

RESEARCHES OF NORWAY SPRUCE INTERPOPULATION GENETIC VARIABILITY

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ABSTRACT

This paper presents the research purposes achieved in five Norway spruce provenance trials at 25 years old. Researches have in view: assessment of genetic variation for most important traits, the magnitude of variation and genetic pattern. There were also calculated similitude and differentiations among tested provenances by means of genetic distances. The tested material includes 90 provenances: 12 Romanian and 78 foreign, from 13 European countries.

In all comparative trials variance analysis shows a great interpopulation genetic variability for all studied traits. Genetic variation is both clinal and ecotype and depends on examined character. Cluster analysis shows a relation among Ice-Age refuges, postglacial migration and grouping provenances. The most valuable provenances, regarding the growth and adaptive performances, are provenances from Herciniano - Carpathian and South - Alps areas.

Keywords: Norway spruce, interpopulational genetic variability, provenance, genetic distance.

INTRODUCTION

Norway spruce is the most important coniferous species in Romania; the Norway spruce area represents 23 % of national forest area and 78 % of coniferous forest.

Generally, the knowledge of the species genetic variation pattern is an essential condition for managing and preserving forest gene resources, which are exposed to great variety factors of stress. Also, wood production, wood quality and resistance to adversities depend of the seed provenance and origin. Therefore, studying Norway spruce interpopulational genetic variability is the most important measure in the way of increasing the forest polyfunctional efficiency.

This paper presents the research purposes achieved in five Norway spruce provenance trials at 25 years old. Researches have in view: assessment of genetic variation for most important traits, similitude and differentiations among tested provenances by means of genetic distances.

MATERIAL AND METHODS

The tested material includes 90 provenances, 12 Romanian and 78 foreign, from 13 European countries: Norway (5), Sweden (6), Finland (13), France (10), Switzerland (8), Germany (6), Austria (14), Italy (3), Poland (3), Czech Republic (2), Slovakia (1), Hungary (4) and Bulgaria (3). The experimental trials were settled on the following forest districts: Adancata, Cosna, Rasnov, Polovraci, Turda.

The studied characters are important in the spruce growth and can be grouped as following: growth and habitus traits, resistance to abiotic factors, adaptability.

Interpopulational variation was measured by means of variance analysis with two tests of signification: "F" and "t multiple". Similitude and differentiations among tested provenances was measured by means of Euclidian standardized distances (Lefort - Busson and Vienne, 1985).

RESULTS AND DISCUSSION

Interpopulational genetic variability

Results of variance analysis for the tree height show a great interpopulation genetic variability, in all comparative trials there are significant differences (table 1).

Character variation is continuous and suggests a polygenic control and their expression is vastly influenced by the environment (figure 1.).

The greatest heights were achieved provenances from: Romania, Czech Republic, Slovakia and Austria. Provenances from Germany and Hungary have good results too. Scandinavian and Bulgarian provenances, from Northern and Southern regions, obviously differ from the other provenances. In all trials they achieve the least growth performances. Swedish provenances present a good adaptability among Northern provenances in the conditions of our country. High-elevated populations from the Alps have poor performances too. Populations from lower elevated regions of the Alps present better outcomes.

Romanian provenances show a high growth potential, in all trials they situate over the general average of the experiment.

Therefore, statistical differences among provenances were obtained for the average volume/tree. There is the same geographic trend of variation. Generally, the largest volume/tree obtained provenances from the Eastern and Centre of Europe. Provenances

from Scandinavian Half - isle, high elevated regions of Alps, Jura Mountains, Vosgi Mountains and Balcanian provenances achieved the least volume/tree. Unstable results present provenances from North - East of Poland and Germany.

Output of wood that can be obtained as result of phenotypical selection of the most valuable populations is included between: 33 - 78 % (Adancata and Turda 1 respectively). Volume / tree obtained of Austrian provenance 50 - Hoyos - Ernest - reith stood on the first place is bigger than the least provenance 1 - Senum (Norway) with about 5 multiple and about 2 multiple given general average, in comparative culture Turda 1.

A great genetic variation was established at level of provenances for characters that determine crown habitus and wood quality. Provenances that will carry out wood of higher quality, that have the diameter branches under general average on experiment, are the ones from Eastern and Centre of Europe (Romania, Czech Republic, Slovakia) and somehow Scandinavian provenances (figure 2.). Western provenances, from Switzerland and France, carry out the thickest branches. Among Romanian provenances, the most valuable are: 68 - Breaza, 66 - Marginea, 70 - Cosna, 71 - Moldovita, 75 - Brosteni.

Adaptation was expressed by percentage of survival. Provenances from: Romania, Austria, Czech Republic, Poland and Germany (figure 3) had the highest percentage of survival, in all trials. Most of them carry out the best growth performances too; therefore, they can use much better the typical ecological condition. Scandinavian provenances have the least adaptability, especially the Finnish ones. Except this genetic variability there is a dependence of survival on the ecological conditions owned by each comparative trial, especially regarding the height of tested place.

Another analyzed character is snow breaks resistance. Variance analysis points out significance differences among tested provenances in 3 of 5 comparative trials. The variability of character is continuous and suggests a polygenic inheritance. The most susceptible provenances are those from: Romania, Poland, Slovakia in almost all trials and provenances from Finland, Sweden, Norway at Adancata and Rasnov. The most resistant provenances on snow breaks there are in Western and Centre of Europe. Therefore, it points out some provenances which have a better growth and resistance too: 50 - Hoyos - Ernest-reith, 51 - Herfenberg, 41 - Eppenstein, 38 - Val Di Fiemme, 39 - Klaunz Bannwald, 99 - Zelezna Ruda, 100 - Kasperske Hory.

Table 1: Variance analysis of studied characters in the Norway spruce comparative trials, 1998

Sursa de variatie	Total height			Volume / tree			Diameter branches			Survival			Snow breaks resistance							
	S.S.	D.F.	s ²	F	S.S.	D.F.	s ²	F	S.S.	D.F.	s ²	F	S.S.	D.F.	s ²	F				
Comparativ trial Adancuta																				
Provenances	26.47	48	0.55	1.72*	18909.36	48	393.94	2.25***	4.49	48	0.09	1.29	13606.58	48	283.47	6.21***	5018.61	48	104.55	2.04***
Repetitions	3.75	2	1.87		792.91	2	396.46		0.03	2	0.01		53.90	2	26.95		262.39	2	131.20	
Rows	5.53	18	0.31		4532.63	18	251.81		1.81	18	0.10		1146.84	18	63.71		676.87	18	37.60	
Columns	14.26	18	0.79		3342.60	18	185.70		1.01	18	0.06		827.98	18	46.00		1218.42	18	67.69	
Errors	16.87	60	0.32		9602.62	60	175.13		3.69	60	0.07		2542.34	60	45.66		2927.61	60	51.35	
TOTAL	66.88				37180.12				11.03				18177.64				10103.90			
Comparativ trial Cosna																				
Provenances	280.90	80	3.51	3.13***	160965.57	80	2012.07	2.81***	13.56	80	0.17	1.21	15681.60	80	196.02	2.11***	5550.58	80	69.38	1.11
Repetitions	1.45	2	0.73		1127.95	2	563.97		1.91	2	0.95		2983.35	2	1491.67		412.87	2	206.44	
Rows	35.81	24	1.49		27132.16	24	1130.51		4.64	24	0.19		2605.88	24	108.58		618.78	24	25.78	
Columns	18.98	24	0.79		26939.88	24	1122.50		2.52	24	0.10		2625.14	24	109.38		1485.32	24	61.89	
Errors	120.45	112	1.12		70930.51	112	716.49		14.45	112	0.14		9823.72	112	92.85		7012.65	112	62.61	
TOTAL	457.59				287096.07				37.08				33719.69				15080.20			
Comparativ trial Rasnov																				
Provenances	582.09	80	7.28	8.18***	193312.31	80	2416.40	6.93***	16.91	80	0.21	1.62*	24700.81	80	308.76	3.30***	18435.65	80	230.45	2.10***
Repetitions	16.40	2	8.20		11806.55	2	5903.27		2.80	2	1.40		2462.94	2	1231.47		3376.18	2	1688.09	
Rows	30.82	24	1.28		9112.59	24	379.69		1.92	24	0.08		3286.40	24	136.93		2689.80	24	112.07	
Columns	41.67	24	1.74		14136.89	24	589.04		3.93	24	0.16		2730.23	24	113.76		2052.48	24	85.52	
Errors	87.56	112	0.89		35723.35	112	348.55		13.76	112	0.13		9577.83	112	93.52		12276.48	112	109.97	
TOTAL	758.54				264091.69				39.32				42758.21				38830.59			
Comparativ trial Turda																				
Provenances	273.27	80	3.42	3.84***	195949.01	80	2449.36	2.77***	5.59	80	0.07	1.75**	26577.41	80	332.22	1.78**	-	-	-	-
Repetitions	0.60	2	0.30		4670.51	2	2335.26		0.15	2	0.08		694.84	2	347.42		-	-	-	-
Rows	74.13	24	3.09		85479.10	24	3561.63		4.19	24	0.17		13231.83	24	551.33		-	-	-	-
Columns	37.21	24	1.55		29819.83	24	1242.49		1.51	24	0.06		5523.14	24	230.13		-	-	-	-
Errors	83.64	112	0.89		84135.47	112	884.68		4.01	112	0.04		18185.95	112	186.73		-	-	-	-
TOTAL	468.85				400053.92				15.45				64213.17				-	-	-	-
Comparativ trial Polovraci																				
Provenances	-	-	-	-	-	-	-	-	20.29	80	0.25	1.79**	34479.34	80	430.99	2.35***	57192.71	80	714.91	2.17***
Repetitions	-	-	-	-	-	-	-	-	0.17	2	0.09		5294.07	2	2647.04		11219.45	2	5609.72	
Rows	-	-	-	-	-	-	-	-	5.35	24	0.22		14657.19	24	610.72		14275.48	24	594.81	
Columns	-	-	-	-	-	-	-	-	3.94	24	0.16		8406.36	24	350.27		15810.01	24	658.75	
Errors	-	-	-	-	-	-	-	-	14.45	112	0.14		17128.62	112	183.05		31692.94	112	329.44	
TOTAL	-	-	-	-	-	-	-	-	44.20				79965.58				130190.59			

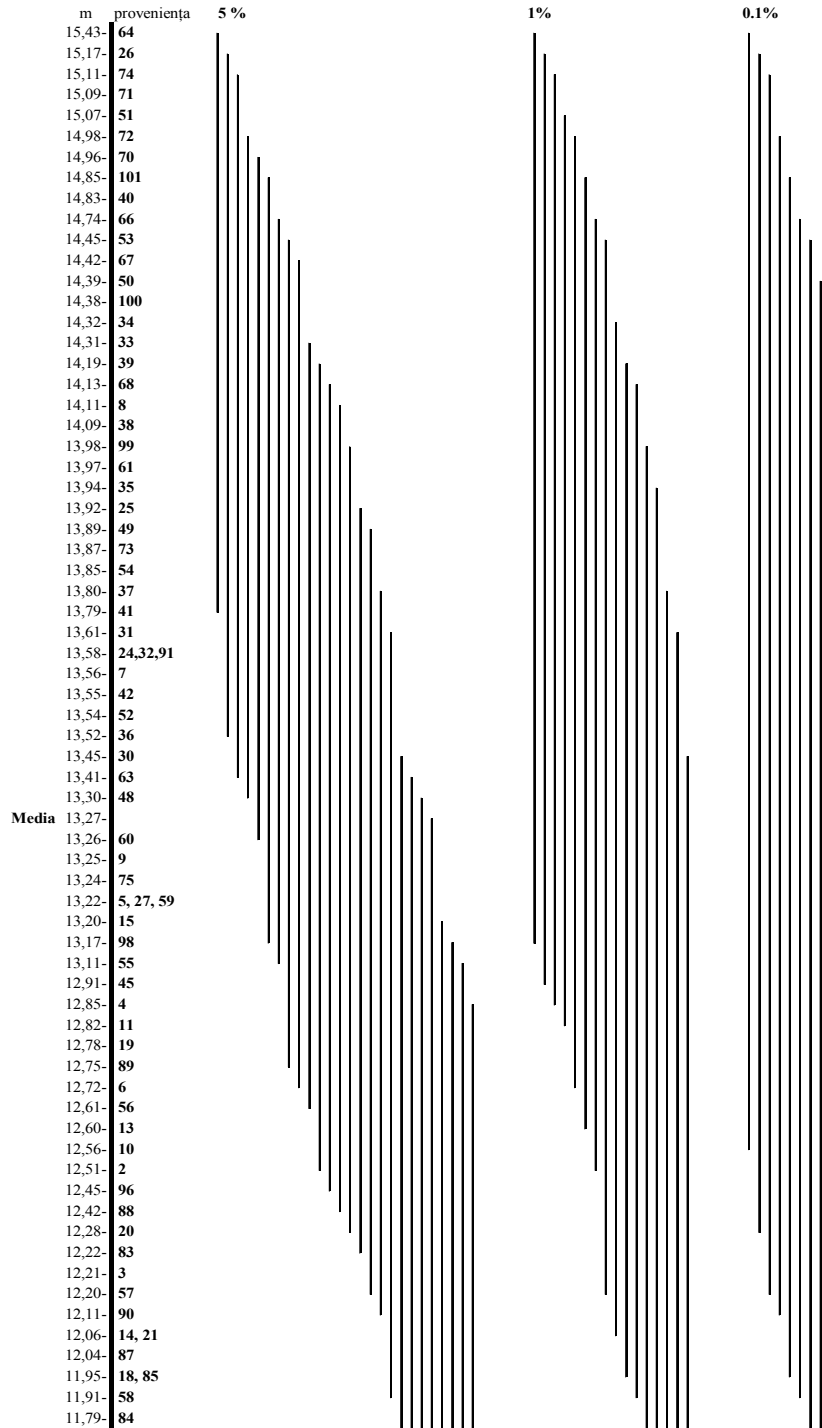


Figure 1. Variation of total height in the comparative trial Cosna, 1998

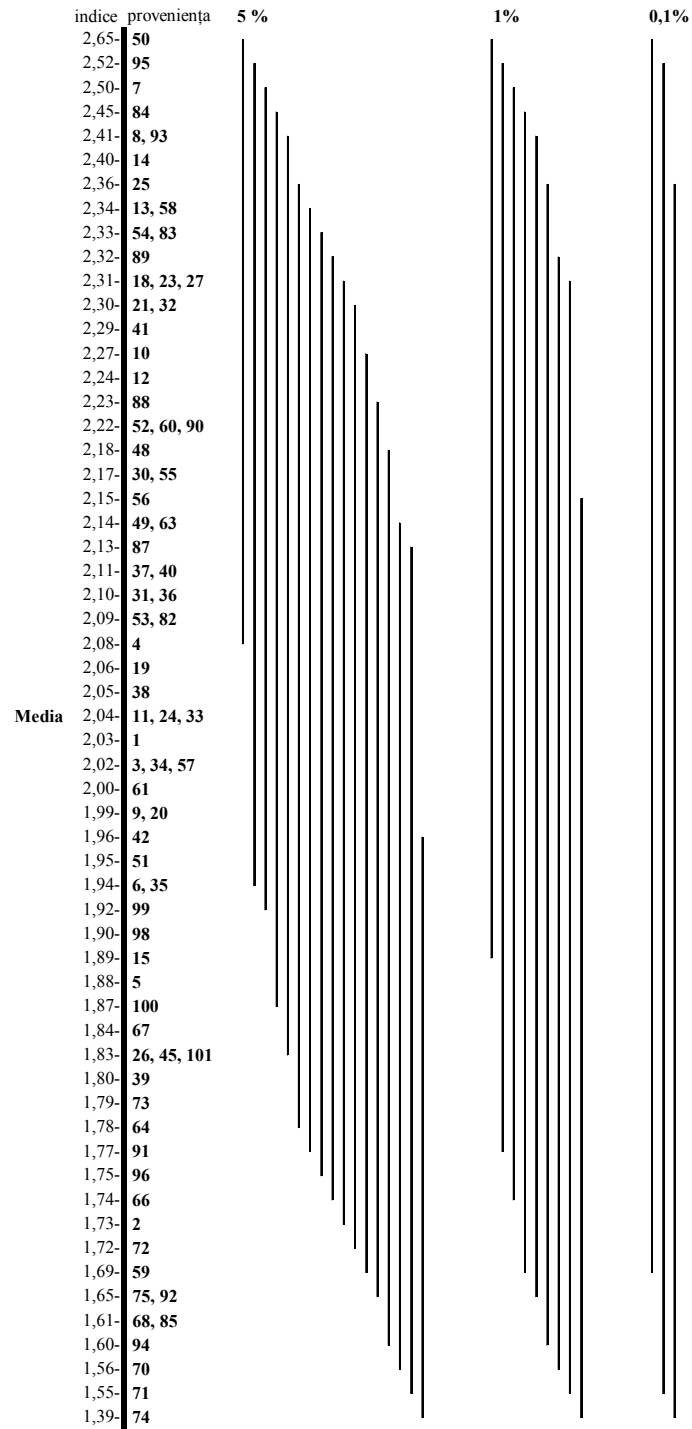


Figure 2. Variation of diameter branches in comparative trial Rasnov, 1998
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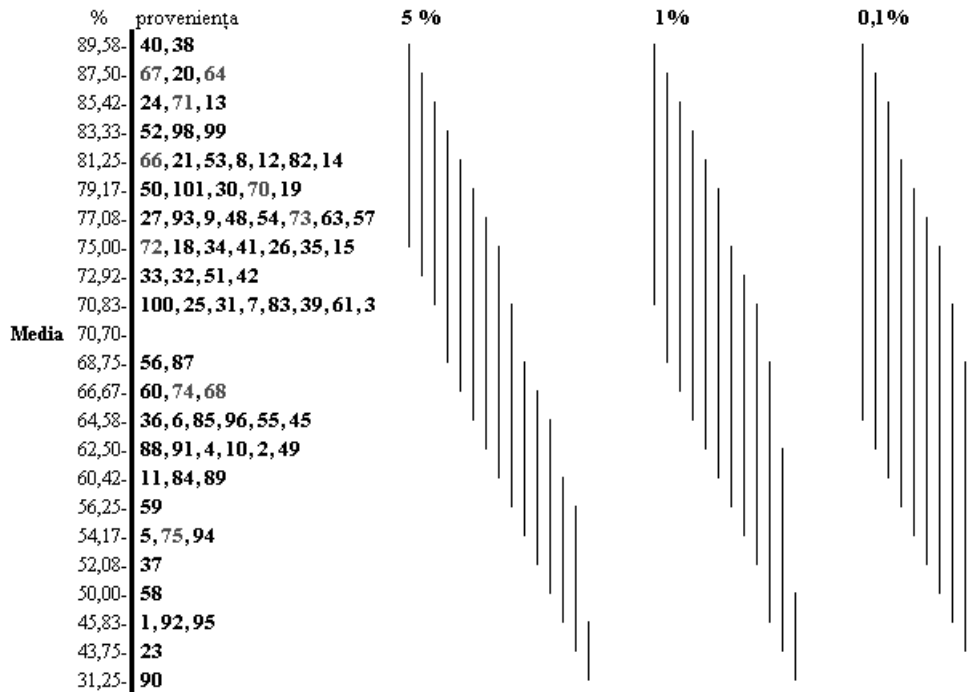


Figure 3. Variation of survival percentage in the comparative trial Cosna, 1998

Genetic distances

Similitude and differentiations among tested provenances were studied in comparative trial Rasnov, by estimating the genetic distances (figure 4). For analysis were used the following uncorrelated characters: average volume / tree, number of branches and survival. There are three distinct clusters of provenances:

Northern and Bulgarian provenances which have the smallest volume / tree, the least thickness of branches and the right stems;

Provenances from Eastern and Centre of Europe and Romania which have the highest volume / tree, medium thickness of branches and right stems;

Provenances from Western area of species with the low growth performances, the most thickness of branches and many stem defects.

Romanian provenances differentiate clearly from the other tested provenances, making a distinct cluster. Provenances from Herciniano - Carpathian area and some of Austrian provenances form a distinct group. The Finnish provenances are separated clearly from the rest of provenances, standing out a trend of genetic variability like a consequence of adaptation at the specific environment.

There is an agreement among Ice-Age refuges (Dinarian Mountains, Carpathian Mountains and Urals), postglacial migration and grouping provenances by cluster analysis.

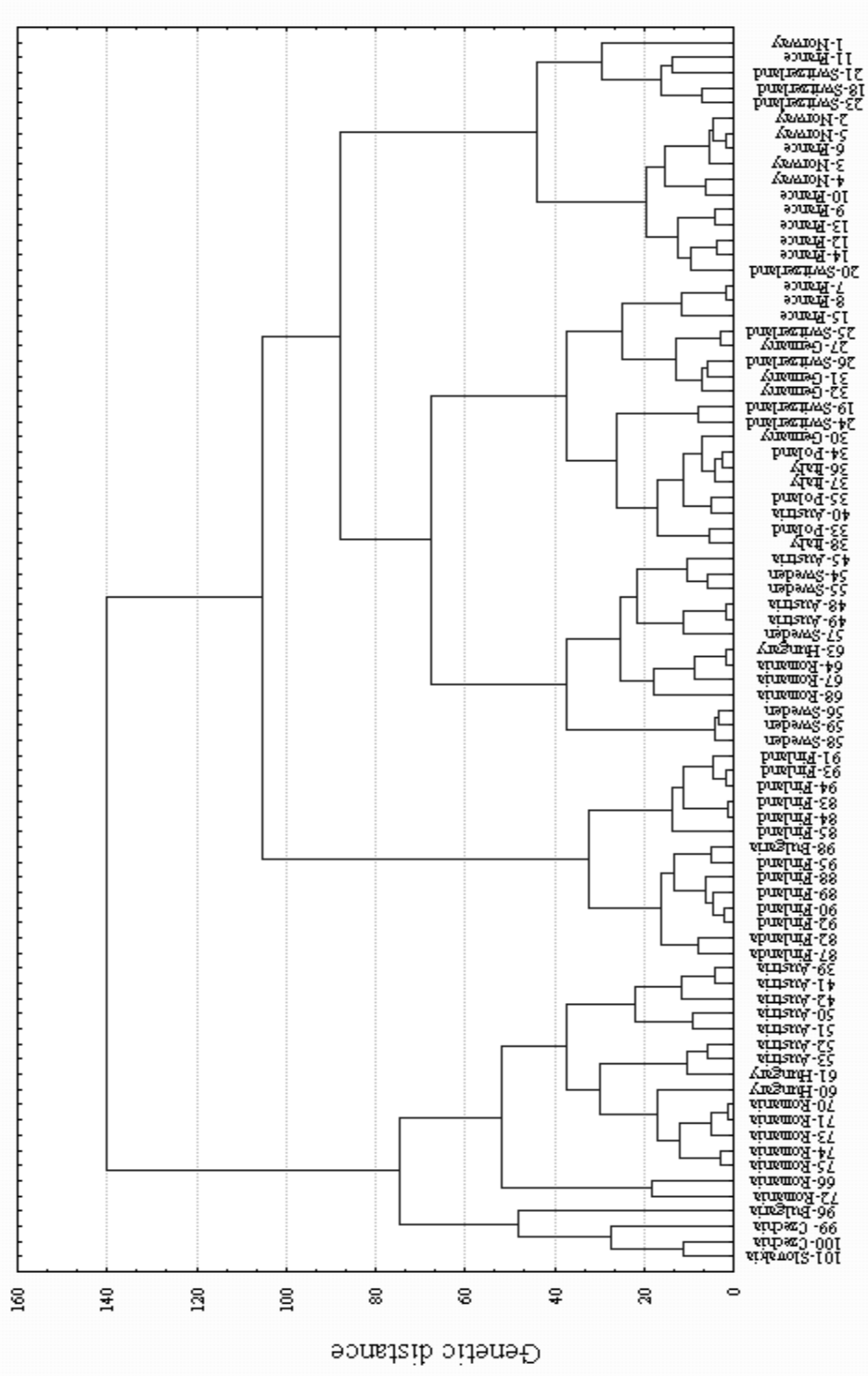


Figure 4. Dendrogram based on the genetic distance of Norway spruce provenances tested in the comparative trial Rasnov

CONCLUSION

There is a great variability for the all studied characters, in all comparative trials. The growth characters are more variable than the quality ones.

The genetic interpopulation variability is both clinal and ecotype and depends on examined character. Thus while growth characters present a variation trend with the main geographical gradients, the characters that determine crown habitus have ecotypical variation.

The most valuable provenances regarding the growth performances and survival are provenances from Herciniano - Carpathian area (Romania, Czechia, Slovakia) and Austria. Provenances from Scandinavia, Bulgaria and high elevated populations from the Alps differentiate clearly from the rest of provenances, obtaining the least results.

Cluster analysis shows a substantial genetic interpopulational variation like a consequence of adaptation at specific environment and provides possibility to obtain significant genetic gains in a breeding programme of Norway spruce.

Research purposes point out the genetic superiority of Romanian provenances from Eastern Carpathian: Gheorghieni, Marginea, Cosna, Moldovita, Dorna Candreni and Breaza.

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