T1980BRE04

VIRULENCE GROUPS OF *OROBANCHE CUMANA* Wallr., DIFFERENTIAL HOSTS AND RESISTANCE SOURCES AND GENES IN SUNFLOWER

A. V. VRĂNCEANU*, V. A. TUDOR**, F. M. STOENESCU*, N. PÎRVU*

INTRODUCTION

Broomrape (*Orobanche cumana* Wallr.) has proved to be an extremely dangerous parasite of sunflowers since the beginnings of this oil crop. For that reason, sunflower breeding works in the U.S.S.R. have been permanently centred on the selection of the host genotypes with satisfactory resistance to the prevailing physiologic races of the parasite. PLATCHEK (1930) showed that the first resistant cultivars (Kruglik A-41, Saratovsky 169, Fuxinka 3, Zelenka 10, Czerneanka 35, etc.) had succeeded to overcome the first *Orobanche* race "A", permitting the crop to survive and develop. By 1934-1935, the Jdanov's open-pollinated varieties were released —Jdanov 8281 and Jdanov 8885— which provided resistance both to this race and to a new, more virulent race called "race B". Soon after, other cultivars with a similar resistance were developed: Armavirsky 762, Zelenka 61, Fuxinka 62, etc. The majority of high oil varieties, released after World War II (VNIIMK 1646, VNIIMK 6540, VNIIMK 8931, VNIIMK 8883, Armavirsky 3497, Armavirsky 9343, Armavirsky 9345, Smena, Peredovik, etc.) have shown a good resistance to the two broomrape races (PUSTOVOIT, 1966).

In Romania, the most important damages caused by broomrape have been reported in the south-eastern part of the country (VRANCEANU, 1974). The open-pollinated variety VNIIMK 8931, known as

* Research Institute for Cereals and Industrial Crops. 8264 Fundulea, Ilfov, Romania.
** County Inspectorate for Seed Quality, Brăila, Romania.

resistant to the group of races B, started to be atacked in this region as early as 1964-1966, while the Romanian cultivar Record has been less damaged. In the other cropping regions, the sunflower genotypes carrying resistance against the group of races B exhibit and presently a good broomrape control, proving that the expansion of the new physiologic races of the parasite is still limited.

A field nursery for screening sunflower resistance to the broomrape attack was organized in 1976 in the locality of Mircea-Vodă from Brăila county, on a heavy infested land on which the present grown high oil varieties have shown a high degree of susceptibility. This paper presents a part of the investigations conducted in this screening nursery during the period of 1976-1979 (TUDOR, 1980).

MATERIALS AND METHODS

The screening of sunflower resistance to broomrape was carried out on a medium leached chernozem soil (pH = 6.8). Important quantities of broomrape seeds, collected from different sites of the area, were uniformly incorporated into the soil, under the basic tillage. The small differences between the replications of the same variant attested the infestation uniforminty of the testing plots.

Tne following material was screened during the four-year period:

— 110 open-pollinated varieties and hybrids of different origin;
— 835 S_3—S_{14} inbred lines with a large genetic diversity;
— 82 progenies of some interspecific hybrids and an important number of hybrid generations F_1, F_2 and test-crosses.

All the variants were studied in 2-5 replications, with 20-40 plants each. Three or four scores of the frequency and intensity of the attack were recorded during the flowering-physiological maturity period.

Tne participation rate of each physiologic race to the broomrape population was calculated in accordance with the average intensity of the attack on a set of sunflower differentials. Five types of resistance (RO-R5), which correspond to the five virulence groups identified to the parasite (A-E) have been established. The χ^2 test was used for confronting the observed segregation ratios with the expected ones.

RESULTS AND DISCUSSION

The most important sources for resistance to the broomrape complex of races existing in the south-eastern regions of Romania

are listed in Tables 1 and 2. They are generally genotypes with high oil content in the seed. The Romanian hybrids Romsun 53, Sorem 80 and HT-63 CRM exhibit a very high level of resistance, the degree of the broomrape attack on them being almost negligible. Valuable sources for resistance are also the high oil varieties Peredovik, Kirovogradsky 23, Armavirsky 3497 A and VNIIMK 1646, the French hybrid Luciole, the Romanian hybrid HT-64 CRM and the U.S. hybrid H-894. Some of these sources have constituted the starting point for the development of certain inbred lines entirely resistant to broomrape, as shown in Table 2. In this regard, a special attention deserves the synthetic population Orizont synthetic-2, from which 11 resistant lines were developed, the Romanian cultivar Orizont which represents the genetic background of 6 resistant lines and the synthetic population Synthetic-11 which originates from the interspecific hybrids *Helianthus tuberosus* × *H. annuus* and which generated 5 resistant inbred lines.

The study of the reaction of a great number of sunflower genotypes to the attack of broomrape population existing in the Mircea-Voda area, has permitted to establish a set of differential hosts with a view to facilitating the identification of the main physiologic races of the parasite (Table 3).

The coefficients of variation for the intensity of the attack on differentials 2-6 have low values (0-13), demostrating that the testing plots were uniformly infested with seeds from different races. The high coefficient variation (s % = 30) ecountered to the first differential does not constitute an inpediment for interpretations, because the intensity of the attack on it is much higher than that recorded on the other differentials.

The Romanian inbred line AD-66, carrying the gen Pl_1 for resistance to *Plasmopara helianthi*, is the genotype with the highest intensity of the attack and therefore has been considered as susceptible to all the *Orobanche* races. The cultivar Kruglik A-41 is a good differential host for the race A, being susceptible to all the subsequent races. The cultivar Jdanov 8281, resistant to races A and B, has proved to be susceptible to all the other races. The cultivar Record and the inbred line H-8280, on which the average intensity of the attack is significantly inferior to that observed on the differentials resistant to races A and B, have been selected as differentials for the new more virulent race designated by the letter C. The inbred lines O-7586 and S-1358 are good differentials for the boomrape race D prevailing in South Romania (Fundulea area) and the inbred line

P-1380-2 is a valuable differential for the newest and the most virulent race E identified in Brăila county.

The average intensity of the broomrape attack on sunflover differentials has permited to estimate the proportion of each physiologic race within the broomrape population and to establish six types of host reactions or resistance types (Table 4). It is obvious that the old races of the parasite (A and B) are still widespread, their participation amounting to over 80%.

Table 5 includes the results of a complex hybridization test in which the progenies of four groups of crosses among inbred lines carrying different genes for resistance were analysed. The plants on which the attack intensity was similar to that of the most resistant parent were considered as resistant and the plants with the attack intensity similar to that of the most susceptible parent as susceptible. Each of the resistance types R5, R4, R3 and R2 have proved to be determined by a single independent dominant gene.

Although the genetic control of the resistance type R1 represented by the culivar Kruglik A-41 has not been precisely established, it appears evident that this resistance is also monogenic and could be ascribed to the gene *Or*1. As a matter of fact, MEISTER communicated – as far back as 1936, that the resistance to broomrape is dominantly inherited and he even referred to simple segregation ratios. The gene *Or*1 described by BURLOV and KOSTIUK (1976) and POGORLETSKY and GESHELE (1976), which affords resistance to the attack of broomrape races A and B, corresponds in this case to the gene *Or*2. This homozygous gene also is present in the genotype of the U.S. line T-66006. The Romanian inbred line H-8280 possesses the dominant gene *Or*3 which induces the R3 type of resistance, i. e. against the physiologic races A, B and C. The gene of the inbred line 0-7586, designated by the symbol *Or*4, determines the R4 type of resistance, against the races A, B, C and D, and the gene of the inbred line P-1380-2, noted by the symbol *Or*5, confers a universal resistance to broomrape, that is to the attack of the five physiologic races identified so far (A, B, C, D and E).

CONCLUSIONS

The data presented in this paper demonstrate the gene-for-gene relationship in the host-parasite system *Helianthus Orobanche* characterized by quite a slow evalution of the physiologic races, proba-

bly because of the low mutation rate to virulence in the parasite population.

The set of differential hosts used in this study has not allowed to distinguish all of the physiologic races of the parasite, due to the fact many host cultivars, primarily the open-pollinated varieties utilized at the beginning, carry more than one resistance gene. Thus, with 5 genes for resistance, each of which having two phenotypes (resistant or susceptible), there should be 2^5, or 32 different races of *Orobanche*. However, the identification of all the races would be practically of no use and in fact sunflower breeding has been performed, still from its beginnings, for resistance to a complex of *Orobanche* races (complex of races A, complex of races B, etc.). The set of differentials proposed by us includes those resistance genes which are in use to control the parasite and which define the races that are the most important agronomically. The set also includes resistance genes which are no longer in use because they do not control prevalent races, but they enabled us to trace the development of new races from older races.

The resistance of sunflower host cultivars and inbred lines is therefore specific, oligogenic. It can be easily transferred into the genotype of any other susceptible inbred line and to develop resistant hybrids.

The majority of the investigated genotypes have exhibited the type of resistance R2 and R3, similar to that of the first high oil varieties, which represent in fact the origin of the most valuable material used at the present time in sunflower breeding programmes (Table 6).

The frequency of the resistance genes in the existing sunflower germ plasm resources seems to be quite high for providing in the future, too, the adequate protection against the new physiologic races of *Orobanche*. In this respect, the identification of the gene Or_5 in the host differential line P-1380-2, which affords resistance to all of the broomrape physiologic races existing presently in the south-eastern regions of Romania, is edifying and ecouraging.

REFERENCES

(1) Burlov, V.V., Kostiuk, S.V., 1976, Proc. 7th Int. Sunflower Conf., Krasnodar, U.S.S.R., 322-326.
(2) Meister, G.K., 1936, Selektzyia y semenovodstvo, Nº 7 (in Russian).
(3) Placek, E.M., 1930, Semenovodstvo, Nº 6 (in Russian).

(4) Pogorletsky, B.K., Geshele, E.E., 1976, Proc. 7th Int. Sunflower Conf., Krasnodar, U.S.S.R., 238-243.
(5) Pustovoit, V.S., 1966, Izbrannye trudy, Izd. Kolos, Moskva (in Russian).
(6) Tudor, V.A., 1980, Study of sunflower resistance to broomrape (*Orobanche* spp.), doctorate thesis, I.A.N.B., Bucharest (in Romanian).
(7) Vranceanu, A.V., 1974, Floarea-soarelui, Bucharest; (Spanish edition, El girasol, Madrid, 1977).

TABLE 1

Sunflower hybrids and open-pollinated varieties with different levels of resistance to broomrape (Mircea-Voda, Braila, 1976-1979(

Hybrids (H) and varieties (OPV)		Origin	Frequency of the attack (F %)	Average intensity of the attack (I)	Degree of the attack $\left(\frac{F \times I}{100}\right)$
Romsun 53	H	Romania	12	2*	0.2
HT-63 CRM	H	Romania	11	4*	0.4
Sorem 80	H	Romania	22	2*	0.4
Peredovik	OPV	U.S.S.R.	59	36	21
Luciole	H	France	70	26	18
Kirovogradsky	OPV	U.S.S.R.	78	31	24
Armavirsky 3497	OPV	U.S.S.R.	78	31	24
HT-64 CRM	H	Romania	82	7	6
H-894	H	U.S.A.	90	16	14
VNIIMK-1646	OPV	U.S.S.R.	91	45	41
AD-66 (check inbred)		Romania	100	319	319
L.S.D. 0.05			8	10	0.8

*) Weak developed broomrape plants, fruitless or producing a small number of seeds.

TABLE 2

Sunflower inbred lines (S_3-S_{14}) carrying full broomrape resistance (Mircea-Vodă, Brăila, 1977-1979)

No. of resistant lines	No. of plants tested for each line	Germ plasm sources
11	98-164	Orizont Synthetic-2, synthetic population made up of 86 inbred lines (S_2) developed from the open-pollinated variety Orizont, Romania.
6	91-143	Orizont, open-pollinated variety, Romania
5	102-136	Synthetic-11, synthetic population originating from the interspecific hybrids *Helianthus tuberosus* × *H. annuus*, Romania
2	100-148	Peredovik, open-pollinated variety, U.S.S.R.
1	136	Record, open-pollinated variety, Romania
1	93	Select, open-pollinated variety, Romania
1	112	Peredoric x Smena, internacional cross, Romania.
1	135	VNIIMK 8931 × Peredovik, intervarietal cross, Romania
1	109	Synthetic-8, synthetic population, Romania
1	120	Comp. 1A-1907, synthetic population, U.S.A.
1	137	H. annuus ssp. annuus × Romsun 52, interspecific hybrid, Romania
1	101	H. petiolaris × Record, interspecific hybrid, Romania

TABLE 3

Reaction of a set of sunflower differential hosts to the broomrape complex of races from Mircea-Vodă, Brăila (1978)

Inbred lines (IL) and open-pollinated varieties (OPV)		No. of plants examined	Frequency of the attack (%)	Intensity of the attack	
				Average number of broomrape individuals on one sunflower plants	Coefficient of variation (s %)
AD-66	IL	132	100	318.7	30
Kruglik A-41	OPV	43	100	130.4	10
Jdanov 8281	OPV	42	100	51.6	8
Record	OPV	132	100	30.1	13
S-1358	IL	132	100	11.0	6
P-1380-2	IL	132	0	0	0

TABLE 4

The array of physiologic races of the broomrape population from Mircea-Vodă, Brăila area (1978)

Differential hosts	Broomrape races					Resistance reactions	Resistance genes
	A	B	C	D	E		
AD-66	S	S	S	S	S	R0	—
Kruglik A-41	R	S	S	S	S	R1	Or_1
Jdanov 8281	R	R	S	S	S	R_2	Or_2
Record (OPV), H-8280 (IL)	R	R	R	S	S	R_3	Or_3
S-1358, O-7586	R	R	R	R	S	R_4	Or_4
P-1380-2	R	R	R	R	R	R_5	Or_5
Proportion of broomrape races %	59.4	24.4	6.9	5.9	3.4		

R = Resistant
S = Susceptible

TABLE 5

Inheritance of resistance to races B, C, D and E of Orobanche cumana *in 6 inbred lines of sunflower*

Crosses	Resistance reactions	Generations	Sunflower plants		Expected segregation ratio	P
			Resistant*)	Susceptible**)		
P-1380-2	R5	F_1	132	0		
×		F_2	74	22	3:1	0.50-0.75
AS-110	R3	test-cross	52	48	1:1	0.50-0.75
0-7586	R4	F_1	124	0		
×		F_2	90	39	3:1	0.10-0.25
H-8280	R_3	F_2	32	11	3:1	> 0.99
H-8280	R_3	F_1	106	0		
×		F_2	41	13	3:1	0.90-0.95
T-66006	R_2	F_2	44	14	3:1	0.90-0.95
T-66006	R2	F_1	116	0		
×		F_2	62	24	3:1	0.90-0.95
AD-66	R0	test-cross	32	38	1:1	0.25-0.50

*) Resistance of the type of the most resistant parent
**) Resistance of the type of the more susceptible parent

TABLE 6

Broomrape resistance of sunflower germ plasm tested at Mircea-Vodă, Brăila (1976-1979)

Sunflower germ plasm*)	Total entries	Resistance reactions					
		R 5	R 4	R 3	R 2	R 1	R 0
Open-pollinated varieties and hybrids	110	7	9	20	45	10	19
Inbred lines (S_3-S_{14})	835	33	105	361	170	56	110
Progenies of the interspecific hybrids	82	2	7	46	27	0	0

*) The germ plasm entries with a heterogenious resistance have been included in the resistance type exhibited by the majority of the plants.