period was 593 mm, while the long-term mean is 620 mm. The yearly average air temperature has exceeded the long-term mean by 1.3 ˚C. As a result, the moisture deficiency in the upper layers of the soil has served as a limiting factor for the radial growth of ash during these years. This effect is evident in Sausinė and Girelė forests, the former Ariogala forestry and Pagryžuvys. The dry 1999 and 2000 (annual precipitation 578 mm and 571 mm, air temperature 7.8 ˚C and

Table 5. **Similarity of the radial growth of European ash in four research plots of Kaunas Botanical Garden**

Groups	KBS-1	KBS-2	KBS-3	KBS-4
KBS-2	71.8	X		
KBS-3	72.7	64.5	X	
KBS-4	62.4	46.4	70.9	X

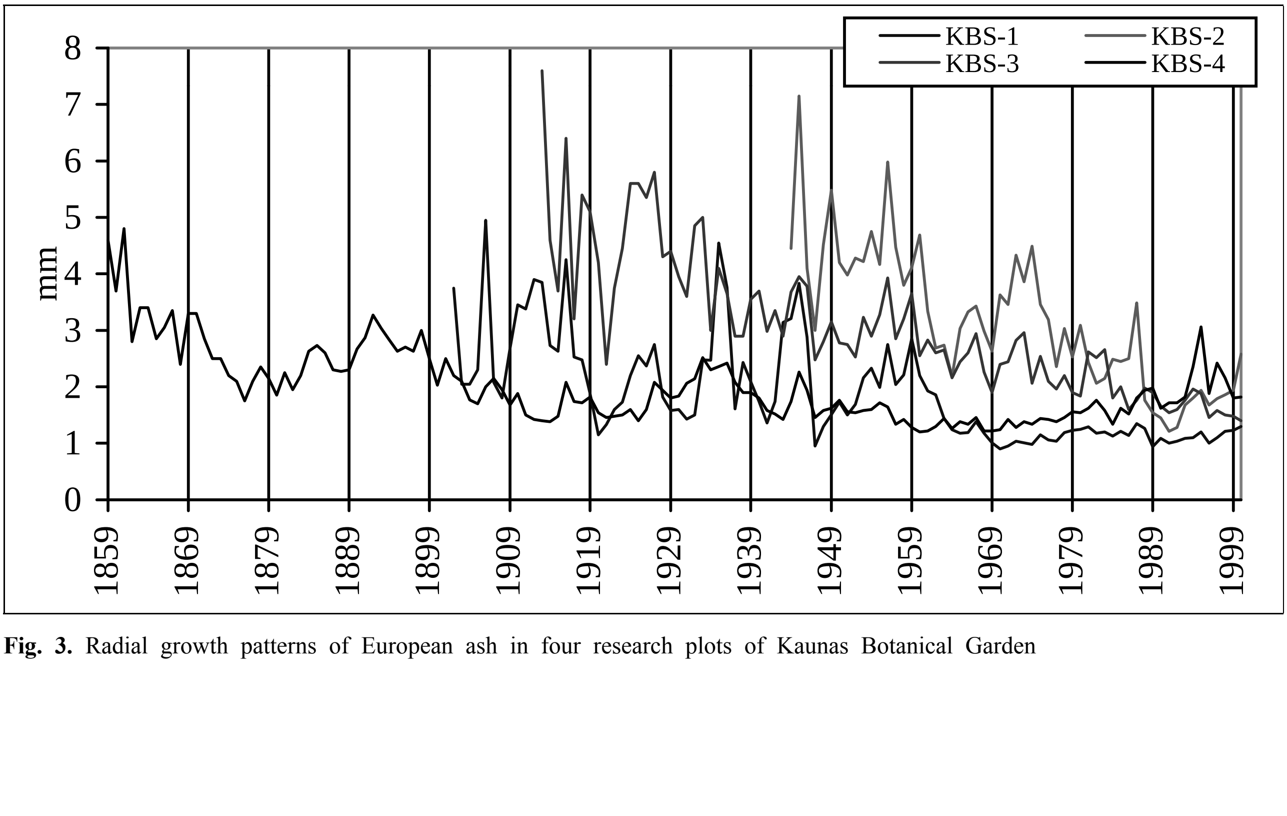

Fig. 3. Radial growth patterns of European ash in four research plots of Kaunas Botanical Garden

8.3 ˚C, respectively) have induced a decrease of the latewood growth in Sausinė and Girelė forests. The earlywood exceeded the latewood already in 2000 (e/l 1.18). A decrease of the latewood radial growth in the former Ariogala forestry was observed already from 1996 (e/l 1.50).

A decrease of the latewood growth in all research plots was discovered as far back as 1990, but it was not so significant as mentioned above and began not in the same time (Table 2). This is explained by a higher air temperature in spring and summer months and a lower amount of precipitation in summer. The long-term (1893–2002) mean of spring air temperature is 6.1 ˚C, summer air temperature being 16.6 ˚C and summer precipitation 78.1 mm. A decrease of the radial growth was observed when spring precipitation exceeded the long-term mean by 42.2 mm, but due to significantly higher spring temperatures its surplus was quickly evaporated and the melt water in spring rapidly infiltrated deeper because of warmer winters in this period (–3.7 ˚C). The decrease of ash in the KBS-1 forms an exception due to the anthropogenic changes in hydrological conditions as discussed above.

A decrease of latewood growth may be provoked by small or huge amounts of precipitation during the hydrological year. This was proven by an analysis on latewood radial growth periodicity in 1949–1972 and while selecting the years when the latewood growth was smaller than in two adjacent years, irrespective of the long-term radial growth changes observed during the minimum or maximum (Table 3).

Decreases of the latewood growth every second or third year are characteristic during this period (Table 3). Especially the three-year periodicity is characteristic of ash growing in Pagryžuvys and the former Ariogala forestry and fully coincides with 1960–1969. The decrease of the radial growth in Kelmė forestry takes the middle position compared to Pagryžuvys and Ariogala and since 1963 is similar to them. This periodicity during 1949–1972 was induced by different climatic conditions. The decrease of latewood growth until 1961 was provoked by a huge amount of annual precipitation and lower air temperatures, except Pagryžuvys in 1957. The decrease of radial growth could be triggered also by lower precipitation rates, especially in summer, and by high temperatures. This is evident from the periodicity of the radial growth in Pagryžuvys and Ariogala from 1961 to 1969. The periodicity of radial growth every second or third year in the other research plots is also connected with the climatic and hydrological conditions presented above. It should be noted that a decrease of radial growth every second year is also common in pines (*Pinus sylvestris* L.) growing in the especially wet conditions of the Žuvintas strict reserve (Êàðïàâè÷þñ, 1993).

The dependence of the radial growth on climatic conditions is well reflected by the e/l ratio of the radial growth in KBS-4 during the period of meteorological observations. The earlywood growth rates of these trees are generally greater than the latewood, in contrast to the other sites. For this purpose we selected the periods during which the e/l ratio was bigger or lower than 1.5 (Table 4).

The defined periods have confirmed that the increase and decrease in the latewood or earlywood radial growth is strongly driven by climatic factors and hydrological conditions of the soil. A decrease in the latewood radial growth was observed when two conditions were true: the amount of precipitation in summer was bigger or close to the long-term mean and the average air temperature was lower than the long-term mean (Table 4). Not only summer months or seasonal climatic conditions have influenced the radial growth ratio. Climatic conditions during the previous periods are also very important. Although the average summer air temperatures during 1937–1947 were higher than the long-term mean, ash did not suffer from moisture deficiency because of cool springs in this period. Due to such conditions soil probably was waterlogged for some time. The possible water logging in the spring of 1957–1977 was compensated by the close to average air temperature and drier summer conditions. This is seen from the e/l ratio in 1993–2000 when rainy and warm springs were followed by drier and warm summers. As a result, the growing conditions for the latewood in KBS-4 were favourable because of the possible waterlogged conditions of the soil (this can be seen in a gleyed clay layer at a depth of 1.6 m (see methods).

The differences in the radial growth were analysed by using coefficients of similarity. The tree ring width in the Kaunas Botanical Garden is characterised by the highest similarity (Table 5). The greatest differences were found in the earlywood growth (60.9%).

The coefficients of similarity have proven that the radial growth patterns are related to the hydrological conditions. The most similar growth patterns are typical of the radial growth of ash in KBS-1, KBS-2 and KBS-3. Ash trees growing in KBS-4 show a good similarity against KBS-3 (70.9%). The biggest dissimilarity was found between KBS-2 and KBS-4.

Such similarity is determined by climatic conditions (amount of precipitation and air temperatures). The fluctuations of the groundwater level depend on the proportion of these conditions. However, in some years the groundwater level could be the same even in different ash growing conditions. This could help to interpret the high similarity values between KBS-3 and KBS-4 growing at a distance of 200 m.

Summarising the results on the links between the radial growth of ash and various factors we should note that in ash the radial growth features are similar to those of the other tree species such as oak, pine and spruce (Bitvinskas, 1972; Êàðïàâè÷þñ, 1993; Kairaitis, Karpavičius, 1996; Karpavičius et al., 1996; Vitas, 2004). The response of the radial growth of ash to climatic conditions, like in other tree species, is closely related to soil lithological texture and groundwater level.

CONCLUSIONS

The state of ash and the radial growth patterns depend on various factors such as lithological soil texture, groundwater level, climatic factors and their distribution during separate periods.

Ash and oak (Kairaitis, Karpavičius, 1996), growing in similar conditions according to lithological soil texture and groundwater level, respond to climatic conditions similarly, even when growing at a distance of several tens of kilometres, comparing to trees growing in different conditions and several hundreds of meters apart.

The earlywood and latewood radial growth responded similarly to the air temperature in autumn (coefficient of correlation up to –0.40).

Ash growing in Sausinė and Girelė forests uniformly responded to annual (coefficient of correlation up to +0.38) and winter (coefficient of correlation up to +0.52) air temperatures. The reaction of ash growing in Kaunas Botanical Garden to the mentioned above air temperatures differs, though in most cases the earlywood growth of ash uniformly responded to the air temperatures in winter (coefficient of correlation up to +0.18). It means that warmer winters increase the probability of high earlywood growth rates.

The decrease of the radial growth, the decline and even dryoff of ash are closely related to hydrological conditions, as the rainy and cooler periods form a surplus of water in the soil, or to water deficiency due to droughts.

The rates of the radial growth and the state of ash over the twenty-year period do not depend on tree age. The dryoff of younger ash trees is a common problem now, whereas the oldest trees growing in Kaunas Botanical Garden are characterised by vital and less damaged crowns, in spite of the rotten stem in ~50% of trees.

One of the main indicators pointing to a decline and dryoff of ash is the fact that the earlywood growth rates have exceeded those of the latewood (e/l > 1.0) and decreased the latewood sensitivity.

A decrease of the radial growth of ash every second or third year is characteristic during 1949–1972 in all research plots. This periodicity was induced by different climatic conditions: a huge amount of annual precipitation and lower air temperatures or lower precipitation rates, especially in summer, and high temperatures.

Climatic conditions belong to the main factors provoking a decline of the radial growth of ash in the last decades.

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PAPRASTOJO UOSIO (*FRAXINUS EXCELSIOR* L.) RADIALIOJO PRIEAUGIO PRIKLAUSOMYBĖ NUO APLINKOS IR KLIMATO VEIKSNIŲ

S a n t r a u k a

Paprastojo uosio radialiojo prieaugio priklausomybės nuo įvairių veiksnių tyrimams buvo parinkti šeši objektai. Dviejuose iš jų uosiai auga parko, o kituose – natūraliomis miško sąlygomis.

Tyrimai parodė, kad dabartinė uosių būklė ir radialiojo prieaugio savitumai bei dėsningumai priklauso nuo įvairių veiksnių: dirvožemio litologinės sudėties, vandens lygio dirvožemyje bei atskirų laikotarpių klimato sąlygų. Nustatyta, kad kiekviename tyrimo objekte uosių radialusis prieaugis į atskirų periodų klimato veiksnių poveikį reaguoja skirtingai. Skiriasi ir atskirų medienų prieaugio reakcija.

Iš visų tyrimo vietų uosių ankstyvasis prieaugis vienodžiausiai reagavo į žiemos mėnesių kritulių ir temperatūrų poveikį. Kai kuriais atvejais r siekia daugiau kaip +0,4. Kuo žiemą iškrenta daugiau kritulių ir jos yra šiltesnės, tuo palankesnės sąlygos uosiams pasiruošti naujam augimo sezonui. Labai panašiai į žiemos klimato sąlygas reagavo ir vėlyvasis prieaugis. Palyginti vienodai (teigiamai) uosių ankstyvasis ir vėlyvasis prieaugis dar reagavo ir į vidutinius metinius kritulius bei neigiamai (r iki –0,4) į rudens mėnesių vidutinę temperatūrą. Pažymėtinas daugiausia teigiamas vasaros kritulių ir neigiamas šio periodo temperatūrų poveikis. Uosių radialiojo prieaugio reakcijos į temperatūrų ir kritulių poveikį savitumams detaliau paaiškinti reikia bent kelerių metų dirvožemio drėgmės pokyčių duomenų.

Nustatyta, kad tirtuose objektuose uosių amžius nėra lemiamas veiksnys, nuo kurio priklauso jų būklė, nors juose pastaruoju metu ypač džiūsta jaunesni uosiai, o gyvybingiausias, su pavienėmis sausomis šakomis, lajas turėjo vyriausi medžiai. Momentai, kai uosių ankstyvosios medienos plotis ilgesnį laiką pradeda viršyti vėlyvosios bei pradeda mažėti vėlyvosios medienos jautrumas aplinkos sąlygų pokyčiams, yra vieni pagrindinių požymių apie jų augimo būklės pablogėjimą ir galimą išdžiūvimą. Be to, tam tikrais laikotarpiais uosiams būdinga prieaugio sumažėjimas kas antri ar treti metai. Nustatyta, kad šitoks ritmiškumas vienais atvejais daugiausia susijęs su gausesniais krituliais ir žemesnėmis temperatūromis, o kitais – atvirkščiai.

Raktažodžiai: uosis, radialusis prieaugis, klimato veiksniai, augavietė, priklausomybė