Distribution and dissemination of sunflower broomrape (*Orobanche cumana* Wallr.) race F in Southern Spain

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ABSTRACT

Sunflower broomrape (*Orobanche cumana* Wallr) is the most important problem in the sunflower crop in Southern Spain. The dissemination and dispersion of the virulent race F of this parasite has been evaluated during the last 10 years. The sunflower crop acreage in Southern Spain was divided into 8 large areas, where the presence and intensity of broomrape race F in sunflower fields was evaluated in the years 2001, 2003, 2005 and 2007. In two of these areas, irrigation lands and Antequera, broomrape race F was not found. In one area, Jerez, the progress of infection and dispersion showed a very slow advance. In the Seville-Huelva and Villamartín areas, the presence of race F accounted for 79% and 69% respectively, although without causing serious damage to the sunflower yield. In the other three areas studied, Córdoba, Écija and Carmona, the broomrape race F infestation was very high, causing important damage to sunflower production.

Key words: broomrape race F – broomrape distribution – *Orobanche cumana.*

INTRODUCTION

Sunflower broomrape (*Orobanche cumana* Wallr.) is a major disease in southern Europe, the Black Sea Region, Ukraine and China (Sackston, 1992; Parker, 1994). This obligate holoparasitic angiosperm attaches itself to the roots of infected plants depleting them of nutrients and water and causing important yield losses. In cases of severe infections, these losses can reach up to 50% and near 100% of sunflower production. Throughout sunflower broomrape history, different races of this holoparasite have developed in infested areas where sunflower has been traditionally cultivated (Vrânceanu et al., 1980).

In Spain, the broomrape was detected for the first time in Toledo province in 1958, attacking confectionery sunflower (González Torres et al., 1982). At the beginning of the 1980's the first broomrape infections in oil sunflower were noticed in Cuenca and El Coronil (Sevilla). In the early 1990's, in the surroundings of Écija (Sevilla) and La Almarcha (Cuenca), all the available commercial hybrids at that time were affected. Race studies showed that these infections were caused by broomrape race E (Melero-Vara, 1999; Domínguez, 2004). After 1993, several sunflower hybrids resistant to this race, most of them carrying the Or5 gene as the resistance source, were developed and commercialized. These hybrids are still being grown currently in most of the areas where sunflower is sown in Spain.

In 1995, a serious broomrape attack on resistant hybrids carrying the Or5 gene was detected for the first time in Spain near Écija (Sevilla) (Alonso et al., 1996). This new broomrape pathotype was determined as race F (Alonso et al., 1996). From that moment until the end of the 1990's, several spots of race F broomrape have been detected in Sevilla, Córdoba and Cuenca provinces (Domínguez, 1999). We report here a study carried out to evaluate the dissemination and dispersion of broomrape race F in the South of Spain during the present decade.

MATERIALS AND METHODS

The sunflower crop acreage in Southern Spain was divided into 8 large areas, where the presence and intensity of the broomrape virulent race F in sunflower fields was evaluated for four years. These areas are shown in Fig. 1 and Table 1. In each selected area, several sunflower fields were chosen at random. The sampling method consisted of selecting roads and ways including each area. Then the sunflower fields close to them located at a distance of 2-3 km. between each field were visited and evaluated. The total numbers of evaluated fields were 453 in 2001, 629 in 2003, 602 in 2005 and 565 in 2007.

For each tested field the following ranks of attack were considered:

- Large plots infected with race F: these are the sunflower fields with presence of plots larger than 1 Ha, highly infected by broomrape and associated with high yield losses.

- Small plots infected with race F: these are sunflower fields with more than 30-50% of infected sunflower plants with a low number of broomrapes per plant or with presence of small plots with a high broomrape infection. The incidence in sunflower yield is low.
- Presence of race F: these are the sunflower fields with a 10-25 % of infected sunflower plants with a low number of broomrapes per plant. The incidence in sunflower yield is practically void.
- Broomrape absence: sunflower fields with an under 10% broomrape infection in sunflower plants. In 2001 and 2003, these fields were clearly associated with non broomrape-infected fields. However, with the presence from 2005 onwards of sunflower race F-resistant hybrids in some studied areas, the absence of broomrape could be associated either with a non infected field or with a race F-resistant sunflower hybrid. In 2005 and 2007 assessments, the classification of a field with broomrape absence was assigned to one category or another by two methods. The first was a direct one, by obtaining information from the farmer about the hybrid sown. The second was a non direct one, on the basis of the information supplied by commercial staff of seed companies.

RESULTS AND DISCUSSION

The evaluation of the evolution of sunflower broomrape race was carried out in Andalusia (Southern Spain). The sunflower crop in this region accounts for approximately 45% of the total sunflower production in Spain, also being the area in which the mean performances are higher. Moreover, Andalusia is the region where broomrape race F has spread most, causing large losses in sunflower production. In order to study the evolution and dispersion of race F of broomrape, the sunflower growing area was divided into 8 large areas (Fig. 1), basically considering their record of the presence of former broomrape races. Table 1 shows for each area the surface taken up by sunflower in the four years of the study.

Fig. 1. Distribution of sunflower crop in Andalusia, subdivided into 8 large areas.

The results of the evaluation showed that throughout these last years, there were only two areas (E and G) where broomrape race F was not found in any field. This may be due to different reasons. In area E, irrigated land, the sunflower is a minor crop that is sown in rotation with corn and cotton. This area is relatively close to areas with a large broomrape presence, and, therefore, the broomrape seed dissemination by short distance movement, wind, water, tillage operations or infested farm equipment (Eplee et al., 1998), could be possible. The absence of *Orobanche* race F in this area could be due to the fact that both cotton and corn are trap crops, that promote the germination of broomrape seeds but without starting any infection in these crops (Rodríguez-Ojeda et al., 2001), resulting in the reduction of broomrape inocula in the soil. The second area with the absence of broomrape was area G, Antequera. This was probably due to the fact that this area is isolated from the rest of sunflower crop areas by large olive groves.

Table 1. Sunflower areas evaluated in Andalusia, location name and number of hectares cultivated in each area during 4 years.

Area	Location name	2001	2003	2005	2007
A	Sevilla-Huelva	28,381	26,822	18,619	20,463
B	Carmona	47,818	47,494	25,125	36,834
C	Écija	47,818	47,494	25,125	36,834
D	Córdoba	50,792	50,822	23,780	36,854
E	Irrigated land	28,189	28,045	15,934	21,722
F	Villamartín	44,339	44,002	24,394	34,276
G	Antequera	19,473	17,050	10,612	10,743
H	Jerez-Arcos	34,582	34,061	26,615	27,574
Total		301,392	295,788	170,204	225,300

The six remaining studied areas can be divided into 2 groups (Fig. 2 and Fig. 3). The areas of Écija, Córdoba and Carmona, C, D and B, respectively, where at present the broomrape race F is considered to be a serious problem for the sunflower crop, and the areas including Villamartín, Jerez and Sevilla-Huelva, F, H and A, respectively, where broomrape race F has been detected later and could be a potential problem for sunflower crop within the next years.

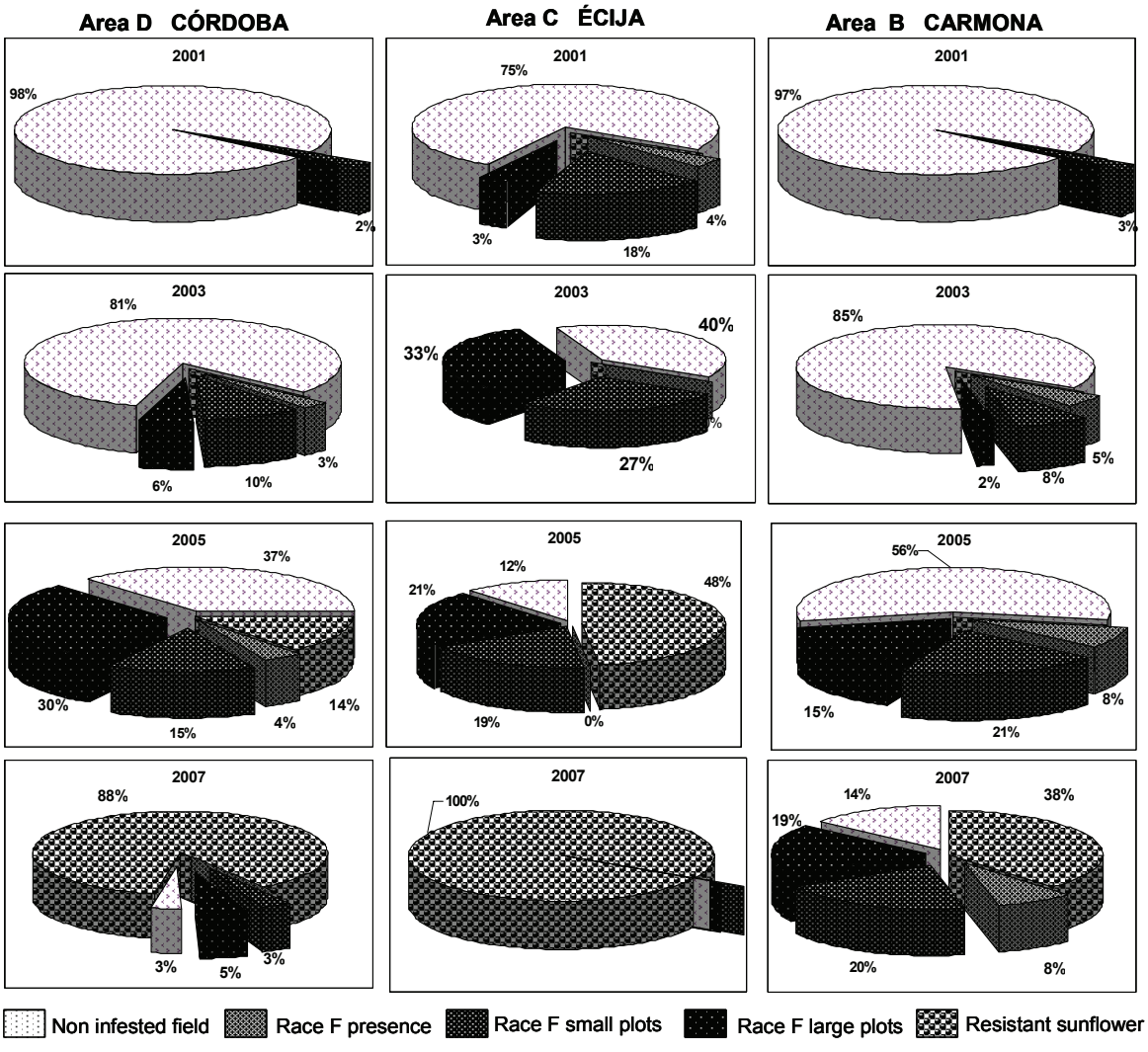

Fig. 2. Distribution of broomrape race F in Córdoba, Écija and Carmona areas during the years 2001, 2003, 2005 and 2007.

The first spots of race F were detected near Écija in the province of Sevilla in 1995 (Alonso et al., 1996). Within the following years, other small spots of this race appeared in new sunflower fields in a radius of about 20 km round Écija (Domínguez, 2004). In 2001 the fields affected by race F reached 25%, with large plots infested in 18% of the cases (Fig. 2). The spreading of race F in this area has been relatively slow, especially if compared with the broomrape race E evolution, which took place in the early 1990's, when the period from the appearance of the first fields with broomrape race E until its presence in over 80% of the fields, was only 4-5 years. From 2001, there has been a constant spread of race F in this area, from a complete absence of broomrape race F in 75% of the fields in 2001 to 40% in 2003, 12% in 2005 and, finally, with the whole sunflower cropped area sown with race F resistant hybrids in 2007 (Fig. 2).

The epidemic rate of growth in the Carmona area has followed a similar pattern to the one in Écija, although with a later appearance of the first race F infections. On the contrary, even though the presence of the first disease spots in Córdoba was simultaneous to that in Carmona, the spreading of race F towards Córdoba has been much faster than in the two previous areas (Fig. 2). One of the most important vectors in broomrape dissemination is the machinery movement among the different growing areas (Eplee et al., 1998). The higher rate of growth of race F in Córdoba may be due to the movement of combine-harvesters from Écija to the Córdoba area, where the harvest is up to 10-15 days later with regard to Écija.

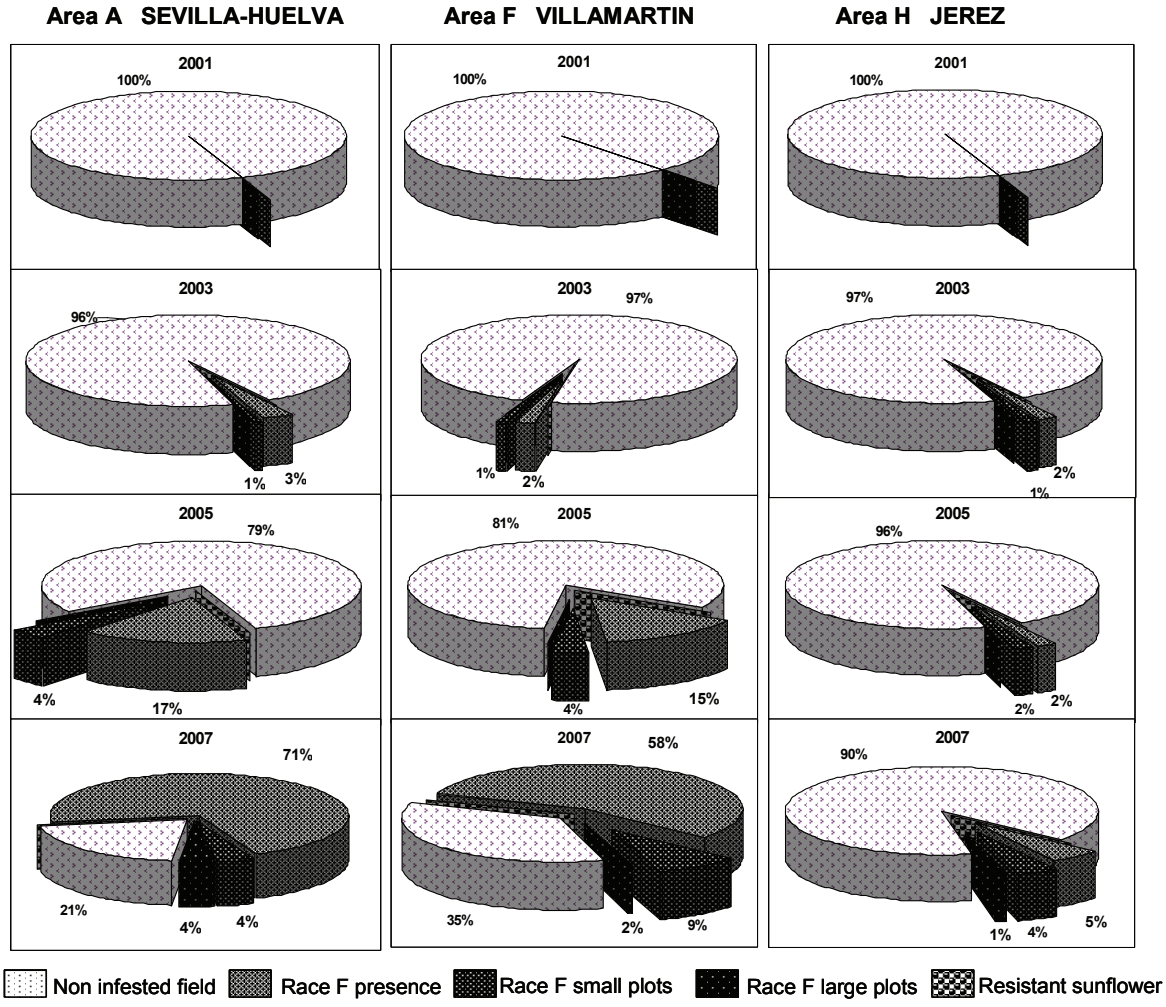

Fig. 3. Distribution of broomrape race F in Seville-Huelva, Villamartín and Jerez areas from 2001 to 2007.

The areas A and F, corresponding to Sevilla-Huelva and Villamartín, showed a similar behaviour regarding the appearance and dispersion of race F both in space and time. In both cases the first infections were detected in 2003, and four years later, the percentage of infected fields reached 79% and 69%, respectively (Fig. 3). It is worth mentioning that in these areas the infection with race F is present in many sunflower fields with 10-25 % of infected plants and a low broomrape number per plant, in contrast to B, C and D areas, where, in the first epidemic stages, the broomrape appears in small plots with a high broomrape infection. This fact may be due to multi-infestations with broomrape seed from the most infected areas (Écija and Carmona) through the combine-harvester movement. In areas A and F the sunflower harvest is carried out around 10 and 15 days later than in B and C areas, with the resulting machinery movement in this direction during harvest.

In the H area, around Jerez, the race F appearance took place in 2003 and with a similar intensity to that of A and F areas. Nevertheless, the rate of growth has been much lower and, in 2007, this race was present in only 10% of the sunflower fields. This situation is similar to that observed in the early 1990's regarding broomrape race E dispersion, when Jerez was the area in which broomrape appeared the latest in comparison to the rest of Andalucía and the spread was quite slow (unpublished results). The reason why broomrape presence and its expansion in the Jerez area is slower than in other sites, both for race E and race F, is unknown, at least by the authors.

The distribution knowledge and the broomrape F race rate of growth in a large area such as Southern Spain, with a sunflower surface of over 250000 has in recent years, may be considered as a model for designing strategies both for farmers and plant breeders. For the former, so that they can prevent broomrape seed dispersion among farms. For the latter, to be able to design alternative systems in order to fight the damage caused by broomrape in sunflower crop. This could be especially interesting in Andalusia, where the presence of a more virulent race (race G) which attacks race F resistant hybrids (Molinero-Ruiz and Melero-Vara, 2005) has already been reported.

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