Growth Dynamics of Scots Pine Geographical Provenances in Latvia

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Abstract

Results from geographical provenance trials (totally 40 foreign provenances from Poland, Eastern Germany, Russia, Belarus, and Ukraine) in three test locations in Latvia have been evaluated.

For analysis only superior trees (10% of the highest trees in each provenance) have been chosen.

Results indicate that credible evaluation (observed trend does not change with increasing tree age) of survival for provenance groups from different regions can be done at the age of 6 years, for growth traits – at 15 years, but growth performance of individual provenances vary considerably up to the age of 28 years. Provenance influence on height and diameter growth is highest, exceeding regional influence even three times for height and twice for diameter.

Results of geographical Scots pine trial are site-dependent. Provenances from the same region tested in 3 different test locations in Latvia at the same age demonstrate differences in survival up to 16% and in yield more than double.

Average growth and survival of Eastern German and Polish Scots pine provenances decrease when comparing the areas with mild, maritime climate (Liepāja and to a lesser extent Zvirgzde) and the areas with harsher, more continental climate (Kalsnava). The decrease is sharper for Eastern German provenances.

In Kalsnava, the performance of Polish and East German provenances differs considerably from the general trend, described in the literature. We suggested that the Kalsnava area could be taken as an indicator for a borderline for growth patterns of transferred Scots pine provenances.

Key words: *Pinus sylvestris* L., provenance trial, growth dynamics, quality, provenance influence

Introduction

Evaluation of growth traits for different provenances has been of interest already for more than a century (Giertych 1991b). Choice of the suitable provenance for local conditions is the primary precondition for successful further breeding and useful outcome (Baumanis *et.al*. 2001). To compare provenances plenty of national and international trials have been established. Most known from them are the IUFRO (International Union of Forest Research Organizations) trials established in 1907, 1938, 1939, and 1982 (Giertych 1979, Kohlstock and Schneck 1998) and Ogievskij pre-revolutionary Russian provenance experiment (Giertych and Oleksyn 1981). Recently the results from a comprehensive provenance trial established in all the territory of former USSR in 1974-1976 have become available (Shutyaev and Giertych 2000).

There are considerable difficulties in evaluating the old-time trials: the differences in establishment method particular trial planting places (Giertych and Oleksyn 1981) can cause errors. Some of the trials on each planting site have no replications, so it is hard to distinguish between the soil and provenance effects (Abraitis and Eriksson 1998).

In spite of that the results obtained in these trials are used to delineate general trends of Scots pine growth (e.g. Giertych, 1991b). In some cases the use foreign provenances in forest regeneration have been recommended because of their growth and quality (e.g. Pedersen 1998).

In spite of numerous trials, the results are usually published only from the latest measurements taken at different ages, but there is lack of growth-dynamics analysis. Usually a considerable area or even a country is represented by only one provenance and it is impossible to distinguish between the influence on the growth and quality of the region (or country) and the particular provenance. The aim of the present study was to evaluate the growth and survival dynamics of foreign provenances in three climatically different localities in Latvia.

Materials and methods

In the trial of geographical Scots pine provenances totally 58 provenances are included – 27 from Eastern Germany, 8 from Poland, 1 from Belarus, 3 from Russia and 1 from Ukraine as well as 18 Latvian provenances. Data on the origin of non-Latvian provenances are presented in Table 1.

Table 1. Geographical origin for pine provenances included in experiment

Origin region	Nr.	Provenance	Geographical origin		
			Latitude	Longitude	Altitude, m
Russia *	125	Ангасяк-2	50°	56°	150
	126	Мелекесс	54°	49°	20
	127	Ангасяк-1	50°	56°	80
Ukraine *	128	Киев	50°	30°	20
Byelo-russia *	129	Борисов	54°	28°	20
Poland	130	Rychtal	51° 06'	17° 53'	80
	131	Pokoj	51° 00'	18° 00'	80
	132	Plaska	53° 50'	23° 00'	60
	133	Rospuda	54° 00'	22° 50'	20
	134	Rytel	53° 30'	17° 50'	70
	135	Supras'l	53° 15'	23° 07'	50
	136	Taborz	53° 35'	20° 00'	50
	137	Tarda	53° 45'	20° 00'	15
Eastern Germany	138	Neusterliz	53° 20'	13° 00'	70
	139	Dippoldiswalde	50° 50'	13° 30'	50
	140	Hagenow	50° 30'	11° 15'	50
	141	Konigstein	51° 00'	14° 00'	80
	142	Rathenow	52° 30'	12° 30'	100
	143	Bad Berka	51° 00'	11° 15'	80
	144	Mirow	53° 15'	12° 45'	150
	145	Oranienburg	52° 40'	13° 15'	70
	146	Eibenstock	50° 30'	12° 45'	80
	147	Neubrandenburg	53° 30'	13° 15'	70
	148	Lobau	51° 10'	14° 45'	80
	149	Nedlitz	52° 10'	12° 205'	80
	150	Niesky	51° 20'	15° 00'	60
	151	Rostock	54° 10'	12° 10'	60
	152	Schleitz	50° 35'	11° 40'	80
	153	Perleberg	53° 00'	11° 50'	60
	154	Neuhaus	53° 15'	11° 00'	150
	155	Gransee	53° 00'	13° 15'	80
	156	Kyritz	52° 50'	12° 30'	80
	157	Tharandt	51° 00'	13° 30'	150
	158	Colbitz	52° 20'	11° 30'	50
	159	Gustrow	53° 50'	12° 15'	80
	160	Oelsnitz	50° 25'	12° 15'	60
	161	Potsdam	52° 20'	13° 00'	120
	162	Peitz	51° 50'	14° 30'	150
	164	Jena	51° 00'	11° 30'	150
	165	Kolpin	52° 20'	14° 00'	80

* - just approximate data on latitude and longitude available

According to a popular methodology (Aitken 2004), each provenance sample is made up from the seeds of 20-25 trees. The trial was established in 3 different places in Latvia – Liepâja, Zvirgzde and Kalsnava (Figure 1), using one-year-old seedling. The site quality for pine was above the average (Site index 2). Trial design – two blocks with 6 replications, 7 x 5 plants in a parcel, initial spacing 2 x 1 m.

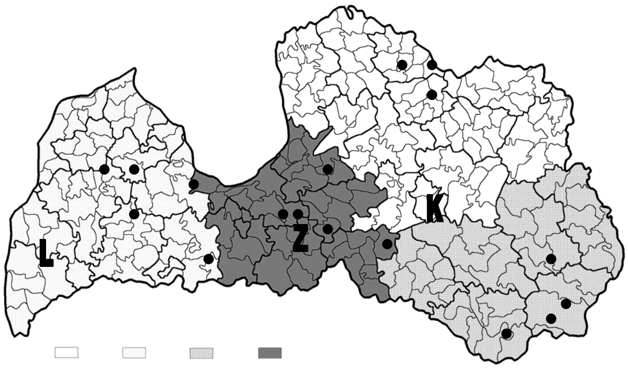

Figure 1. Test locations and native pine sample collection places in Latvia
L-Liepāja, Z – Zvirgzde, K – Kalsnava; black dots – seed collection places; with different colours pine seed zones are labeled

The trees on the trial plot were measured at the age of 5, 10, 11, 15, 21 and 28 years (Birģelis 1983, Baumanis *et al*. 1986, Áàóì àíèñ *et al*. 1990, Birģelis *et al*. 1994, Jansons and Baumanis 2005).

The survival was assessed up to age of 21 year, when the first thinning was made, leaving 1/3 of the initial number of trees

Stem straightness and branchiness at the age of 28 years has been assessed by using 3 grades – where Grade1 – straight stems or thin branches; Grade 3 – crooked stems or thick branches.

The statistical analysis was done by using Microsoft Excel. The following ANOVA model was used:

$$y_{ijkl} = \mu + t_i + r_{j(i)} + o_k + p_{l(k)} + e_{ijkl}, \quad (1)$$

where y_{ijkl} – individual tree height; μ – overall mean; t_i – test site effect; $r_{j(i)}$ – replicate within test site effect; o_k – origin region effect; $p_{l(k)}$ – provenance within origin region effect; e_{ijkl} – error within provenance.

Only three regions (Latvia, Poland and Eastern Germany) were used in the analysis.

For assessment of yield, the stem volume of trees up to 10 cm in diameter has been calculated according to the formula suggested by Gerkis (Ãåð-êèñ 1981):

$$m = 0.019 + 0.01142(d_{1,3} + 2)^{2,61614} \times h^{0,76489}, \quad (2)$$

where m – stem volume, dm^3; $D_{1,3}$ – diameter at breast height (1.3 m), cm; h – tree height, m.

The tree volume for the trees thicker than 10 cm d.b.h. (hereinafter the diameter at breast height – 1.3 m) was assessed according to the formula suggested by Ozoliņš (Ozoliņš 1997):

$$V = \frac{\pi D^2 \cdot H \cdot I}{4 \cdot 10^4 \cdot (P(\frac{1,3}{H}))^2}, \quad (3)$$

where V – stem volume, m^3; H – tree height, m; D – d.b.h., cm; I = 5298,6; P – perturbation coefficient; π = 3,14159.

Degree of influence (η) has been calculated according to the method described by Liepa (1974):

$$\eta_A = SS_A * SS_{Total}^{-1}, \quad (4)$$

where η_A – degree of the influence of evaluated factor (factor A); SS_A – sum of squares for factor A; SS_{Total} – total sum of squares.

The factor, that most strongly affects the measured trait, has the highest value of η.

To compare growth for different provenances and get the most accurate results, it is important to use traits with small variation. The variation coefficient for the stem volume components (height and diameter) is decreasing with time in all the trials. However, the diameter variations invariably exceed height variation (Table 3). That is why the height has been chosen as the major measure for delineating the tree group for further calculations. Height as a measure has been recommended also in the literature – see e.g. the review by Nilsson (1991).

The suppressed trees are not representatives of the population (Abraitis and Eriksson 1996). So it is important to delineate them from the calculations. To ensure equal representatives for each provenance we decided to use 10 % from initially planted trees – 3 highest trees in each replication that makes 18 trees for each trial plot.

If we chose sample group 10% of the highest trees for each provenance (instead of bigger sample group e.g. 20%), the degree of the influence of replication usually decreased, but the degree of the influence for provenance increased compared to the evaluation of all the planted trees. The small group of dominant trees (as 10% highest) makes the influences more visible (Figure 2).

Moreover, 10% from the initial number of trees (e.g. 500 tree/ha) make the amount recommended as optimal for final felling in the particular growth conditions in Latvia (Anonymous 2000).

So we chose the group standing for 10% of the highest trees from initially planted ones for the growth and quality comparison trial.

For the calculations of standing volume and other comparative means at age 28 years (last measurement) in Table 4 sample group of the 20% highest trees were used. It is the approximate amount (1,000 trees per ha) recommended in Latvia to be optimal in certain conditions of growing site for Scots pine stands (Anonymous 2000). Results of each provenance in Table 4 have been compared with the average performance of Latvian provenances with the difference in % (S%) calculated.

In the analysis provenance origin regions are defined correspondingly to country borders. It is done in order to evaluate, what differences are in performance of provenances from one country and what effects are in choosing just one (or very few) provenances to represent country in international provenance trial. Provenances in the group from the former USSR differs a lot in longitude of origin, but can not be separated, because there are too few provenances representing particular country. For that reason these groups are not much used in the analysis, but still left in dataset in order to show observed performance of particular provenances.

Results

The growth and survival are obviously two related factors, describing the final stand volume and quality –the authors, who study Scots pine provenances in Europe, conclude that the major source of observed variations among the wood volume production is related to dissimilarities in the growth rate and survival (e.g. Oleksyn *et al*. 1999).

Survival. Table 2 shows survival rates for provenances from different regions planted in 3 different test locations in different parts of Latvia. In all three test locations the Latvian provenances showed the best survival. The Polish provenances demonstrated average survival, slightly better than that for Eastern German provenances. For distant populations from the former USSR the survival was exceptionally low.

Table 2. Survival rates (% from initially planted) for provenances from different regions

Liepāja					
Provenience origin	**Age, years**				
	6	**10**	**11**	**15**	**21**
Former USSR	17	17	17	16	15
Poland	52	52	52	51	44
Estern Germany	52	52	51	50	43
Latvia	58	58	57	56	47
Zvirgzde					
Provenience origin	**Age, years**				
	6	**10**	**11**	**15**	**21**
Former USSR	20	20	16	16	16
Poland	50	50	44	43	39
Estern Germany	45	45	39	37	35
Latvia	52	52	45	43	39
Kalsnava					
Provenience origin	**Age, years**				
	6	**10**	**11**	**15**	**21**
Former USSR	19	19	18	16	15
Poland	45	45	44	40	35
Estern Germany	35	35	35	32	29
Latvia	65	65	63	57	46

Most of the differences in survival appeared during the juvenile growth (first 6 years). Afterwards the survival decreased only slightly and quite equally for all the provenance groups in Zvirgzde. In Liepāja and Kalsnava the survival decreases somewhat faster for the Latvian provenances than for introduced ones.

The provenances from the former USSR have equally low survival in all test locations. The Polish provenances showed the highest survival in Liepāja. If survival in Liepāja is presumed as 100%, survival in Zvirgzde is 96% and in Kalsnava 91%. The same trend was observed for the Eastern German provenances (decrease in survival compare to Liepāja 8% and 16%, respectively) (see Table 2). The lowest survival for Latvian provenances are in Zvirgzde. There the difference between the Latvian and Polish provenances in survival is negligible too. The highest survival for local populations of the age up to 15 years is in Kalsnava, but for the age of 21 years the survival in Kalsnava and Liepāja is almost equal.

Survivals of individual provenances differ from the mean values of the region, but differences seldom exceed 10%. The results of survival for individual provenances in Kalsnava are presented in Table 5.

Growth. Provenance has the highest influence on height growth in every tree age and provenance group has the second highest influence (Figure 2, Table 3).

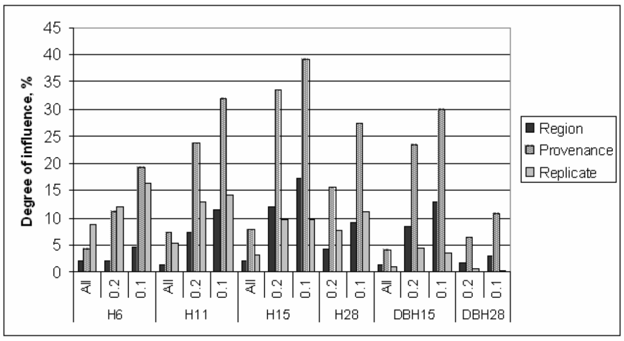

Figure 2. Degree of influence of region, provenance and replicate on height and diameter of trees
H– height, DBH – diameter at breast height, adjacent numbers indicate experiment age, when measurements have been taken (e.g. H6 – height at age 6 years). All – all trees considered, 0.1 (0.2) – sample group of 10% (20%) of the highest trees considered

In determining the average diameter for 10% of the highest trees provenance plays the major role in every tree age group. The region and the replication are of minor importance. The influence of provenance and region starts to decrease at the age of 15 years in Liepāja and Kalsnava, but in Zvirgzde it continuously decreases throughout the entire observation period.

Table 3. Results of the statistical analysis

Trait	Variation coefficient			Degree of influence (η) % and its significance									
				Test location	Liepāja			Zvirgzde			Kalsnava		
	Liepāja	Zvirgzde	Kalsnava		Reg.	Prov.	Repl.	Reg.	Prov.	Repl.	Reg.	Prov.	Repl.
H6	21	14	15	8 ***	5 ***	19 ***	16 ***	4 ***	20 ***	3 ***	5 ***	14 ***	24 ***
H10	20	15	14	7 ***	10 ***	29 ***	12 ***	10 ***	33 ***	2 *	9 ***	33 ***	3 ***
H11	20	15	14	3 ***	11 ***	32 ***	14 ***	8 ***	32 ***	2 ***	10 ***	34 ***	3 ***
H15	15	14	15	8 ***	17 ***	39 ***	10 ***	9 ***	34 ***	2 *	12 ***	38 ***	5 ***
H21	10	10	14	33 ***	22 ***	47 ***	4 ***	12 ***	32 ***	6 ***	15 ***	43 ***	7 ***
H28	10	10	12	25 ***	9 ***	27 ***	11 ***	4 ***	21 ***	10 ***	9 ***	30 ***	12 ***
DBH10	33	26	23	7 ***	6 ***	22 ***	11 ***	8 ***	26 ***	2 ***	4 ***	20 ***	3 ***
DBH11	29	23	22	3 ***	10 ***	27 ***	12 ***	8 ***	24 ***	2 *	5 ***	22 ***	2 ***
DBH15	23	20	21	15 ***	13 ***	30 ***	3 ***	5 ***	20 ***	1 *	5 ***	22 ***	5 ***
DBH21	21	19	21	30 ***	8 ***	22 ***	2 ***	5 ***	17 ***	2 *	7 ***	21 ***	4 ***
DBH28	21	20	20	16 ***	3 ***	11 ***	0	2 ***	14 ***	1 *	3 ***	15 ***	7 ***
Stem 28	43	45	46	1 ***	11 ***	18 ***	2 *	10 ***	16 ***	4 ***	12 ***	20 ***	2 *
Branch 28	26	30	27	0 *	2 ***	8 *	2 *	2 ***	13 ***	0	3 ***	11 ***	2 *

Trait: H – height, DBH – diameter at breast height, Stem – stem straightness, Branch – branchiness. Adjacent numbers indicate experiment age, when measurements have been taken (e.g. H6 – height in age 6 years). Significance level of calculations: * - α=0.05, ** - α=0.01, *** - α=0.001

In each test location the influence of provenance increases up to the age of 21 years, then decreases slightly. The same trend is observed for the influence of the region. Replications are quite important in the juvenile growth (up to the age below10 years) and again at the age close to 28 years, when these influences can be equally important or even slightly exceed the influence of the region.

The variation coefficient for stem straightness is twice as high as for the diameter. The relation between branchiness and height variation coefficients is the same (Table 3). The stem quality as an integrated volume from branchiness and stem straightness are most strongly influenced by the provenance, to a lesser extent by the region and negligibly (not exceeding 4%) – by the replication.

The test location has an increasing influence with the older trials reaching maximum values at the age of 21 year, – 33 for the height, and 30 for the diameter. The planting sites influence the stem quality negligibly – less than by 1% (Table 3).

The next step is to understand, whether all the foreign proveniences grow equally well in all the test locations. As revealed by the correlation analysis, the height for a particular provenance at the same age correlated strongly and was significant between Liepāja and Zvirgzde (Figure 3). The weakest correlation on average is between the tree height in Kalsnava and Liepāja.

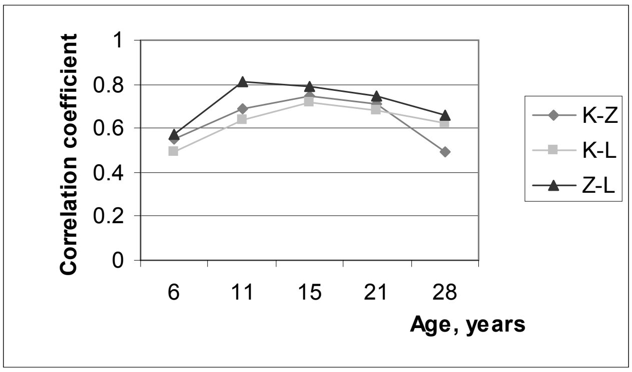

Figure 3. Correlation between tree height in different test locations; K-Kalsnava, Z- Zvirgzde, L- Liepāja, K-Z –correlation between tree height in Kalsnava and Zvirgzde

In order to evaluate the time, when the correct assessment of the results of the experiment can be stated we calculate the correlations between the height at provenance level at the age of 28 years and other ages. There were almost no differences between the average correlation value for the height between the ages of 28 and 21 year as well as between 28 and 15 years. In two cases (Kalsnava and Zvirgzde) the correlation 28-15 was even stronger (Table 4). That is in agreement with the average tree height for the provenances from different regions – the trend is the same as for the age group of 15 and 28 years. A sharp decrease (more than 10 %) in correlation tightness was observed between the correlations 28-11 and 28-6.

Correlation tightness for d.b.h. for 10% of the highest trees at the age of 28 years and other ages increased, as older the measurement was (Table 4).

In general, the correlation was the strongest between the average height for 10% of the highest trees in the same test location between two nearest measurements in time (e.g. Kalsnava at the age of 15 and 11 years r=0.98) (data not shown). The average index for these correlations was 0.91 and highly significant (α=0.001). The correlations in this line were weakest between the heights at 6 and 11 years, in all other cases exceeding r=0.90.

Table 4. Correlation between height and diameter at age 28 years and other ages in different test locations

Trait	Test location	Age, years			
		6	11	15	21
Height at age 28 years	Kalsnava	0.77	0.89	0.93	0.91
	Zvirgzde	0.56	0.80	0.82	0.81
	Liep•ja	0.77	0.88	0.90	0.93
DBH at age 28 years	Kalsnava		0.77	0.87	0.91
	Zvirgzde		0.57	0.63	0.8
	Liep•ja		0.74	0.79	0.84

Correlations calculated at provenance level
All correlations are significant at confidence level α=0.001

The provenances at each measured age are ranked according to the average height of 10% of the highest trees from 1 (highest) to 58 (lowest) (Table 5). The correlations for the ranking demonstrate the same trends as described above. The pattern for regional differences demonstrates quite the same as for the age starting from 15 years. But the variations in ranking for individual provenances can be considerable (e.g. provenance Niesky in Liepāja at the age of 15 years is ranked 26, but at the age of 28 years – 3).

The correlation between the height rank and the yield (m^3/ha) at the age of 28 years is high (Liepāja r=-0.73; Zvirgzde r=-0.81 and Kalsnava r=-0.85) and significant (α=0.001). For Liepāja and Zvirgzde, better correlation can be obtained between the average height rank and the yield at the age of 28 years (r=-0.77 and r=-0.86 respectively).

The Eastern Germany provenances show higher yield in Liepāja (+17% compared to the average of Latvian provenances), lower - in Zvirgzde (+3%) and Kalsnava (-19%) For survival the trend is the same. The stems of the Eastern Germany provenances show considerably higher crookedness (31-41%) than the Latvian provenances and also the branchiness is more considerable (7-9%). The Polish provenances show a higher yield in Liepāja (+19%) and also in Zvirgzde (+23%) (regardless of slightly lower survival), while in Kalsnava the yield (+4%) is approximately the same as for the indigenous provenances. For Polish provenances the stem straightness (12-25%) is worse than for the Latvian ones, but better than for the Eastern German provenances. The branchiness (6-15%) is even poorer than for the Eastern German provenances.

Table 5. Main growth, survival and quality parameters for Scots pine provenances in Kalsnava.
Height rank is given for all provenances (including Latvian), but data on Latvian pine growth are not shown. Rank 1 – highest provenance, rank 58 – lowest; x – average; S% – difference (%) from the average result of Latvian provenances, Survival – % from initially planted trees

Origin region	Nr.	Provenance	Height rank in 6 years	11	15	21	28	Survival in age 21 year, %	Yield, m³/ha $\bar{x}$	Yield S %	Stem straightness $\bar{x}$	Stem straightness S %	Branchiness $\bar{x}$	Branchiness S %
Russia	125	Ангасяк-2	57	58	58	58	58	6	9	-89	1.5	9	1.6	-14
	126	Мелекесс	55	55	56	55	54	9	17	-79	1.8	31	1.8	-5
	127	Ангасяк-1	56	57	57	56	57	6	13	-84	1.4	2	1.6	-16
	$\bar{x}$							**7**	**13**	**-84**	**1.6**	**15**	**1.7**	**-11**
Ukraine	128	Киев	58	56	55	57	56	**5**	**20**	**-75**	**2.0**	**46**	**2.0**	**5**
Belorus	129	Борисов	5	3	6	10	10	**49**	**101**	**24**	**1.5**	**8**	**2.0**	**5**
Poland	130	Rychtal	12	28	38	39	45	23	66	-20	2.2	59	2.3	22
	131	Pokoj	46	48	50	52	49	21	55	-33	1.9	41	2.2	15
	132	Plaska	27	24	26	32	14	41	104	27	1.5	11	2.1	8
	133	Rospuda	31	41	31	25	8	30	91	11	1.4	1	2.0	7
	134	Rytel	3	2	1	6	1	50	112	37	1.6	15	2.4	25
	135	Supras'l	7	18	17	17	12	33	82	0	1.7	22	2.1	11
	136	Taborz	13	10	4	1	2	47	99	21	1.9	35	1.8	-4
	137	Tarda	4	15	14	14	15	35	85	4	1.7	21	2.2	15
	$\bar{x}$							**35**	**87**	**6**	**1.7**	**24**	**2.1**	**12**
Eastern Germany	138	Neusterliz	42	40	43	24	40	31	62	-24	2.1	53	2.0	5
	139	Dippoldiswalde	19	50	52	53	55	20	30	-63	1.4	-2	1.5	-20
	140	Hagenow	47	34	33	29	31	32	86	5	2.0	46	2.2	17
	141	Konigstein	29	31	37	38	37	30	63	-23	1.8	33	1.7	-11
	142	Rathenow	33	53	53	50	51	23	48	-41	2.0	46	1.8	-7
	143	Bad Berka	44	44	44	19	24	29	59	-28	2.0	46	2.1	9
	144	Mirow	35	29	28	15	16	36	93	14	2.0	42	2.2	15
	145	Oranienburg	36	33	30	22	18	28	81	-1	2.1	56	2.1	10
	146	Eibenstock	18	37	36	28	47	46	63	-24	1.8	29	1.8	-8
	147	Neubrandenburg	9	1	7	4	5	36	106	30	1.9	35	2.2	16
	148	Lobau	22	22	22	16	27	33	72	-11	1.9	36	1.9	1
	149	Nedlitz	53	51	48	51	46	24	64	-22	1.9	35	2.1	12
	150	Niesky	26	36	34	49	22	25	60	-27	2.0	43	2.0	7
	151	Rostock	30	19	21	33	28	39	89	9	1.7	25	2.2	17
	152	Schleitz	48	46	47	47	50	26	53	-35	2.0	46	1.9	0
	153	Perleberg	50	45	46	48	48	19	44	-47	1.9	35	2.1	11
	154	Neuhaus	49	47	45	44	43	24	70	-15	2.0	44	2.2	14
	155	Gransee	45	43	40	36	26	27	65	-21	2.1	51	2.2	13
	156	Kyritz	21	21	20	30	25	31	78	-5	2.0	44	2.2	16
	157	Tharandt	52	49	49	46	44	31	59	-28	2.0	46	2.0	5
	158	Colbitz	43	42	42	41	39	22	69	-16	2.2	57	2.0	4
	159	Gustrow	34	14	12	8	20	40	86	6	1.8	28	1.9	-2
	160	Oelsnitz	16	16	25	20	35	33	68	-17	1.9	38	2.0	5
	161	Potsdam	40	17	23	23	42	31	68	-17	1.9	42	2.1	12
	162	Peitz	54	54	54	54	53	19	42	–-48	2.1	49	2.2	15
	164	Jena	15	5	9	11	23	38	77	-6	1.9	40	2.1	8
	165	Kolpin	51	52	51	43	52	16	40	-51	2.3	70	2.1	8
	$\bar{x}$							**29**	**67**	**-19**	**1.9**	**41**	**2.0**	**7**

Discussion

Survival. Good survival of seedlings in the local conditions is the first prerequisite to recommend their use in forest regeneration.

Oleksyn et al. (2000) as a result of experimenting with geographically diverse Scots pines concluded, that most of the difference in standing volume was because of differences in survival (number of standing trees per ha) rather than the average volume of individual trees within the provenance. Introduced provenances often show lower resistance to the local pests and diseases. Stephan (1991) concluded that transfer of populations from south to north increased susceptibility to the needle cast. It has been true also in the Latvian trial – the foreign provenances suffer from the needle cast (Бауманис *et al.* 1989). In analyzing native populations in juvenile age (3-5 years) Birģelis (1983) concluded, that the meteorological factors could have a dominant role of growth determination. It can be true also for early survival. In Kalsnava the climate is far more continental – e.g. the period without frost in Kalsnava is 120 days per year, but in Liepāja – 150 days (Fomina *et al*. 1992). Also the Latvian populations from western ad central part of the country where the climate is more maritime and milder – (Liepāja and Zvirgzde) are not recommended for use in forest regeneration in the eastern part of Latvia because of poorer growth and survival (Baumanis *et al.* 2001).

Decrease in the number of trees at later development stages (after 6 years) can be related mostly to tree competition for light and nutrient resources. That explains also a sharper decrease in survival for the Latvian provenances caused by higher initial competition for survival among trees starting earlier and being more intense.

Growth. Influence of replications on juvenile growth can be explained by slight differences in soil preparation, since stumps had to be removed. These differences are partly related to the intensity of pine weevil attacks (Baumanis *et al*. 1986). Besides, browsing damages occur unevenly all over the area (unpublished data).

Region characterizes the conditions for particular provenance growth. These conditions are partly due to genetic adaptation in the evolution process (Eriksson 1998) and serve as the basis for regular growth and quality pattern for pines from one region (Oleksyn *et al.* 2000, Shutyaev and Giertych 2000).

In the analysis provenance origin regions are defined correspondingly to country borders. Poland and Germany exceed Latvia more than twice by latitude. It means, that also heterogeneity of growth conditions will be higher and a comparison between the regions in the analysis less reliable. However, in most of the international province trials one or few provenances usually represent the country. By choosing regions in the same way we reveal what consequences this method has.

Our results demonstrate that the provenance influence on the height and diameter growth is even three times as high as the region influence.

Stem straightness at the age of 28 years is accordingly more influenced by the provenance, than the region, but the difference in these influences is not so high (no higher than twice). Besides, a negligible influence of the replication can indicate that stem straightness is strongly determined genetically. It is in agreement with the previous studies (e.g. Prescher and Ståhl 1985, Giertych 1991a). The same pattern of influences has been observed for branchiness. All evaluated influences were lower than those for stem straightness. It can be determined by the influence of different spacing (because of different early survival). It is also in agreement with the results of the geographical provenance trials in Germany, where significant differences have been found for branchiness of different provenances as well as for branchiness for the same provenance in different spacing patterns. Also the dependence between the provenance and spacing in relation to branch diameter was significant (Kohlstock and Schneck 1998). Significant population differences for most of the quality traits have been found also in Sweden (Eriksson *et al.* 1987).

According to our results we argue, that country or region with similar size cannot be objectively represented with only one or few provenances.

Test location at the age of 21 and 28 years has almost the same influence on the height and diameter growth as the provenance. It means, that the performance of introduced Scots pine provenances will be different in different places of Latvia. General conclusion: the results of geographical trial for Scots pine are site-dependent. The above-mentioned differences in survival for provenance groups in test locations also support this conclusion. The correlation analyses for height growth reveal similarities between Liepāja and Zvirgzde (on average r=0.71, α=0.001) and lower between the above-mentioned locations and Kalsnava (average r=0.63), where the climatic conditions are harsher.

It agrees with the suggestions of Pedersen (1998) from provenance trials in Denmark, but disagrees with the idea about "general trends" (Giertych 1991b, Aitken 2004), suggesting the same performance of a particular provenance over all the territory of such a globally small area as Latvia. The weakest point for our conclusion is the heavy incidence of root rot around the age of 21 years (when the peak of the influence of the test location observed). This disease was most harmful in Zvirgzde, less in Kalsnava and almost absent in Liepāja (data not published). It can lead to an overestimation of the importance of test location.

The results of correlation analysis suggested that the conclusions about the average performance of provenance group from one region could be drawn already at the age of 15 years. But the growth performance of a particular provenance varies considerably up to the age of 28 years and recommendations of their use cannot be made before that age. The exception is 10-12 inferior provenances and 5-7 best ones that can be recommended already at the age of 15 years.

The general results of the growth, quality and survival for Russian and Belarus provenances are in agreement with the trends suggested by Shutyaev and Giertych (2000). According to these conclusion as well as the results of geographical Scots pine provenance trial in Lithuania (Abraitis and Eriksson 1996) the provenance from Ukraine (Kiev) should not show so inferior growth performance. But it can be explained by the fact already mentioned, that a single provenance cannot represent the whole region.

The average performance for the growth and quality of the Eastern German and Polish Scots pine provenances in Liepāja and Zvirgzde is in agreement with the trend observed in previous provenance studies in Europe (review by Giertych 1991b, Matras 1998). Performance in Kalsnava is quite different.

For example – German provenances are reported as superior in growth up to 60^0N latitude and are found to be superior in Liepāja and Zvirgzde. At the same time only one from tested Eastern German provenances is among the 15 best in height growth in Kalsnava (Table 5). Also survival for these provenances is considerably reduced as compared to Liepāja (Table 2).

We suggest, that it can indicate a borderline for growth patterns (transferring effects) of geographical provenances.

Conclusions

1. Survival trend for provenances tends to stabilize already at age 6 years, in contrary to growth trend that is variable in the whole period of the experiment. It underlines once more the necessity for a considerable time span until the results in geographical provenance experiments can be obtained.

2. Provenance influence on the height growth is even three times as high as the region influence, to the diameter growth - twice as high as region influence. It means, that observed trend in international provenance trials will be notably influenced by choosing of provenance that represents a particular country or region.

3. Provenances from one region in 3 different test locations in Latvia demonstrate differences in survival at the same age up to 16% and in yield more than twice. The results of Scots pine trials (even in regions with moderate climate gradient) are site-dependent and test location will have notable influence on observed growth trends.

4. Average growth performance of Eastern German and Polish Scots pine provenances in Liepāja and

Zvirgzde is in agreement with the trends deduced in the previous provenance studies in Europe. Performance in Kalsnava differs considerably and can indicate a borderline for growth patterns of geographical provenances.

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ХОД РОСТА ГЕОГРАФИчЕСКИХ ПРОВЕНЕНЦИЙ СОСНЫ ОБЫКНОВЕННОЙ В ЛАТВИИ

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Резюме

Проведена оценка хода роста 40 сосновых провененций в трех географических регионах Латвии. Анализированы только самые высокие по росту деревья (10%). Определено, что наиболее достоверное сравнение показателей сохранности провениенции с разных регионов происхождения возможно в 6-ти летнем, а показателей роста – в 15-ти летнем возрасте, хотя показатели индивидуального роста каждой провененции имеют различия даже до 28-летнего возраста. Особое значение имеет влияние конкретной провененции на величину прироста в высоту и толщину деревьев – оно в два раза по высоте и в три – по толщине – превышает влияние региона происхождения данной провененции. Определены существенные различия по росту и диаметру деревьев между опытными объектами, заложенными в разных климатических зонах Латвии.

Наилучшие показатели по росту и сохранности проявили провененции сосны обыкновенной восточногерманского и польского происхождений в регионе с наиболее мягким (приморским) климатом в Лиепае, а самые низкие – в местах произрастания в континентальном климате.

Ключевые слова: сосна обыкновенная, географическая провененция, высота, диаметр, сохранность, ход роста.