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INTERSPECIFIC HYBRIDIZATION IN SUNFLOWER BREEDING FOR ECONOMICALLY VALUABLE CHARACTERISTICS

N.P. Tavoljanskiy, A.N. Tavoljanskiy, P.V. Chiryaev and V.T. Tikhomirov*

Veidelevka Institute of Sunflower (VIS), Ltd, Centralnaya 43 "a", Veidelevka, Belgorod region, 309720, Russia

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SUMMARY

The paper described the features of wild sunflower species that are used to develop original material possessing economically valuable and breeding characteristics.

Key words: wild sunflower species, interspecific hybrid, original material

INTRODUCTION

Constant rearrangements of genes into new combinations due to sexual reproduction and accidental mutations, which result either in the occurrence of new genes or in changes of the expression of the already available genes, invariably increase the variability of plants. This process intensifies when plants are grown under different climatic conditions. In the case of cultivated forms and especially lines, the variability is still larger. Basic stock plants had been selected many years ago during the initial stages of cultivation. Natural and artificial selections reduce the originally high genetic potential variability while the amounts of the important genes and characteristics decrease. In our opinion, the best way out of this situation is to include wild types, as sources of numerous economically valuable characteristics, in the breeding of cultivated plants. In the case of sunflower, the wild types have complex resistance to the major sunflower diseases (Tavoljanskiy *et al.,* 2001; Tavoljanskiy *et al.,* 2002).

Wild types can also be used to improve the qualitative composition of oil and increase the protein content in seed. Cytoplasmic male sterility of sunflower was obtained as a result of a phylogenetically distant hybridization with wild forms. Wild annual sunflower serves as a reliable source of genes for male sterility restoration. We should also bear in mind that wild forms are sources of new characteris-

* Corresponding author, e-*mail: msch@mail.ru.*

tics and traits of samples valuable for breeding. All these things determine the importance of the study of wild sunflower forms.

In this connection, together with Prof. A.V. Anaschenko, we have carried out theoretical and practical studies on wild sunflower forms.

MATERIALS AND METHODS

In this study we used 350 samples that are hybrid and self-pollinated offsprings (F_1, VS and F_2), obtained from phylogenetically distant crossing of cultivated sunflower with wild perennial and annual forms. CMS PET-1 type of the following lines: VB 132, VB 246 and VB 4703, was used as a source of sterility (Tavoljanskiy *et al.*, 2001; Tavoljanskiy *et al.*, 2002).

Classification of A.V. Anaschenko (Anaschenko, 1980)

Annual wild types (2n=34)	Perennial types (2n=34)
Helianthus annuus L.	*H. mollis*
subsp. *annuus*	*H. angustifollius*
subsp. *lenticularis*	subsp. *nuttali*
var. *argophyllus*	subsp. *giganteus*
subsp. *petiolaris*	*H. divaricatus*
var. *debilis*	*H. strumosus* (2n=68)
var. *niveus*	*H. tuberosus* (2n=102)
H. praecox	
H. paradoxus	

As a result of the experiments on interspecific hybridization and analyses of F_1, F_2 and VS_1 hybrid plants, we came to the conclusion that the pollen of diploid and tetraploid perennial types that were used as male parents in crosses with annual types often has the stimulating effect only. This stimulation promotes self-pollination, mitigating to a certain degree the effect of self-incompatibility. As a result, there appear the so-called "false" hybrids, obstructing all subsequent work. Even invalid conclusions can be made. So, the whole work on interspecific hybridization is carried out with preliminary castration of the female parent or with the sterile forms.

RESULTS AND DISCUSSION

When crossed in the type "perennial × annual" under optimum conditions, usually 1-2%, in exclusive cases 5%, of hybrid achenes formed ovaries. With hexaploids, especially *H.tuberosus*, this factor increases largely, reaching the maximum of 33%. However, these combinations often produce a small number of hybrid plants which are basically sterile and unable to produce seeds when backcrossed.

A study of perennial varieties and their hybrids under field conditions showed that the root systems of all diploid forms were almost identical - the root is fibrous,

dense, with numerous root hairs. Tetraploids have a different type of root system. Usually 5-9 large lateral roots are formed while there is no tap root. The secondary root system is also nearly absent. Rhizoids are short and they form late in the season. Hexaploids are remarkable for long rhizoids (0.5-1.0 m) and sometimes tubers. It should be noted that when the number of chromosomes increases the blade also becomes thicker and the midrib is not clearly seen, while the total number of ribs increases.

In our opinion, emphasis during the initial stage of breeding should be placed on wild annual species. Due to good ability to cross with the cultivated forms they can be easily used in concrete breeding programs. They also possess numerous traits and characteristics valuable for breeding, new types of CMS-Rf genes, vertical and horizontal resistance to diseases, etc. (Tavoljanskiy *et al.,* 2001).

Laboratory analyses have shown that the oil percentage of annual wild species is not high. It varies from 25% to 40%, 25% in *H.annuus*, 34% in *H. deserticola*, 37% in *H. petiolaris*, 38% in *H. anomalus* and 40% in *H. niveus*. In our opinion, the low oil percentages in achene are not limiting factors for use of these species in breeding programs, since it can be easily increased by repeated crossings with cultivated forms.

It is better to use sunflower seed oil with high linoleic acid content (more than 70%) in margarine industry. *H. debilis*, which contains up to 77.6% of linoleic acid can be a good source for this purpose.

The following samples have oil with high contents of oleic acid: *H. praecox* - 41%, *H. annuus* - 46%, *H. argophyllus* - 47.5%.

H. paradoxus possesses resistance to soil salinity, which is probably controlled by a single dominant gene. This species is a valuable donor of genes for tolerance to salinity.

H. argophyllus possesses the highest resistance to drought since this species has tomentose silver leaves. The tomentose feature reflects sunbeams and reduces transpiration. The nature of inheritance of this characteristic is probably controlled by a single dominant gene, as the inheritance of this characteristic goes on morphological scheme.

We have also obtained valuable results on genes of pollen fertility restoration (*Rf*) for cytoplasm ret-1 (Table 1).

The study of phenotypic realization of *Rf* genes has shown that it varied from 0% up to 100% and depended upon the plant genotype and the original material used. The original material that has been obtained from phylogenetically remote crossing of cultivated sunflower (lines VB 132, VB 246 and VB 4703 which were used as a source of PET-1) with *H. niveus* had the largest number of restoration determinants of pollen fertility. It was also noted that the farther the wild annual sunflower species are located from cultivated ones phylogenetically, the bigger is the

number of *Rf* genes they have in their genotype. This trait is obviously controlled by not less than 5 genes.

Table 1: Characteristics of the original material of sunflower regarding pollen fertility restoration (VIS, 1998-2002)

Original material (source of CMSp × ...)*	Fertile samples (%)					
	0	1-20	21-40	41-60	61-80	81-100
× *H. annuus*	1.43	1.71	8.85	4.86	2.0	1.14
× *H. lenticularis*	0	0	1.43	1.43	2.0	1.14
× *H. argophyllus*	0	10.86	11.43	8.57	2.0	1.43
× *H. petiolaris*	0	0	2.0	0.86	2.57	1.43
× *H. debilis*	0	0	0	8.57	3.14	2.57
× *H. niveus*	0	0	0	12.29	3.43	2.86
P=4%						

Note: * - the source of CMSp are high-informative lines VB 132, VB 246 and VB 4703

In further research we tried to assess the obtained and original materials for early ripening, general combining ability and autogamy.

Data on the variability of growing season duration are presented in Table 2.

Table 2: Characteristics of the original material of sunflower regarding the duration of the vegetative period (VIS, 1998-2002)

Original material (source of CMS × ...)	Samples (%) with vegetative period (in days)				
	up to 78	79-88 (group - st*)	89-98	99-108	109 and more
× *H. annuus*	5.22	5.72	3.28	1.65	0
× *H. lenticularis*	2.34	3.15	5.83	3.24	0.15
× *H. argophyllus*	0.75	1.83	6.29	7.21	1.93
× *H. petiolaris*	1.07	2.44	6.87	2.97	0.12
× *H. debilis*	0.15	0.93	7.92	7.21	3.02
× *H. niveus*	0.10	0.55	8.21	8.03	1.82
P=4%					

Note: * - Belgorodsky 94 St. - 83 days

The majority of the samples and the original material (62.7%) were early-ripening forms, among which the highest percent (14.2%) was found in the samples obtained by crossing the CMSp source with H. annuus subsp.annuus. A study of the nature of inheritance of the growing season duration showed that this characteristic is inherited mainly intermediately when crossing genetically opposite forms. When crossing closely related forms, inheritance is dominated by parental lines, usually the female line.

It is known that the hybridization of genetically different materials produces the highest heterotic effect. In these experiments, the original material had greatest genetic differences, as confirmed by the data of estimation on general combining ability (GCA) (Table 3).

The largest part of the original material (87.4%) has high (37.47%), good (37.45%) or satisfactory (12.48%) GCA. The original material phylogenetically distant from the cultivated sunflower had top GCA marks.

Table 3: Characteristics of the original material of sunflower regarding GCA (VIS, 1998-2002)

Original material (source of CMS × ...)	Samples (%) with GCA				
	5	4	3	2	1
× *H. annuus*	3.24	3.15	0.93	0.10	2.97
× *H. lenticularis*	5.83	5.22	1.82	0.15	1.55
× *H. argophyllus*	6.29	5.72	1.93	0.75	0.65
× *H. petiolaris*	6.87	7.21	2.34	1.07	0.15
× *H. debilis*	7.21	7.92	2.44	1.83	0.12
× *H. niveus*	8.03	8.21	3.02	3.28	0
P=3.7%					

It is known that the level of autogamy depends on the genotype, but at the same time it is controlled by external conditions (Burlov, 1973). The original material phylogenetically close to the cultivated sunflower had the top level of autogamy (Table 4).

Table 4: Characteristics of the original material of sunflower regarding autogamy (VIS, 1998-2002)

Original material (source of CMS × ...)	Samples (%)				
	high	good	average	low	self-incompa-tible
× *H. annuus*	10.86	8.57	2.57	3.00	0.69
× *H. lenticularis*	8.57	2.86	1.43	1.43	0.50
× *H. argophyllus*	8.85	2.57	2.00	1.71	1.10
× *H. petiolaris*	4.86	2.00	1.14	1.43	2.50
× *H. debilis*	3.43	1.43	1.43	5.0	2.86
× *H. niveus*	3.14	1.14	2.00	6.43	5.50
P=3.7%					

The study of wild species sunflower collection on economically valuable characteristics was an opportunity to start a program of development of original material of selection lines with improved characteristics in the following 8 directions:

1. Contents of linoleic acid - the best source *H. debilis* contains 77.6%;
2. Contents of oleic acid - the best source *H. argophyllus* contains 47.5%;
3. Soil salinity - resistance source is *H. paradoxus;*
4. Drought resistance - the best source is *H. argophyllus*;
5. All annual species possess genes of pollen restoration of CMS-forms. It is herewith noted that the farther wild annual species stand from cultivated forms phylogenetically, the higher the saturation of *Rf* genes;
6. Duration of the growing season - the best source of early ripening is *H. annuus*;

7. GCA - the best source of high combining ability is the wild species which is phylogenetically distant from the cultivated sunflower;
8. Autogamy - the best source of autogamy is the wild species which is phylogenetically close to the cultivated sunflower.

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HIBRIDACIÓN DE INTERESPECIES EN EL MEJORAMIENTO DE GIRASOL EN LAS PROPIEDADES ECONÓMICAMENTE VÁLIDAS

RESUMEN

En este trabajo están descritas las características de las especies silvestres de girasol, que se utilizan para la formación del material original de las características de mejoramiento económicamente válidas.

HYBRIDATION INTERSPÉCIFIQUE DU TOURNESOL CULTIVÉ POUR OBTENTION DES CARACTÉRISTIQUES DE VALEUR ÉCONOMIQUE

RÉSUMÉ

Dans cet article les caractéristiques décrites d'espèces sauvages de tournesol sont celles qui sont utilisées pour la création de matériel des traits de valeur économique.