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Department of Plant Pathology, E.T.S.I.A.,
University of Córdoba, and National Department for Oilseed Crops,
C.R.I.D.A.-10, I.N.I.A., Córdoba, Spain

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R. Gonzalez-Torres, R. M. Jimenez-Diaz, and J. M. Melero-Vara

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Department of Plant Pathology, E.T.S.I.A.,
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R. GONZALEZ-TORRES, R. M. JIMENEZ-DIAZ, and J. M. MELERO-VARA

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Three species of broomrape, namely *Orobanche aegyptiaca* Pers., *O. cernua* Loefl. (*O. cumana* Wallr.) and *O. ramosa* L., are pathogenic to sunflower, *Helianthus annuus* L. (DIAZ CELAYETA 1974, PIETERSE 1979, SACKSTON 1978). *O. cernua* is regarded as the most important (VRANCEANU 1977) because of the severity of yield losses caused by that parasite which may vary between 20—30 % (ACIMOVIC, personal communication) and the pathogenic variation of the parasite. The latter problem reduces the usefulness of the resistant cultivars used nowadays as the best measure to control the disease. Until recently three race-groups of the pathogen, A, B and M, have been differentiated (ACIMOVIC, pers. comm.). However, new sets of differentials used by eastern workers (ACIMOVIC 1980, VRANCEANU *et al.* 1980) may allow us to distinguish simpler races.

In Spain *O. cernua* was found on sunflower in a locality of Toledo province in 1958 (DIAZ CELAYETA 1974), but no information was given on the severity of the attack at that time. Further records of the parasite are provided by JIMENEZ-DIAZ and SACKSTON (1977), who, while studying systematically the occurrence of sunflower diseases in Spain, found *Orobanche* sp. only in Cuenca province. They recorded severe attacks in white seed (WS) cultivars used for human consumption, and trace incidences in the oilseed (OS) cultivar 'Peredovik' which is resistant to race-groups A and B (ACIMOVIC, pers. comm.).

This report presents the results of an investigation undertaken to gain further information on the importance and distribution of sunflower broomrape in Spain, to identify the parasitic species and to determine the pathogenic variation occurring in their populations. Information on the susceptibility of sunflower cultivars used in Spain to the prevalent race-groups found is also presented. A summary of this work has been published elsewhere (GONZALEZ-TORRES *et al.* 1980).

Materials and Methods

Distribution of sunflower broomrape in Spain

Disease surveys were carried out in the main areas of sunflower cultivation in 1978 and 1979. In 1978 surveys were done systematically on 182 commercial fields distributed in 13 provinces of four regions. Those fields covered 8500 ha, representing 1.5 % of the national sunflower acreage. The methodology described by SACKSTON (1978) was used. The 1979 surveys were not systematic but, instead, qualitative observations were made. They included 41 commercial fields in 9 provinces belonging to three of the regions surveyed in 1978.

Identification of the parasite

Specimens at the flowering stage were used. They were collected during disease surveys or obtained from seeds harvested in those surveys. Taxonomic criteria for the identifications were those described by CHATER and WEBB (1972) and HEPPER (1973).

Virulence of broomrape populations

Two virulence studies (tests 1 and 2) were performed with potted plants. The first test included *O. cernua* populations BS-78 and PT-78 (Table 1) and seven sunflower cultivars or inbred lines listed in Table 2. In the second test four cultivars (Table 2) and three populations, BS-78, PT-78, BF-79 (Table 1) were used.

Infections were accomplished by planting 2 to 3-day-old seedlings in Jiffy pots with a sterile soil mixture (sand : silt, 1 : 1, v) infested with 200 mg of brommrape seeds per kg of soil (PANCHENKO 1975). The plants were placed in a growth chamber adjusted to 26/20 °C day/night and to a photoperiod of 16 000 lux 14 h/day. After 15 days, the Jiffy pots with the plants were placed in clay pots containing 4 kg of soil mixture (peatmoss : sand : silt, 2 : 2 : 1, v) supplemented with fertilizers. At weekly intervals the plants were irrigated with a nutrient solution. In test 1, the plants were moved to a greenhouse 15 days after planting. Incidence and severity (No. of broomrapes/host plant) of infections were recorded at 2 to 3-day intervals from the appearance of the first broomrape for 30 days. The test 2 plants were maintained in the growth chambers for the entire 2 months of growth and only final data were recorded.

Table 1
Populations of *Orobanche cernua* used in this investigation

Code	Host cultivar	Locality and province	Year of collection
BS-78	Local (white seed)	Saelices (Cuenca)	1978
BF-79	Dwarf D.Y. 1 (white seed)	Fuente Piedra (Málaga)	1979
PT-78	Peredovik (oilseed)	Torrubia (Cuenca)	1978

Table 2
Sunflower inbred lines and cultivars used in tests 1 and 2

Denomination	Source	Observation
	Test 1	
CMS-9*)	Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia	—
CMS-13*)	Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia	—
RHA-18*)	Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia	—
Armavirsky-3497**)	All Union Research Institute of Plant Industry, Leningrad, USSR	Resistant to race-groups A, B
VNIIMK-1646**)	All Union Research Institute of Plant Industry, Leningrad, USSR	Resistant to race-groups A, B
SH-25***)	Semillas Pacífico, Sevilla, Spain	—
	Test 2	
Kruglik A-41**)	All Union Research Institute of Plant Industry, Leningrad, USSR	Resistant to race-group A
Zhanovsky-8281**)	All Union Research Institute of Plant Industry, Leningrad, USSR	Resistant to race-group B
Peredovik**)	Prograsa, Córdoba, Spain	Resistant to race-groups A, B
Sundak**)	Semillas Pacífico, Sevilla, Spain	—

*) Inbred line.
**) Open pollinated cultivar.
***) Hybrid cultivar.

Analyses of variance were performed for incidence and severity of infections in both tests. Incidence values were transformed to arc sin $\sqrt{}$/percentage for the analyses. Mean comparisons were done according to Duncan's multiple range test (STEEL and TORRIE 1960).

Susceptibility of sunflower cultivars to *Orobanche cernua* under field conditions

Two trials were performed in 1979 and 1980 in naturally infested fields where WS cultivars have been traditionally cropped (Table 6, 7). In 1979 two-row plots 5-m long and 75-cm apart, were sown at 25-cm plant spacing in a field in Cuenca. A randomized complete block design with two replications was used. In 1980 plots consisted of three rows 5-m long, 90-cm apart sown at 25-cm hill space in Málaga. Hills were not thinned. The experiment was replicated four times in a randomized complete block design.

Results

Morphology and identification of the parasite

In the field, broomrapes appeared isolated, in groups around sunflower plants or growing between them. This made the assignment of parasitic stems to a specific host plant uncertain. Stems of the parasite are erect, vigorous, slightly swollen at the base, purplish-brown or yellow, up to 50 cm high and

Fig. 1. Stems and flowers of sunflower broomrape (*Orobanche cernua* Loefl.)

3 cm in diameter, having a glandular pubescence and non-chlorofilic transformed leaves or scales (Fig. 1). Flowers are hermaphroditic, zygomorphous, pentamerous, and arranged in a scanty dense spike (Fig. 1). Individual flowers are inserted in the axile of a lanceolate bract having no bracteoles. The calyx is bilobate, bifid, with same colour than bracts. The corolla is white or violet, curved, glabrous, swollen and glossy at the base, bilabial, the lower labium being trilobate and the higher bilobate. In the center of the corolla there are four stamens with glabrous filament and mucronate anther. The ovary has two carpels in one loculus, the style is almost glabrous and the stigma is white.

The morphology of our specimens agrees with that of *O. cernua* (CHATER and WEBB 1972, HEPPER 1973). The main characteristics separating this species from other *Orobanche* spp. are the lack of bracteoles at the base of the calyx; the colour of the stigma, white not purple, and that of the corolla, white or violet, not red; and the corolla being swollen and glossy at the base.

Distribution of *Orobanche cernua* on sunflower crops in Spain

In 1978 *O. cernua* was found only in one (Cuenca) of 13 provinces surveyed. The results are summarized in Table 3. The parasite was found in

Table 3
Distribution of *Orobanche cernua* on sunflower crops in the province of Cuenca in 1978

Cultivar	Number of fields		Number of fields with given incidence			Mean number of broomrapes/host plant in fields with a given incidence		
	total inspected	with infected plants	<1%	1 to 25%	>25%	<1%	1 to 25%	>25%
Peredovik	19	5	3	1	1	1.6	6.5	29.4
Unknown (White seed)	8	2	—	—	2	—	—	28.0
Others (Issanca, SH-25, SH-75)	3	—	—	—	—	—	—	—

25.9 % of the fields inspected in Cuenca, which included 13.9 % of the surveyed acreage. Infections were observed in similar proportions in WS cultivars (denomination unknown) and in 'Peredovik'. However, WS cultivars were affected more severely than 'Peredovik', for which incidence ranged from trace to 30 % and average severity from 1.6 to 29.4 broomrapes/host plant. Cuenca was not included in surveys carried out in 1979, in which *O. cernua* was found only in a field of the WS cultivar 'Dwarf D.Y.1' in Fuente Piedra (Málaga). Incidence was almost 100 % and broomrapes were so numerous that it was not practical to count them (Fig. 2).

Fig. 2. Sunflower cultivar 'Dwarf D.Y. 1' severely affected by broomrape (*Orobanche cernua* Loefl.) in a field at Fuente Piedra (Málaga)

Virulence of populations of *Orobanche cernua*

The broomrape populations were similarly virulent when used to inoculate several sunflower inbred lines and cultivars in tests 1 (Table 4) and 2 (Table 5). In test 1 stems of the parasite were first visible at about 1 month after planting. Disease progress curves are shown in Figure 3. Inbreds 'CMS-13' and 'RHA-18' were more susceptible than inbred 'CMS-9' and cultivars 'Armavirsky-3497', 'Peredovik', 'SH-25' and 'VNIIMK-1646'. The interaction population × cultivar-inbred line was not statistically significant. Differences in susceptibility among inbred lines and cultivars, shown by comparisons of disease incidence values, were similar to those indicated by the disease progress curves. Comparisons among disease severity values did not illustrate differences in susceptibility as clearly as those among incidence values, probably because of a wider variation among the data (Table 4).

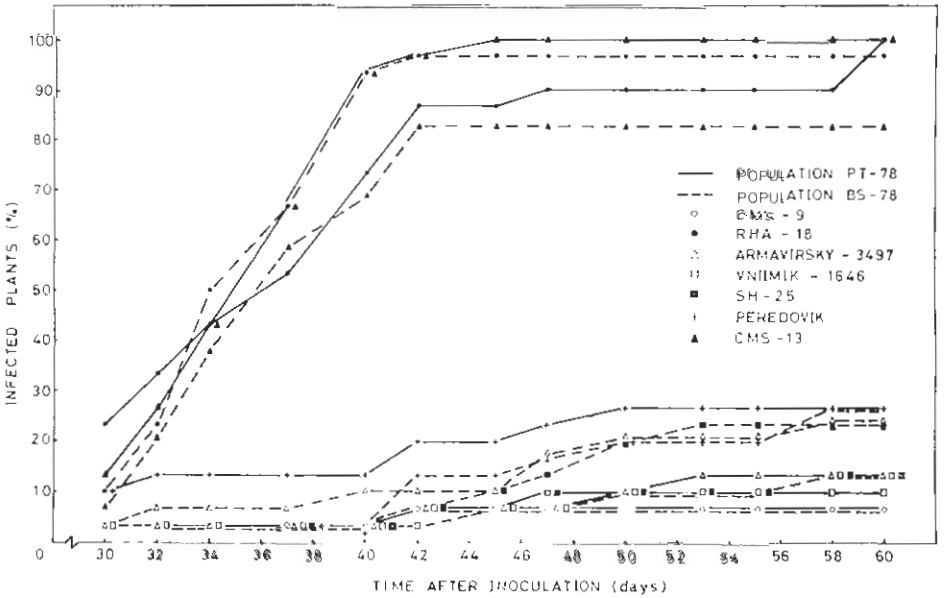

Fig. 3. Disease progress curves caused by populations PT-78 and BS-78 of *Orobanche cernua* Loefl. in sunflower inbred lines (CMS-9, CMS-13, RHA-18) and cultivars (Armavirsky-3497, Peredovik, SH-25, VNIIMK-1646)

The results in test 2 confirmed the lack of significant population × cultivar interaction. It also indicated that cultivars 'Kruglik A-41', 'Sundak' and 'Zhanovsky-8281', are more susceptible to the pathogen than 'Peredovik' as shown by the incidence values (Table 5).

An interesting difference in the pigmentation of the populations was observed consistently in the two tests. Population BS-78 consisted of two chromatic types of broomrapes, one having a yellow stem and white flowers while the other had a purplish-brown stem and violet flowers. On the other

Table 4
Virulence of populations PT-78 and BS-78 of *Orobanche cernua* to several sunflower cultivars and inbred lines*)

Inbred line or cultivar	Number of inoculated plants**)		Infected plants (%)			Mean number of broomrapes/host plant		
	PT-78	BS-78	PT-78	BS-78	mean ***)	PT-78	BS-78	mean ***)
CMS-13	30	29	100.0	82.8	91.4a	56.8	62.3	59.6a
RHA-18	30	30	100.0	96.7	98.3a	54.8	54.2	54.5ab
Armavirsky-3497	30	29	13.3	24.4	18.7b	8.7	28.9	18.8bc
CMS-9	30	29	6.7	6.9	6.8b	3.0	48.0	25.5abc
Peredovik	30	30	26.6	26.6	26.6b	20.0	19.6	19.8bc
SH-25	30	30	13.3	23.3	18.3b	1.0	2.1	1.6c
VNIIMK-1646	30	30	10.0	13.3	11.6b	36.0	31.3	33.6abc
Mean***)			38.5a	39.7a		25.7a	35.1a	

*) Sunflower seedlings were grown in a greenhouse in pots with infested soil. Data were taken 2 months after planting.

**) Broomrape populations differed in host cultivar and locality from which they were collected. See Table 1.

***) Values in the same row or column followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Table 5
Virulence of populations PT-78, BS-78 and BF-79 of *Orobanche cernua* to race differential sunflower cultivars*)

Cultivar***)	Number of inoculated plants**)			Infected plants (%)				Mean number of broomrapes/host plant			
	PT-78	BS-78	BF-79	PT-78	BS-78	BF-79	mean****)	PT-78	BS-78	BF-79	mean****)
Kruglik A-41	16	12	14	88.2	94.1	93.8	92.0a	9.9	12.1	21.3	14.4a
Peredovik	16	15	15	31.3	40.0	33.3	34.8b	5.8	4.7	12.0	7.5a
Sundak	14	14	14	100.0	78.6	85.7	88.1a	10.7	9.1	21.3	10.7a
Zhanovsky-8281	17	17	16	100.0	83.3	87.7	90.3a	11.6	15.7	12.8	13.4a
Mean****)				79.9a	74.0a	75.1a		9.5a	10.4a	14.6a	

*) Sunflower seedlings were grown in a greenhouse in pots with infested soil. Data were taken 2 months after planting.

**) Broomrape populations differed in host cultivar and locality from which they were collected. See Table 1.

***) Kruglik A-41 is resistant to race-group A, Zhanovsky-8281 is resistant to race-group B and Peredovik is resistant to race-groups A and B.

****) Values in the same row or column followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

hand, for populations PT-78 and BF-79 all broomrapes were similarly pigmented, with purplish-brown stems and violet flowers. Apparently, such a difference in the morphology of the populations bore no relation to the host cultivar they parasitized, as indicated by our observations in the tests under controlled environment.

Susceptibility of sunflower cultivars to *Orobanche cernua* under field conditions

Results of field trials indicated that WS cultivars are more susceptible to *O. cernua* than OS cultivars (Table 6, 7). Among OS cultivars, 'hybrid SH-25' consistently showed the highest degree of resistance (Table 6, 7). On the contrary, cultivars WS-12, 13, 15, 16, 'Dwarf D.Y.1' and 'Sundak' showed the highest degree of susceptibility, to the point that all plants had died by full bloom, about 2 months after planting (Table 7). In general, when the same plant material was used in the two trials, incidence and severity in 1980 were higher than in 1979. That could be related to the extremely high level of infestation in the 1980 experimental plot.

Table 6
Susceptibility of sunflower cultivars to *Orobanche cernua* under field conditions in 1979*)

Cultivar**)	Source	Infected plants (%)	Mean number broomrapes/ host plant
Armavirec	All Union Research Institute of Plant Industry, Leningrad, USSR	22.2a***)	3.9a***)
Armavirsky-3497	All Union Research Institute of Plant Industry, Leningrad, USSR	4.4a	1.0a
Cernianka	All Union Research Institute of Plant Industry, Leningrad, USSR	8.3a	1.6a
VNIIMK-1646	All Union Research Institute of Plant Industry, Leningrad, USSR	20.5a	1.5a
VNIIMK-6540	All Union Research Institute of Plant Industry, Leningrad, USSR	20.2a	3.7a
VNIIMK-8883	All Union Research Institute of Plant Industry, Leningrad, USSR	7.3a	1.5a
Issanka	Prograsa, Córdoba, Spain	14.3a	2.9a
Peredovik	Prograsa, Córdoba, Spain	16.6a	2.9a
Pemir	National Department for Oilseed Crops, Córdoba, Spain	12.9a	2.4a
Sundak	Semillas Pacífico, Sevilla, Spain	97.2b	14.6b
SH-25	Semillas Pacífico, Sevilla, Spain	3.7a	0.5a

*) The trial was carried out in a field at Horcajo de Santiago (Cuenca) known to be infested by the parasite. Planting was on May 5, 1979 and data were taken on August 8.

**) Oilseed cultivars except Sundak which is white seed.

***) Values followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Table 7
Susceptibility of sunflower cultivars to population BF-79 of *Orobanche cernua* under field conditions in 1980*)

Cultivar**)	Source	Infected plants (%)***)	Mean number of broomrapes/ host plant
WS-1	Tresjuncos (Cuenca)	86.6cd****)	15.2a****)
WS-2	Puebla de Almenara (Cuenca)	88.4bc	16.1a
WS-3	Puebla de Almenara (Cuenca)	92.9abc	14.1a
WS-4	Villamayor de Santiago (Cuenca)	88.9bc	12.2a
WS-5	Saelices (Cuenca)	88.2bc	11.8a
WS-6	Saelices (Cuenca)	90.3abc	15.5a
WS-7	Horcajo de Santiago (Cuenca)	93.6abc	11.3a
WS-8	Villamayor de Santiago (Cuenca)	86.1cd	10.3abc
WS-9	Saelices (Cuenca)	61.1d	13.8a
WS-10	Saelices (Cuenca)	79.0cd	10.6ab
WS-11	Tresjuncos (Cuenca)	90.0abc	12.4a
WS-12	Torre Alquima (Cádiz)	92.7abc	—•)
WS-13	Alcalá del Valle (Cádiz)	100.0a	—
WS-14	Fuenta Piedra (Málaga)	78.9cd	10.5ab
WS-15	Fuenta Piedra (Málaga)	100.0a	—
WS-16	Cecosa, Madrid	97.1ab	—
Dwarf D.Y.1	Hazera Seed, Haifa, Israel	100.0a	—
Sundak	Semillas Pacífico, Sevilla	100.0a	—
VNIIMK-1646	All Union Research Institute for Plant Industry, Leningrad, USSR	14.6ef	3.5d
Issanka	Prograsa, Córdoba	21.1e	4.2cd
Peredovik	Prograsa, Córdoba	22.3e	4.5bcd
SH-25	Semillas Pacífico, Sevilla	6.1f	3.1d

*) The trial was carried out in a field at Fuente Piedra (Málaga) from which the population BF-79 was obtained in 1979. Planting was on April 9, 1980 and data were taken on July 22.

**) All cultivars listed are white seed except VNIIMK-1646, Issanka, Peredovik and SH-25 which are oilseed.

***) Plants in hills were not thinned. Incidence and severity have been calculated using the hills as units.

****) Values followed by the same letters are not significantly different (P = 0.05) according to Duncan's multiple range test.

•) Plants of cultivars WS-12, 13, 15, Dwarf D.Y.1 and Sundak died before the final data were taken and broomrapes which had developed were not considered for statistical analysis.

Discussion

Orobanche cernua has been the only parasitic plant species found to attack sunflower in Spain. Our results indicate that the parasite is mainly established in the province of Cuenca, in Central Spain. This agrees with observations by JIMENEZ-DIAZ and SACKSTON in 1976 and 1977 (1977). We could not confirm the occurrence of O. *cernua* in Toledo recorded by DIAZ CELAYETA (1974) since that province was not included in our surveys. On the other hand, the severe attack observed in Fuente Piedra (Málaga), Southern Spain, in 1979, extends the distribution of the parasite and indicates the possibility of spread of O. *cernua* to new areas in the country. Furthermore, preliminary observations in 1980 suggest that inoculum from this field is spreading to nearby ones, as indicated by the occurrence of light to moderate attacks by the parasite in three new sunflower fields located in the vicinity of the heavily infested one.

In their surveys, JIMENEZ-DIAZ and SACKSTON (1977) found severe broomrape attacks in WS cultivars but only traces of infections in the OS cultivar 'Peredovik', with 1—2 broomrapes/host plant. Our observations are in keeping with theirs, except for two fields where 'Peredovik' was affected as severely as WS cultivars (Table 3). That suggests that broomrape populations in those fields might belong to the M race-group of O. *cernua*, recently found in Bulgaria (SACKSTON 1978), Rumania (ILIESCU, pers. comm.), USSR (MAMONOV 1976) and Yugoslavia (ACIMOVIC, pers. comm.). The results of artificial inoculations of race-group differentials (Table 4, 5) indicated that three populations differing in geographical origin belonged to the M race-group (ACIMOVIC, pers. comm., MAMONOV 1976, VRANCEANU 1977), and so confirmed the occurrence of components of that dangerous race-group in a place other than Eastern European countries.

In our trials, WS cultivars were much more susceptible to O. *cernua* than OS cultivars, and among those WS-12, 13, 15, 16 'Dwarf D.Y.1' and 'Sundak' showed the highest susceptibility (Table 7). It would be worthwhile to note that all other WS cultivars are local cultivars from Cuenca, where the parasite has been established for sometime, and where the farmers have undertaken their own selection. On the contrary the most susceptible WS cultivars originate from places in which the parasite is not known to occur (SACKSTON 1978).

Summary

Sunflower disease surveys carried out in 1978—1979 indicated that broomrape (*Orobanche cernua* Loefl.) is mainly established in the Cuenca province, in Central Spain, where the parasite was found in 25.9 % of inspected fields, including 13.9 % of the acreage surveyed. In 1979 severe infections were also found in a field at Fuenta Piedra (Málaga) in Southern Spain, which suggests that the parasite is spreading in the country, probably through infested seeds. In artificial inoculation experiments three populations of O. *cernua* collected from Cuenca and Fuente Piedra showed virulence according to the M race-group of the parasite. This is the first record of such a race-group in a Western country. In trials carried out in naturally infested field plots all white seed cultivars were severely affected. Oil seed cultivars were affected to a lesser degree, the 'hybrid SH-25' being the most resistant one.

Resumen

Prospecciones fitopatológicas en cultivos de girasol realizadas en 1978—79, indicaron que el jopo (*Orobanche cernua* Loefl.) está establecido principalmente en la provincia de Cuenca, donde el parásito fué encontrado en el 25.9% de los campos inspeccionados que incluían el 13.9% de la superficie prospectada. En 1979 también se encontraron infecciones severas en un campo de Fuente Piedra (Málaga), lo que sugiere que el parásito se está extendiendo por el país, probablemente a través de semillas infestadas. Tres poblaciones de *O. cernua* recolectadas en Cuenca y Fuente Piedra mostraron en inoculaciones artificiales una virulencia acorde con la de la propia del grupo de razas M del parásito. Esta es la primera cita de tal grupo de razas en un país occidental. En experimentos desarrollados en parcelas infestadas naturalmente todos los cultivares de semilla blanca fueron afectados severamente por el patógeno. Los cultivares de semilla oleaginosa fueron menos severamente afectados y de ellos el híbrido SH-25 fué el más resistente.

Zusammenfassung

Verbreitung und Virulenz von *Orobanche cernua* auf Sonnenblumen in Spanien

Auf Grund von 1978 und 1979 durchgeführten Beobachtungen ist *Orobanche cernua* auf Sonnenblumen vor allem in der Provinz Cuenca in Zentralspanien verbreitet; der Parasit wurde in 25,9% der untersuchten Felder und auf 13,9% der untersuchten Fläche gefunden. 1979 wurden auch in einem Feld in Fuente Piedra in Südspanien gefunden; dies deutet darauf hin, daß sich der Parasit ausbreitet (wahrscheinlich durch infizierte Samen). In Infektionsversuchen mit drei Populationen aus beiden Gebieten stimmte die Virulenz des Parasiten mit der M-Rassengruppe überein. Diese Rassengruppe wurde damit zum ersten Mal in einem westlichen Land nachgewiesen. In natürlich infizierten Feldern waren alle Sorten mit weißen Samen stark befallen. Ölsamen liefernde Sorten wurden weniger stark befallen; am resistentesten war der Hybrid SH-25.

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Literature

ACIMOVIC, M., 1980: Physiological races of *Orobanche cumana* Wallr. on sunflowers in Yugoslavia. Abstr. Pap. IX Intern. Sunflower Conf., Torremolinos, Spain, p. 17.

CHATER, A. O., and D. A. WEBB, 1972: *Orobanchaceae*. In: P. W. BALL, A. O. CHATER, R. A. DE FILIPPS, I. K. FERGUSON, and I. B. K. RICHARSON (eds.), Flora Europaea, Vol. 3, 285—294. Cambride Univ. Press, London.

DIAZ-CELAYETA, F., 1974: Algunas plantas parásitas de otras de interés agrícola o medicinal. An. INIA Ser. Prot. Veg. **4**, 143—160.

GONZALEZ-TORRES, R., R. M. JIMENEZ-DIAZ, y J. M. MELERO-VARA, 1980: Distribución y virulencia de *Orobanche cernua* Loefl. en los cultivos de girasol en España. Abstr. Pap. IX Intern. Sunflower Conf., Torremolinos, Spain, p. 39.

HEPPER, F. N., 1973: Problems in naming *Orobanche* and *Striga*. Proc. Eur. Weed Res. Counc. Symp. Parasitic Weeds, Malta, 9—17. Univ. Press, Malta.

JIMENEZ-DIAZ, R. M., y W. E. SACKSTON, 1977: Investigaciones preliminares para la elaboración de un mapa de enfermedades de girasol en España. II Reun. Anu., Grup. Especializ. Fitopat., S.E.M., Madrid, 1—7.

MAMONOV, I. F., 1976: Breeding sunflower resistant to new races of broomrape. Proc. VII Intern. Sunflower Conf., Krasnodar, U.S.S.R., 268—272.

PANCHENKO, A. Y., 1975: Early diagnosis of broomrape resistance in breeding and improving seed production of sunflower (in Russian). Viestnik Sielkskojosia stvennog Nauki **2**, 107—115.

PIETERSE, A. H., 1979: The broomrapes (Orobanchaceae). A review. Abstr. Trop. Agric. **5**, 9—35.

SACKSTON, W. E., 1978: Sunflower disease mapping in Europe and adjacent mediterranean countries. Proc. VIII Intern. Sunflower Conf. Minneapolis, U.S.A., 7—29.

STEEL, R. G. D., and J. H. TORRIE, 1960: Principles and Procedures of Statistics, 481 pp. McGraw-Hill Book Co., Inc., New York.

VRANCEANU, A. V., 1977: El girasol, 379 pp. Ed. Mundi-Prensa, Madrid.

— —, V. A. TUDOR, F. M. STOENESCU, and N. PIRVU, 1980: Virulence groups of *Orobanche cumana* Wallr., differential hosts and resistance sources and genes in sunflower. Abstr. Pap. IX Intern. Sunflower Conf., Torremolinos, Spain, p. 5.

Authors' addresses: R. M. JIMENEZ-DIAZ, Departamento de Patología Vegetal, E.T.S. I.A., Universidad de Córdoba, Apdo 3048, Córdoba (España). J. M. MELERO-VARA, Departamento de Oleaginosas y Plantas de Gran Cultivo, C.R.I.D.A.-10, I.N.I.A., Apdo 240, Córdoba (España).