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ASSESSMENT OF HETEROTIC EFFECT IN SERBIAN SPRUCE HYBRID COMBINATIONS

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The occurrence and magnitude of heterotic effect was determined among hybrid combinations and parent individuals obtained by open pollination in Serbian spruce seedling seed orchard at Godovik. The heterotic effect was analysed for cone length and width and the average number of seeds per cone. The study results show the different heterotic effect, both for the same trait in different hybrid combinations and for different traits of the same hybrid.

Key words: Serbian spruce, hybrid combinations, heterosis

INTRODUCTION

In plant breeding, a special place is devoted to the study of hybrid vigour or heterosis. In a series of forest tree species, heterosis enables a considerable, even multiple increase of wood volume increment or the improvement of the characteristics attractive for man. GUSTAFSSON, 1951 (after INGE-VEČTOMOV, 1989) classifies heterosis in plants into: (1) reproductive, expressed by better growth of reproductive organs, (2) somatic, expressed by the effective development of the vegetative mass, and (3) adaptive, expressed by the greater vitality of plants.

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The reproductive, somatic and adaptive heterosis is identified and studied in a considerable number of forest tree species, e.g.: intraspecific hybrids of *Picea abies, Betula verrucosa, Populus tremula, Populus nigra, Populus alba*; interspecific hybrids of the species of the genera: *Abies, Larix, Picea, Pinus, Betula, Castanea, Juglans, Salix, Populus,* etc. (TUCOVIĆ and ISAJEV, 1995). In the species of the genus *Picea*, heterosis is identified in the intraspecific hybrids of the species *Picea abies* (NILSSON, 1963) and interspecific hybrids between *Picea glauca X Picea engelmani* (VIDAKOVIĆ and KRSTINIĆ, 1985; VINCET and MAEHANIČEK, 1972; WRIGHT, 1962). The most expressed heterotic effects were recorded in the tests with inter-specific hybrids *Populus tremula x Populus tremuloides* and *Populus alba x Populus grandidentata,* as well as in the reciprocal hybrids. The data on spontaneously occurring and artificially produced hybrids *Populus deltoides x Populus nigra* point to the possibility of achieving the heterotic effects in black poplars (GUZINA *et al*., 1996).

The reproductive heterosis of forest trees became increasingly important when LARSEN (1956), through his theoretical and practical activities, developed the method of production of forest seeds in seed orchards, which has been widely accepted throughout the world.

Hybrid vigour in general in woody plants has a high significance, especially because parent plants can be cloned by autovegetative and heterovegetative reproduction and used for mass production of heterotic seeds in the specialised seed orchards. The previous research shows generally that the levels of heterosis realised in seed orchards are not maximal.

MATERIAL AND METHOD

By the application of different levels of selection – group and individual, half-sib lines were selected based on the morphological variability of habitus and in them the parental genotypes, based on the yield regularity and morphometric characteristics of the cones, among which controlled hybridisation was performed by the method of incomplete diallel crossing (ŠIJAČIĆ-NIKOLIĆ, 2001). The aim of this study is to determine the occurrence and magnitude of heterotic effect between hybrid combinations and parent individuals obtained by free pollination in the Serbian spruce seedling seed orchard at Godovik.

The magnitude of heterotic effect was determined between hybrid combinations and parent individuals obtained by free pollination, by the following model:

P:	A X S	X	B X S
F_1:		A X B	

A X S – mother obtained by free pollination
B X S – father obtained by free pollination
A X B – hybrid combination.

Heterotic effect was calculated in relation to the average parent, for three hybrid cone characters: cone length and width and average number of seeds per cone, according to the formula (MLADENOVIĆ-DRINIĆ, 1995):

$$H(pr) = \xi F_1 - \frac{P1 + P2}{2}$$

$$H(\%) = \frac{Hpr}{Xpr} 100$$

where:

F_1 – mean value of the hybrid combination
$P1$ – mean value of one parent
$P2$ – mean value of the other parent
Xpr – mean value of the parental average

Also, “positive” and “negative” heterosis was recorded in the cases when hybrid cones by their analysed characters, were superior to the better parent, i.e. inferior to the poorer parent.

RESULTS AND DISCUSSION

Of the 26 analysed hybrid combinations, heterotic effect occurs in 13 combinations by some of the study characters, which is half of the total number of the combinations (Table 1).

For cone length, heterotic effect was identified in 8 combinations, which accounts for 30.77% of the total number of crossings. The "positive heterosis" was identified in 3 combinations (11.53%), while the "negative heterosis" was identified in 8 combinations (30.77%). The values of heterotic effect for the study character are very much variable and range from 0.81% in the combination 1C4/3 X 1A1 to 22.46% in the combination 1B1/1X1F7/1.

Cone width is the character for which heterotic effect occurred in five hybrid combinations, which accounts for 19.23% of the total number. “Positive heterosis” was identified in one combination and “negative heterosis” in 11 combinations. The magnitude of heterotic effect ranges between 2.86 and 13.82%.

Seed number per cone is the character for which heterotic effect was recorded in the highest number of combinations. Of 26 combinations, heterotic effect was recorded in 12 combinations, which amounts to 46.15%. The magnitudes of heterotic effect range between 1.63 and 124.64%. “Positive” heterosis occurred in 5 hybrid combinations, and “negative” heterosis was recorded in 7 hybrid combinations.

Table 1. Heterotic effect in hybrid combinations

HYBRID COMBINATION	CONE LENGTH			CONE WIDTH			NUMBER OF SEEDS PER CONE		
	+ heterosis	- heterosis	H	+ heterosis	- heterosis	H	+ heterosis	- heterosis	H
1C2/1X1A1			-3.02			-20.24			-36.63
1C2/2X1F7/2	*		3.16			-22.07	*		80.05
1C2/2X1A1	*		17.78			-1.03	*		124.63
1C2/3X1F1/3		*	-20.79		*	-3.022		*	-61.96
1C2/3X1F7/3		*	-13.45		*	-17.04		*	-85.41
1C2/3X1A1			-10.12		*	-23.88		*	-65.74
1C2/4X1A1			8.81	*		10.36			66.31
1C4/1X1F7/3			-5.97		*	-15.57			-22.94
1C4/1X1A1			12.43		*	-11.81	*		85.37
1C4/2X1F7/2		*	-25.25		*	-17.22		*	-41.24
1C4/2X1A1		*	-11.72		*	-21.40			-50.28
1C4/3X1F7/3			-9.50			-0.30		*	-45.39
1C4/3X1A1			0.81			-4.04			1.64
1C4/3X1F1/3			-5.76			13.82			-5.36
1B1/1X1F7/1	*		22.46			-11.71			38.43
1B1/1X1A1			8.71			2.86			45.64
1B1/2X1F7/2		*	-28.80		*	-10.73		*	-46.00
1B1/2X1A1		*	-17.18		*	-25.82			-40.37
1B1/3X1F1/3		*	-9.38			6.17			14.33
1B1/3X1F7/3		*	-14.61			-10.28		*	-31.01
1B1/3X1A1			-4.32			-4.21			37.96
1B1/4X1A1			3.13			-1.18	*		75.76
1D1/1X1F7/1			-12.95		*	-16.79			-8.79
1D1/1X1A1			-2.01		*	-15.29			6.01
1D1/2X1A1			-8.41			-19.63			-31.85
1D1/4X1A1			-0.36			7.29	*		100.54

The comparative analysis of the combinations with the heterotic effect shows that the heterotic effect is most often expressed for two characters in the same combination (in 7 combinations). Only two hybrid combinations show heterotic effect for all the three study characters (1C2/4 X 1A1 and 1B1/1 X 1A1). The heterotic effect in hybrid combinations most frequently occurs for cone length and the number of seeds per cone (in 8 combinations), which is the consequence of the high degree of correlation between these characters.

Based on the analysis of hybrid combinations with the heterotic effect, it can be concluded that of altogether 13 combinations with the heterotic effect in some of the analysed characters, in 9 combinations the pollinator was the individual 1A1 (*var. borealis*), while in four combinations the pollinator was some of the individuals in the line 1F7, i.e. 1F1 (*var "argentea"*). Mother individuals in these hybrid combinations most often belonged to the lines 1C2 and 1C4 (*var. serbica*), 1B1 (*var. semidihotomy*) and 1D1 (*var."nana"*).

CONCLUSION

The study results show that the heterotic effect is expressed in those combinations in which parental individuals are phenotypically most different, as it is the case in the combinations of individuals which have a typical habitus of Serbian spruce and those whose habitus is very similar to spruce, or in the combinations of individuals with «false dichotomy» and those with a typical spruce habitus. According to the concept of the hypothesis of physiological stimulation reported by Shell, Ist and Hajs (TUCOVIĆ, 1990), which explains the genetic nature of heterosis, the hybrid vigour of F_1 generation results from heterozygosity (diversity) created by the crossing of genetically different organisms, such as various inbreeding lines, varieties, subspecies or species. Heterozygosity conditions the stimulation effect on the development of the corresponding characteristics of the hybrid organism, and it can also condition the increase of the productive vigour of the hybrids compared to the parental organisms. Such an effect can be especially expressed in the trees which differ most among themselves, conditioning the complementary effect in biochemical sense, in which the effect of harmful recessive mutations is suppressed by the dominant genes of both parents (TUCOVIĆ, 1990).

The hybrid combinations characterised by heterosis, if also characterised by high mean values of the analysed characters, in future can be the basis for the mass production of Serbian spruce hybrid seeds in the specialised seed orchards of the next generations.

Seed production by Serbian spruce spontaneous hybridisation is based on seed stands seed orchards, and the specialised seed orchard at Godovik. Its further improvement should be realised by: the establishment of experimental seed orchards of the second and subsequent generations; testing the hybrid combinations obtained by free pollination at the parental and intermediary sites, by testing the progeny of full sibs, and by the establishment of commercial biparental (line or biclonal) seed orchards from parent trees with the best general and specific combination capacity.

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PROCENA HETEROTIČNOG EFEKTA KOD HIBRIDNIH KOMBINACIJA SRPSKE OMORIKE

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Izvod

U oplemenjivanju biljaka posebno mesto ima izučavanje hibridne snage ili heterozisa. Kod drvenastih vrsta, utvrđivanje hibridnih kombinacija u kojima se ispoljava heterotični efekat, od velikog je značaja za proizvodnju hibridnog semena u specijalizovanim semenskim plantažama. Pojava i veličina heterotičnog efekta utvrđena je između hibridnih kombinacija i roditeljskih individua, dobijenih slobodnim oprašivanjem u generativnoj semenskoj plantaži omorike u Godoviku. Efekat heterozisa je analiziran za dužinu, širinu šišarica i prosečan broj semenski po jednoj šišarici. Dobijeni rezultati pokazuju različite vrednosti heterotičnog efekta, kako u odnosu na istu osobinu u različitim hibridnim kombinacijama, tako i u odnosu na različita svojstva jednog istog hibrida. Pored pozitivnog, evidentirane su i hibridne kombinacije sa negativnim vrednostima heterotičnog efekta. U daljem radu, hibridne kombinacije u kojima su konstatovane visoke vrednosti heterotičnog efekta, za jedno ili više analitziranih svojstava, treba da posluže kao osnova za dalje oplemenjivanje vrste.

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