

INTERSPECIFIC HYBRIDIZATION IN SUNFLOWER BREEDING

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INTRODUCTION

The study of the genetic potential of the wild species of different genera to which the cultivated plants belong becomes more and more important.

The genus *Helianthus* includes a great number of species, some of which are of special interest for including them in hybridization with cultivated sunflower as sources of genes conditioning earliness, disease resistance, better oil quality, higher protein content etc. (Pustovoit 1960, Pustovoit 1966, 1968, 1975, Georgieva-Todorova 1976, 1979). On the other hand, the interspecific hybridization might be used as a source for obtaining forms with cytoplasmic male sterility (Leclercq 1971).

The aim of our investigations on utilization the wild *Helianthus* species in hybridization with cultivated sunflower, carried out for more than 20 years, is to study the genetic relationship between them, applying such criteria as crossability, characteristics of the F₁ hybrids, the meiotic behaviour of the chromosomes in F₁ and F₂ hybrids, morphology of the chromosomes and the karyotype, to study the formation process with regard to obtaining forms with valuable biological and economic properties. The present paper is a brief report only on some of these results.

MATERIAL AND METHODS

Over the years of study, different wild *Helianthus* species were included in hybridization work with cultivated sunflower. From the annual species *H.debilis*, *H.argophyllus*, *H.ruderalis*, *H.bolanderi* (all

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diploid with $2n = 34$) were used, and from the perennial diploid species ($2n = 34$) —*H.mollis*, *H.grosseseratus*, *H.maximiliani*, *H.nuttallii*, *H.giganteus*, *H. divaricatus*. From the hexaploid species ($2n = 102$) *H. tuberosus* and *H.rigidus* were included and from the tetraploid species ($2n = 68$) the following species: *H.decapetalus*, *H.hirsutus* and *H.scaberimus*. The hybridization was carried out with pre-castration of the mother plant, because our investigations on the self-compatibility of more than 25 *Helianthus* species, including the above mentioned ones showed that nearly all of them manifested some (though very low) self-compatibility. The hybrids were studied in regard to a complex of properties: morphology, duration of the growing period, character of the meiosis in PMCs, viability of the pollen, fertility of the plants, oil content in the seeds. The most perspective of them were studied also in regard to the content of high butyric acids and disease resistance.

RESULTS AND DISCUSSION

The realization of the wide hybridization program showed that in most cases the crossing of the cultivated sunflower with the wild *Helianthus* species was difficult. Less expressed barriers of incompatibility were found to exist between the species *H.annuus* and the annual species *H.debilis*, *H.argophyllus* and *H.bolanderi*. The degree of crossability in these cases reached 85%. The F_1 hybrids showed intermediate inheritance and in most cases resembled the wild parent. The meiosis in the PMCs was near the normal. The repeated backcrossing with pollen from the cultivated species *H.annuus* till BC7 lead to obtaining of plants of a completely cultivated type, differing from the type of the initial variety "Peredovik" both in general phenotype and some biological properties, the most characteristic of which is their earliness. The earliest ripening which are of particular interest for sunflower breeding in this respect are 15-20 days earlier than "Peredovik". The seeds from this material are with 46-53% oil content. From the hybridization of *H.annuus* x *H. bolanderi* elite material has been selected which is included into preliminary variety testing.

Our repeated efforts to cross *H.annuus* with the perennial diploid species *H.salicifolius*, *H.giganteus*, *H.maximiliani*, *H.divaricatus*, *H.nuttallii* were unsuccessful. Partial hybridization has been successful between *H.annuus* and *H.grosseseratus*. The most characteristic feature of these hybrids was their viability (in some cases the stem height reached 3 meters). The rich foliage makes the plants

interesting for sunflower breeding and its utilization as fodder. In F₂ of this cross appeared plants with full pollen sterility. The meiosis in PMCs was normal, but with non-viable pollen. The further behaviour of these plants showed that sterility was CMS, and they served as initial material for the CMS-type of sunflower obtained by us. This type combines good biological and economic characters. Its comparatively early with a medium-high stem, diameter of the disc 20-25 cm and oil content in seeds about 46-48%. Now this type of sunflower is being tested to estimate its combining ability and we are trying to find restorers of fertility.

Later generations of the same combination gave plants, some of which served as initial material for obtaining a sunflower variety with high oil content in the seeds. Table 1 presents the characteristics of this variety which has been submitted for state variety testing. Its average seed yield per hectare for 3 years exceeds that of "Peredovik" with about 15%, and the oil yield with 18%. The most outstanding feature of this new promising variety n^o 1114 obtained by interspecific hybridization, is the higher content of linolic acid in seed exceeding that of "Peredovik" with an average of about 7%, which makes it interesting for the oil industry. Unfortunately however its stem is very high and the vegetation period longer — properties, inherited from the wild species. When tested to downy mildew resistance it manifested sensibility and only a small percent was resistant.

The hybridization of *H.annuus* with the tetraploid species *H.scaberimus*, *H.decapetalus* and *H.hirsutus* also appeared to be very difficult. The incompatibility between the cultivated sunflower and the above, mentioned species was expressed in the low crossability and especially in the almost complete seed sterility. The small number of F₁ plants obtained from the combination *H.annuus* × *H.decapetalus* and *H.annuus* × *H.hirsutus* are the first hybrids produced from crosses between the cultivated sunflower and the mentioned species. These hybrids behave as the perennial parent does, but according to phenotype they occupy an intermediate position. The meiosis in the PMCs of the hybrids *H.annuus* × *H.hirsutus* proceeds with great disturbances. In spite of the repeated backcrossing with cultivated sunflower the seed sterility could not be overcome. It was as late as in 1978 that four seeds were obtained. As a result of their cultivation in an artificial nutrient medium the first hybrid F₂ plants *H.annuus* × *H.hirsutus* were produced.

The crossability of *H.annuus* with the tetraploid species *H.decapetalus* was also very low. The F₁ hybrids were of intermediate type

with slightly branched stem and very small inflorescences: from 5 to 12 cm. in diameter. The plants developed after the type of the perennial parent and bloomed at the same time. After backcrossing with cultivated sunflower some plants gave a few seeds, a total of 12, but only 4 of them reached full maturity. In F₃ these plants produced progenies differing from the initial species. The hybrids were very viable, with large firm leaves and comparatively big inflorescences. Their most characteristic feature was that they grew and developed in almost the same way as the annual parent and their inflorescences were greater in diameter —12-15 cm. Single hybrids from this cross, when tested, manifested resistance to *Plasmopara helianthi*, *Verticilium dahliae*.

In F₄ a total of about 700 plants is grown, which give us a chance to carry out more detailed genetic analysis, paying special attention to such features as disease resistance and oil content.

The hybridization of the cultivated sunflower *H.annuus* with *H.scaberimus* was successful only when the species with higher level of polyploidy was used as female parent. The obtained a few F₁ are hybrids of intermediate type, but closer to the female parent and completely sterile. All our efforts to overcome the complete sterility by applying different methods remained unsuccessful so far. As a result of the introduction of embryo cultures into nutrient medium we obtained callus and regenerates. From crossing *H.annuus* with hexaploid species till now only hybridization of *H.annuus* with *H.tuberosus* was successful. As far as these results are reported in another paper I am not going to discuss them. I should like only to underline that the resistance of the hybrid species to downy mildew is closely related to the meiotic behaviour of the chromosomes and their number: The closer to the cultivated sunflower it stands, the less resistant the hybrids are (Fig. 1).

CONCLUSION

The data presented as well as our whole hybridization work show that crosses of *H.annuus* with some wild *Helianthus* species result in hybrids with several valuable properties utilizable in sunflower breeding. The basic conclusion is that *H.annuus* is in a very close genetic relationship only to the annual species *H.argophyllus*, *H.debilis* and *H.bolanderi*. Evidence of this is presented by the comparatively regular meiosis, the high pollen viability of F₁ hybrids, as well as the high fertility. *H.bolanderi* may be used as a source of

genes determining earliness, a characteristic which remains even after several back crosses with cultivated sunflower.

H. annuus manifests a very low degree of compatibility with the perennial diploid species, belonging to different taxonomic sections. With some perennial species, such as *H. salicifolium*, *H. augustifolium*, *H. nuttallii*, *H. argophyllus* and *H. divaricatus*, *H. annuus* shows complete incompatibility. Some forms resulted from the hybridization with the diploid perennial species *H. mollis* and *H. grosseserratus*, which are of interest for applied sunflower breeding in view of their seed-oil content, seed yield per hectare, linolic and protein content etc. Materials of particular interest in regard to disease resistance were obtained for the first time by hybridization between *H. annuus* × *H. decapetalus*, *H. annuus* × *H. hirsutus* after repeated backcrosses and overcoming the sterility of the hybrids and by using them in sunflower breeding. Our investigations showed also that by using other species (such as *H. grosseserratus*) in hybridization with cultivated sunflower CMS forms may be obtained which could be utilized also for breeding work.

Irrespective of all that, it is wrong to think that the utilization of the wild *Helianthus* species in hybridization work with cultivated sunflower leads to quick obtaining of forms valuable for breeding. In view of the fact that most of the wild *Helianthus* species are branched, with small inflorescences, small and easily seeds and a number of other undesirable features, which are in most cases dominantly inherited, the difficulties proceeding from their using in hybridization with cultivated sunflower should be also taken into consideration. In this respect our attention is focused on their utilization for creating forms with high content and better quality of the oil, i.e. increased content of linolic and oleinic acid.

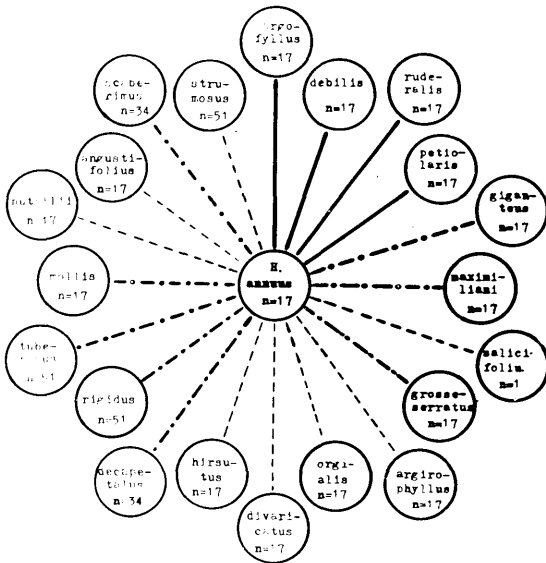
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TABLE 1

Seed and oil yield in kg/ha in variety "III4"

year of variety trials		seed yield c/ha		oil content %	oil yield c/ha		content of the linoleic acid. % of respect in dry seed / check /
		kg/ha	% in respect in dry seed / check /		kg/ha	% in respect in dry seed / check /	
1977	"III4"	2371,70	116,41	53,97	1280,00	116,52	—
	"Peredovik" / check /	2030,30	100,00	53,92	1098,50	100,00	—
1978	"III4"	2987,40	126,44	49,26	1471,60	126,49	108,00
	"Peredovik" / check /	2362,70	100,00	49,21	1163,40	100,00	100,00
1979	"III4"	1754,30	103,54	48,35	848,20	111,70	106,70
	"Peredovik" / check /	1694,30	100,00	44,87	760,20	100,00	100,00
AT AU AVERAGE							
	"III4"	2371,10	115,46	50,52	1199,90	118,19	107,35
	"Peredovik" / check /	2031,40	100,00	49,33	1007,30	100,00	100,00

Fig. 1. Polygon for the crossability of *H. annuus* with the different wild species *Helianthus*.