Eco-genetic Variation of Development and Adaptedness Traits of Seedlings of Local Scots Pine Populations in Lithuania

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Abstract

Reaction of progenies (seedlings) of different Scots pine (*Pinus sylvestris* L.) populations at the juvenile stage on new climatic and microclimatic conditions was investigated. Differences in the development and adaptation parameters of seedlings of three most distant according to continentally (Telšiai, Labanoras, Veisiejai) populations from different geographical regions of Lithuania were revealed and heritability of these traits was established. By variance analysis, the influence of climatic and microclimatic conditions of the environment on the general variation of traits of the seedlings has been found out. Due to a greater trait genetic variation, the selection of families inside populations can be more effective than between populations. In favorable microclimatic conditions (in the greenhouse) variation of growth and biological productivity parameters of seedlings is higher, therefore selection would be more effective on population, family and individual levels. Seedlings of the most continental Labanoras population surpass the representatives of Telšiai population formed in the maritime conditions and the southern Veisiejai population of medium continentally according to growth and biological productivity parameters. The Telšiai population was distinguished by slow growth and lower biological productivity. The survival of seedlings of different populations decreases from the north to the south: the seedlings of Telšiai population formed in the maritime conditions according to this parameter have an advantage over the representatives of the most continental (Labanoras) and medium continental (Veisiejai) populations.

Different adaptation character of individual populations was observed. The general adaptation is typical of Labanoras population, because their progenies grow well in all regions. Low general adaptation character is typical of Telšiai population, that's why it is suitable to grow only in place of its origin. This population has a rather high phenotypic plasticity, because it has the greatest reaction to the changes in climatic conditions.

Key words: Scots pine seedlings, provenance, geographical transfer, genetic variation, heritability, adaptation, phenotypic plasticity

Introduction

It was found, that local populations are best adapted to the existing environmental conditions, however, it is impossible to state that they are the best ones (Persson 1994, Danusevičius *et al.* 1998, Abraitis 1999). In the process of species spreading various obstacles could lead to the formation of communities not of the most suitable structures, which under changing conditions failed to adapt and from the selection viewpoint became of low value. Therefore, studies enabling to ascertain the genotypic structure of provenances, to evaluate the validity of their transfer boundaries and degree of adaptedness are necessary.

The idea of provenance transfer has deep roots in the West European forestry and is widely applied, ascertaining selection zones and elaborating seed transfer models (Danusevičius *et al.* 1998). Ecogenetic studies of the Lithuanian populations ascertain rather big differences in the growth of progenies of dif-

ferent Lithuanian populations, however, clinal variation in population transfer inside Lithuania are insignificant (Ramanauskas *et al.* 1993, Pliūra, Gabrilavičius 1994, Pliūra 1995, Pliūra, Gabrilavičius 1997). The growth of progenies in new conditions is influenced by changes in temperature sum, photoperiod humidity, related to changes in the geographical latitude. Height increment of provenances increases from the north to the south up to the optimal region of the species. Afterwards, moving south in the same direction, the growth of provenances decreases (Vinš, Vančura 1977). Therefore, transfer of progenies from marginal regions is undesirable, because changes in climatic conditions have negative effect on plants (Pliūra, Gabrilavičius 1994). Growth rate of seedlings of the first year is mostly dependent on the weight of small roots and their length (Смирнов 1981, Gunia 1993).

Studies of growth rhythm of progenies allow revealing the norm of genotype reaction to environmental conditions (Weisgerber 1982). The degree of trait inheritance and genotype response to environmental factors is more observable when seedlings of several provenances are grown in the same conditions and when seedlings of one provenance are grown under different conditions (Danusevičius 2000). Seedlings, grown in nursery, were characterized by a greater aboveground portion and root weight, as compared to grown outdoors (Смирнов 1981). Seedlings grown from large seeds are more perspective, because their aboveground weight is bigger than that of grown from small seeds, while the ratio of aboveground portion and root weight is similar (Baltrušaitienė 1994).

The best survival is characteristic of those one-year-old seedlings, the origin of which is related to vegetation period and the sum of efficient temperatures being lower or close to growing conditions (Черепнин 1970, Danusevičius 2000). The mentioned authors admit, that the main reason for successful growth of progenies is the correspondence of seed origin and growth conditions.

Phenotypic plasticity is considered to be a genetically controlled trait (Eriksson 1991). However, adaptation degree of each population most frequently fails to reach its maximum, because environmental conditions change faster than the genetic constitution of population, and the latter is unable to adapt properly and completely.

Seasonal growth duration belongs to climatic modifications, preconditioned by the corresponding local climate. Ramanauskas (1977) has found out, that sporification (flowering) of Scots pine in southern Lithuania occurs 6 days earlier than in the northern-east Lithuania and 12 days earlier than in the littoral flat. Many studies (Rohmeder 1972, Патлай 1974, Morgenstern *et al.* 1975, Vinš, Vančura 1977, Барнишкис 1982, Danusevičius 2000) confirm, that provenances differed according to growth duration and increment.

The work was aimed to evaluate the response of three most distance according continentality Lithuanian Scots pine populations to new climatic and microclimatic conditions and ascertain genetic variation and heritability of the traits of seedlings.

Materials and methods

Mature pure pine stands of similar site class and stocking level, growing on N_{bl} site (according to Buivydaitė *et al.* (2001) the soil is characterized as *Albic Arenosols*) were selected in natural Scots pine populations of Telšiai, Labanoras and Veisiejai. Seeds were collected in stands and seedlings were grown in the Dubrava nursery outdoors and in the greenhouse. Additionally, seedlings of the mentioned populations were grown in the place of their origin, in the nurseries of Telšiai, Švenčionėliai and Veisiejai forest enterprises. Each population was represented by 50 trees, from which 150 cones were collected. The cones were scaled and the seeds were dispensed according to size into 3 fractions: large, small, general sample.

The peculiarities of Telšiai, Labanoras and Veisiejai populations were studied according to seed progenies. Two types of methods were applied: when seedlings of one population are grown under different conditions and when seedlings of several populations are grown in the same conditions.

Ist trial. To evaluate the reaction of one-year-old seedlings to different climatic conditions fractioned seeds were sown using a stencil (3×3 cm) in small pots (90×120×120 mm) in the place of origin of each population: in the nurseries of Telšiai, Švenčionėliai and Veisiejai forest enterprises. The trials were done in the same soil from Dubrava nursery. Each population was represented by a mixture of 2800 fractioned seeds of 50 families, each forest natural region – by 8400 seeds. The trials were done with 5 replications.

IInd trial. To ascertain the peculiarities of two-year-old seedlings, seeds of 150 families of all three populations according to weight fractions were separately sown using a stencil (5×5 cm) outdoors in Dubrava nursery and in the greenhouse. The seeds of each family were sown in the same soil conditions with 5 replications.

The height of seedlings was measured with 0.1 cm, while stem diameter with 0.1 mm accuracy. The seedlings were dried at 103±2°C temperature for 17±1 hours (Standards used at the Forest Seed Control Station). Electronic scales were used for weighing with 0.01 g accuracy. The days were estimated for growth duration.

Statistical analysis of the data was conducted applying the methods of genetic studies of forest tree species (Falconer 1989). The results of multiple analysis of variance show the influence of separate variance sources, which is significant for the variation of the traits of seedlings.

In the first trial variance analyses of traits of seedlings (the height of seedling, the diameter of stem) were done in the several eco-climatic region according to the following model (nested design, *GLM*):

$$Y_{jl} = m + S_j + P_l + SP_{jl} + B_m + E_{jl},$$

where: Y_{jl} – observed value on l-th population in the j-th site (eco-climatic region), m – overall mean, S_j – effect of j-th site (eco-climatic region), P_l – effect of l-th population, SP_{jl} – effect of l-th population and j-th site (eco-climatic region) interaction, B_m – effect of block, E_{jl} – random residual of the jl-th observation, assumed normal distribution.

In the second trial variance analyses of traits of seedlings (the height of seedling, the diameter of stem, the weight of aboveground, the weight of underground, the ratio of aboveground/underground weight) were done in the greenhouse according to the following model (nested design, *GLM*):

$$Y_{jlk} = m + P_j + SP_{jl} + B_m + E_{jlk},$$

where: Y_{jlk} – observed value on k-th tree from the l-th family in the j-th population, m – overall mean, P_j – effect of j-th population, SP_{jl} – effect of l-th family within j-th population, B_m – effect of repetition (block), E_{jlk} – random residual of the jlk-th observation, assumed normal distribution.

Ecological plasticity of each population was estimated in the several eco-climatic regions according to the following model (Федин, Драгавцев 1973):

$$X_{ij} = m + rI_{ij} + d_{ij},$$

where: X_{ij} – observed value on i-th population in the j-th eco-climatic region, m – overall mean, r_i – regression coefficient of i-th population, I_j – the index of environmental (ecological) conditions in j-th eco-climatic region, d_{ij} – the variance of i-th population in j-th eco-climatic region. To evaluate the index of environmental (ecological) conditions standardized selection differentials were used.

Family variance components were calculated for all traits by using the following formulae:

$$I_s^2 = \sigma_s^2 / (\sigma_s^2 + \sigma_e^2),$$

where: I_s^2 – family variance component, σ_s^2 – family variance, σ_e^2 – within family (error) variance.

Family individual tree heritability were computed according to the following formulae:

$$h_{isg}^2 = 4\ \sigma_s^2 / (\sigma_s^2 + \sigma_e^2),$$

where: h_{isg}^2 - family individual tree heritability, σ_s^2 – family variance, σ_e^2 – within family (error) variance.

The correlations of the traits of seedlings were conducted using linear regression analysis. In all cases and all the data are used only under their essential reliability, when p=0.0001-0.05. Statistical analysis was conducted using *MEAN* (*MS EXCEL*), *GLM* (*STATISTICA 5.5*).

Results and discussion

Influence of different climatic conditions on the growth and adaptation of seedlings of different populations

The same soil used in three forest natural regions allowed to assess the reaction of progenies of the studied populations to environmental conditions under new climatic conditions. The results of analysis of variance show the influence of separate variance sources (site, population, site × population interaction, replication), which is significant for the variation of the traits of seedlings (Table 1). Differences in the traits of one-year-old seedlings among populations are reliable in different forest natural regions (p= 0.0003-0.03).

Differences of the populations in each forest natural region reveal the following regularity: one-year-old seedlings of Labanoras population surpass in their

Traits	Seeds size	Source of variance									
		Population			Family (population)			Replication			Quantity of measurements
		Degree of freedom df	Fishers test F	Reliability p	Degree of freedom df	Fishers test F	Reliability p	Degree of freedom df	Fishers test F	Reliability p	
Height of seedling	Large	2	1661.8	0.0001	147	33.7	0.0001	4	6.3	0.0003	8846
	Small	2	804.5	0.0001	147	8.9	0.0001	4	20.2	0.0001	8846
	General sample	2	1832.0	0.0001	147	20.3	0.0001	4	16.7	0.0001	8846
Diameter of stem	Large	2	404.2	0.001	147	6.0	0.001	4	30.3	0.001	8846
	Small	2	268.4	0.001	147	4.6	0.001	4	54.2	0.001	8846
	General sample	2	407.9	0.001	147	4.3	0.001	4	47.9	0.001	8846

Table 1. Assessed ANOVA growing results from the one-year-old traits of seedlings in the eco-climatic region

growth rate the seedlings of Telšiai and Veisiejai populations. According to the height increment the seedlings of general sample of Labanoras population in the place of their origin by 7.8%, while according to stem diameter in Sūduva-Dzūkija highlands by 12% surpass the representative seedlings of Telšiai population. It was found, that the seedlings of Telšiai population grow worse and are characterized by greater variability of growth indices in the studied forest natural regions. The seedlings of Veisiejai population are closer in their growth to Labanoras population.

Similar results were obtained by Barniškis (1977), Abraitis and Eriksson (1996), who stated, that very often the growth of transferred northern provenances of Scots pine is worse than that of southern ones. Greater height increment variability of seedlings from large seeds is predetermined by their seeds heterogeneity. It was found, that higher phenotypic plasticity is characteristic of the seedlings from large and small seeds of the Telšiai population and to the seedlings of Veisiejai general sample seeds, distinguished by specific adaptability. Meanwhile, Labanoras population, which has lower phenotypic plasticity, is characterized by general adaptability.

Vegetation duration of populations seedlings

Different growth duration of the seedlings of Telšiai, Labanoras and Veisiejai populations is characterized by specific local climatic conditions. After studying the duration of vegetation, a significant influence of the population has been found.

Our studies reveal regularity that vegetation duration of the seedlings of Veisiejai population is greater than that of Labanoras and Telšiai populations. The greatest difference in vegetation duration between Veisiejai and Telšiai populations was obtained in Švenčionys district. It comprised 7.3%, while the difference between these populations in Telšiai district was 6.4%. The greatest difference in vegetation duration of the representatives from Veisiejai and Labanoras populations was ascertained in Veisiejai district and comprised 2.6%. Length of vegetation period shortened gradually moving from the south to the north (Figure 1).

Each ecotype of Scots pine, having acquired modified traits and properties in ontogenesis, can sustain them when transferred into other climatic conditions. Similar results were obtained also by other researchers (Правдин 1978, Райт 1978, Danusevičius *et al.* 1998, Danusevičius 2000).

Present study found out, that one-year-old seedlings of Telšiai population are the most sensitive to vegetation duration in the place of their origin, therefore they are characterised by specific adaptability. In Švenčionys and Veisiejai districts such adaptability is characteristic of one-year-old seedlings of Veisiejai population. Correlation between vegetation duration and the height of seedlings was of average strength

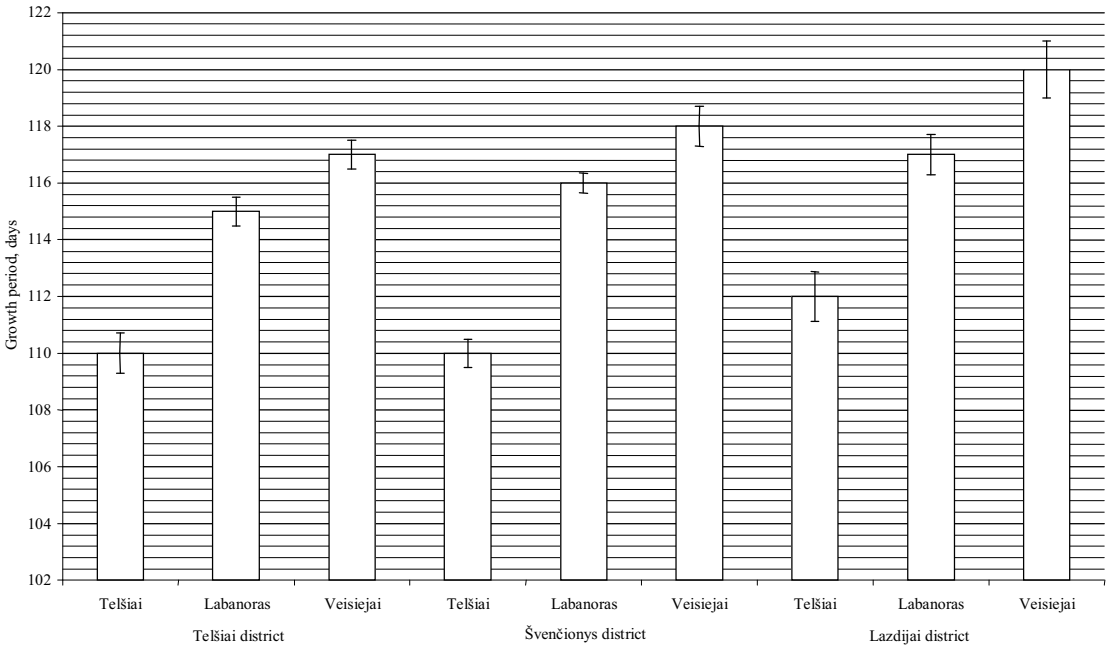

Figure 1. Length of populations seedlings growth period from general sample seeds. Bars show average various population growth period of general sample seedlings, vertical lines – standard deviation.

(r=0.41; p<0.001). Similar results were obtained in experimental plantations of Rokai Kelmynas (Dubrava ETFE), where the height of seedlings was closely correlated with the growth duration (r=0.997; p<0.001) (Danusevičius 2000).

Influence of growth conditions outdoors and in the greenhouse on the growth and adaptation of seedlings

Growing different populations in one place outdoors and having analysed them at three levels (among populations, among families and within a family), peculiarities of genotypic variation of individual populations were ascertained. The study, carried out at the same time in a greenhouse, shows a provoked reaction of population progenies (seedlings) to changes in environmental conditions. The results of analysis of variance show the influence of separate variance sources (population, family within a population, replication), which is significant for the variation of the traits of seedlings (Table 2). Differences in the traits of two-year-old seedlings on population, family, individual levels are reliable in the greenhouse (p= 0.0003-0.0001). Results of analysis of variation components show, that the variation of traits of seedlings studied outdoors and in the greenhouse is more influenced by random variation (85.0-92.5%) than by the family (7.5-15.0%). Results of correlation analysis show, that growth correlation at population level remains similar in the greenhouse and outdoors. Correlation of ranks according to seedling height was 0.85-0.99 (p= 0.01-0.05) and stem diameter was 0.86-0.98 (p= 0.01-0.05).

greatest differences in the height and stem diameter increment of one-year-old seedlings from large seeds ascertained among families within a population in a greenhouse comprise 119% and 38%, respectively (Veisiejai population), while outdoors – 24% and 10% (Labanoras population). A similar tendency is observed in two-year-old seedlings only biggest percent: in the greenhouse the greatest height increment of seedlings from large seeds in Labanoras population comprises 208%, while outdoors the greatest difference of this variable in seedlings from small seeds in Telšiai population reach 82%. Differences in stem diameter increment are slightly less: in the greenhouse the greatest difference of this variable in seedlings from large seeds was ascertained in Telšiai population and comprised 81%, while outdoors the greatest difference in stem diameter increment of seedlings from small seeds in Veisiejai population comprised 50%. Differences in the studied growth indices reveal growth differentiation of the families from different populations, which in the families of one-year-old and two-year-old seedlings is greater according to height than according to stem diameter. Similar results were presented by Danusevičius (2000), determining different growth rates of the families of yellow pine at the initial stages of its ontogenesis.

In the greenhouse, among individuals within a family the greatest difference in the height increment of one-year-old seedlings from large seeds was from 12% to 35% (Labanoras population), while outdoors – from 22% to 29% (Telšiai population). It shows, that under better growth conditions the increment differentiation is higher. Studies have shown, that the variation of growth traits among families within a population is far greater than at interpopulation and individual levels. Due to a greater range of variation of trait family means in populations, selection of families would be more perspective as gives higher genetic gains. Similar results were obtained by Gullberg *et al.* (1985), Prus-Glowacki (1991), Pliūra and Gabrilavičius (1997), Danusevičius (2000).

Table 2. ANOVA results of growth traits of two-year-old seedlings in the greenhouse

Traits	Seeds size	Source of variance									
		Population			Family (population)			Replication			Quantity of measurements
		Degree of freedom df	Fishers test F	Reliability p	Degree of freedom df	Fishers test F	Reliability p	Degree of freedom df	Fishers test F	Reliability p	
Height of seedling	Large	2	1661.8	0.0001	147	33.7	0.0001	4	6.3	0.0003	8846
	Small	2	804.5	0.0001	147	8.9	0.0001	4	20.2	0.0001	8846
	General sample	2	1832.0	0.0001	147	20.3	0.0001	4	16.7	0.0001	8846
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	Small	2	268.4	0.001	147	4.6	0.001	4	54.2	0.001	8846
	General sample	2	407.9	0.001	147	4.3	0.001	4	47.9	0.001	8846

The greatest differences in the height increment of seedlings from large seeds between Labanoras and Telšiai populations are more expressed in the greenhouse (one-year-old – 26%, two-year-old – 55%) than outdoors (one-year-old – 15%, two-year-old – 47%). The greatest differences in stem diameter increment of seedlings of the same seed fraction among the populations were observed in the first year outdoors (8%), in the second year – in the greenhouse (32%). The

In the greenhouse heritability of the height increment (h^2_{isg} = 0.598) of one-year-old seedlings remains the highest in Labanoras population, while heritability of the stem diameter increment was highest (h^2_{isg} = 0.524) in Veisiejai population. The least heritability of height (h^2_{isg} = 0.335) and stem diameter (h^2_{isg} = 0.409) increment was obtained for Telšiai population. A similar tendency is repeated studying two-year-old seedlings, where similar heritability of height (h^2_{isg} = 0.323-0.581) and heritability of stem diameter (h^2_{isg} = 0.373-0.513) increment limits were ascertained in Table 3.

Table 3. Variance components and family means heritability of traits of different population seedlings in the greenhouse

Population	Traits	Seeds size	Variance components, %		Family heritability
			Family	Random error	
Telšiai	Height	Large	14.2	85.8	0.570
		Small	8.1	91.9	**0.323**
		General sample	11.5	88.5	0.462
	Diameter	Large	9.6	90.4	0.383
		Small	9.3	90.7	**0.373**
		General sample	9.4	90.6	0.378
Labanoras	Height	Large	14.5	85.5	**0.581**
		Small	8.4	91.6	0.334
		General sample	11.8	88.2	0.471
	Diameter	Large	10.3	89.7	0.402
		Small	10.7	89.3	0.428
		General sample	10.3	89.7	0.411
Veisiejai	Height	Large	14.3	85.7	0.573
		Small	8.5	91.5	0.341
		General sample	11.6	88.4	0.465
	Diameter	Large	12.8	87.2	**0.513**
		Small	9.8	90.2	0.393
		General sample	12.2	87.8	0.488

It was found significant correlation between height and geographical conditions of the place of origin of two-year-old seedlings from different populations. The height of seedlings is correlated with geographical latitude (r= -0.48; p= 0.001-0.01), eastern longitude (r= 0.82; p< 0.001) and altitude (r= -0.13; p= 0.001-0.01).

Along with the growth indices of seedlings of different populations, the variability of the weight of parts of biological productivity was additionally studied. The results of analysis of variance show the influence of separate variance sources (population, family within a population, replication), which is significant for the variation of the biological productivity traits of seedlings (Table 4). The difference in indices of two-year-old seedlings among populations and among families within a population is statistically significant (p= 0.0001-0.001). Studies of the variability of biological productivity indices of two-year-old seedlings under different microclimatic conditions have shown, that in the greenhouse conditions the greatest biomass was accumulated by seedlings of Labanoras population. Progeny of this population had also a relatively greater weight of roots. A similar regularity was observed outdoors too. However, root development was weaker outdoors. It is considered, that warmth is the main factor stimulating root development, therefore, soil scarification, allowing warmer air to enter it, may stimulate root development. The seedlings of Telšiai population were characterized by the least weight of the parts of biological productivity different microclimatic conditions and greater aboveground weight variability outdoors. In the greenhouse conditions, greater variation of indices of biological productivity was expressed in Labanoras population. Outdoors greater variability of underground weight was ascertained in Veisiejai population. The large seeds produced larger seedlings. The greatest aboveground weight differences of seedlings from general sample seeds in the greenhouse and outdoors between Labanoras and Telšiai populations comprised 27% and 45% respectively, while the greatest differences in underground weight of the latter seed fraction reach 32% and 75% respectively. Larger weight of small roots ensures for the seedlings of Labanoras population an even development of aboveground portion and their better establishment. Similar results were obtained by Смирнов (1981), Baltrušaitienė (1994).

Table 4. ANOVA results of biological productivity traits of two-year-old seedlings in the greenhouse

Traits	Seeds size	Source of variance									Quantity of measurements
		Population			Family (population)			Replication			
		Degree of freedom df	Fishers test F	Reliability p	Degree of freedom df	Fishers test F	Reliability p	Degree of freedom df	Fishers test F	Reliability p	
The weight of aboveground	Large	2	3939.9	0.001	147	106.8	0.001	4	34.1	0.001	8846
	Small	2	497.2	0.001	147	109.9	0.001	4	49.8	0.001	8846
	General sample	2	2471.7	0.001	147	77.8	0.001	4	53.9	0.001	8846
The weight of underground	Large	2	1173.0	0.001	147	55.8	0.001	4	58.5	0.001	8846
	Small	2	153.3	0.001	147	27.5	0.001	4	30.1	0.001	8846
	General sample	2	883.8	0.001	147	38.2	0.001	4	63.5	0.001	8846
The ratio aboveground/ underground weight	Large	2	9.1	0.0001	147	7.3	0.0001	4	7.8	0.0001	8846
	Small	2	64.3	0.0001	147	19.2	0.0001	4	7.9	0.0001	8846
	General sample	2	31.3	0.0001	147	60.5	0.0001	4	64.1	0.0001	8846

Phenotypic correlation between the weight of needles and roots is higher outdoors (r= 0.98; p= 0.001-0.01) than in the greenhouse (r= 0.63; p= 0.001-0.01). It shows the vitality of seedlings.

Survival of the seedlings of population families

The differences of the variable among populations and among families within population was statistically significant (p= 0.0001).

Seedlings grown in the greenhouse survived better than seedlings grown outdoors. On population level the best survival was recorded for Telšiai, the worst – for the seedlings of Veisiejai population. Two-year-old seedlings are characterised by higher mortality than one-year-old seedlings. In the greenhouse the latter index in the first year comprised 5%, in the second year from 14% to 23%. Outdoors mortality in the first year comprised from 10% to 13%, in the second year from 23% to 30%. The greatest differences in survival one-year-old and two-year-old seedlings between Telšiai and Veisiejai populations in the greenhouse comprise respectively 3.7% (Figure 2) and 11%, while outdoors the difference of two-year-old seedlings between the mentioned populations reached 10%. Similar studies by Черепнин (1980) and Danusevičius (2000) results show, that the best survival is characteristic of those one-year-old seedlings, the provenance of which is related to short vegetation period and efficient sum of temperatures, which is lower or close to growth conditions. Resistance to frost in the early autumn is applicable to the indication of acclimatization during the frost of the first year and confirms better survival of the provenances from northern latitudes (Jonsson *et al.* 1981, Nilsson 1995).

Under different microclimatic conditions reliable correlations with seed weight and geographical latitude were ascertained. In the greenhouse a stronger dependence of the survival of seedlings and seed weight was expressed among families within a population (r= -0.66-0.73; p< 0.001) than among populations (r= -0.53-0.58; p< 0.001). Outdoors a strong correlation was ascertained between the survival of seedlings and geographical latitude (r= 0.80-0.89; p< 0.001), as well as populational dependence.

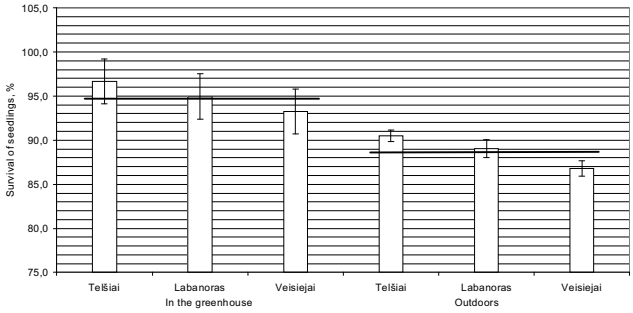

Figure 2. Adaptation of different populations seedlings from general sample seeds in the different microclimatic conditions. Bars show average of various populations survival, vertical lines – standard deviation. Horizontal lines show the average of survival in the various microclimatic conditions

Conclusions

Scots pine populations of Telšiai, Labanoras and Veisiejai populations, formed in different geographical regions of the country, according to many morpho-physiological and biometrical traits of seedlings essentially differ.

The reaction of three different populations, having transferred them into new ecological conditions, differs according to qualitative traits. Population (Labanoras) formed in the most continental conditions according to the mentioned traits surpasses the rest and is essentially distinguishable among other populations. Population (Telšiai) formed in the maritime conditions demonstrated the most negative reaction to new climatic conditions. The southern population (Veisiejai) of medium continentality occupied an intermediate position. Seedlings of the most continental population (Labanoras) grew best in Sūduva-Dzūkija highlands, while the seedlings of populations of maritime (Telšiai) and medium continentality (Veisiejai) – in autochthonous locations.

The reaction of individual families to new environmental conditions is also different. In more favourable conditions (nursery) greater variation of growth and biological productivity indices was observed, thus selection in the nursery might be more efficient at population, family and individual levels. A greater phenotypic plasticity of Telšiai and Veisiejai populations is related to a specific adaptability. The progenies of Telšiai population, growing worst in all studied eco-climatic regions, are suitable for growing only in the place of their origin. The highest height increment heritability coefficient remains in Labanoras, while the least in Telšiai populations.

The population effect in the duration of vegetation period is highly significant and this shows a great genetic relativity of this trait. Progenies of various populations transferred into different eco-climatic regions retain their growth duration (the longest growth is characteristic of the seedlings of medium continentality (Veisiejai), the shortest – of maritime (Telšiai) populations).

References

Abraitis, R. 1999. *Pinus sylvestris* L. provenance and family adaptedness under controlled and natural conditions. Doctoral dissertation, p. 72-78.

Abraitis, R. and Eriksson, G. 1996. *Pinus sylvestris* L. East European populations: growth and behaviour in one Lithuanian field trial. Baltic Forestry, 2: 28-35.

Baltrušaitienė, V. 1994. Priešsėjinio pušies sėklų kalibravimo ir sodmenų auginimo tankumo įtaka miško želdinių augimui [The influence of presowing calibration of pine seeds and seedling density on the growth of plantations]. Miškininkystė, 34: 5-10. (in Lithuanian)

Barniškis, E. 1977. Geografinės pušų kultūros Vilniaus miškų ūkyje po penkiolikos metų [Geographical pine forest planting of fifteen years old in Vilnius forest enterprise]. Girios, 11: 9-11. (in Lithuanian)

Buivydaitė, V.V., Vaičys, M., Juodis, J. ir Motuzas, A. 2001. Lietuvos dirvožemių klasifikacija [Classification of Lithuanian soil]. Vilnius, p. 62-128.

Danusevičius, J. 2000. Pušies selekcija Lietuvoje [Pine selection in Lithuania]. Kaunas, p. 21-351. (in Lithuanian)

Danusevičius, J., Baliuckas, V., Plačiakis, R. ir Abraitis, R. 1998. Perspektyvių pušies rūšių selekcinė introdukcija ir hibridizacija, sukuriant sparčiai augančius ir vertingus hibridus [Selectional introduction and hybridization of perspective pine species, developing fast growing and valuable hybrids]. Girionys, p. 33-53. (in Lithuanian)

Eriksson, G. 1991. Challenges for forest geneticists. Silva Fennica, 25(4): 257-266.

Falconer, D.S. 1989. Introduction to quantitative genetics. Third edition. Longman Scientific and Technical. London, 437 p.

Gullberg, U., Yazdani, R. and Rudin, D. 1985. Allozyme variation in Scots pine (*Pinus sylvestris* L.) in Sweden. Silvae Genet., 34: 193-201.

Gunia, S. 1993. Recenzja [The critique]. Sylwan, 9: 93-98. (in Polonian)

Jonsson, A., Dormling, I. and Eriksson G. 1981. Studies on frost hardiness of *Pinus contorta* Dougl. seedlings grown in climate chambers. Studia Forestalia Suecica, 157: 1-47.

Morgenstern, E.K., Holst, M.J., Teich, A.H. and Yeatman, C.W. 1975. Plus tree selection: review and outlook. Dept. Environment.Can. For. Serv. Pub. 1347: 1-72.

Nilsson, J.E. 1995. Genetic variation in the natural pollen cloud of *Pinus sylvestris* L.: a study based on progeny testing. Scan. J. For. Res. 10: 140-148.

Persson, B. 1994. The effects of climate and provenance transfer on survival, production and stem quality of Scots pine (Pinus sylvestris L.) in Northern Sweden. Swedish University of Agricultural Sciences, Department of Forest Yield Research, Report 37, 42p.

Pliūra, A. 1995. Lietuvos pušies populiacijų palikuonių produktyvumo komponentų genetinė variacija ir ekologinis plastiškumas [Genetic variation and phenotypic plasticity of progenies productivity components from Lithuanian Scots pine populations]. Miškininkystė, 36: 24-54. (in Lithuanian)

Pliūra, A. ir Gabrilavičius, R. 1994. Ecological plasticity of Lithuanian Scots pine populations. In: Scots pine breeding and genetics Proceedings of the IUFRO S.02.18 Symposium. Lithuania. Kaunas-Girionys, p. 54-62.

Pliūra, A. ir Gabrilavičius, R. 1997. Lietuvos pušies populiacijų palikuonių augimo ekogenetiniai dėsningumai [Eco-genetical regularity of growth progenies from Lithuanian Scots pine populations]. In: Lietuvos mokslas: Lietuvos miškininkystė (Raida ir perspektyvos), 13-14: 176-194. (in Lithuanian)

Prus-Glowacki, W. 1991. Biochemical polymorphism. In: Genetics of Scots pine. Elsevier Science Publishers, Amsterdam, p. 73-86.

Ramanauskas, V. 1977. Atskirų pušies populiacijų susikryžminimo galimybių tyrimas Lietuvoje [Studies on cross-breeding possibilities of individual pine populations in Lithuania]. In: Genetika ir selekcija liaudies ūkiui. Vilnius-Kaunas, p. 47-48. (in Lithuanian)

Ramanauskas, V., Andriuškevičienė, I. and Pliūra A. 1993. Adaptation of pine populiations to the environmental conditions. Proceedings of the Lithuanian Forest Research Institute, 33: 43-53.

Rohmeder, E. 1972. Das Saatgut in der Forstwirtschaft. Verlag Paul Parey. Hamburg und Berlin, p. 60-259.

Vinš, B., Vančura, K. 1977. Provenance trial with Spruce (*Picea abies*) IUFRO 1964/68 in Czechoslovakia. Comm. Inst. Forestalis, p. 89-109.

Weisgerber, H. 1982. Züchtungsfortschritte durch Nachkommenschaftsprüfungen. Forstarchiv, p. 9-13. (in German)

Барнишкис, Э. 1982. Изучение влияния географического происхождения на рост основных лесообразующих пород в Литовской ССР [The study of influence geographical origin on the growth species from Lithuania]. В кн: Географические опыты в лесной селекции Прибалтики. Рига, с. 5-16. (in Russian)

Патлай, И.Н. 1974. Сезонный прирост сосны обыкновенной в высоту в географических культурах и плантациях [Seasonal height increment of Scots pine on the geographical forest planting and plantations]. Лесоведение и агролесомелиорация, с. 87-94. (in Russian)

Правдин, Л.Ф. 1978. Значение генетики в развитии учения о лесе [The role of genetic on the development of forest study]. В кн: Научные основы селекции хвойных древесных пород. Наука. Москва, с. 7-27. (in Russian)

Райт, И. 1978. Введение в лесную генетику [Introduction to forest genetics]. Москва, с. 165-399. (in Russian)

Смирнов, Н.А. 1981. Выращивание посадочного материала для лесовосстановления [Growing of planting material for forest regeneration]. Москва, с. 168. (in Russian)

Федин, М.А., Драгавцев, В.А. 1973. Генетический анализ количественных и качественных признаков с помощью математико-статистических методов [Genetic analysis of qualitative and quantitative traits with the aid of mathematical-statistical methods]. Москва, с. 5-109. (in Russian)

Черепнин, В.Л. 1970. Сосна обыкновенная в Восточной Сибири [Scots pine in Western Sibirien]. Автореф. канд. дис.. Красноярск, с. 24. (in Russian)

Черепнин, В.Л. 1980. Изменчивость семян сосны обыкновенной [Variation of Scots pine seeds]. Москва, с. 181. (in Russian)

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ЭКО-ГЕНЕТИЧЕСКАЯ ВАРИАЦИЯ ПРИЗНАКОВ РАЗВИТИЯ И АДАПТИВНОСТИ СЕЯНЦЕВ МЕСТНЫХ ПОПУЛЯЦИЙ СОСНЫ ОБЫКНОВЕННОЙ В ЛИТВЕ

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Резюме

Изучена реакция сеянцев различных популяций сосны обыкновенной перемещенных на новые климатические и микроклиматичесие условия. Выявлены особенности развития и адаптивности сеянцев трлх найболее отдаллнных по континентальности популяций (Тельшяй Лабанорас Вейсеяй) в различных географических регионах Литвы. Установлена генетическая детерминация этих признаков. При помощи анализа вариации компонентов климатических и микроклиматических условий среды установлено их влияние на общую изменчивость биометрических показателей сеянцев. Отбор семей внутри популяции является более эффективным чем отбор отдельных популяций. Однако в благоприятных микроклиматичесих условиях (в теплице) проявляется найбольшая изменчивость показателей роста и биологической продуктивности сеянцев существенно выше чем в не благоприятных условиях (открытом грунте). Поэтому при выращивании потомства в теплицах найболее эффективным является отбор на популяционном, семейном и индивидуальном уровнях. Сеянцы найболее континентальной популяции (Лабанорас) по показателям роста и биологической продуктивности превосходят представителей популяции сформировавшейся в условиях морского климата (Тельшяй), а также популяции средней континентальности (Вейсеяй). Тельшяйская популяция отличается низким ростом и меньшей биологической продуктивностью. Однако сохранность сеянцев сосны Тельшяйской популяции выше чем сеянцев более континентальных популяций. Установлено, что сохранность сеянцев во всех экспериментальных посевах уменьшается по мере их происхождения с севера на юг.

Установлена различная адаптивность потомства отдельных популяций. Лабанорская популяция отличается высокой общей адаптивностью. Её потомство хорошо растёт во всех трёх исследованных географических регионах. Близкой к Лабанорской популяции по темпу роста сеянцев является Вейсеяйская популяция. Потомство Тельшяйской популяции отличается более низкой общей адаптивностью. Она найболее чувствительна к изменению климатических условий, обладает более высокой фенотипической пластичностью. Поэтому сеянцы этой популяции целесобразно использовать только в регионе происхождения.

Ключевые слова: сеянцы сосны обыкновенной, популяция, географический перенос, генетическая изменчивость, наследственность, адаптация, фенотипическая пластичность