Thaiszia, Košice, 1:113-118, 1991

Utilization of introduced species of firs (*Abies* sp.) in artificial hybridization

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KORMUŤÁK A. (1991): Utilization of introduced species of firs (*Abies* sp.) in artificial hybridization. - Thaiszia, Košice, 1:113-118. ISSN 1210-0420.

ABSTRACT: The hybridological relationships within selected group of fir species (*Abies* sp.) were tested by means of artificial hybridization of five European and two North American representatives of firs. The highest degree of crossability was typical for the interspecific combination of *A. concolor* x *A. grandis* reaching on average 3.80 %. The mutual compatibility of European representatives of firs has varied considerably ranging within the limits of 0.51-2.61 %. Of the eight interspecific combinations tested the heterotic growth was displayed by the three combinations of species (*A. concolor* x *A. grandis*, *A. cephalonica* x *A. nordmanniana*, *A. pinsapo* x *A. alba*) whose progeny had surpassed at the stage of 1-year old seedlings the offspring of the corresponding maternal species from self-pollination.

KEYWORDS: *Abies* species, crossability, hybrid seeds

Introduction

The European silver fir (*Abies alba* Mill.) as the only representative of the genus *Abies* in Central Europe poses a serious problem to our forestry, mainly because of its extensive withering throughout the whole territory of Slovakia. The genetic interpretation of this phenomenon emphasizes the inbred nature of the natural populations of the European silver fir as the primary cause of its wasting away. The production of hybrid seeds on the basis of interspecific hybridization is offered as a possible solution of this problem (VINCENT and KANTOR 1971). Introduction of the foreign species of firs and their involvement into hybridization with the domestic silver fir along with their mutual intercrossing is regarded in this connection to be one of

the promising approaches to preservation of the fir stands in our forests (KORPEĽ and al. 1982). BENČAŤ (1982), for example, recommended the introduction of the white fir (*A. concolor*), the grand fir (*A. grandis*) and Caucasian fir (*A. nordmanniana*), whereas HOLUBČÍK (1968) and TOKÁR (1973) extended the list of suitable species also to the Greek fir (*A. cephalonica*) and cilician fir (*A. cilicica*) both of which display equally good performance under climatic conditions of Slovakia.

The combining abilities of all these species as the main prerequisity of their utilization in a large-scale hybridization were tested by the artificial hybridization of individual pairs of species with the objective to reveal the most efficient combinations of species which produce the reasonable amounts of hybrid seeds. In addition, the performance of interspecific hybrids was followed and compared at the seedling stage.

Material and methods

The experiment with artificial hybridization of firs was performed in Arboretum Mlyňany where a relatively rich collection of *Abies* species is located. Of the species growing here the European silver fir (*A. alba* Mill.), the Caucasian fir (*A. nordmanniana* (Stev.)Spach), the Greek fir (*A. cephalonica* Loud.), the cilician fir (*A. cilicica* (Ant. et Kotschy) Carr.), the Spanish fir (*A. pinsapo* Boiss.), the white fir (*A. concolor* (Gord. et Glend.)Lindl.), and the grand fir (*A. grandis* (Dougl.) Lindl.), respectively, were used.

The combinations in which the combining abilities of individual species were tested are given in Tab. 1. As a control to the interspecific crossings served the variants with self-pollination of the maternal trees. The artificial pollination was carried out according to the procedure described earlier (KORMUŤÁK 1985). The degree of mutual crossability of individual pairs of species was estimated according to the proportion of fully developed seeds within the sample of 400 seeds (Czechoslovak standard ČSN 48 1211) using the formulae

$$\frac{\text{number of filled seeds from interspecific crossing}}{\text{number of filled seeds after selfing}}$$

The differences in quality of seeds between the variants from intra - and interspecific crossings were verified by Z-test (ŠMELKO and WOLF 1977), whereas the differences in the height parameters of 1-year old seedlings by t-test (DUBOVSKÝ 1969).

Combinations of species	Number of pollinat. female strobili	Number of collect. mature cones	Percentage of filled seeds	Degree of crossa-bilities
Abies concolor -self	132	132	8.00	
A. concolor x *A. grandis*	359	359	31.00^{++}	3.80
A. alba -self	30	25	24.00	
A. alba x *A. cilicica*	67	56	33.75^{+}	1.40
A. cephalonica -self	10	10	12.25	
A. cephalonica x *A. alba*	42	22	7.75^{+}	0.63
A. cephalonica x *A. nordmanniana*	15	15	6.25^{+}	0.51
A. cephalonica x *A. cilicica*	20	15	32.00^{++}	2.61
A. pinsapo -self	20	17	28.75	
A. pinsapo x *A. alba*	91	48	35.50^{+}	1.23
A. pinsapo x *A. cilicica*	30	18	29.50	1.02
A. pinsapo x *A. cephalonica*	35	24	27.75	0.96

Statistical significance of deviations from the selfed control corresponding to $p<0.05$ ($^{+}$) and $p<0.01$ ($^{++}$)

Table 1. The results of artificial hybridization of selected group of fir species

Results and discussion

All the interspecific combinations of firs tested so far proved to be compatible but the degree of compatability differed between them profoundly. It is evident from Tab. 1 that the highest affinity exists between the North American species of *A. concolor* and *A. grandis* the intercrossing of which resulted in 31 % yield of sound seeds as compared with only 8 % of filled seeds obtained after selfing of the maternal species. The calculated degree of mutual crossability reached the level of 3.8 %. At the seedling stage the interspecific hybrid of *A. concolor* x *A. grandis* surpasses by its height growth (x=10.7 cm) the seedlings from a selfed control (x=7.4 cm) which may be taken as additional evidence of a highly heterotic nature of this interspecific crossing. With respect to this fact it is desirable to introduce both these species to our forests not separately but in the form of mixed stands what is the only way how to ensure the regular production of hybrid seeds of this interspecific combination.

Relatively high genetic affinity has also been revealed between the species of *A. alba* and *A. cilicica*. The crossing of our domestic species with the representative of the genus in Minor Asia resulted in 1.4 % of crossability of *A. alba* x *A. cilicica* combination. The higher quality of hybrid seeds than that of the seed offspring from selfing of the European silver fir (Tab. 1) has however contrasted with a better performance of 1-year old seedlings of *A. alba* from selfing. The latter variant reached on average 5.0 cm height as compared with 4.2 cm height of the interspecific hybrid (Tab. 2).

Of the three interspecific variants tested in combination with the maternal species of *A. cephalonica* only the interspecific combination of *A. cephalonica* x *A. cilicica* yielded a higher proportion of fully developed seeds (32 %) than a control from self-pollination of *A. cephalonica* (12.25 %). The genetic affinity of both the above species is characterized by 2.61 % of their crossability. The two remaining combinations, i.e., *A. cephalonica* x *A. alba* and *A. cephalonica* x *A. nordmanniana* have not reached even the efficiency of a selfed control, producing only 7.75 and 6.25 % of sound seeds and reaching, respectively, the degree of crossability of 0.63 and 0.51 % (Tab. 1). In contrast with the differences observed at the seed level the performance of seedlings of all the interspecific crosses and those from selfing of *A. cephalonica* was relatively uniform. The corresponding parameters ranged within the limits of 4.3-4.8 cm and were not statistically significant (Tab. 2).

Type of crosses	n	$\bar{x}$ (cm)
A. concolor - self	100	7.4±2.31
A. concolor x A. grandis	100	10.7±0.76
A. alba - self	100	5.0±1.02
A. alba x A. cilicica	100	4.2±0.80
A. cephalonica - self	20	4.6±3.35
A. cephalonica x A. alba	94	4.3±0.09
A. cephalonica x A. nordmanniana	42	4.8±2.05
A. cephalonica x A. cilicica	100	4.3±1.20
A. pinsapo - self	100	5.0±0.97
A. pinsapo x A. cilicica	100	4.6±1.03
A. pinsapo x A. alba	100	5.5±1.51
A. pinsapo x A. cephalonica	100	4.4±1.10

Table 2. The height growth parameters of 1-year old seedlings of some interspecific crosses and the corresponding control from self-pollination

Comparable results were obtained from the crosses of *A. pinsapo* with the domestic species of *A. alba* and those of *A. cilicica* and *A. cephalonica*. The minor differences observed in quality of seed progenies of *A. pinsapo* x *A. alba* (35.5 % of filled seeds), *A. pinsapo* x *A. cilicica* (29.5 %) and *A. pinsapo* x *A. cephalonica* (27.75 %) combinations correlated with the relatively stable hybridological abilities of the species involved (0.96 - 1.23 % of crossability). However, at the seedling level the interspecific combination of *A. pinsapo* x *A. alba* has surpassed by its height parameters ($\bar{x}$=5.5 cm) the two remaining crosses reaching on average only 4.4-4.6 cm (Tab. 2).

As a summary we can state that the results presented so far are in accordance with suggestions of our authors (KORPEĽ and al. 1982) concerning utility of foreign species of firs in increasing the genetic variability of degenerating silver fir in our country as well as with the suggestion of MAYER (1981) postulating the perspective of a large-scale introduction of the interspecific hybrids of *A.* x *borisii-regis* (*A. alba* x *A. cephalonica*), *A.* x *bornmuelleriana* (*A. cephalonica* x *A. nordmanniana*) and *A.* x *equi-trojani* (*A. cephalonica* x *A.* x *bornmuelleriana*) to Central Europe.

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Accepted 14 January 1991