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Jan Matras

Genetic value of the Silesian Beskid populations of Norway spruce *Picea abies* (L.) Karst. in the IUFRO 1972 provenance experiment

Abstract: The paper presents the results of research concerning the genetic variation in the growth traits and phenotypic plasticity of Norway spruce populations from the Silesian Beskid Mts and compares them with those of twenty Polish spruce provenances planted on thirty plots established in Europe and Canada in the IUFRO 1972 provenance experiment. The Silesian Beskid spruce is represented by six populations from the Wisła and Ujsoły Forest Districts. The variation in the growth traits of all populations discussed (data from all plots) is 6.009 standard deviation units. At population level this variation is also comparatively high and ranges between 4.674 for the Kartuzy spruce and 2.1920 for the Rycerka Zwardoń spruce. The Silesian Beskid spruce populations are not homogeneous but they belong to the populations with a high or moderate growth rate. The Istebna Bukowiec spruce performed the best on most plots. Only on Finnish and Canadian plots the growth traits of this population were below the average.

Additional key words: breeding, provenances, plasticity

Address: J. Matras, Forest Research Institute, Department of Forest Genetics and Tree Physiology, Bitwy Warszawskiej 1920 r. No 3, 00-973 Warsaw, Poland, e-mail: matrasj@ibles.waw.pl

Introduction

Studies concerning the variation in the growth and qualitative characteristics of Norway spruce *Picea abies* (L.) Karst. populations have been conducted by the Department of Forest Genetics and Tree Physiology (before 1994, the Department of Seed and Selection) of the Forest Research Institute, Warsaw, since the 1950s. Initially, the Department has carried out research entrusted by the US Forestry Department on the quality and productivity of Polish spruce populations in mature stands. The research has been continued on six Silesian Beskid spruce populations: Wisła Malinka, Istebna Bukowiec, Istebna Zapowiedź, Rycerka Zwardoń, Rycerka Praszywka 700 m and Rycerka Praszywka 950 m. The results have demonstrated that the Silesian Beskid populations exhibit certain specific morphological (i.e. crown structure, branching), incremental and technical wood characteristics (Tyszkiewicz 1968a, b).

The permanent experimental plots with spruce set up within the framework of this research have been used to collect seeds to establish parallel plots in an experiment on the variation in Norway spruce populations.

One of the main objectives of this research was to investigate the genetic variation in Polish spruce populations (including spruce from the Silesian Beskid Mts) and to determine the phenotypic plasticity of these populations, that means their adaptability to growing under different environmental conditions. Such information can be obtained from the provenance plots on which the growth of various populations in similar conditions and the same populations in different conditions are investigated.

Material and methods

The location of the plots from which seeds for the experiment were collected in 1965/1966 and 1971/1972 is shown in Figure 1. A total of 95.6 kg of seeds were collected from twenty permanent study plots. Detailed data about seed collection, sowing efficiency and multiannual seedling preparation for the establishment of plots have been provided in an earlier report (Kocięcki 1980a).

In 1972, twenty one foreign research institutes from twenty countries and four Polish universities and institutes were invited by the Department to participate in the provenance experiment with Norway spruce. Eighteen institutions from thirteen countries and four Polish institutions accepted the proposal. The list of participants and the specification of populations to be used in the experiment have been provided in another publication (Kocięcki 1980a).

The experiment was approved by the International Union of Forest Research Organisations and considered as the IUFRO 1972 provenance experiment.

Within the framework of the IUFRO 1972 trial in Poland five experimental plots with spruce were established. Two plots were established by the Department of Forest Genetics in Knyszyn and Istebna (the Istebna plot was destroyed in 1981 by the fire), two plots in the nearby locations by the Warsaw Agricultural University, one by the Department of Silviculture, Agricultural University of Poznań, and one by the Institute of Dendrology of the Polish Academy of Sciences in Kórnik.

Additional information about some plots established in the country and abroad can be found in the publications describing research results received from these plots (Kocięcki 1980a; Kocięcki et al. 1990; Matras 1993, 1996, 1997, 1998, 2001; Matras et al. 1996; Matras and Janson 1998; Matras and Kowalczyk 1998; Rau et al. 1998; König 2002).

According to preliminary agreements, the seeds of twenty spruce populations were sent to twenty one research centres in Europe and Canada. The Forest Research Institute as an initiator of the experiment was in contact with the institutions which had declared willingness to participate in the experiment and set up their experimental plots; the Institute also collected data about the established plots. Altogether, forty-three experimental plots were established representing by three to twenty Polish spruce populations. Information about the plots has been provided in earlier publications (Kocięcki 1980a; Kocięcki et al. 1990; Matras et al. 1996).

The measurements of sapling growth were conducted periodically on the experimental plots established. In the initial period (up to 10 years), the measurements included height, then (at the age 10–25) diameter at breast height (d.b.h.), and finally the diameters of all the trees and the cross-sections of model trees, on the basis of which the volume per plot or per hectare was assessed. The Forest Research Institute collected every information about the plots and created a database for the growth and development of Polish spruce populations for the whole experiment.

Since the plots were set up and the measurements were conducted in various years, statistical analyses were performed and the quality of spruce populations was assessed on the basis of standardised data expressed in standard deviation units for the averages from the plots.

The data from all plots were analysed and the results were periodically published (Kocięcki 1980b; Kocięcki et al. 1990; Matras 1993, 1997) or presented at scientific conferences. Some additional measurements and observations were conducted on some plots based on individual research programmes and the results were subsequently published (Rau et al. 1998; König 2002).

An analysis of variance was applied to the results of measurements and observations to reveal differences, and the significance of the differences was verified using Tukey's test. The S-PLUS 4.0 program and available procedures were used for statistical analyses.

Results

Characteristics of the Silesian Beskid spruce populations on the plot in Knyszyn

The results of measurements and observations made after 23 years of growth of the Knyszyn populations are given in Table 1. An analysis of differences in the values of tree characteristics demonstrated that all the parameters significantly differed between the populations (Table 2).

The values of mean diameter on the Knyszyn plot ranged between 93.9 mm for the Nowe Ramuki population and 61.0 mm for the Kartuzy population, which means that the variation in this trait is rather high (37.8%). The differences found in d.b.h. were not always associated with the occurrence of a population within one or another subrange of spruce distribution. Slow- and fast-growing populations were found in both north-eastern and southern subranges. Between all spruce populations from the Silesian Beskid Mts, those with large and medium diameters came from Istebna Zapowiedź (89.4 mm), Zwierzyniec Lubelski (85.0 mm) and Rycerka Praszywka 950 m (80.6 mm) (Table 2).

The ranking of provenances according to cross-section area was somewhat different. The first six positions in the ranking were occupied by the Beskid and Tarnawa populations, while the best population from the northeastern natural range (Zwierzyniec Krzyże) took seventh place.

Table 1. IUFRO 1972 experiment with Norway spruce in Knyszyn; mean d.b.h. (mm), cross-section area at b.h. (m^2), volume of individual tree (m^3) and volume of production ($m3 \cdot ha^{-1}$) after 23 years of experiment

Provenance		Characteristic			
		d.b.h. (mm)	cross section area (m^2)	volume of single tree (m^3)	volume (m^3 ha^{-1})
1.	Zwierzyniec Pogorzelec	89.6	0.46	0.0554	76.4
2.	Zwierzyniec Krzyże	90.6	0.66	0.0597	117.6
3.	Wigry	64.2	0.45	0.0397	81.5
4.	Przerwanki	81.5	0.59	0.0470	98.5
5.	Borki	78.6	0.63	0.0425	106.1
6.	Nowe Ramuki	93.9	0.50	0.0632	88.5
8.	Międzygórze	76.7	0.63	0.0455	105.9
9.	Stronie Śląskie	73.9	0.58	0.0356	89.2
10.	Wisła	79.1	0.68	0.0441	107.7
11.	Istebna Bukowiec	81.6	0.70	0.0540	125.4
12.	Istebna Zapowiedź	89.4	0.70	0.0564	113.0
13.	Rycerka Zwardoń	73.4	0.69	0.0378	109.4
14.	Rycerka Praszywka 700 m	81.0	0.66	0.0440	104.9
15.	Rycerka Praszywka 950 m	80.6	0.59	0.0479	99.3
16.	Orawa	71.0	0.63	0.0317	90.8
17.	Witów	63.9	0.28	0.0220	33.0
18.	Tarnawa	78.9	0.64	0.0423	104.8
19.	Zwierzyniec Lubelski	85.0	0.66	0.0480	109.7
20.	Bliżyn	83.1	0.63	0.0494	105.5
21.	Kartuzy	61.0	0.34	0.0211	41.9
	Ppd	71.3	0.46	0.0338	73.7
	Ppn	80.5	0.64	0.0475	107.3

Ppd – late-flushing progenies from Wisła, Istebna and Rycerka, Ppn – late-flushing progenies from northeastern subrange

Due to the weak relationship between diameter and cross-section area also the relationship between the volume of an average tree and the volume calculated per plot and per hectare was week. The variation in the average volume of an individual tree was high and amounted to 0.0474 m^3 (70.2%) (Nowe Ramuki – 0.0632 m^3, Witów – 0.022 m^3). The variation in volume among the populations could be compared to that of average diameter: the populations from the northeastern natural range occupied first four positions in the ranking, followed by the southern populations from Istebna Zapowiedź, Istebna Bukowiec, Zwierzyniec Lubelski and Rycerka Praszywka 950 m.

The greatest differences between the provenances at the age of 23 on the Knyszyn plot were found in productivity (volume per plot and volume per hectare). The maximum variation in productivity as calculated per plot was 4.3303 m^3, i.e. 73.7% (Witów – 1.5490 m^3, Istebna Bukowiec – 5.8793 m^3). The Silesian Beskid populations (except the Istebna Bukowiec spruce) showed the highest increments (above 5 m^3) per plot, followed by spruce from Istebna Zapowiedź (5.2996 m^3), Rycerka Zwardoń (5.1303 m^3), Wisła (5.0504 m^3), Zwierzyniec Lubelski (5.1470 m^3) and only one population from the northeastern natural range, i.e. Zwierzyniec

Table 2. Analysis of variance of Norway spruce provenances in IUFRO 1972 experiment

Experimental plots	Characteristic	Degrees of freedom	Sum of squares	Mean square	F	p
Knyszyn	d.b.h.	21	5706.779	271.751	3.04727	0.00035
	height	21	86.370	4.113	3.71244	0.00003
	cross section area	21	2066834724296	98420701157	2.67837	0.00141
	volume of single tree	21	0.01013702	0.000482715	3.132812	0.00025
	volume of production	21	146.668	6.98419	2.24713	0.00729
Poland	height	19	38.0282	2.001483	2.310818	0.00242
Whole experiment	mean height, d.b.h. or volume in standard deviation units	19	162.9012	8.573746	12.62402	0.00000

Krzyże 2 (5.5161 m^3). Only one of the Silesian Beskid populations revealed moderate growth (Table 2). Greater variation in increments as well as growth dynamics among populations was observed in successive measurement periods (Matras et al. 1996). The rising tendency was observed for the Silesian Beskid spruce, while the trend was declining for spruce from the northeastern range.

Growth of the Silesian Beskid spruce on the remaining plots in Poland

The growth of spruce on the experimental plots in Poland was distinctly modified by the environmental conditions existing on these plots (Table 3).

The location of the experimental plot affected the growth of populations, which manifested itself in the position they occupied in the ranking of populations according to the analysed characteristics on individual plots (Fig. 2, Table 3). Environmental impact was also seen in the plasticity of populations, which was reflected in the differences between the ranks of the populations achieved on different plots (Table 3). Such a comparison was very useful in order to rank the populations within statistically homogeneous groups.

The mean ranks, which reflected the growth dynamics of populations on all the plots, markedly differed between populations, allowing their classification into distinct groups. The first group with the populations of highest increments, i.e. Istebna Bukowiec (2.75 – mean rank on 4 plots), Wisła (4.00), Zwierzyniec Lubelski (5.50) and Istebna Zapowiedź (6.00), comprised three populations from the Silesian Beskid.

The remaining populations from the Silesian Beskid Mts, i.e. Rycerka Zwardoń (7.50) and Rycerka Praszywka 700 m (8.25), belonged to the well-growing group, and only one Silesian Beskid population, Rycerka Praszywka 950 m (14.25), was in the group with moderate or poor increments. The Witów population, definitely differing from all the populations in the experiment, occupied the last position on all plots (Table 3).

The differences in phenotypic plasticity between populations were defined as the maximum dispersion in the ranks of populations on four experimental plots. For the 20 populations analysed, the maximum differences in plasticity were very high (16 positions in the ranking), however, most of the Silesian Beskid populations showed fairly low to medium values of dispersion, which means that they are relatively plastic. The dispersion in their ranks was as follows: Istebna Bukowiec and Rycerka Praszywka 950 m – 5, Rycerka Zwardoń and Wisła – 7, and Rycerka Praszywka 700 m – 9 (Table 3).

The above simplified classification of plasticity clearly indicates the lack of relationships, or even a negative relationship, between the adaptability and growth of the populations in question. The only exception is the Istebna Bukowiec spruce which belongs

Table 3. IUFRO 1972 experiment with Norway spruce; ranking of populations on experimental plots in Poland

Provenance		Experimental plot				Mean	Dispersion
		Knyszyn	Siemianice	Kórnik	Głuchów		
1.	Zwierzyniec Pogorzelec	18	4	19	16	14.25	15
2.	Zwierzyniec Krzyże	2	14	18	2	9.00	16
3.	Wigry	17	16	5	–	12.67	12
4.	Przerwanki	13	11	13	–	12.33	2
5.	Borki	7	17	11	13	12.00	10
6.	Nowe Ramuki	16	19	16	4	13.75	15
8.	Międzygórze	8	7	8	9	8.00	2
9.	Stronie Śląskie	15	3	9	14	10.25	12
10.	Wisła	6	8	1	1	4.00	7
11.	Istebna Bukowiec	1	1	6	3	2.75	5
12.	Istebna Zapowiedź	3	2	4	15	6.00	13
13.	Rycerka Zwardoń	5	6	12	7	7.50	7
14.	Rycerka Praszywka 700 m	10	12	3	8	8.25	9
15.	Rycerka Praszywka 950 m	12	13	15	17	14.25	5
16.	Orawa	14	5	10	12	10.25	9
17.	Witów	20	20	20	–	20.00	0
18.	Tarnawa	11	18	14	10	13.25	8
19.	Zwierzyniec Lubelski	4	10	2	6	5.50	8
20.	Bliżyn	9	9	17	11	11.50	8
21.	Kartuzy	19	15	7	5	11.50	14

Fig. 1. Location of Norway Spruce populations i IUFRO 1972 experiment

to the group of populations exhibiting superior growth and phenotypic plasticity.

Growth of spruce on foreign plots

The results of measurements of the growth parameters of populations growing on foreign plots established within the framework of the IUFRO 1972 provenance experiment were expressed in standardised units (Table 4).

At experiment level, the differences in the growth parameters between populations were great (6.0991 standard deviation units) and ranged between +2.6762 and –3.4229, while for some spruce populations, namely those from Kartuzy, the differences were from +1.9181 to –2.756, and for spruce from Rycerka Zwardoń – from +1.437 to –0.755. Only spruces representing the Witów population showed negative values.

Based on the declining mean values of the analysed parameters (expressed in standard deviation units) on all plots in Poland (Table 4, Fig. 3) it was possible to divide the populations into several distinct groups. Assuming the 0.5 range of standard deviation, the groups can be characterised in the following way:

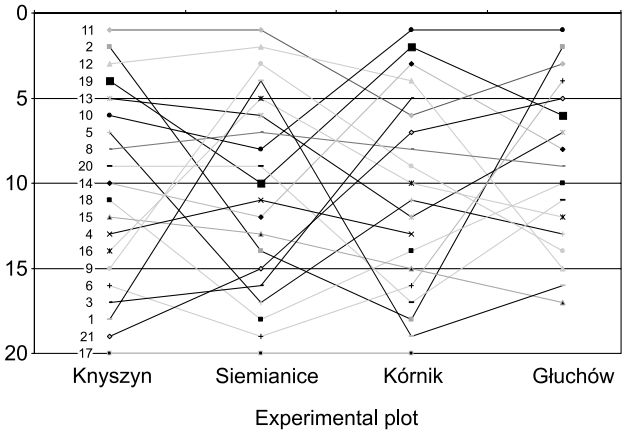

Fig. 2. IUFRO 1972 experiment with spruce; differences in ranking of provenances on Polish experimental plots

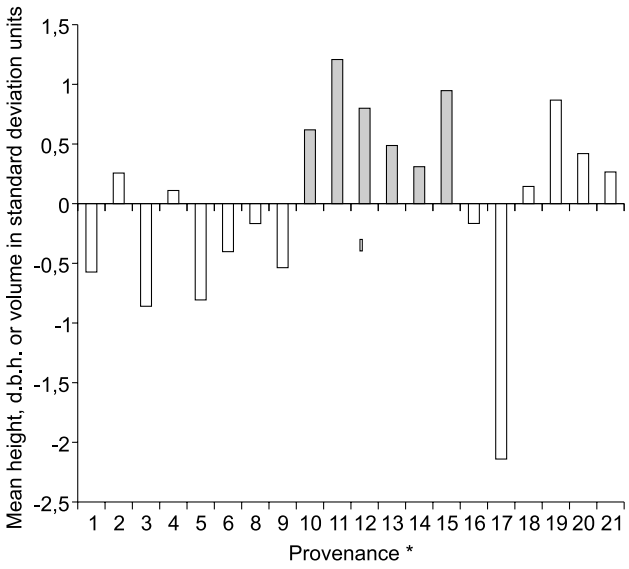

Fig. 3. IUFRO 1972 experiment with spruce; mean for Polish plots

* 1–21 see Figure 1

I. above 1.0 standard deviation units – the group represented by spruces from two Silesian Beskid populations – Wisła and Istebna Bukowiec,
II. 0.5 to 1.0 standard deviation units – the group represented by spruces from the Zwierzyniec Lubelski population and one Silesian Beskid population from Istebna Zapowiedź,
III. 0.5 to 0.0 standard deviation units – the group represented, i.e., by Rycerka Zwardoń and Rycerka Praszywka 700 m,
IV. –1.0 to –0.5 standard deviation units – the group including, i.e., the Rycerka Praszywka 950 m population, the only Silesian Beskid population with poor increments.

The spruce populations on the Slovak plots differed in growth from the populations on the plots in Poland (Fig. 4). The Silesian Beskid populations were clearly superior and were in the following order: Istebna Bukowiec, Rycerka Praszywka 700 m, Rycerka Zwardoń, Istebna Zapowiedź, Wisła, Rycerka Praszywka 950 m. These were followed by Orawa, Zwierzyniec Lubelski, Bliżyn and Kartuzy, and the northern populations occupied the last, poorest position.

On the German plots (Fig. 5) the differences among spruce populations were distinctly smaller despite the rather high number of plots (10). All the Silesian Beskid populations on these plots showed the values above the general average. Except the Istebna Bukowiec population, which exhibited notably better growth, the increments of the remaining Silesian Beskid populations were poor and comparable with the increments of spruce populations from Zwierzyniec Lubelski, Kartuzy and Zwierzyniec Białowieski, or were even poorer.

Table 4. Growth of Norway spruce provenances in IUFRO 1972 experiment; mean height, d.b.h. or volume in standard deviation units

Plots	Provenance*																			
	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Poland	–0.92	0.33	–0.12	–0.05	–0.23	–0.37	0.39	0.01	1.09	1.13	0.55	0.37	0.30	–0.60	–0.01	–2.49	–0.30	0.70	–0.01	–0.43
Slovakia	–0.09	–0.15	0.00	–0.06	–0.18	–1.14	0.54	–0.16	0.48	1.08	0.52	0.63	0.79	0.00	0.42	–2.52	–0.06	0.33	0.13	0.31
Germany	–0.11	0.24	0.02	–0.34	–0.22	–0.64	–0.09	–0.21	0.47	0.75	0.55	0.38	0.12	0.14	0.21	–1.66	0.12	0.59	–0.06	0.38
Finland	0.63	0.76	0.74	–0.52	0.26	0.67	–0.03	–0.42	0.20	–0.62	–0.47	0.09	0.45	–0.56	–0.47	–0.67	–0.01	0.25	0.20	–0.20
Belgium	–1.42	–0.31	–0.72		–0.71	–0.30	0.00	–0.05	1.27	1.06	1.76	0.55	0.42		0.18	–2.30	–0.36	–0.07		1.00
France	–0.74	–0.62	–0.79	–0.86	–1.50	–0.17	–0.03	0.12	1.93	0.54	0.54	0.23	0.55	1.16	–0.39	–2.40	–0.05	1.26	0.87	0.37
Norway	0.48	0.57	–1.06	1.08	–0.21	–0.46	–0.29	–0.98	–1.06	0.99	0.74	1.16	0.22	0.74	0.22	–2.69	–0.12	1.42	–0.03	
Croatia	–0.61	1.40				–0.68	–0.35	–1.24	0.34	2.24	0.17	0.01	0.04		–0.68	–1.17	1.10			–0.58
Mean for Europe	–0.57	0.26	–0.86	0.11	–0.81	–0.40	–0.17	–0.54	0.62	1.21	0.80	0.49	0.31	0.95	–0.17	–2.14	0.14	0.87	0.42	0.27
Canada	0.61	0.62	–1.29	0.18	0.80	0.07	–0.57	–0.58	0.00	–0.06	0.50	–0.07	0.18	–0.72	–0.31	–2.04	0.59	1.13	–0.25	–0.54
General mean	–0.08	0.35	–0.25	–0.07	–0.06	–0.30	0.01	–0.32	0.48	0.58	0.41	0.32	0.36	–0.13	–0.06	–1.92	0.08	0.65	0.07	–0.04

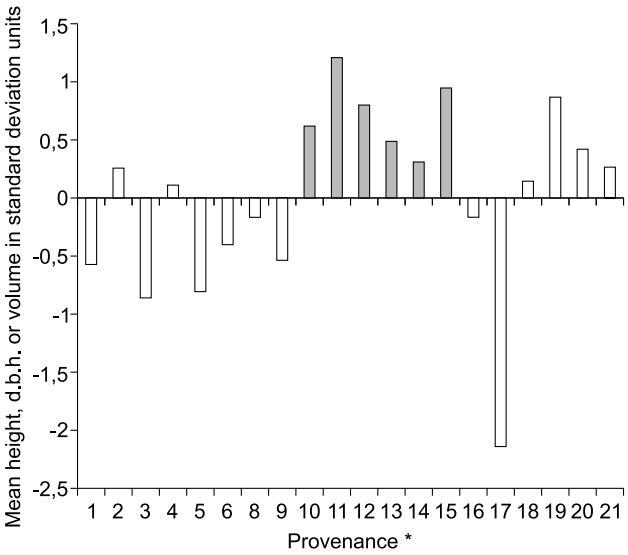

Fig. 4. IUFRO 1972 experiment with spruce; mean for Slovak plots
* 1–21 see Figure 1

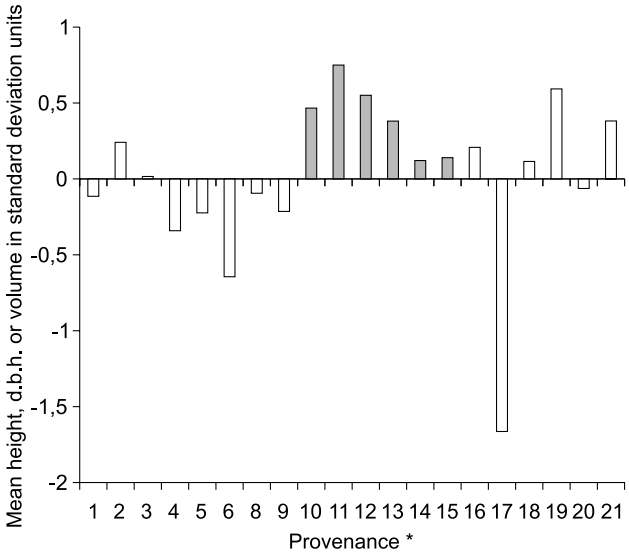

Fig. 5. IUFRO 1972 experiment with spruce; mean for German plots
* 1–21 see Figure 1

In Finland, Polish populations performed somewhat different. The best populations (group I) were from the northeastern range, except the spruce from Przerwanki which had a negative index value (group III). Of southern populations, only Wisła, Rycerka Zwardoń and Rycerka Praszywka 700 m had a positive index, close to the average (group II), while populations such as Istebna Bukowiec and Rycerka Praszywka 950 m showed poor increments (group IV) similar to that of the Witów population (Fig. 6).

In Canada the performance of lowland populations from the northern range of spruce distribution could be compared to the performance of the populations in Finland; those were included in the first or second group with the growth index always above the average. Of southern populations, only those from Zwierzyniec Lubelski and Tarnawa represented the first group while the increments of the Silesian Beskid populations remained at the average level so the populations were classified into the second or third group. The Sudeten populations and the spruces from Rycerka Praszywka 950 m and Kartuzy had very poor increments. All these populations were classified into the poorest fourth group (Fig. 7).

According to the incremental criteria for grouping based on the averages for Europe (Fig. 8) and for the

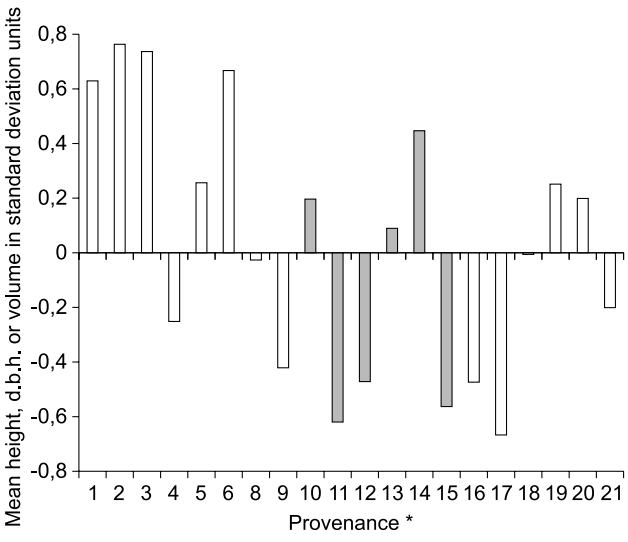

Fig. 6. IUFRO 1972 experiment with spruce; mean for Finnish plots
* 1–21 see Figure 1

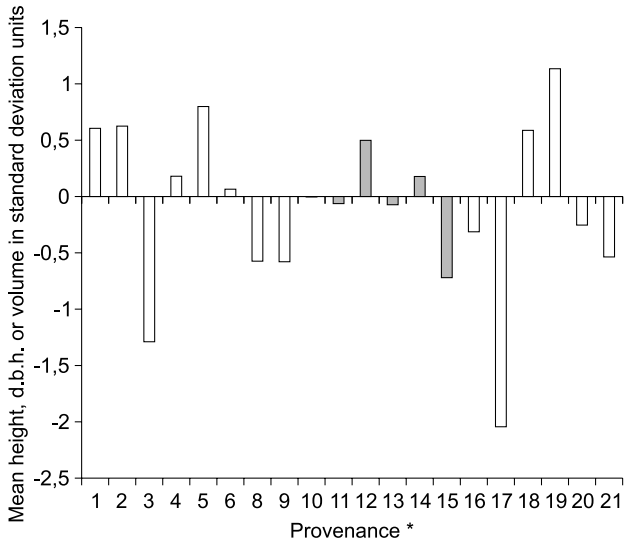

Fig. 7. IUFRO 1972 experiment with spruce; mean for Canadian plots
* 1–21 see Figure 1

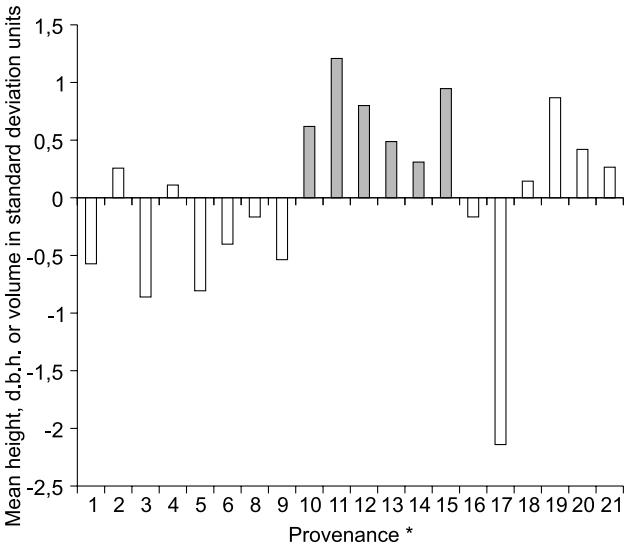

Fig. 8. IUFRO 1972 experiment with spruce; mean for European plots
* 1–21 see Figure 1

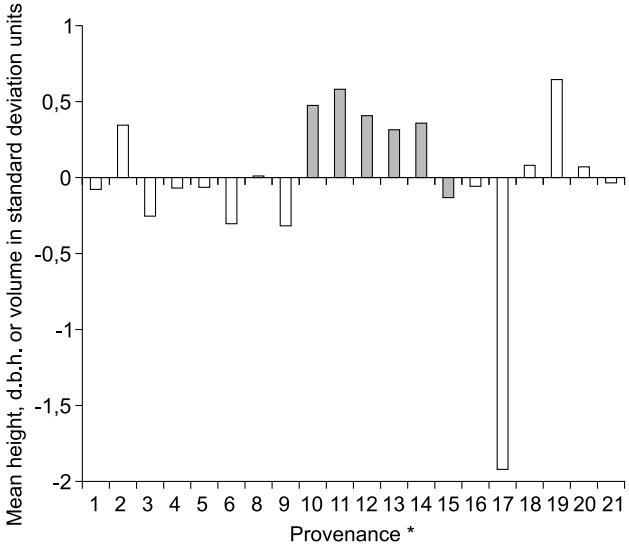

Fig. 9. IUFRO 1972 experiment with spruce; general mean
* 1–21 see Figure 1

whole experiment (Fig. 9), the following groups of populations can be distinguished:

above 1.0	–	no populations,
1.0 to 0.5	–	Istebna Bukowiec, Zwierzyniec Lubelski,
0.5 to 0.0	–	Wisła, Istebna Zapowiedź, Rycerka Praszywka 700 m, Rycerka Zwardoń, Zwierzyniec Krzyże, Tarnawa and Bliżyn,
0.5 to 0.0	–	Międzygórze, Kartuzy, Wigry, Zwierzyniec Pogorzelec, Orawa, Przerwanki, Borki, Rycerka Praszywka 950 m, Nowe Ramuki, Stronie Śląskie,
–1.0 to –0.5	–	no populations,

The variation in population plasticity for the whole experiment was estimated on the basis of the range of average values of the analysed characteristics expressed in standard deviation units (Fig. 10). The differences found among the populations were significantly greater than those for the Polish plots, but in general had a similar character (classification into the groups of similar plasticity).

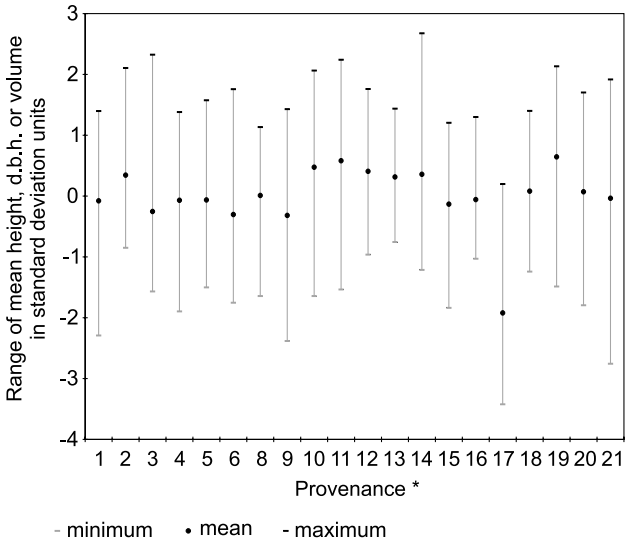

Fig. 10. IUFRO 1972 experiment with spruce: data for all plots
* 1–21 see Figure 1

Discussion

The growth of populations represented on experimental plots in the IUFRO 1972 provenance trial varied greatly. This variability in both the morphological and incremental characteristics of Polish spruce populations has been confirmed by many investigations (Holst 1963; Fober and Giertych 1971; Lines 1974; Giertych 1976, 1987a, b, 1991; Holubsik 1979; Giertych and Królikowski 1982; Barzdajn 1995, 1996a, b; Rau et al. 1998; König 2002). It is undoubtedly connected with specific conditions prevailing in Poland, the glaciation periods and migration of species from various refugia, and the related three different subranges of spruce in Poland, divided by so-called spruceless belts – Central Poland and Carpathian disjunctions (Kocięcki 1980b).

The values of growth parameters of the provenances differ between the populations, allowing their

division into a number of groups showing a particular reaction to certain environmental conditions. The groups having similar increments are comparable only in a few cases to the groups representing similar phenotypic plasticity.

The Silesian Beskid populations exhibit fast growth and relatively high phenotypic plasticity especially in the climatic conditions of West and Central Europe where they attain their maximum increments and as a rule are more productive than the indigenous populations. On the other hand, the introduction of these species into more severe Nordic conditions (Scandinavia and Canada) is unjustified, as demonstrated by the performance of spruce on the Finnish and Canadian plots where the increments of spruce populations from the northeastern subrange were clearly better. This unquestionably confirms the different provenance of spruce from the two main subranges of this species in Poland.

The mountain provenances of Norway spruce growing on the experimental plots showed poor increments in lowland conditions. It can be proved that there is an altitude – increment interaction in the populations whose increments are declining with increasing altitude. Distinct differences in growth were observed in the populations which were located at an altitude of 700–900 m. The Rycerka Praszywka 700 m population was included in the same group as the remaining Silesian Beskid populations from lower altitudes, whereas the increment of the Rycerka Praszywka 950 m population was poorer at least by one group. This suggests a poor usability of mountain populations of spruce for the cultivation of this species in lowland conditions.

Conclusions

1. The differences in growth parameters between Polish spruce populations in the IUFRO 1972 provenance experiment are very high. This variation, expressed in standard deviation units, currently amounts to 6.099.
2. The range of differences in the growth parameters of individual populations in the whole experiment reflects their capability for adaptation (plasticity). The differences in plasticity among populations are also significant.
3. The growth of spruce populations is greatly modified by environmental conditions. One cannot therefore identify any "universal population" of spruce which would be capable of adapting to the whole variety of conditions in the cultivation of this species.
4. The correlations between the increments of spruce populations and their phenotypic plasticity are usually negative so that the groups formed on the basis of single traits often encompass other provenances, and the weight which is attributed to individual characteristics can determine the general value of a given population.
5. The majority of the Silesian Beskid populations exhibit good increments especially in the environmental and climatic conditions of West and Central Europe.
6. The increment of the Silesian Beskid populations is rather poor in northern Europe and Canada due to more severe climatic conditions.
7. Spruce from Istebna Bukowiec is superior to other Silesian Beskid populations. It has a fairly high silvicultural value and a high phenotypic plasticity. In the climatic conditions of Poland this population should definitely be used more widely.
8. Among the Silesian Beskid populations, the Rycerka Praszywka 950 m spruce appears to be the least useful for the cultivation in lowland conditions.

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