VIRULENCE AND AGGRESSIVENESS OF SUNFLOWER BROOMRAPE (*OROBANCHE CUMANA* WALLR.) POPULATIONS, IN ROMANIA

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ABSTRACT

The pathogenic composition of broomrape populations has changed over the years, slowly at first, then rapidly in Eastern Europe, Turkey and Spain. In Romania there are three important areas infested with broomrape (*Orobanche cumana* Wallr.), different as infestation degree and presence of different virulence groups. A new highly virulent population of broomrape has attacked sunflower in Romania in 2005. Many commercial hybrids belonging to different companies lost their resistance to this parasite. In the sunflower germplasm collection of the Fundulea institute a restorer line, AO-548, has been identified as fully resistant to this new broomrape population. Since this line could be used directly as a parent to produce commercial hybrids, as well as a source of resistance to broomrape in sunflower breeding program, the inheritance of its resistance to the new population of *Orobanche cumana* was studied. Progenies of the cross of the cytoplasmic male sterile inbred line AD-66, very susceptible to this population of the parasite, as a female parent, with AO-548 (F1, F2 and BC1 to both parents), as well as the parental lines, were analyzed for their reaction to the new broomrape population. The results of the observed resistant/sensitive plants vs. expected ratio (15:1 and 3:1) indicated that the inheritance of resistance to broomrape in the line AO-548 is conferred by two independent dominant genes.

Key words: inheritance, sensitive, sunflower, resistant, virulence.

INTRODUCTION

Broomrape (*Orobanche cumana* Wallr./ *Orobanche cernua* Loefl.) attacks sunflower crop in parts of Europe, the Near East and China (Vrânceanu, 2000). In the last years the parasite migrated to Western Europe (in 2007 the parasite attacked sunflower crop in France).

Sunflower breeding for resistance to this parasite was started by Pustovoit in 1912 at VNIIMK Institute in Krasnodar, Russia (Sackston, 1992). Using the method of growing all available sunflower material in heavily infested plots, Pustovoit had, by 1927, selected strains with up to 99% resistant plants (Pustovoit, 1967). However, by that year, previously resistant sunflower strains were succumbing to what turned out to be a complex of new races of broomrape. Repeated selection produced lines resistant to the new race complex. Pustovoit did not try to determine the nature of genes controlling this resistance.

Some early Soviet sunflower breeders did study genetic ratios. Meister (1936) reported that resistance to broomrape was inherited as a dominant character, and referred to simple segregation ratios. Later, the scientists found that resistance to broomrape races A and B derived from the perennial *H. tuberosus* L. was controlled by a single simply inherited dominant gene (Burlov and Kostyuk, 1976; Pogorletsky and Geshele, 1976).

The virulence of the parasite populations has changed over the years. Vrânceanu et al. (1980) reported five virulence groups (races or groups of races) of broomrape encountered in Romania, and five types of resistance effective against the respective groups. These investigators set up series of differentials permitting identification of the five virulence groups, although not the individual races of the pathogen, as each resistance type was effective against a specific race group. The results of complex crossing studies demonstrated a gene-for-gene relationship between virulence groups in the broomrape and resistance in sunflower. The gene *Or5,* which gives resistance to all five race groups, was successfully introduced into inbred lines with high combining ability that were the parents of existing or prospective hybrids, and released resistant hybrids.

The different reactions of resistance or varieties of different pathogen sensitiveness in sunflower were reported in the last years. Ciriaev (1987) reported the oligogenic resistance controlled by two genes. Juan Dominguez (1996), identified the line R-41 having resistance to broomrape controlled by two independent dominant genes. Melero-Vara and Fernandez-Martinez (2004) reported two

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independent recessive genes for resistance to broomrape.

In Romania, the race F, as well as the gene (one dominant gene) conferring resistance to this race, were identified in 1997 (Păcureanu Joița, 1998).

Melero-Vara et al. (1989) and other authors after him quoted work indicating possibilities of chemical control of broomrape, but agreed that genetic resistance is the most important method for controlling the parasite. Possibly, IMI resistance sunflower hybrids can be another way to control the parasite.

This paper presents the results obtained in identifying a new race of *Orobanche cumana* in sunflower in Romania, as well as a source of resistance and the inheritance of this resistance.

MATERIAL AND METHODS

Several sunflower genotypes (hybrids, lines and populations) were tested in fields naturally infested with broomrape, in two important areas in Romania, in order to identify new sources of resistance to the most virulent populations of the parasite. Differentials permitting identification of different virulence groups of the parasite were used. Crosses between sensitive lines and new resistant ones were performed in order to establish the inheritance of the genetic resistance. The testing was performed under artificial inoculation using broomrape seeds originating from two infested areas in Romania. The Pancenko (1975) method was used for testing under artificial infestation conditions.

RESULTS AND DISCUSSION

In Romania, more than 55% of the sunflower cultivated area is infested with broomrape. There are three important areas, as infestation degree and the presence of different virulence groups (Figure 1). The high infestation degree in the first area, situated near Black See, is given by the race F, but race G was also identified in this area. In the second area, situated in Ialomița-Brăila, the race F is well represented.

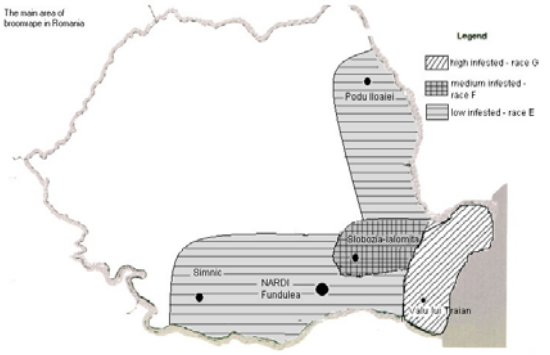

Figure 1. Main area of broomrape infestation in sunflower crop in Romania

In the last years, in sunflower crop in Romania, the parasite *Orobanche cumana* has developed new races in a short time, comparing with the first period (Figure 2). So, if from the A and B races to the identification of E race 15 years passed, as well as from E race to F race, the races G and maybe H, have appeared in shorter time and spread quickly in a large area.

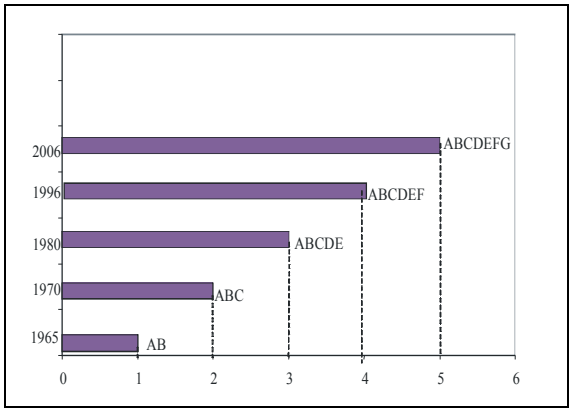

Figure 2. Evolution of the broomrape races in sunflower crop in Romania

In the year 2006, in sunflower crop cultivated in Tulcea area, near Black See, some of the hybrids resistant to the race F lost their resistance, being infested in a high percentage (Figure 3). The hybrids having resistance to the races G or H were fully resistant.

Using broomrape seeds collected from this area, several inbred lines used as differentials for the races E, F and G, as well as some resistant hybrids were tested under the artificial infestation conditions, in the greenhouse.

At the same time, we tested the same genotypes, using the broomrape seeds collected from Ialomița - Brăila area.

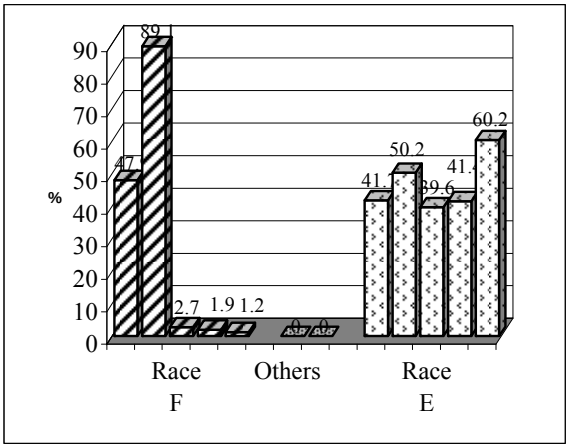

Figure 3. Behavior of several sunflower hybrids cultivated in an area infested with broomrape (România, 2006)

The results presented in Table 1 show that the differential for the race F, the inbred line LC 1093, lost its resistance in Tulcea area, having full resistance in Brăila - Ialomița area. The inbred line AO-548 was resistant in both cases. The same behavior was observed in the hybrids having these two lines as parents (Favorit and Daniel).

The test done under natural infestation conditions in Brăila area, using some differentials for the races E, F and G, confirmed that in this area the race G is not still present (Table 2).

All tests for resistance to broomrape, which were performed in 2006 and 2007 years, showed that in all infested areas, the restorer inbred line AO-548 was fully resistant. This line was crossed with AD-66, a CMS line, in order to establish the inheritance of resistance, in this restorer line.

Table 1. The reaction of several sunflower genotypes to the broomrape attack (Fundulea, 2006-2007)

Sunflower genotype	Reaction to the broomrape races	Source of broomrape			
		Ialomița - Brăila		Tulcea - Constanța	
		No of infested sunflower plants	Infestation degree (%)	Number of infested sunflower plants	Infestation degree (%)
P-1380-2	E - A	10/10	41.7	10/10	77.4
LC-1093	F - A	0/10	0.0	3/10	1.9
Kd-3-2	F - A	0/10	0.0	2/10	1.2
AO-548	G - A	0/10	0.0	0/10	0.0
Od-832-2b	F - A	0/10	0.0	3/10	1.8
Favorit	F - A	0/10	0.0	5/10	2.3
F-225	F - A	0/10	0.0	7/10	2.9
PR64A83	(E)F - A	8/10	19.7	10/10	73.1
PR64A71	(G)H	0/10	0.0	2/10	0.9
Daniel	G - A	0/10	0.0	0/10	0.0

Table 2. The reaction of several sunflower genotypes to the broomrape attack under natural infestation conditions (Brăila, România, 2007)

Sunflower genotypes	Reaction to the broomrape races	Infestation degree (%)
P-1380-2	E - A	49.7
LC-1093	F - A	0.0
O-7455	E - A	8.7
Sel-10481	E - A	19.7
Kd-3-2	F - A	0.0
AO-548	G - A	0.0
AD-66	Sensitive	69.7

The F1 generation was obtained in the field, and the crosses and selfings to obtain BC1 and F2 generations were done in artificial infestation conditions, in pots, in the greenhouse. The plants were kept in pots until maturity, after that they were uprooted and their roots carefully washed to observe any established broomrape nodules. The plants free of nodule or stalk in the root were considered resistant.

The observed ratio of resistant and susceptible plants, in each generation, as well as

the goodness of fit of observed – expected ratios are shown in table 3. The F2 progeny segregated in a ratio of 15:1 (resistant : susceptible), whereas the BC1 on the susceptible parent, AD-66, segregated according to 3:1 (resistant : susceptible), indicating that resistance to *Orobanche cumana* in AO-548 line is conferred by two single genes with independent action.

Table 3. Resistant and susceptible plants in the parental, F1, F2 and BC1 generations of crosses between AD-66 (cms) and AO-548, and the goodness of fit of observed (vs) expected ratios

Material (generations)	Plants		Expected ratio	P%
	Resistant	Susceptible		
AD-66 (P1)	-	15	-	
AO-548 (P2)	15	-	-	
F1	15	-	-	
F2	189	14	15:1	80-90
BC1 (AD-66)	50	15	3:1	50-70
BC1 (AO-548)	65	-	-	

The parasite *Orobanche cumana* has became more and more dangerous for the sunflower crop in Romania. In the year 2006, most of resistant sunflower hybrids cultivated in areas infested with this parasite, were attacked, some of them having a high attack degree (80%).

The behavior of several sunflower genotypes regarding resistance to broomrape, under natural and artificial infestation conditions, showed that the virulence of the parasite increased. The inbred line AO-548 was fully resistant.

The inheritance of resistance to broomrape in AO-548 line is conferred by two independent dominant genes. This line has a good combining ability, being used directly in obtaining commercial hybrids.

CONCLUSIONS

In the last years, the parasite *Orobanche cumana* has developed new and virulent populations, in the sunflower crop in Europe, including Romania.

One sunflower genotype resistant to the most virulent population of broomrape in Romania, it was identified in the germoplasm collection at Fundulea Institute.

This genotype (an inbred line) can be used as parent for the commercial hybrids, as well as a source of resistance for the genes transferring.

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