individual basal area these percentages are 10.3% for trial no. 1 and 1.3% for trials nos. 2 to 10 (*Table 10*).

For trials nos. 3, 7, 8, 9 and 10 the 3 comparisons are non-significant for each of the 12 correlation coefficients r_1, r_2, ..., r_{12}. For r_4, r_6, r_{10} and r_{12} no comparison among the 3 groups is statistically significant for none of the trials nos. 2 to 10 (*Table 10*).

The large differences of percentages of significant comparisons between trial no. 1 at the one side and trials nos. 2 to 10 at the other side (9% to 4% for diameter, 10% to 1% for height and individual basal area) may be mainly due to the larger sample sizes for trial no. 1 compared to the other trials. By these larger numbers of observations (HÜHN and LANGNER, 1992) smaller differences can be considered as statistically significant.

The calculation and interpretation of the spatial neighbourhood correlation coefficients r_1, r_2, ..., r_{12} are based on several simplifying assumptions. A critical discussion of these simplifications has been given in HÜHN and LANGNER (1995) and we refer to this paper.

The preceding very general and rough comparisons and conclusions can be, of course, precised by a more sophisticated separate analysis and discussion of the individual spatial neighbourhood correlation coefficients r_1, r_2, ..., r_{12}. Such an extended analysis can be easily carried out based on the results from *tables 1* to *9*. In the context of this paper, however, such a sophisticated analysis is unnecessary: In 'Introduction and Problem' the question of this paper has been stated as: Are there significant differences among the spatial neighbourhood correlation patterns of the 3 groups of entries: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY? Based on the data sets of this study the answer is: No!

Acknowledgement

The authors gratefully acknowledge the cooperation and help provided by Mrs. H. JENSEN, Mrs. B. PALLASCH, Dr. K. ROETHER and Dr. G. RAVE.

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Results of the IUFRO 1982 Scots Pine (*Pinus sylvestris* L.) Provenance Experiment in Southwestern Germany[1])[2])

By B. R. STEPHAN and M. LIESEBACH[3])

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Summary

Seed of 24 provenances of Scots pine (*Pinus sylvestris* L.) from 13 countries within the area of natural distribution was sown in 1983. During the first 3 years in the nursery several traits were measured and assessed, e.g. height growth and the number of twigs in the uppermost whorl. In spring 1986 a field trial (3.3 ha) has been established in forest district of Bensheim, southwestern Germany. During the last years the following traits were measured and assessed: height growth after several vegetation periods, diameter at breast height, branching, stem form, damage by the beetle *Brachyderes incanus* and mortality. Regarding these characters the provenances show a considerable variation and can be divided into at least 6 main groups (clusters).

Key words: Scots pine, provenances, genetic variation, growth characters, insect damage.

FDC: 165.3; 165.5; 232.11; 232.12; 174.7 *Pinus sylvestris;* (430).

Zusammenfassung

Im Rahmen des internationalen IUFRO Herkunftsversuchs 1982 mit Kiefern (*Pinus sylvestris* L.) wurde im Jahre 1986 in Südwest-Deutschland ein Feldversuch mit 3jährigen Pflanzen von 24 Herkünften angelegt. Bis 1991 wurden wiederholt verschiedene Merkmale gemessen (Baumhöhe, Stammstärke, Aststärke) oder bonitiert (Stammform, Befall durch Graurüßler). Eine Auswertung der Daten zeigt, daß zwischen den Herkünften in allen Merkmalen eine große Variation besteht. Die Ergebnisse lassen sich für den Prüfstandort wie folgt zusammenfassen: Herkünfte mit gutem Höhen- und Dickenwachstum stammen aus Gebieten zwischen dem 47. und 55. Breitengrad. Die beste Wuchsleistung hat eine Samenplantagen-Absaat aus Belgien (Groenendaal). Wüchsig sind auch Herkünfte aus Deutschland, Ost-Frankreich, Polen und Ungarn. Allerdings lassen bei einigen dieser Herkünfte, vor allem bei denen aus Frankreich und Südwest-Deutschland, die Stammformen im Vergleich zu den anderen Herkünften zu wünschen übrig. Herkünfte aus südlicheren und nördlicheren Breitengraden sind unter den gegebenen Umweltbedingungen mattwüchsig. Dieses sind Kiefern-Herkünfte aus Schweden, Lettland, Rußland, vom Balkan und aus der Türkei. Allerdings zeichnen sie sich durch gute Stammformen aus. Negativ zu beurteilen ist ihre offenbar große Anfälligkeit für den Kiefern-Graurüßler (*Brachyderes incanus*). Ein besonders schwaches Wachstum, verbunden mit einem starken Graurüßler-Befall und einer

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[1]) Dedicated to Professor Dr. WOLFGANG LANGNER on his 90th birthday

[2]) Modified version of a paper presented on the IUFRO Symposium "Scots Pine Breeding and Genetics", Kaunas/Lithuania, September 1994

[3]) Federal Research Centre for Forestry and Forest Products, Institute for Forest Genetics, Sieker Landstrasse 2, D-22927 Grosshansdorf, Germany

Table 1. – Origin of seeds for the IUFRO 1982 Scots pine provenance experiment.

No.	Country (abbreviation)	Origin	Latitude [°N]	Longitude [°E]	Altitude [m]
1	Russia (RUS)	**Roshchinskaya Dacha**. Roshchinskij L.P.Ch. Roshchinskoe Lesnicestvo. Leningradskij L. Ch. P. O. comp. 60, 61	60°15'	29°54'	80
2	Russia (RUS)	Tichvinskij Leschoz **Kondezhkoe** Lesnicestvo Leningradskij Z. Ch. P. O.	59°58'	33°30'	70
3	Russia (RUS)	Luzskij L.P.Ch. **Serebryanskoe** Lesnicestvo. Luga	58°50'	29°07'	80
4	Latvia (LR)	Daugavpilskij L.P.Ch. Lesnicestvo **Silene** sector 655, comp. 22	55°45'	26°40'	165
5	Poland (PL)	Nadl. Milomlyn obreb **Milomlyn**. Lesnictwo Pilawki, comp. 39a, 84g, 84i	53°34'	20°00'	110
6	Poland (PL)	Nadl. Suprasl, obreb **Suprasl**, Lesnictwo Krasne, comp. 246d	53°12'	23°22'	160
7	Poland (PL)	Nadl. Spala, obreb **Spala**, Lesnictwo Malomierz, comp. 174f	51°37'	20°12'	160
8	Poland (PL)	Nadl. Sycow, obreb **Rychtal**, Lesnictwo Sadogora, comp. 183f	51°08'	17°55'	190
9	Poland (PL)	Nadl. Bolewice, obreb **Bolewice**, comp. 253a	52°24'	16°03'	90
10	Germany (D)	Staatlicher Forstwirtschaftsbetrieb Neuhaus, Oberförsterei **Neuhaus**, Revier Wolletz, comp. 18c	53°02'	13°54'	40
11	Germany (D)	Forstamt Knesebeck, Försterei **Betzhorn**, several comp.	52°30'	10°30'	65
12	Germany (D)	Forstamt Lampertheim, Försterei **Lampertheim**, comp. 25	49°30'	8°30'	97
13	Belgium (B)	Region, Sud de Sambre et Meuse **Ardennes**, Seed plantation no. 502 Ba in Groenendaal	50°46'	4°26'	110
14	France (F)	Forst de **Haguenau**. Alsace. Plain	48°49'	7°47'	157
15	Sweden (S)	**Sumpberget**. Hedemora District Owner, Stora Kopparberg Bergvik, Ludvika Forest District	60°11'	15°52'	185
16	Czech Republic (CZ)	**Zahorie**	48°46'	17°03'	160
17	Hungary (H)	**Pornoapati**. 13/A Seed stand no. 262	47°20'	16°28'	300
18	Yugoslavia (YU)	**Maocnica**. Crna Gora, Pljevlja	43°10'	19°30'	1,200
19	Bosnia and Herc. (BiH)	**Prusacka Rijeka**. Bosnia and Hercegovina, Banja Luka, Section 70	44°06'	17°21'	885
20	Turkey (TR)	Forest District Eskisehir-**Çatacik**, comp. 44	40°00'	31°10'	1,400
21	Germany (D)	Forstamt **Minden**, comp. 162a	52°20'	8°55'	98
24	Germany (D)	Forstamt **Wolfgang**, comp. 80	50°08'	9°00'	305
25	China (TJ)	Wan Shou Shan Aboretum **Peking**	46°	127°	700
26	Germany (D)	Forstamt **Gartow**, comp. 213 (standard)	53°10'	11°30'	102

auffallend gelblichen Nadelfarbe, besitzt auch die im Versuch vertretende Herkunft aus China.

Unter Berücksichtigung von 11 gemessenen oder bonitierten Merkmalen sowie den geographischen Angaben bilden die 24 Herkünfte 6 relativ einheitliche Gruppen (Cluster).

Introduction

In 1982 the Working Party "Breeding Scots Pine" of the International Union of Forest Research Organizations (IUFRO) established an international provenance experiment on Scots pine (*Pinus sylvestris* L.). Nine European countries participated. This provenance experiment was the fourth one organized by IUFRO with Scots pine since 1907 (GIERTYCH and OLEKSYN, 1992). Informations about the concept, the participating institutions and the first results were given by KOCIECKI (1985), OLEKSYN (1988) and GIERTYCH and OLEKSYN (1992). In the following paper results are presented on the behaviour of Scots pine provenances until the age of 9 years from a trial in southwestern Germany, established by the Institute for Forest Genetics, Grosshansdorf.

Material and Methods

Provenances

20 provenances of the IUFRO seed collection and additional 3 German and 1 Chinese (*P. sylvestris* var. *mongolica*) seed lots were studied. The origin of the provenances and their geographical data are given in *table 1*. The provenances originated from an area between around 40° to 60° of latitude North, 4° to 34° of longitude East with one far eastern provenance from 127°, and from 40 m to 1,400 m altitude above sea level.

Nursery stage

All seedlots were sown in May 1983 in the nursery of the Institute for Forest Genetics at Grosshansdorf (northern Germany). For practical reasons the seedlings had to be transplanted in containers (size 8 cm x 8 cm) in September 1983, and outplanted in the nursery field in May 1985.

Field trial

With 3 year old plants a field trial was established in April 1986 at the forest district of Bensheim (southwestern Germany). Geographical data: latitude 49°39' N; longitude 8°31' E; elevation 92 m to 96 m asl. Data on climate: annual average precipitation 609 mm (313 mm during the vegetation period from May to September); annual average temperature 9.5 °C (16.2 °C during the vegetation period). Soil: sand of the brown-soil-gley type.

Before planting the trial area was ploughed and treated with Gamma-Streunex against the grubs of the cockchafter (*Melolontha melolontha* L.).

The field trial was planted with 4 replications, 121 plants/plot (11 x 11) and 2 edge rows around the trial. Spacing was 1.5 m x 1.5 m with 3 m wide gaps between the replications. The total area was about 3.3 ha.

Traits measured and assessed

During the nursery stage height of seedlings at age 2 and 3 was measured, and the number of twigs/whorl was counted. Values of the 1,000-seed-weight and the germination rate were taken from KOCIECKI (1985). In the field trial the following traits were measured or assessed: mortality; height growth at age 4, 5, 6, and 9; diameter at breast height (1.3 m) at age 9 (1991); height – diameter proportion; diameter of the thickest branch of the third whorl from the top of the tree; stem form 1991; damage by the needle feeding beetle *Brachyderes incanus* L. in 1991. The traits were measured or assessed in 44 plants/plot (all plants in the 2., 3., 9., and 10. row), totally in about 176 plants/provenance.

Statistics

Analyses of variance, PEARSON's correlation coefficients, SPEARMAN's rank correlation coefficients, cluster analysis (UPGMA = unweighted pair-group method using arithmetic averages) and stepwise discrimination analysis were calculated with the SAS program package (SAS Institute Inc., 1989). Depending of the trait, mean values of the provenances or single tree values were used for the various calculations.

Results

Present situation of the field trial

There are considerable differences between the 24 provenances regarding all traits measured or assessed. The mortality of the provenances is still low. About 94% of all plants survived the first vegetation period (1986). The differences in mortality varied between 1% and 32% with a mean value of 5.5%. The highest mortality values were obtained for provenances from former Yugoslavia no. 18 (13%) and no. 19 (22%) and from Turkey no. 20 (32%).

Growth performance

Regarding mean height growth, differences between all provenances were significant in all years. At the age of 9 years (1991) average values varied between 316.8 cm (provenance no. 13, Belgium) and 159.0 cm (no. 25, China) with an overall average of 242.5 cm. The development of the provenances from age 4 to 9 is shown in *figure 1*. Several groups of provenances can clearly be distinguished: In all years the best growing population was a seed lot from a Belgian seed plantation (no. 13), followed by provenances from Poland, Germany, France and Hungary. A third group was formed by 4 provenances from Latvia, Germany and the Czech Republic. Weakly growing provenances came from Russia, Sweden, the former Yugoslavia, Turkey and China. The ranking of the provenances was very similar over the years.

Regarding diameter at breast height (dbh) at age 9 years, the results were in good agreement with the results for height growth with highest values for the Belgian and lowest values for northern, southwestern and far eastern provenances. The values varied between 37.2 mm (no. 13, Belgium) and 14.5 mm (no. 25, China) with an average of 27.6 mm.

The values for height 1991 and dbh 1991 were used to calculate mean slenderness ratio of the provenances. The slenderness ratio can be a decisive character for the stability of a tree against wind, storm or snow. It could be shown that the faster growing provenances have height/dbh ratio values of about 90, whereas poorly growing ones are more slender with values of about 115 (*Figure 2*).

Branching

Differences in growth performance are expressed also in other characters, as for instance in branching. Already at the age of 3 years, there were significant differences between provenances in the number of twigs/whorl (*Figure 3*), and a good positive correlation between this trait and the height of trees.

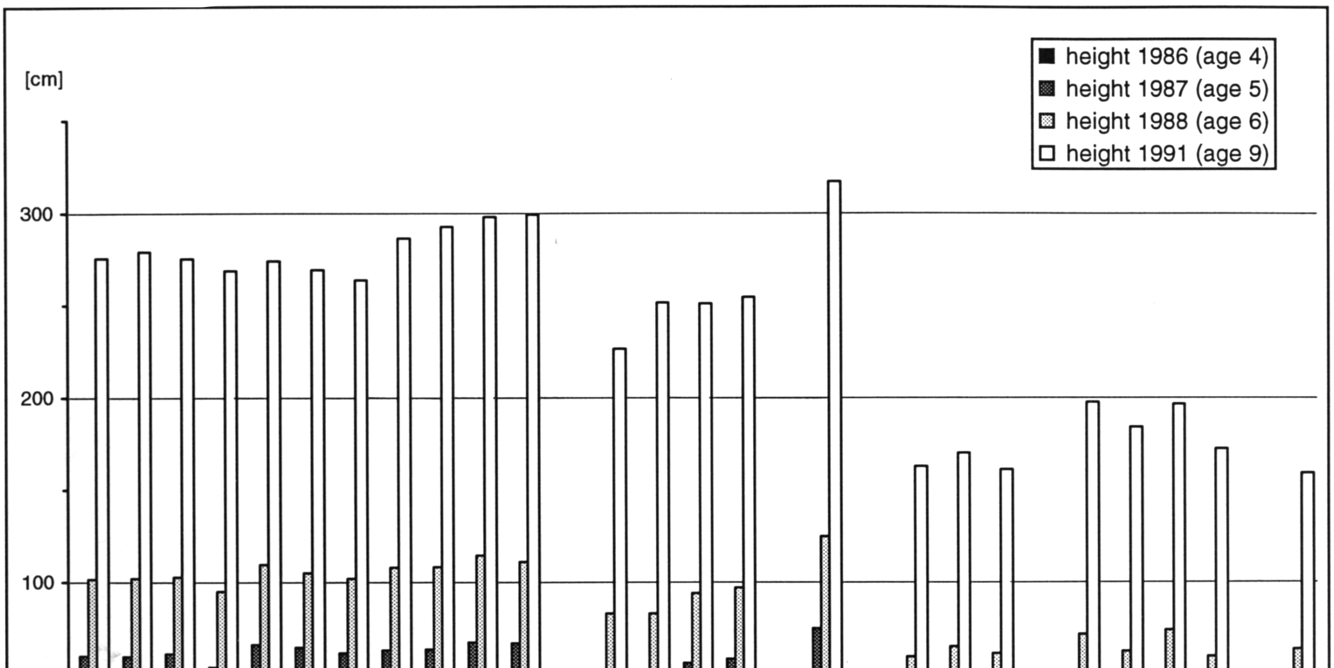

Fig. 1. – Height growth of Scots pine provenances at age 4, 5, 6 and 9.

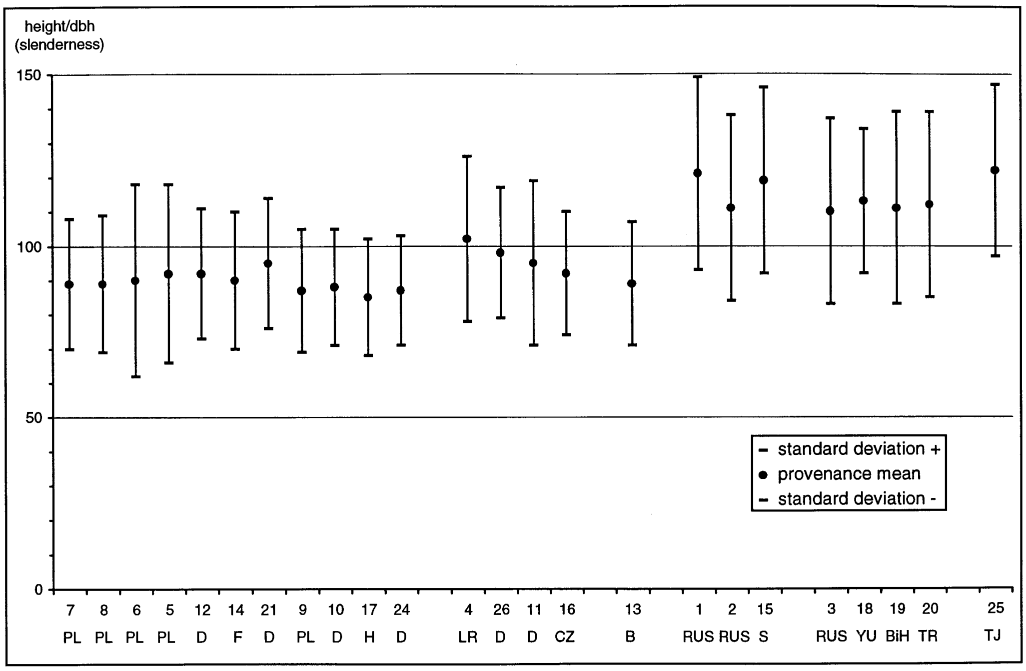

Fig. 2. – Ratio between height and diameter (DBH, 1.3 m) 1991 (slenderness).

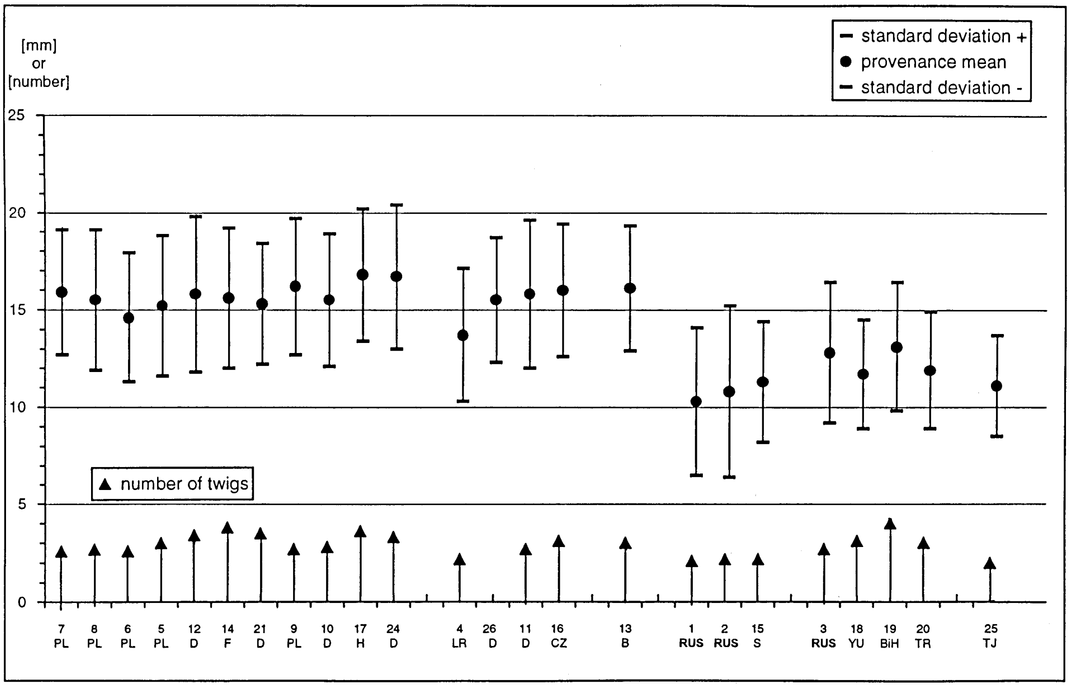

Fig. 3. – Number of twigs of the uppermost whorl 1985 and diameter of branches 1991 (1 branch of the 3rd whorl from the top, 3 cm from the stem).

Even at the age of 9 years, good growing provenances had thicker branches in the third whorl from the tree top than slow growing ones (*Figure 3*).

Stem form

Assessment of tree form on a 6 step point scale indicated great variation between provenances (*Figure 4*). The faster growing group of provenances from Poland, Germany, France and Hungary had a high percentage of trees with unsuitable tree form. Well known for their crooky stem forms are especially provenances from eastern France and southwestern Germany. The 2 provenances from that area, no. 12 (Lampertheim) and no. 14 (Haguenau) had already at this young age the highest percentage (about 70%) of trees with bends or bows (*Figure 4*). Exceptional among the best growing provenances was the Belgian seed lot (no. 13) with about 70% straight stems.

High percentages of good forms were also found among the slow growing provenances from Sweden, Latvia, Russia, former Yugoslavia and Turkey. Similar was the behaviour of Chinese Scots pine.

Four provenances from Poland (no. 9, Bolewice), Germany (no. 26, Gartow) and former Yugoslavia (no. 18, Maocnica; no. 19, Prusacka Rijeka) had also a few individuals with bushy forms (*Figure 4*).

Damage by Brachyderes incanus

In 1991 a generally severe attack by the needle feeding beetle *Brachyderes incanus* could be observed on Scots pines. After first inspection it was obvious that there was conspicuous variation between provenances. The assessment of the trial showed in fact that the 4 replications were homogeneously damaged, and that provenances less attacked in one replication showed a lower damage also in the other 3 replications. The results of the assessment are shown in *figure 5*. Susceptibility of the 24 Scots pine provenances shows considerable differences, and again, several Scots pine groups can be distinguished. The good growing provenances were in general weakly or medium attacked, whereas in the slower growing provenances more than 50% of the trees were heavily attacked by the insect. Nearly all needles showed beetle damage. In the Chinese provenance there was no tree without damage (*Figure 5*).

Comparison of all traits

For all 24 Scots pine provenances the mean values of the 12 measured or assessed traits and the 3 geographical parameters were subjected to correlation analyses (*Table 2*). The traits tree height, dbh and diameter of branches were highly significantly correlated for all test years and showed negative correlation coefficients with geographical longitude. The damage by the beetle *Brachyderes incanus* was negatively correlated with the growth traits but positively with geographical longitude. The 1,000-seed-weight was in a few cases positively correlated with growth traits, but had a highly significant negative correlation with geographical latitude. The germination rate had a positive but weak correlation with early height measurements of the seedlings and was negatively correlated with geographical longitude. Mortality was significantly correlated only with the 1,000-seed-weight, and negatively with geographical latitude. In general, from the 3 geographical parameters only longitude resulted in significant, negative correlation coefficients with the growth measurements.

On basis of 9 measured or assessed traits and 2 geographical coordinates the similarity of the 24 Scots pine provenances has been investigated by cluster analysis. The resulting dendrogram is presented in *figure 6*. There is a very clear differentiation between 2 main groups. The first larger group can be divided at the similarity distance of about 0.5 into another 3 subgroups with the following provenances:

(1.1) 11 provenances from Poland (no. 5 and 9), Germany (no. 10, 12, 21 and 24), France (no. 14) and Hungary (no. 17);

(1.2) 4 provenances from Latvia (no. 4), Germany (no. 11 and 26) and Czech Republic (no. 16);

(1.3) a single provenance from Belgium (no. 13).

Also in the second, but smaller group 3 further subgroups can be distinguished:

(2.1) 3 provenances from Russia (no. 1 and 2) and Sweden (no. 15);

(2.2) 4 provenances from Russia (no. 3), former Yugoslavia (no. 18 and 19) and Turkey (no. 20);

(2.3) the single and very separate provenance from China (no. 25).

Additionally, it has been checked by discrimination analysis, which of the traits had the highest discriminating influence on the clusters. It could be shown that the first 5 steps were

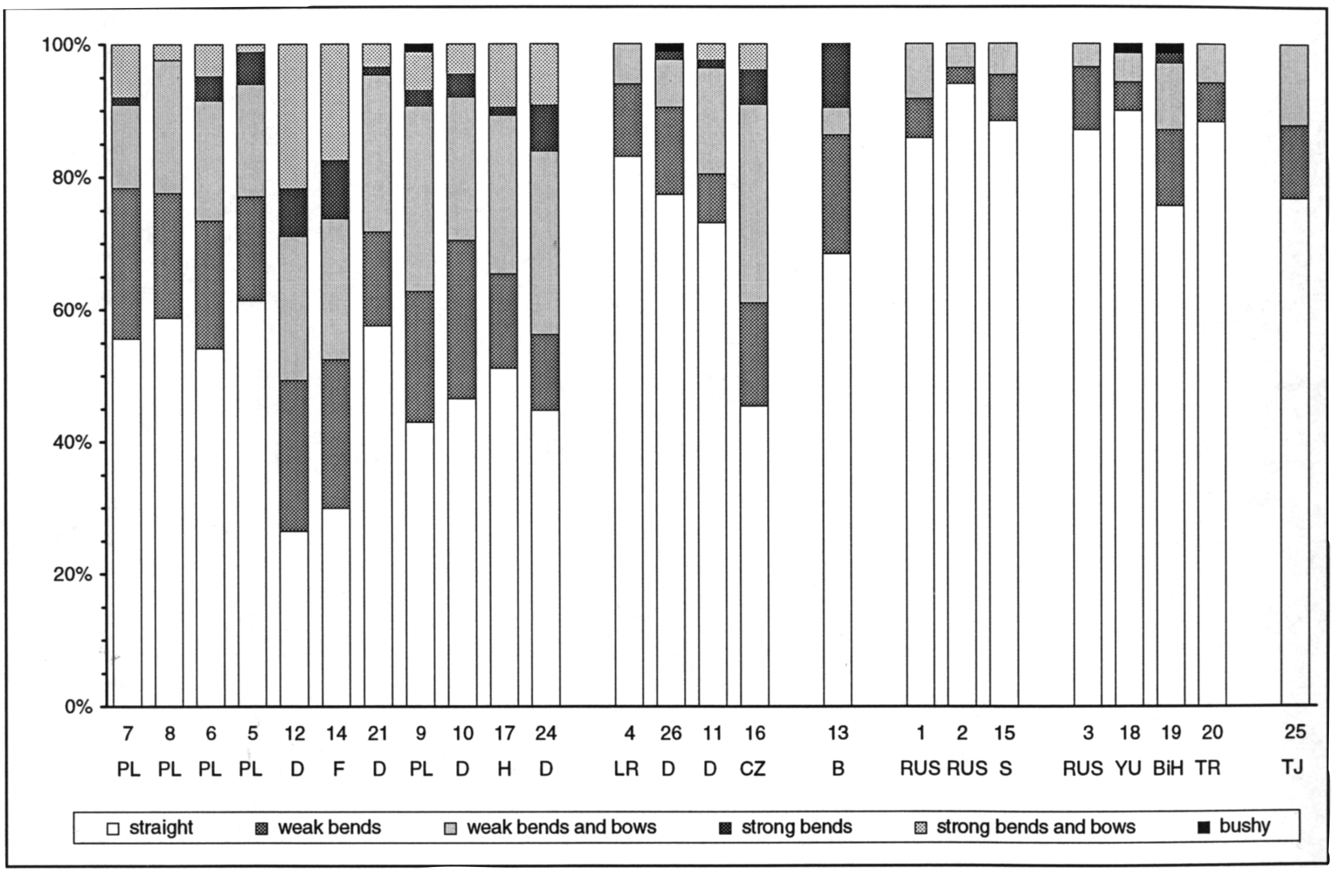

Fig. 4. – Stem form assessment in Scots pine provenances.

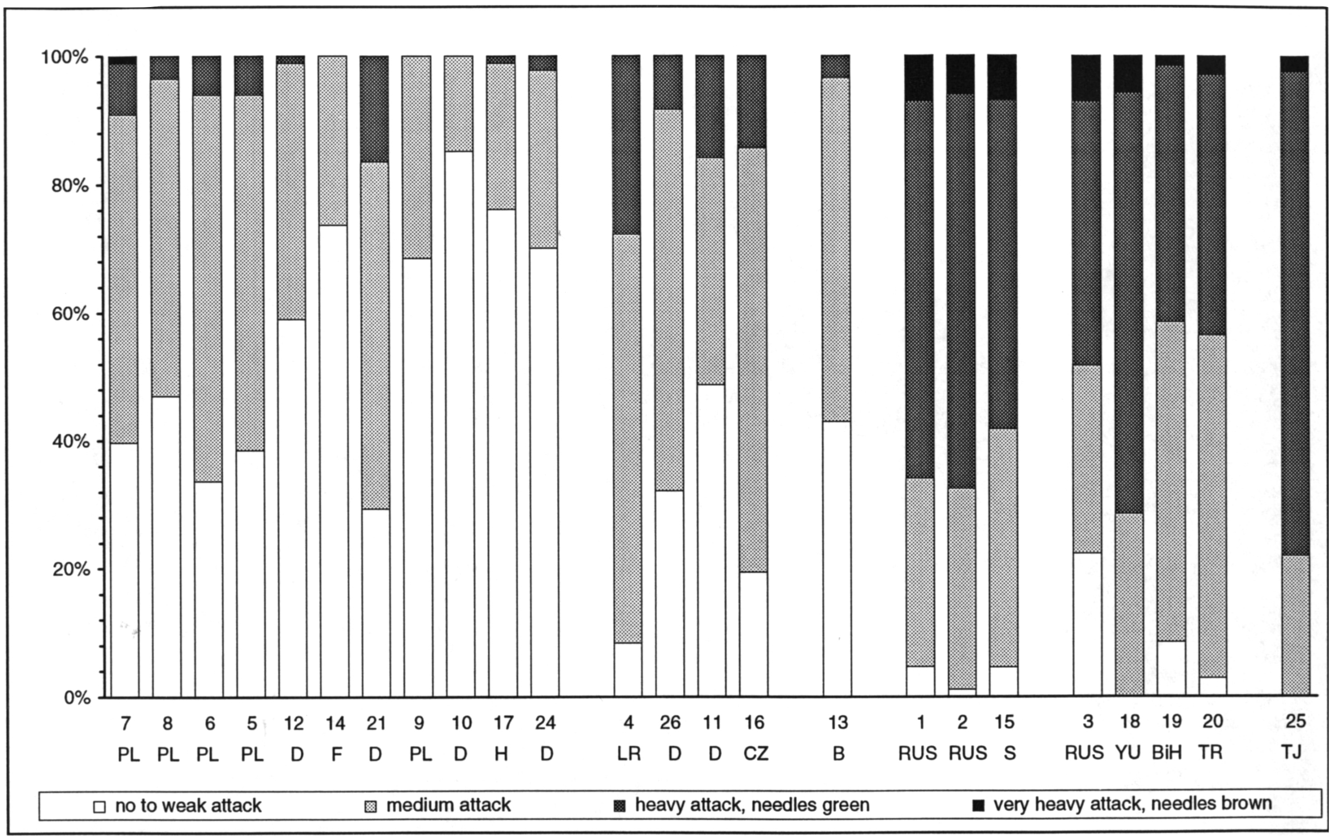

Fig. 5. – Damage by *Brachyderes incanus* L..

Table 2. – Correlation coefficients between 12 measured or assessed traits and 3 geographical parameters of Scots pine provenances (number of provenances 24; except for height 1984 and 1985, seed weight and germination rate, where the number of provenances is 19 to 23).

	MORT	H84	H85	H86	H87	H88	H91	DBH91	BRANCH	INSECT	SEEDW	GERM	LATIT	LONGIT
H84	0.057 ns													
H85	0.004 ns	0.831 ***												
H86	-0.033 ns	0.781 ***	0.916 ***											
H87	-0.112 ns	0.783 ***	0.927 ***	0.941 ***										
H88	-0.109 ns	0.758 ***	0.917 ***	0.927 ***	0.993 ***									
H91	-0.141 ns	0.683 ***	0.881 ***	0.858 ***	0.918 ***	0.942 ***								
DBH91	-0.132 ns	0.688 ***	0.881 ***	0.870 ***	0.927 ***	0.950 ***	0.993 ***							
BRANCH	0.093 ns	0.751 ***	0.831 ***	0.823 ***	0.863 ***	0.855 ***	0.863 ***	0.858 ***						
INSECT	0.041 ns	-0.744 ***	-0.852 ***	-0.834 ***	-0.883 ***	-0.887 ***	-0.898 ***	-0.902 ***	-0.837 ***					
SEEDW	0.537 *	0.440 ns	0.494 *	0.551 *	0.449 ns	0.447 ns	0.490 *	0.440 ns	0.498 *	-0.416 ns				
GERM	0.038 ns	0.476 *	0.445 *	0.335 ns	0.337 ns	0.307 ns	0.249 ns	0.229 ns	0.342 ns	-0.424 ns	0.003 ns			
LATIT	-0.570 **	-0.311 ns	-0.342 ns	-0.303 ns	-0.190 ns	-0.171 ns	-0.150 ns	-0.118 ns	-0.296 ns	0.095 ns	-0.768 ***	-0.201 ns		
LONGIT	-0.032 ns	-0.702 ***	-0.697 ***	-0.644 ***	-0.710 ***	-0.675 ***	-0.582 **	-0.573 **	-0.677 ***	0.663 ***	-0.411 ns	-0.640 **	0.164 ns	
ALTIT	0.234 ns	-0.231 ns	-0.069 ns	-0.134 ns	-0.178 ns	-0.187 ns	-0.126 ns	-0.154 ns	-0.084 ns	0.264 ns	0.230 ns	0.160 ns	-0.646 ***	0.210 ns

MORT - mortality 1986
H84 - height 1984 (age 2)
H85 - height 1985 (age 3)
H86 - height 1986 (age 4)
H87 - height 1987 (age 5)
H88 - height 1988 (age 6)
H91 - height 1991 (age 9)
DBH91 - diameter (1.3 m) 1991
BRANCH - diameter of branches 1991
INSECT - damage by *Brachyderes incanus* 1991
SEEDW - seed weight
GERM - germination rate
LATIT - latitude
LONGIT - longitude
ALTIT - altitude

ns - not significant
* - significant at 0.05
** - significant at 0.01
*** - significant at 0.001

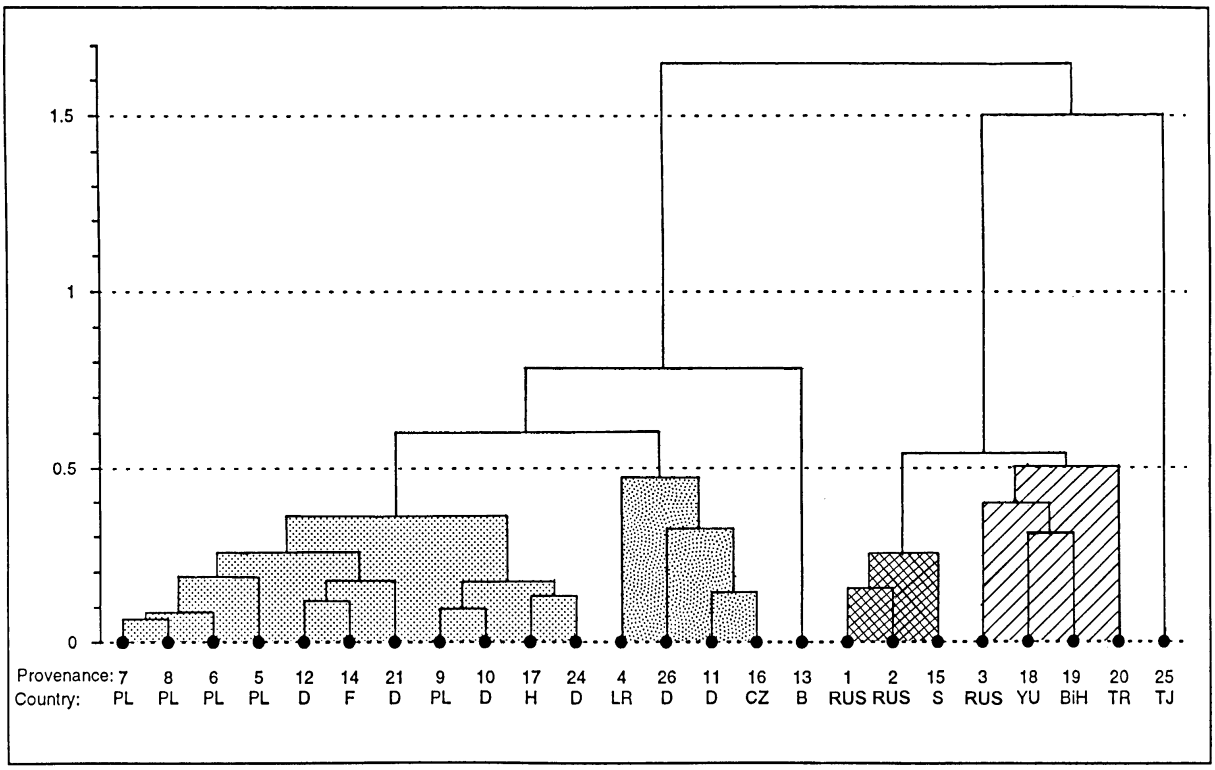

Fig. 6. – Dendrogram (cluster analysis UPGMA) illustrating the similarities of 24 Scots pine provenances based on 9 measured or assessed traits and 2 geographical coordinates.

occupied by recent growth measurements of height 1991, diameter of branches 1991 and dbh 1991 together with geographical longitude and latitude (*Table 3*).

Discussion

Pinus sylvestris is the pine species with the largest natural distribution area. It is not surprising therefore that great variation between provenances can be found in numerous characters, even in a young field trial. Until the age of 9 years central European provenances between 47° and 55° of northern latitude are the best growing provenances under the environmental conditions of southwestern Germany. Among these provenances a Belgian seedlot from a seed plantation at Groenendaal has the first rank. In Belgium this seedlot is recommended for practical use as an elite provenance, which is superior to other provenances in relation to its performance, good stem form, fine branches, and good resistance against the needle cast caused by the fungus *Lophodermium seditiosum* (NANSON, 1978). Scots pine is an introduced species in the Belgian Ardennes, probably from southwestern Germany or the Baltic region (GIERTYCH, 1991). In other and older provenance trials this provenance has shown also its good growth performance (GIERTYCH, 1979, 1991; GIERTYCH and OLEKSYN, 1992). Also a seed stand provenance from Hungary belongs to the good growing group.

Table 3. – Results of discrimination analysis between 9 measured or assessed traits and 2 geographical coordinates of 24 Scots pine provenances.

variable entered	step	F statistic	Wilks' lambda	average squared canonical correlation
height 1991	1	86.123 ***	0.04012 ***	0.1920 ***
longitude	2	39.201 ***	0.00320 ***	0.3752 ***
diameter of branches 1991	3	6.713 **	0.00103 ***	0.4849 ***
diameter (1.3 m) 1991	4	5.595 **	0.00036 ***	0.5624 ***
latitude	5	4.037 *	0.00015 ***	0.6444 ***

Also Polish, German, and eastern French provenances show growth characters above the trial average. The Polish provenances have the advantage of better stem forms. The provenances north of 55° and south of 47° of latitude are slow growing compared with the central European ones. Although the IUFRO 1982 provenance trial is still very young, the results can be a basis for a general judgement, because they are in good agreement with results from other experimental sites (e.g. OLEKSYN, 1988; GIERTYCH and OLEKSYN, 1992; KOHLSTOCK and SCHNECK, 1994; GRACAN and PERIC, 1996).

Great variation can also be observed in stem form of the trees. The well-known bad form of Scots pine stands from eastern France and southwestern Germany (TROEGER, 1962) is exhibited already in the young trees. In this connection it is of interest that the southwestern German provenance from Lampertheim (no. 12) has high homozygosity as shown by isozyme studies (PRUS-GLOWACKI, personal communication). But it is too early to suggest a relation between form and homozygosity. Also the known good and straight form of northern and eastern provenances can be confirmed, but it is combined with weak growth.

The observation of different susceptibility of the provenances against insect damage could be valuable. It can be considered advantageous that damage and growth are negatively correlated. Faster growing provenances were in general less attacked than slow growing ones. More details about variation in susceptibility to *Brachyderes incanus* were published by STEPHAN and LIESEBACH (1996).

Differentiation of the 24 Scots pine provenances into 6 main groups by cluster analysis confirms the results based on separate characters. It could be shown that the central European provenances belong to groups, which can be separated from northern, southern and particularly far eastern provenances. The separate position of the Chinese provenance can be confirmed on the basis of growth traits and insect damage.

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Morphological Changes in Transgenic *Populus* Carrying the *RolC* Gene from *Agrobacterium rhizogenes*

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Dedicated to WOLFGANG LANGNER on the occasion of his 90th birthday

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Summary

We have employed the reporter gene *rolC* gene from *Agrobacterium rhizogenes* as a morphologically detectable marker system for investigating growth alterations in *Populus.* A hybrid aspen (*P. tremula* L. x *P. tremuloides* MICHX.) clone, Esch5, was transformed using different chimeric gene constructs including the *rolC* gene to study its effect on morphological and physiologically-conditioned parameters. Mainly, transgenic aspen carrying the *rolC* gene under control of the cauliflower-mosaic-virus 35S-promoter and the light inducible *rbcS* promoter from potato were compared with controls. Other gene constructs, in which *rolC* expression is prevented by insertion of the transposable element *Ac* from maize were also included. Differences in growth parameters (e.g. plant height, stem diameter, number of leaves), and growth arrest and terminal bud formation were observed between the control and the *35S-rolC* transgenic aspens. Evaluation of onset of dormancy in the autumn and flushing in the next spring revealed differences between untransformed controls and, in particular, the *35S-rolC* transgenic plants. These tree-specific morphological and developmental characteristics are discussed in the light of the transferred foreign genes in aspen-*Populus*, a woody plant model system.

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Introduction

Genetic engineering of plant species has successfully been introduced as a new tool in plant breeding programs. However, for forest trees many questions are still left, e.g. is it relevant to ask if foreign genes will be stably integrated and expressed (AHUJA, 1988a and b), and remain active during the long life cycle of trees. In genetically engineered crop species, a number of known reporter genes have been used. For long-term investigations in forest trees reporter genes having no phenotypic effect, for example, those coding for neomycin phosphotransferase (*npt*) and glucuronidase (GUS or *uidA*) can be used in transient or stable transformation experiments. However, reporter genes which affect the morphology of the plant are of special interest, as they can be used as visual markers throughout the life of a plant.

The *rolC* gene of *Agrobacterium rhizogenes* as a morphologically selectable marker gene has been tested earlier in annual plant species like tobacco (SPENA et al., 1987; SCHMÜLLING et al., 1988) and potato (FLADUNG, 1990; FLADUNG and BALLVORA, 1992; KAENDLER et al., 1996). Following transfer of the *rolC* gene to tobacco and potato, species-specific alterations in plant