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BROOMRAPE RESISTANCE OF SOME BACKCROSS DERIVATIVES OF HA-89 AND THEIR HYBRIDS

Ali Aydin[1], Kayihan Z. Korkut[2]

[1] *Thrace Agricultural Research Institute, P.O. Box 16, 22100 Edirne, Turkey*
[2] *Thrace University, Faculty of Agriculture, Dept. of Field Crops, Tekirdag, Turkey*

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SUMMARY

Seven sunflower female lines, obtained from HA-89 after incorporating broomrape resistance with 3-4 backcrosses using different broomrape resistant sources, were evaluated for development of broomrape resistant hybrids.

Eight female lines (CMS of the maintainer HA-89 and 7 new females), 2 restorers, and their 16 F_1 hybrid combinations were used in the study. Female lines, restorers and their F_1 hybrids were tested against *Orobanche*. Agronomic and quality characterization of the parental lines were also carried out in this study.

Although 7 backcross derivatives of HA-89 were found to be resistant to broomrape, only six of them gave resistant hybrid combinations after crossing with broomrape susceptible restorers. When compared with HA-89, some of the backcross derived female lines were found to be similar or improved for several characters, such as oil content.

Key words: **Sunflower, *Helianthus annuus* L., broomrape (*Orobanche cumana* Wallr.).**

INTRODUCTION

Broomrape resistant sunflower hybrids have been preferred by most farmers in Turkey since the majority of sunflower cultivation area is infested with *Orobanche*. Broomrape resistant hybrids developed at the Thrace Agricultural Research Institute have been obtained by using resistant female lines in their combinations. Since these lines have poor self-compatibility characters in common, their seed production becomes difficult and expensive. This character is also observed in many hybrids developed by using these female lines.

The sunflower female line HA-89 has been utilized in many sunflower breeding programs in the world. It is a selection from VNIIMK 8931 (Brigham, 1988; Korell *et al.*, 1992). Since it is susceptible to broomrape in Turkey, it is almost impossible to make *Orobanche* resistant hybrids with using broomrape susceptible restorer lines in cross combinations (personal observation). But HA-89 has the very good

self compatibility character (Škaloud and Kovačik, 1994) to produce seed. It is possible to incorporate *Orobanche*-resistance into susceptible parental lines, like HA-89, by using backcrossing. It was attempted to obtain *Orobanche* resistant HA-89 type lines by using different broomrape-resistant sources at the Thrace Agricultural Research Institute. After 3-4 backcrosses and selection for *Orobanche* resistance, HA-89 type maintainer lines were obtained. At the same time, they were converted into sterile cytoplasm (PET1) by at least 5 backcrosses to make the CMS lines.

The objectives of this study were: a) To evaluate these female lines and their hybrids after crossing with broomrape susceptible restorers against *Orobanche*; b) To characterize them for agronomic and quality features.

MATERIAL AND METHODS

The experiments were conducted at the Thrace Agricultural Research Institute, Edirne, located in the northwest part of Turkey, in 1992-1993.

Seven broomrape resistance incorporated HA-89-derived lines plus HA-89 itself were used as females (maintainers and CMS counterparts). Two restorers, 0536-R and 3510-R, were used to make hybrid combinations with the 8 females. In 1992, 8 CMS lines and 2 restorers were planted and crossed to get sufficient amount of seeds of 16 F_1 hybrids.

Parental lines and 16 F_1 hybrids were planted in two replications under *Orobanche*-inoculated conditions to test them against broomrape in 1992 and 1993. Each plot consisted of one row, 5 m in length. The distance between rows was 1 m to prevent inaccurate *Orobanche* shoot counts for collecting data. At the physiological maturity stage, sunflower plants, plants parasitized by *Orobanche* (frequency), *Orobanche* shoots per parasitized sunflower plant (intensity) and *Orobanche* shoots per sunflower plant (attack rate) were calculated from the data collected in the field.

Eight female lines (maintainers) and 2 restorers were also planted in a randomized complete block design with 4 replications under non-infested conditions in 1992. The plots consisted of 4 rows, 70 cm apart, and 7.5 m in length while plant-to-plant distance was maintained at 30 cm. The data were collected for achene yield, oil content, days to flowering and physiologic maturity, plant height, head diameter, 1000-achene weight and self-compatibility. Achene yield was taken from heads harvested and threshed from the 2 central rows per plot. The oil content data were obtained by using NMR. Days to flowering and physiological maturity were taken as the number of days from emergence date. Plant height and head diameter were measured at the physiologic maturity time. Five heads were bagged just before flowering on one of the border rows of a plot and the average achene yield of these selfed heads were compared with the 5 open-pollinated heads' average achene yield on the same border row. The ratio of self fertility was taken to determine self-com-

patibility of the parental lines. Variance analysis was calculated through software MSTAT-C version 1.3 developed at the Michigan State University, USA.

RESULTS AND DISCUSSION

Some agronomic and quality features of the female and restorer lines

Maintainers of HA-89 and 7 backcross derivatives, plus 2 restorers, were compared for 8 characters in a randomized complete block design. It was found that there were highly significant differences among these lines and restorers for all characters studied.

Two restorer lines, 0708-R and 3510-R, had the lowest achene yield (Table 1). HA-89 and its backcross derivatives MNT-4, MNT-2, MNT-7 and MNT-3 had the highest achene yields. Oil content of MNT-2 was significantly better than HA-89. Oil content differences between HA-89 and MNT-1, MNT-6 and MNT-4 were not significant ($p \leq 0.05$). Days to flowering of MNT-6 was similar to HA-89. It was 3 days earlier and one day later than HA-89 for the other females. Days to physiological maturity of the lines and restorers were between 100.3 and 107.8 days. While MNT-5 and MNT-2 were 3-5 days later than HA-89, the other female lines had similar physiological maturity dates as HA-89. Among the female lines, MNT-7 was taller and MNT-3, MNT-2, MNT-5 and MNT-1 were shorter than HA-89 ($p \leq 0.05$). Compared with HA-89, except MNT-4, the other six female lines had similar head diameters. Self-compatibility was between 34.40-89.85% among the parental lines. While this character was poor for the restorer 3510-R, there was no difference between HA-89 and its 7 backcross derivative females.

Table 1: Agronomic and quality features of the lines

Line	Achene yield (kg ha^{-1})	Oil content (%)	Days to flower	Days to physiolog. maturity	Plant height (cm)	Head diameter (cm)	1000-achene weight (g)	Self-compatibility (%)
HA-89-B	1621a	45.3 b	69.0 b	102.5 cde	108.3 c	10.4 a	39.5cde	80.8 ab
MNT-1	1334 c	44.4 b	66.0 e	103.0 cd	87.8 e	10.6 a	40.1 cd	72.1 ab
MNT-2	1540 ab	47.0a	66.0 e	105.8 b	93.8 de	11.1 a	50.9 a	55.4 bc
MNT-3	1470 abc	42.1 c	66.0 e	101.3 def	94.3 d	10.2 a	44.7 b	56.8 bc
MNT-4	1560 a	45.6 ab	70.0 a	103.8 c	107.3 c	9.2 b	37.2 e	85.4 a
MNT-5	1367 bc	41.4 c	67.0 d	107.8 a	89.8 de	10.4 a	46.5 b	71.8 ab
MNT-6	1353 c	44.2 b	69.0 b	101.3 def	103.5 c	10.7 a	37.9 de	85.0 a
MNT-7	1479 abc	39.3 de	68.0 c	100.8 ef	132.8 a	10.7 a	41.5 c	90.0 a
0708-R	841 d	39.1 e	65.5 f	100.5 f	115.5 b	7.7 c	19.6 f	68.5 ab
3510-R	698 d	40.8 cd	67.0 d	100.3 f	129.8 a	7.0 c	19.6 f	34.4 c
LSD (0.05)	181.5	1.64	0.26	1.74	6.40	0.95	2.79	25.47
CV	9.42	2.65	0.27	1.17	4.15	6.72	5.10	25.08

Broomrape test results of female and restorer lines

Orobanche resistance incorporated seven HA-89 backcross-derived female lines were found to be resistant to broomrape (Table 2). *Orobanche* shoots were not observed on lines CMS-1, CMS-2, CMS-3, CMS-5 and CMS-7. Although few *Orobanche* shoots were observed on lines CMS-4 and CMS-6, their parasitism scores were within the resistance limits. It was reported that (Uludere *et al.*, 1989) sunflowers with below 10% frequency and 0-1 attacking rate indices were accepted as resistant genotypes. HA-89 was found to be susceptible to broomrape (Table 2). Two restorers, 0708-R and 3510-R, were also susceptible to broomrape.

Broomrape test results of hybrids

Sixteen F_1 hybrid combinations between 8 CMS lines and 2 restorers were tested against *Orobanche* in 1993. The results are given in Table 3.

Table 2: Broomrape test results of female and restorer lines

Line	Total sunflower plants	Plants parasitized by *Orobanche*	Total *Orobanche* shoots	Frequency (%)	Intensity	Attack rate
CMS-HA-89	35	17	38	48.57	2.23	1.09
CMS-1	34	0	0	0	0	0
CMS-2	33	0	0	0	0	0
CMS-3	32	0	0	0	0	0
CMS-4	33	3	9	9.10	3.00	0.27
CMS-5	32	0	0	0	0	0
CMS-6	34	2	2	5.88	1.00	0.06
CMS-7	34	0	0	0	0	0
0708-R	34	15	35	44.12	2.33	1.03
3510-R	33	25	158	75.76	6.32	4.79

The F_1 hybrid combinations of two CMS lines (CMS-5 and CMS-7) with two restorers (0708-R and 3510-R) were free of *Orobanche* infection. CMS-5 and CMS-7 were also found to be resistant to broomrape in previous year. It can be said that these two CMS lines might be of value to utilize in broomrape resistant hybrid breeding programs. Although there was no *Orobanche* infection on lines CMS-1, CMS-2 and CMS-3 in 1992, some *Orobanche* infection was observed in their hybrids with 0708-R and 3510-R in 1993. But the infection indices are accepted within the resistance limits of these hybrids.

CMS-4 and CMS-6 female lines had shown some *Orobanche* infection, but were within the resistance limits in 1992. Their hybrids with the 2 broomrape susceptible restorers were infected with *Orobanche* in 1993. Although parasitism indices for CMS-6 x 0708-R and CMS-6 x 3510-R were within the limits of resistance, higher *Orobanche* scores were obtained from hybrids CMS-4 x 0708-R and CMS-4 x 3510-R. The parasitism index for CMS-4 was the highest among the 7 new CMS lines tested in 1992. We can conclude that *Orobanche* resistance of a line must also

be detected in hybrid combinations, especially using an *Orobanche* susceptible parent as the restorer. Since hybrids with CMS-4 were susceptible to *Orobanche*, this line would not be recommended to be utilized in a breeding program for *Orobanche* resistance.

Table 3: Broomrape test results of F_1 hybrids

Hybrid	Total sunflower plants	Plants parasitized by *Orobanche*	Total *Orobanche* shoots	Frequency (%)	Intensity	Attack rate
CMS-HA 89x0708R	34	13	28	38.23	2.15	0.82
CMS-HA-89x3510R	30	8	17	26.66	2.12	0.56
CMS-1 x 0708-R	34	3	6	8.82	2.00	0.17
CMS-1 x 3510-R	33	3	8	9.09	2.66	0.24
CMS-2 x 0708-R	33	2	5	6.06	2.50	0.15
CMS-2 x 3510-R	33	3	4	9.09	1.33	0.12
CMS-3 x 0708-R	32	3	11	9.37	3.66	0.34
CMS-3 x 3510-R	31	3	6	9.67	2.00	0.19
CMS-4 x 0708-R	33	10	22	30.30	2.20	0.66
CMS-4 x 3510-R	33	4	5	12.12	1.25	0.15
CMS-5 x 0708-R	33	0	0	0	0	0
CMS-5 x 3510-R	33	0	0	0	0	0
CMS-6 x 0708-R	33	1	1	3.03	1.00	0.03
CMS-6 x 3510-R	31	3	10	9.67	3.33	0.32
CMS-7 x 0708-R	34	0	0	0	0	0
CMS-7 x 3510-R	34	0	0	0	0	0

The hybrids with CMS HA-89 were proved to be susceptible to *Orobanche*. Both hybrids, CMS HA-89 x 0708-R and CMS HA-89 x 3510-R, had highest parasitism scores for frequency index.

CONCLUSIONS

It is possible to incorporate *Orobanche* resistance to a line with a limited number of backcrosses (3-4 backcrosses). After incorporating *Orobanche* resistance and 3-4 backcrosses with HA-89, 7 HA-89-type female lines were obtained and converted to CMS cytoplasm. Testing these lines and their F_1 hybrids with 2 *Orobanche* susceptible restorer lines against *Orobanche*, 6 new female lines were found to be resistant and capable of giving *Orobanche* resistant hybrids. When compared with HA-89, some of its backcross derivative female lines were found to be similar or improved for several characters such as oil content.

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RESISTENCIA AL JOPO DE ALGUNOS DERIVADOS DE RETROCRUCES DE HA-89 Y SUS HÍBRIDOS

RESUMEN

Siete líneas hembra de girasol que fueron obtenidas de HA-89, despues de incorporar resistencia a jopo mediante 3-4 retrocruces utilizando diferentes fuentes de resistencia, fueron evaluadas para el desarrollo de híbridos resistentes a jopo. Ocho líneas hembra (CMS y mantenedoras de HA-89 y 7 nuevas hembra), dos restauradores y sus 16 combinaciones híbridas F_1 fueron usadas en este estudio. Las líneas hembra restauradoras y sus híbridos F_1 fueron testados contra *Orobanche*. La caracterización agronómica y de calidad de las líneas parentales fueron tambien llevadas a cabo en este estudio.

Aunque 7 derivados de retrocruces de HA-89 fueron resistentes a jopo, sólo seis de ellos fueron combinaciones híbridas resistentes con restauradores susceptibles. Cuando se compararon con HA-89 algunas de estas líneas hembra derivadas del retrocruce fueron encontradas similares o mejoradas para algunos caracteres como contenido en aceite.

RÉSISTANCE À L'OROBANCHE DE BACKCROSSES DÉRIVÉS D'HA-89 ET DE LEURS HYBRIDES

RÉSUMÉ

Sept lignées femelles de tournesol issues d'HA-89, dans lesquelles on a incorporé diverses sources de résistance à l'orobanche après 3 ou 4 backcrosses, ont été évaluées pour la création d'hybrides résistants à l'orobanche.

Huit lignées femelles (CMS et mainteneurs d'HA-89 et 7 nouvelles femelles), 2 restaurateurs et leurs 16 combinaisons hybrides ont été utilisées dans cette étude. Les lignées femelles, restauratrices et leurs hybrides F_1 ont été testés par l'orobanche. La caractérisation agronomique et la détermination de la qualité des lignées parentales ont été aussi réalisées dans cette étude.

Bien que 7 backcrosses dérivés d'HA-89 aient été trouvés résistants à l'orobanche, seulement 6 d'entr'eux donnèrent des hybrides résistants avec les restaurateurs sensibles à l'orobanche. Comparées à HA-89, quelques lignées femelles dérivées de backcrosses, se sont révélées identiques ou améliorées pour plusieurs caractères tels que la teneur en huile.