RESEARCHES CONCERNING NARROW- CROWNED SPRUCE IDEOTYPE (*Picea abies* f. *pendula* (LAWSON) SYLVEN) IN ROMANIA

GHEORGHE PÂRNUȚĂ
Forest Research and Management Institute, Bucharest, Romania

ABSTRACT

The paper presents results of the research concerning selection and description of the narrow- crowned spruce trees ideotypes; study of reproduction system and full diallel cross between pendula and common - crowned spruce trees; testing of full-sib families in nursery and experimental trials to provide information about genetic variation and inheritance of traits useful for breeding.

Seed from controlled cross families were sown in a greenhouse, and then, the seedlings were transplanted in individual polyethylene pots in potting spruce humus. The pots with the seedlings were placed in the nursery, and then, in experimental trials and arranged in randomized complet block design. The main traits useful for breeding were measured and a general least-square was made.

The results of research:

1. The narrow - crowned ("pendula ") spruce trees have thin and pendular branches, with the angle of insertion on the trunk higher than 120°; primary branches are irregularly branched; high quality of pruning, straight shape of trunks, and are more resistant to snow and wind damages than common spruce from the same population.

Were selected and described more of 250 "Pendula" spruce trees that are spread mainly (80%) in the Apuseni Mountains.

2. Genetic variabiliy of the dry matter in full-sib spruce families (at age 4) in the nursery test indicated highly significant differences among female genetic effects for all analysed traits in pendula x common hybrid combination and no significant effects for any trait in reciprocal one. So, selection of female trees can be made only within narrow-crowned population.

3. Estimates of both high and mid-parent heterosis in pendula x common hybrid were negative for all dry matter traits, while heterosis were positive for all traits in reciprocal one.

4. The dry matter of all seedling components was higher in pendula x pendula (PxP) crossing type and smaller in pendula x common (PxC) one. Dry matter of total seedlings was 33% higher in pendula trees than in common

spruce trees.

5. Genetic variability of spruce hybrides tested in multi-sited experimental trials is higher and it occurs under different forms both in the first year and the second year from planting, according to the site conditions where the experiments are made. It may noticed the existance of an additive genetic control of the traits in both spruce hybrids, making possible the selection of valuable parents to be used in spruce breeding programme.

Keywords: *Picea abies* f. *pendula*, genetic variability, general and specific combining ability, hybrid, heterozis.

INTRODUCTION

The spruce (*Picea abies* (L.) Karst), is the conifer species with the largest spreading and most valuable in Romania, with a vast and ecologically complex distribution range; it presents a strong polymorphism and a high intraspecific genetic diversity.

Also, it is acknowledged that the spruce forests have a relative stability to the influence of the damaging climate factors; they are predisposed mainly to wind and snow fellings and breaks. The general evolution of the climate in the last period was characterized by sudden changes and intensification of extremes, which lead to the increase of the impact on forests resulting, sometimes in significant calamities.

In our country, in natural spruce populations located in different site conditions there is a high variability of the habitus; the narrow-crowned spruce trees are more resistant to snow breaks.

The first researches that had as objective the study on the spruce with a narrow crown and pendular branches were started in Finland. In 1954 Saarnijoki, (quoted by Karki,1980) published a report on a group of 30 mature spruce trees *pendula* (*P.abies f. pendula* (Jacq. and Herincq). He stressed, beside the very narrow crown, also the valuable traits of the trunks and stems in the selected trees.

The crown form of the Norway spruce is a variable character; a large part of the variation can be explained by the enviromental factors (Schmidt-Vogt, 1997) and the genetically determination of the crown form is obviously based on the pollygenic system (Pulkkinen, 1991).

The crown form of Pendula spruce (*Picea abies f. pendula* (Lawson) Sylven) is extremely narrow, and the inheritance of the crown form is based on only a few genes or gene groups (Lepisto, 1985).

It is believed that narrow crown, harvest index, biomass partition were under genetic control in pendula spruce mutant (Pulkkinen & Poykko, 1990, Pulkkinen, 1991), Scots pine (Pinus sylvestris L.) (Velling & Tigerstedt, 1984, Poykko &Velling, 1993), Lodgepole pine (Pinus contorta ssp latifolia, (Hu and Yeh, 1997) and other species.

The form of the crown has been noticed to be important factor determinating the biomass production of the trees and it also affects allocation ratios between tree components (Cannell et al. 1983, Pulkkinen 1991).

In 1986, a beeding programme of Norway spruce was launched, and in the frame of this programme was performed: selection and phenotipical variability of narrow-crowned ideotype in comparison with normal-crowned spruce trees (Parnuta, 1991,1993); a full diallel mating design and testing of half-sib and full-sib famillies in nursery (Parnuta, 2001) and experimental trials to provides information about genetic variation and inheritace of traits useful for breeding.

Materials and methods

The selection of the spruce ideotypes has been performed according to the crown shape on a vertical level and the angle of insertion of branches on the trunk. Narrow-crowned spruce trees with thin and pendular branches (*Picea abies f. pendula* (Lawson) Sylven) were selected.

Up to 40 quantitative and qualitative traits, significant for the selection, have been measured, observed and described (on typical charts) for each selected tree, in order to observe the phenotypic variability. The description of each trait was done by measuring and the qualitative traits have been observed and estimated by using qualifying grades and numerical indexes with several gradations, in accordance with the diversity and complexity of the trait.

Thirty trees of common spruce have been described as a reference in each population where narrow-crowned ideotypes had been selected. These trees had to be located close to the selected ones and the description was made on standard charts containing the same traits, as the ideotypes, for comparison reasons.

Initial material and mating design used in spruce hybridization.

The parents were selected in two mixed pendula-common spruce natural population located in the Western Carpathians at about 1 200m altitude.

Four selected parents from each of two pendula and common crowned spruce trees

Male / Female	Pendula crown (P)				Common crown (C)			
	P1	P7	P66	P67	C39	C40	C41	C42
P1	X	x	x	x	x	x	x	x
P7	x	X	x	x	x	x	x	x
P66	x	x	X	x	x	x	x	x
P67	x	x	x	X	x	x	x	x
C39	x	x	x	x	X	x	x	x
C40	x	x	x	x	x	X	x	x
C41	x	x	x	x	x	x	X	x
C42	x	x	x	x	x	x	x	X

Crossing type (abreviation)

P x P	P x C
C x P	C x C

Figure 1. Full diallel crossing design according to GRIFFING (1956) Method 1

were used in a full diallel crossing design and four hybrid types were obtained from two separate diallel and factorial mating designs, respectively (Fig.1)

Seed from controlled cross families were sown in a greenhouse, and then, the seedlings were transplanted in individual polyethylene pots in potting spruce humus. The pots with the seedlings were placed in the nursery, and then, in five experimental trials and arranged in randomized complet block design. The main traits useful for breeding were measured and a general least-square was made.

Matematic model and statistical analysis

In order to estimate the genetic components of variance the following statistical model (Griffing s method 1- 1956) was assumed:

$$X_{kij} = u + b_k + g_i + g_j + s_{ij} + m_i - m_j + r_{ij} + e_{kij} \quad (1)$$ where:

x_{kij} is the mean of the i- th female tree crossed to the j-th male tree over k replicates: u is the general mean; b_k is the effect of the k-th block; g_i is the g c a efect associated with the i-th male tree: g_j is the g c a effect associated with the j-th male tree; s_{ij} is the s c a effects associated with the cross between the i-th female tree and j-th male tree, m_i and m_j are maternal effects of the parents i and j; r_{ij} are differences caused by cross direction between parents i and j ; e_{kij} is the random error.

Statistical analysis was made using DIAL programme according to Schaffer and Usanis (1969)

Measurements

Nine biomass traits were measured at age 4, as presented in table 1:

Table 1 - Measured traits

Trait	Unit	Symbol
Total length of stem	cm	TLS
Total number of branches	No	TNB
Total number of roots	No	TNR
Total dry matter of stem	Dg	TDMS
Total dry matter of branches	Dg	TDMB
Total dry matter of needles	Dg	TDMN
Total dry mattere of roots	Dg	TDMR
Total dry matter above ground	Dg	TDMAG
Dry matter of total seedling	Dg	DMTS

Five seedling samples per hybrid combination were measured. Each seedling was divided into stem, branches and roots.

Table 2. Measured traits in experimental trials

Traits	U.M.	Symbols*)
Total height	mm	TH_1; TH_2
Yearly growth in height	mm	YGH_1; YGH_2
Number of branches	No.	NB_1; NB_2
Maximum length of branch	mm	MLB_1 : MLB_2
Forking	%	F_1 ; F_2
Survival	%	S_1 ; S_2

*) Indices 1 and 2 indicates the year of measurement. the first and second year after planting, respectively.

Table 3 . Experimentals trials

Experimental trials	Forest branch	Forest district	U.P., u.a.	Surface (ha)
LEPSA I – SCHIT	Focşani	Lepşa	II, 117P	0,71
LEPŞA II.VL.MĂRULUI	Focşani	Lepşa	V,70 Z	0.70
COMANDĂU	Sf. Gheorghe	Comandău	VI, 21 B	0,75
ILVA MICĂ	Bistriţa	Ilva Mică	III, P 132	1,06
PURU	Rm.Vâlcea	Voineasa	IV, 44 A	0,85

The seedling components were dried for 48 hours at 105 C, then all components were weighted.

RESULTS

Selection and description of the narrow crowned spruce trees ideotypes

Were selected and described more then 250 narrow-crowned spruces trees, which were spread mainly (80%) in the Apuseni Mountains.

The selected ideotypes are characterized, mainly as it follows:

- **Pendula form** - narrow-crowned spruce, with thin and pendular branches, more or less joined to the trunk (angle of insertion of the branches higher than 120^0); primary branches irregularly branched (a main ax cannot be followed to the branch top).

The specimens characterized like this have been included in the typical form belonging to the subspecific taxonomic unit- *Picea abies f. pendula* (Lawson) Sylven (according to Pulkkinen,P.,1991)

- **Columnaris form** - narrow-crowned spruce, with very short primary branches, horizontal or slightly nutant, and secondary, tertiary branches and the many following ones forming a columnar crown.

The specimens characterized by these traits belong to the subspecific taxonomic unit - *Picea abies var. columnaris* (Jacq.) Carr.(according to Dumitriu-Tataranu,1961).

The study on the reproduction of the narrow-crowned and normal spruces shows that the pollen dissemination and the responsiveness of the female strobilus occur in the same time, both in ideotype trees and the common spruce trees, with the possibility for interbreeding between the two types, within the same population.

Controlled pollination in complete diallel system between pendula and normal spruce trees, resulting in full seeds in all types of crosses, shows the reproductive compatibility of the two spruce types.

Genetic variation in dry matter distribution between components in full-sib families

Genetic variation

ANOVA indicated highly significant ($p<0.01$; $p<0.001$) differences among female genetic effects for all analysed traits in *pendula x common* hybrid combinations (Table4, row 1, upper line) and no significant effects for any trait in *common x pendula* crowned hybrid combinations (Table 4, row 1, lower line). So, selection of female trees can be made only within narrow crowned population.

Differences among male effects were significant ($p<0.05$) or highly significant ($p<0.01$) for: TDMB, TDMN and DMTS in pendula x common combinations (Table 4, row 2, upper line), and significant for TDMS and TDMN in common x pendula combinations (Table 4, row 2, lower line);

Therefore, selection of male trees can be made in both populations.

With only one exception, male x female interaction effects were not significant in both types of hybrids (Table 4, row 3)23.2

Table 4: Analysis of variance of the tested traits in Picea abies f. pendula x P. abies (upper line) and Picea abies x P.abies f. pendula (lower line) hybrid populations

Source of variance	Df	Mean squares / traits [1]				
		TDMS	TDMB	TDMN	TDMR	DMTS
Females	3	**39.6****	**44.6****	**85.8****	**31.3****	**770.5****
		23.2	15.5	9.2	2.9	169.9
Males	3	10.1	**8.2****	**37.1****	9.2	**210.7***
		37.2*	9.7	31.8*	7.8	290.5
F x M	9	7.5	**4.4***	10.5	3.8	95.4
		15.3	4.6	10.1	4.6	116.9
Error	64	5.6	2.0	7.2	3.9	67.8
		13.3	5.7	11.4	5.7	126.7

[1] All values were divided by 100

Heterosis effect

Estimates of both high and mid-parent heterosis, in pendula x common crowned hybrid,were negative for all tested traits.

In other words, the hybrid performances were lower than those of the perents. For example, the HPH was accounted for -50% in TDMS and -75% in TDMB. However, a smaller dry matter in branches represents a positive feature. On the contrary, estimates of both high - and mid-parent heterosis, in common x pendula crowned hybrid, were positive for all traits. For example, the HPH was accounted for 22% in TDMR and 52% in TDMS.

Combining ability effects

Table 5: Estimates of general combining ability (g.c.a.) effects for Picea abies f. pendula x P. abies common hybrid population

Trait / Parent	TDMS	TDMB	TDMN	TDMR	DMTS
			Females		
P 1	- 17.60	-18.75	-26.51	-15.51	-77.79
P 7	3.45	2.40	5.39	3.44	13.66
P 66	16.35*	17.60***	23.44**	14.54*	72.46**
P 67	-2.21	-1.26	-2.31	-2.48	-8.32
			Males		
C 39	-9.70	-8.26	-15.13	-7.81	-40.61
C 40	-0.55	-1.66	-7.00	-3.08	-11.74
C 41	3.35	6.14	15.20	3.46	27.39
C 42	6.64	3.79	6.92	7.42	24.96

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

The pendula female parent P66 was the best g c a combiner in pendula x common combination, ranked first for all dry matter traits, while the P 1 ranked last (Table 5, upper part).In the same combination, the common spruce male parent C42 ranked first and C39 ranked last.Consequently, parents P66 and C42 should be selected for the next breeding works; the other trees should be rejected.

The common spruce female parent C 40 of the common x pendula combination ranked first while the parent C 41 ranked last for all dry matter traits.

Within the same combination, the pendula spruce male parent P66 ranked first, while the P 7 ranked last for dry matter traits.

Therefore the best combiners for dry matter are C 40 and P 66 and they should be selected, and the others should be discarded.

The best specific crosses in pendula x common hybrids for "dry matter of the total seeding" as well as for "dry matter of needles" were P1 x C41, P7 x C39 and P 66 x C41.

These three combinations should be propagated by both sexual and vegetative way.

The best specific crosses in common x pendula spruce hybrid for both " dry matter of the total seedling" as well as for " dry matter of nedles" were C39 x P7 and C40 x P1 and C41 x P66.

The above mentioned combinations should be used for both sexual and vegetative propagation.

Table 6 : Phenotypical correlation between tested traits in pendula x common (upper line) and common x pendula crowned (lower line) hybrids

Traits	TDMB	TDMN	TDMR	DMTS
TDMS	0.996**	0.999***	0.999***	0.999***
	0.919	0.964*	0.643	0.961
TDMB		0.996**	0.993**	0.998**
		0.986*	0.875	0.990**
TDMN			0.999***	0.999***
			0.823	0.999***
TDMR				0.999***
				0.826

*p<0.05; **p<0.01; ***p<0.001 (D.f.=2)

Phenotypic correlation

Highly significant correlations were found in pendula x common crowned hybrid among all dry matter traits (Table 6). This suggests that indirect selection can be applied.

In the common x pendula hybrid, significant ($p<0.05$) corelations were found between TDMS and TDMN, and also between TDMB and TDMN.

Highly significant correlations were found between: TDMB and DMTS, and also between TDMN and DMTS (Table 6).

Dry biomass distribution between components. Harvest indices

The dry biomass of seedling components (stem, branches, needles and roots) were higher in P x P hybrid than in all other combination (Table 7)

Table 7: Dry biomass distribution (in dg) between seedling components and their percentage (%), according to the crossing type [1)]

Component	Crossing type							
	P x P		P x C		C x P		C x C	
	Dry biomass							
	dg	%	dg	%	dg	%	dg	%
Stem (TDMS)	7.54	25.0	5.79	26.5	7.08	26.8	6.18	27.4
Branches (TDMB)	5.57	18.5	3.50	16.0	4.43	16.8	3.51	15.6
Needles (TDMN)	10.37	34.4	7.20	32.9	8.63	32.7	7.26	32.2
Above-ground(TDMAG)	23.48	77.9	16.5	75.4	20.14	76.3	16.95	75.2
Roots (TDMR)	6.67	22.1	5.37	24.6	6.27	23.7	5.58	24.8
Total seedling (DMTS)	30.15	100	21.9	100	26.4	100	22.5	100

[1)]see Fig 1

The percentage of needles and branches from the above ground seedling was higher in the P xP than in C x C combination. However, the percentage of the stem and roots from the

P x P were lower than in C x C combinatioo.

Dry biomass of the seedling components (roots, stem, branches, needles) was higher in PxP and smaller in PxC combinations.

In all cases, the CxP hybrid was intermediate between parental PxP and CxC combinations.

Both net and total harvest indices were relatively closed each other; the smallest and the biggest indices were obtained in PxP and CxC combinations, respectively.

The TDMS / TLS and TDMR / TNR ratios were higher in PxP than in CxC combination; this suggest a higher wind firmness and a higher resistance to snow breaking in pendula crowned spruce .

The TDMN was 52% higher in PxP than in CxC combination, suggesting a higher density of the pendula crowned spruce.

Genetic gain

Genetic gain calculated as twice of the g c a , s is presented in table 8.

The best four parents for DMTS were pendula female trees P66 and P7 and common

Table 8 : General combining ability effects (g c a). breeding values (BV) and genetic gains Λ G)

Parents	g.c.a.	BV	ΔG(%)
Dry matter of total seedling (dg)			
P 66	72.46	144.9	64.2
C 41	27.39	54.8	24.3
C 42	24.96	49.9	22.1
P 7	13.66	27.3	12.1
Mean	34.62	69.2	30.7
Total dry matter of needles(dg)			
P 66	23.44	46.88	63.1
C 41	15.20	30.40	40.9
C 42	6.92	13.84	18.6
P 7	5.39	10.78	14.5
Mean	12.73	25.46	34.3

spruce male trees C41 and C42; their average breeding value was 69.2 dg, which would represent an increase of 30.7% in the general mean (225.3dg) for DMTS.

Similary for TDMN, the best four parent trees were the same as above; their average breeding value was 25.46dg, which would represent a genetic gain of 34.3% in the overall mean (74.3dg) for TDMN.

TESTING OF SPRUCE HYBRIDS IN EXPERIMENTAL TRIALS

The results are presented only for the experimental trial Lepsa II- Valea Mărului, one year and, respectively, two years since the planting.

Genetic variation. ANOVA shows that among hybrid families are significant ($p<0,05$) and highly significant ($p<0.01$; $p<0.001$) differences due to the maternal and paternal efects, for seedling height and the current growth in height for adaptation traits

Table 9: Analysis of variance of the PxC hybrid traits in Lepsa II experimental trial

Source of variance	Df	Mean squares (s^2)/ traits					
		TH_1 / TH_2	YGH_1 / YGH_2	NB_1 / NB_2	MLB_1 / MLB_2	F_1 / F_2	S_1 / S_2
Blocks	3	29,8	90,3	1,02	6,84	347,2	0,06
		99,5	25,0	0,52	6,6	559,9	1,4
Hybrids (H)	15	**37,0**^{xxx}	**12,8**^{x}	0,32	3,02	**884,7**^{xx}	**0,36**^{x}
		233,3^{xxx}	**128,7**^{xxx}	**0,41**^{xx}	**15,1**^{xx}	**1063,3**^{x}	**1,2**^{xx}
- Female(F)	(3)	**34,7**^{x}	**17,3**^{x}	0,23	0,04	**2417,4**^{xxx}	0,10
		187,9^{xx}	**315,4**^{xxx}	0,15	6,6	**4025,4**^{xxx}	**1,4**^{x}
- Male (M)	(3)	**117,0**^{xxx}	**31,1**^{xx}	**0,64**^{x}	**9,50**^{xx}	377,1	0,23
		747,7^{xxx}	**187,4**^{xxx}	0,06	**38,3**^{xxx}	**544,6**	**1,4**^{x}
- F x M	(9)	11,2	5,2	0,24	1,85	543,0	**0,49**^{xx}
		77,0	**46,9**^{xxx}	**0,61**^{xxx}	10,2	248,9	**1,0**^{x}
Errors	45	9,9	5,7	0,21	1,96	345,2	0,16
		31,1	8,0	0,15	5,5	462,0	0,4

Table 10: Analysis of variance of the CxP hybrid traits in Lepsa II experimental trials

Source of variance	Df	Mean squares (s^2)/ traits					
		TH_1 / TH_2	**YGH_1 / YGH_2**	**NB_1 / NB_2**	**MLB_1 / MLB_2**	**F_1 / F_2**	**S_1 / S_2**
Blocks	3	9,1	41,6	0,22	11,72	1242	0,02
		41,1	35,7	0,21	14,7	1059,3	0,02
Hybrids (H)	15	**60,0**^{xx}	**17,3**^{xxx}	0,42	**4,63**^{xxx}	**886,3**^{xxx}	0,26
		176,5^{xxx}	**36,5**^{xxx}	0,12	**10,71**^{xx}	**1191,9**^{xxx}	**0,30**^{x}
- Female(F)	(3)	**211,0**^{xxx}	**66,0**^{xxx}	0,56	**15,52**^{xxx}	**1398,2**^{xxx}	**0,56**^{x}
		711,5^{xxx}	**139,3**^{xxx}	0,14	**49,4**^{xxx}	**1628,7**^{xxx}	**0,60**^{x}
- Male (M)	(3)	25,8	4,1	0,13	**5,72**^{xxx}	**1675,2**^{xxx}	**0,56**^{x}
		10,2	**26,1**^{x}	0,05	0,7	**3088,6**^{xxx}	**0,56**^{x}
- F x M	(9)	21,0	5,5	0,48	0,64	**452,7**^{x}	0,06
		53,5	5,8	0,14	1,2	413,7	0,10
Errors	45	18,7	3,4	0,26	0,73	191,7	0,15
		40,5	9,9	0,11	3,6	213,4	0,14

(seedling forking and survival). The intensity of the significance is different in accordance with the trait, type of hybrid and location of the experimental culture.

For Lepsa II trial, the hybrid type *pendula x common* spruce (PxC) for growth (TH and YGH) and adaptation traits (F) the differences among families are distinct and very significant; the paternal genitor has a stronger influence for growth traits and branch length and the maternal genitor for forked seedling frequency and seedling survival (Table 9);.

For the current growth in height and number of branches, the interaction between the genitors strongly influences the differences among the hybrid families in the second year since the plantation.

For the hybrid *common x pendula* spruce(CxP, Table 10) the differences are highly significant for height and current growth in height of the seedlings, (TH and YGH) branch length (MLB) and seedling forking (F) and only significant for seedling survival (S).

The maternal parent influences the variability of the growth traits (TH,YGH and MLB) and both parents the variability of the adaptation traits (F and S).

Heterosis effect

Estimates of both high and mid-parent heterosis in *pendula x common* crowned hybrid were negative for all tested traits in the first year of testing and positive in the second year (Table 11).

Table 11: Estimates of heterosis (He1 = high parent heterosis; He2 = mid-parent heterosis) and hybrid performances (P1 x C40) and reciprocal (C40 x P1)

Combinaţia		Traits					
		TH_1 / TH_2	YGH_1 / YGH_2	NB_1 / NB_2	MLB_1 / MLB_2	F_1 / F_2	S_1 / S_2
P_1 (female)		49.8	16.7	4.5	10.5	55.3	100.0
		88.0	37.6	3.8	21.7	54.3	100.0
Hybrid (P_1 x C_{40})		53.3	11.0	4.5	9.4	41.5	99.8
		109.9	55.2	4.5	26.9	83.0	99.0
C_{40} (male)		53.3	14.3	4.0	10.9	39.5	100.0
		90.8	36.4	3.6	24.0	34.5	100.0
[2] **Heterosis (%)**							
	H_{e1}	**0**	**-34.1**	**0**	**-13.8**	**-25.0**	**-0.2**
		+21,0	**+46,8**	**+18,4**	**+12,1**	**+52,8**	**-1,0**
	H_{e2}	**-3.4**	**-29.0**	**-5.9**	**-12.1**	**-12.4**	**-0.2**
		+22,9	**+51,6**	**+21,6**	**+17,5**	**+86,9**	**-1,0**
C_{40} (female)		53.3	14.2	4.0	10.9	39.5	100.0
		90.8	36.4	3.6	24.0	34,5	100.0
Hybrid (C_{40} x P_1)		57.9	14.4	4.2	10.3	47.0	100.0
		101.3	41.0	3.6	25.1	56.5	100.0
P_1 (male)		49.8	16.7	4.5	10.5	55.3	100.0
		88.0	37.6	3.8	21.7	54.3	100.0
Heterosis (%)							
	H_{e1}	**+8.6**	**-13.8**	**-6.7**	**-5.5**	**-15.0**	**0**
		+11,6	**+9,0**	**-5,3**	**+4,6**	**+4,1**	**0**
	H_{e2}	**+12.2**	**-7.1**	**-1.2**	**-3.7**	**-0.8**	**0**
		+13,3	**+12,6**	**-2,7**	**+9,6**	**+27,3**	**0**

For reciprocal hybrid (CxP) heterosis were negative for all traits (except TH) in the first year of testing and positive for all traits (except number of branches -NB) in the second year of testing . (Table 11).

Combining ability effects

The pendula female parent P1 was the best g.c.a. cobiner in *pendula x common* combination ranked first for total height (TH), yearly growth in height (YGH) and forking(F) in second year of testing.

In the same combination the common spruce male parent C40 ranked first in TH, YGH and maximum length of branch (MLB).

The common spruce female parent C40 of the *common x pendula* combination ranked first for TH, YGH and MLB, while the parent C42 ranked last for all traits.

Within the same combination, the pendula spruce male parent P1 ranked first for forking.

The best specific crosses in *pendula x common* hybrits for total height was P7 x C 39, evaluate in second year of testing.

CONCLUSIONS

1. The narrow - crowned ("pendula ") spruce trees have thin and pendular branches, witn the angle of insertion on the trunk higher than 1200; the primary branches are irregularly branched; high quality of pruning, straight shape of trunks, and are more resistant to snow and wind damages than common spruce from the same population More then 250 "Pendula" spruce trees were selected and described, trees that are spread mainly (80%) in the Apuseni Mountains.

2. Genetic variabiliy of the dry matter in full-sib spruce families (at age 4) in the nursery test indicated highly significant differences among female genetic effects for all analysed traits in pendula x common hybrid combination and no significant effects for any trait in reciprocal one. So, selection of female trees can be made only within narrow-crowned population.

3. Estimates of both high and mid-parent heterosis in *pendula x common* hybrid were negative for all dry matter traits, while heterosis were positive for all traits in reciprocal one.

4. The dry matter of all seedling components was higher in *pendula x pendula* (PxP) crossing type and smaller in *pendula x common* (PxC) one. Dry matter of total seedlings was 33% higher in pendula trees than in common spruce trees.

5. By using the best combiners in hybrid production, a genetic gain of about 30% in dry matter of total sedling could be expected.

6. Genetic variability of spruce hybrides tested in multi-sited experimental trials is higher and it occurs under different forms both in the first year and the second year from planting, according to the site conditions where the experiments are made. It may noticed the existance of an additive genetic control of the traits in both spruce hybrids, making possible the selection of valuable parents to be used in spruce breading pro-

gramme.

7. The assessment of the heterosis, both in *pendula x common* hybrid and in reciprocal one, were negative for all tested traits in the first year of testing and positive in the second year. The hybrids performances are assessed in the juvenile stage (at age 7), show a different evolution in time, which makes it necessary to continue the researches for scientifically substantiating the strategy for spruce breeding.

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