Investigations on Hybrid Combinations between Cultivated Sunflower and the Wild Species *H.neglectus*, *H.giganteus*, *H.decapetalus* and *H.strumosus*

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Abstract

Conventional crossing methods were used to produce interspecific hybrids between cultivated sunflower and four wild *Helianthus* species - *H.neglectus* (2n=34), *H.giganteus* (2n=34), *H.decapetalus* (2n=68) and *H.strumosus* (2n=102). The investigation was carried out in the Institute for Wheat and Sunflower, Bulgaria. The purpose of the study was to compare the cross compatibility of these species, belonging to different ploidy level groups. Hybridization was made in both directions. When used as maternal parents, best results showed the annual *H.neglectus*. The perennial species represented themselves as difficult background for hybridizing. Greatest number of hybrid plants was obtained with *H.decapetalus*. The cross compatibility was lowest for the diploid perennial species *H.giganteus*. All four species, used as pollinators, showed relatively high compatibility with cultivated sunflower. The annual species *H.neglectus* gave again best results.

Introduction

Use of conventional crossing methods has been sufficient to produce interspecific hybrids between cultivated sunflower and some of the wild species, especially the diploid annuals (Seiler, 1988).

Many of the species in the genus, particularly the perennial species have never been successfully hybridized with the cultivated sunflower (Skoric, 1988).

Whelan (1978) used wild *H.annuus* as an "intermediate" parent to procure the first hybrids between *H.annuus* and *H.giganteus* and *H.maximiliani*. Chandler and Beard (1983), using embryo culture, produced interspecific hybrids *H.neglectus* x *H.annuus* and *H.strumosus* x *H.annuus*. Georgieva-Todorova (1984) produced successful hybridization with *H.decapetalus*, used only as a male parent.

The purpose of our study was to compare the cross compatibility of several *Helianthus* species, belonging to different ploidy level groups and to show the results of the interspecific hybridization with *H.annuus* and the plant characteristics of the obtained hybrid progenies.

Materials and Methods

Four different wild *Helianthus* species were used in the investigation. The wild annual species *H.neglectus* Heiser (2n=34) belongs to Section Annui (Schilling and Heiser, 1981). The diploid perennial species *H.giganteus* L.(2n=34) belongs to Section Divaricati, Series Gigantei and the perennial species *H.decapetalus* L.(2n=68) and *H.strumosus* L.(2n=102) belong to the same Section, Series Divaricati. These species differ in their cross compatibility, when hybridized with cultivated sunflower.

The wild perennial species were maintained and reproduced in a stationary garden in the Collection of wild *Helianthus* species in IWS. *Helianthus neglectus* was reproduced by seed. The accessions, which were used in the investigation have official numbers from the Collection as follows: *H.neglectus* - GT-E-017; *H.giganteus* - GT-M-011; *H.decapetalus* - GT-M-043; *H.strumosus* - GT-M-110 and GT-M-126.

Seeds, identified as accession E-017 of *H.neglectus* were sown in greenhouse in April and were planted on the field at a true leaf stage. For the purposes of the interspecific hybridization seeds from 6 inbred lines and one cultivar of *H.annuus* were sown on the field. Plants were isolated prior to anthesis. A and B lines were used. Plants from the B lines were emasculated. Inflorescence from the wild species were emasculated too. The following cross combinations were made:

H.annuus x *H.neglectus* - E-017
H.annuus x *H.giganteus* - M-011
H.annuus x *H.decapetalus* - M-043
H.annuus x *H.strumosus* - M-110
H.annuus x *H.strumosus* - M-126

and

H.neglectus - E-017 x *H.annuus*
H.giganteus - M-011 x *H.annuus*
H.decapetalus - M-043 x *H.annuus*
H.strumosus - M-110 x *H.annuus*
H.strumosus - M-126 x *H.annuus*

The hybridizations were made in 1993 and repeated in 1994. Self-pollination, sib-pollination and backcrossing were made on the F_1 material, obtained. Detailed morphological phenological observations were done during the vegetation period.

Results and Discussion

The results from the hybridization are presented in Table 1 and 2.

Helianthus neglectus

Rogers, Thompson and Seiler (1982) reported that *H.neglectus* hybridizes easily with

several wild annual *Helianthus* species. Our results showed that *H.neglectus* could not hybridize so easily with cultivated sunflower. Still, when used as maternal parent or pollinator, *H.neglectus* gave best results, compared to the other species in the study. Both types of F_1 hybrids had an intermediary phenotype with predominating features of the wild parent - the brown spotted stem, hispid to hirsute, with long, hard, white hairs; the dense branching at the basil part of the stem; the type of branching; the long peduncle - 50 - 60 cm. The branches formed characteristic swellings at the place, where they were attached to the stem. The shape of the leaves was closer to the cultivated sunflower, but smaller in size, cordate, serrulate, with slightly anthocyanin petioles. Anthocyanin were also the cusps of the disk florets. The inflorescence resembled to the wild parent. *Helianthus neglectus* hybridized easier, when was used as pollinator and the number of F_1 plants produced was greater (Tables 3, 4).

Similar were the results with the perennial species. They also hybridized easier, when used as pollinators. Highest cross compatibility showed the tetraploid *H. decapetalus*.

Helianthus decapetalus

Hybrid F_1 plants were produced in both directions. When *H.decapetalus* was used as maternal parent, all F_1 hybrid plants resembled to the wild parent - they had perennial growth habit and very well expressed heterosis effect. But when *H.decapetalus* was used as pollinator, both annual and perennial F_1 plants were obtained. The number of the perennial hybrids exceeded several times the number of the annuals. All perennial F_1 hybrid plants, except for the great heterosis, looked like the wild parent and produced vital pollen. The annual F_1 plants were also bigger in size than both parents, but almost 2/3 of them were sterile. They stayed closer to the cultivated sunflower in phenotype, but there were several features, very common to the wild species - the slightly anthocyanin stem and petioles, the extremely anthocyanin cusps of the disk florets, the number of the leaves, the branching, the size of the head, etc. Some morphological data is given in Tables 3 and 4.

Helianthus strumosus

Analogous to those were the results with *H.strumosus* - M-110 and M-126. As female parents they produced F_1 hybrids with perennial growth habit, which resembled them in most features. As pollinators they hybridized with cultivated sunflower more readily and as a result F_1 plants were obtained, both annual and perennial. The perennials produced vital pollen and were closer in morphology to the wild parent. The results from the morphological observations are given in Table 3 and 4. The annual hybrid material was similar in phenotype with cultivated sunflower, but there were also some typical for the perennials characters - anthocyanin coloring of the stem, petioles and disk florets; branching; etc. The second hybrid generation of these two accessions of *H.strumosus* consisted of a wide diversity of plants, showing a great rate of segregation. Some morphological data could be found in Table 5 and 6. The plants differed in height, head diameter, branching type, anthocyanin presence or absence, etc. A suc

cessful selection could be made on different characters and this generation could be also used as initial material for the development of new female or restorer lines.

Helianthus giganteus

The only perennial species in the study, which could not produce F_1 plants as a maternal parent was *H.giganteus*. As a pollinator it gave better results. The plants had intermediate phenotype, but they all were annual. A clear heterosis was present. The morphological data is presented in Table 3 and 4. The F_1 plants differed in type of branching. Some of them preserved the branching type of the wild species. Some plants had dark purple colored disk florets and other were almost yellow. The fact that the plants varied even in first hybrid generation is interesting and needs further investigations.

Conclusions

As a conclusion we could summarize the results as follows:
1. When used as maternal parents, the wild annual diploid species gave best results. From the perennial *Helianthus* species, the tetraploid and hexaploid species hybridized easier than the diploid one.

2. When used as pollinators, the wild annual diploid species gave again best results, followed by the tetraploid species. The perennial diploid species hybridized easier as pollinator and larger number of hybrid plants was produces.

3. A conclusion could be made about the F_1 progeny of the tetraploid *H.decapetalus* and the hexaploid *H.strumosus* that one of the characters, which these poliploid perennial species most easily transfer to the hybrid plants is the perennial growth habit.

References

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Table 1A. Hybridization between *H.neglectus, H.giganteus, H.decapetalus, H.strumosus* and cultivated sunflower.

Species	Pollinator											
	line 1607			line 2607			line 1234			line 3064		
	Np	Ns	NF_1	Np	Ns	NF_1	Np	Ns	NF_1	Np	Ns	NF_1
1994												
E-017	5	16	4	5	3	2	6	5	0	5	5	0
M-011	5	4	0	5	7	0	5	33	0	5	9	0
M-043	5	1	0	5	0	0	5	1	0	5	2	1
M-110	5	1	0	5	2	1	5	0	0	5	0	0
M-126	5	4	0	5	13	0	5	2	0	5	5	1
1995												
E-017	-	-	-	5	16	0	5	6	0	-	-	-
M-011	-	-	-	5	17	0	7	14	0	-	-	-
M-043	-	-	-	5	0	0	5	0	0	-	-	-
M-110	-	-	-	5	0	0	5	6	0	-	-	-
M-126	-	-	-	5	0	0	5	4	0	-	-	-

* Np - Number of pollinations;
* Ns - Number of seeds;
* NF_1 - Number of F_1 plants.

Table 1B. Hybridization between *H.neglectus, H.giganteus, H.decapetalus, H.strumosus* and cultivated sunflower.

Species	Pollinator											
	line HA-300			line HA-821			Peredovik cv			Mixed pollen		
	Np	Ns	NF_1	Np	Ns	NF_1	Np	Ns	NF_1	Np	Ns	NF_1
1994												
E-017	5	1	0	5	32	0	5	11	4	5	18	0
M-011	4	25	0	6	21	0	5	9	0	5	7	0
M-043	5	0	0	5	0	0	5	6	0	7	0	0
M-110	5	37	0	5	20	1	5	0	0	5	0	0
M-126	5	1	0	5	6	1	6	3	0	5	1	0
1995												
E-017	8	4	0	6	5	0	7	8	0	5	6	0
M-011	5	1	0	5	2	0	5	5	0	5	1	0
M-043	5	0	0	5	11	1	5	0	0	5	1	0
M-110	5	2	0	5	3	0	5	1	0	5	4	0
M-126	5	1	0	5	0	0	2	1	0	-	-	-

* Np - Number of pollinations;
* Ns - Number of seeds;
* NF_1 - Number of F_1 plants.

Table 2. Interspecific hybridization between cultivated sunflower and *H.neglectus, H.giganteus, H.decapetalus, H.strumosus.*

H.annuus	Pollinator														
	E-017			M-011			M-043			M-110			M-126		
	Np	Ns	F1	Np	Ns	F1	Np	Ns	F1	Np	Ns	F1	Np	Ns	F1
1994															
1607	4	106	15	4	3	0	2	68	12	4	7	2	1	0	0
2607	4	27	15	4	10	0	4	52	10	5	13	7	2	31	1
1234	4	2	1	4	13	6	4	0	0	4	20	3	1	12	1
3064	4	43	8	2	0	0	-	-	-	2	0	0	2	0	0
HA-300	4	11	1	2	1	1	2	2	1	2	2	0	2	1	1
HA-821	2	0	0	2	0	0	1	0	0	-	-	-	-	-	-
Peredovik	2	17	2	2	20	0	-	-	-	2	0	0	-	-	-
1995															
1607	2	96	36	2	0	0	4	75	*	4	17	*	-	-	-
2607	4	32	0	3	3	3	4	3	0	5	42	8	4	18	*
1234	5	64	27	2	30	13	3	12	*	4	23	*	2	8	*
3064	2	12	0	2	1	1	2	70	*	3	0	0	-	-	-
HA-300	4	53	0	5	65	18	3	5	*	4	6	3	2	39	0
HA-821	2	8	0	4	24	6	4	86	*	4	8	3	-	-	-
Peredovik	2	0	0	2	18	2	2	0	0	2	34	3	-	-	-

Np - Number of pollinations; Ns - Number of seeds; NF_1 - Number of F_1 plants.
* - Plants with perennial growth habit + annual plants.

Table 3. Morphology of some characters of the plants, investigated, 1995

Material	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Nr. of I class branches	Length of the longest branch (cm)	Stem thick ness (cm)
Hybrid combinations							
1234 x E-017	180	10.0	7.3	4.8	13	111.1	1.9
1234 x M-011	222	34.3	40.7	24.0	13	132.0	4.1
1234 x M-043	170	38.0	36.0	19.0	2	110.0	3.3
*	220	18.0	15.5	7.0	17	170.0	2.1
1234 x M-110	215	42.0	48.0	17.0	0	0	4.0
*	125	15.0	10.0	4.0	2	79.0	0.7
1234 x M-126	270	36.5	34.5	16.0	15	192.0	4.3
*	170	22.0	17.0	6.5	17	152.0	1.8
Wild *Helianthus* species							
E-017	130	5.5	3.3	2.7	11.3	112.0	1.7
M-011	238	12.0	3.3	2.0	44.0	37.0	1.2
M-043	180	11.2	5.2	1.5	15.0	82.0	1.0
M-110	159	18.8	8.3	1.4	11.0	79.0	0.9
M-126	240	14.2	9.7	2.5	24.0	100.0	1.3
Cultivated sunflower - *Helianthus annuus*							
line 1234	113	28.4	24.8	15.6	0	0	2.2

Table 4. Morphology of the inflorescences of the investigated material, 1995

Material	Head diameter (cm)	Head thickness (cm)	Nr. of bract leaves	Length of bract leaves (cm)	Width of bract leaves (cm)	Nr. of ray floret	Length of ray florets (cm)	Width of ray florets (cm)	Colour of the stigma
Hybrid combinations									
1234 x E-017	7.2	0.7	40.0	2.5	1.1	24	5.2	2.3	black
1234 x M-011	20.7	2.0	66.0	6.2	2.9	47	6.5	2.2	black
1234 x M-043	13.0	1.5	53.0	4.0	1.9	37	6.5	2.0	black
*	5.0	1.5	30.0	3.4	1.0	12	6.0	2.0	black
1234 x M-110	37.0	3.0	85.0	7.2	2.4	51	6.5	1.9	anth.
*	4.0	1.5	32.0	2.3	0.9	21	4.0	2.2	black
1234 x M-126	22.0	3.0	54.0	6.1	2.6	43	5.5	1.9	anth.
*	4.0	1.5	30.0	3.0	0.5	14	5.2	1.6	black
Wild *Helianthus* species									
E-017	3.0	0.6	34	1.3	0.3	20	2.1	0.9	black
M-011	2.4	0.7	33	1.4	0.2	13	1.5	0.6	black
M-043	1.9	0.6	22	1.8	0.3	8	2.0	0.8	black
M-110	1.0	0.6	24	1.3	0.2	7	2.2	0.5	black
M-126	2.0	0.7	22	1.7	0.4	9	3.7	1.1	black
Cultivated sunflower - *Helianthus annuus*									
line 1234	19.6	2.4	74	6.8	3.4	55	8.0	1.7	black

* - A plant with a perennial growth habit.

Table 5. Morphology of some characters of F2 material investigated (1995)

Material	Nr	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Nr. of I class branches	Length of the longest branch (cm)	Stem thickness (cm)
F_2(HA-821 x M-110)	1	-	-	-	-	-	-	-
	2	270	37	40	19	3	26	4.4
	3	295	28	28	19	8	240	4.0
	4	230	16	11	6	25	160	3.6
	5	320	35	35	27	0	0	4.4
F_2(1234 x M-126)	1	170	22	13	15	15	149	3.2
	2	185	22	17	13	22	91	3.0
F_2(HA-300 x M-126)	1	210	33	39	23	15	115	4.0
	2	165	27	28	19	0	0	3.9
	3	160	27	24	14	0	0	4.2
	4	190	36	35	17	0	0	3.6
	5	-	-	-	-	-	-	-

Table 6. Morphology of the inflorescences of F2 material investigated (1995)

Material	Nr	Head Diameter (cm)	Head thickness (cm)	Nr. of bract leaves	Length of bract leaves (cm)	Width of bract leaves (cm)	Nr of ray florets	Length of ray florets (cm)	Width of ray florets (cm)
F_2(HA-821 x M-110)	1	-	-	34	5.0	2.3	31	7.1	2.3
	2	36	1.5	53	6.9	5.3	42	9.8	2.9
	3	19	1.3	50	7.1	2.5	33	7.8	2.7
	4	16	1.0	44	4.7	2.8	27	6.5	2.2
	5	29	1.7	61	4.7	2.5	33	6.2	2.1
F_2(1234 x M-126)	1	11	1.5	33	3.6	2.8	30	6.8	1.1
	2	12	1.8	56	3.5	1.8	32	5.2	1.7
F_2(HA-300 x M-126)	1	33	1.5	64	3.7	2.1	31	8.0	2.7
	2	32	1.5	73	9.5	3.7	50	10.5	2.7
	3	40	2.5	87	8.0	4.0	57	9.0	2.5
	4	40	2.7	74	7.7	4.3	43	9.2	2.0
	5	-	-	100	7.2	3.9	60	10.5	2.4