HELIA, **27**, Nr. 40, p.p. 199-210, (2004) UDC 633.854.78:632.53:632.954(560)

SUNFLOWER (*Helianthus annuus* L.) BREEDING IN TURKEY FOR BROOMRAPE (*Orobanche cernua* Loeffl.) AND HERBICIDE RESISTANCE

Y. Kaya[1*], M. Demirci[2] and G. Evci[1]

[1]*Trakya Agricultural Research Institute, Po Box:16, 22100, Edirne, Turkey*
[2]*BASF TURK, Sehit Fethibey Cad. Penpar Ishani, No: 49/603, Alsancak, Izmir, Turkey*

Received: October 08, 2003
Accepted: January 05, 2004

SUMMARY

New broomrape races threaten sunflower production in Turkey. Pioneer hybrid P-4223 was resistant in all parts but TARSAN-1018 and some inbred lines were resistant only in some areas in Trakya region. At least one or more new races than F race appear to exist in the region. Use of imidazolinone herbicide and resistant hybrid started in 2003. Farmers used this Clearfield System® without any problem. This system will be preferred in coming years by farmers in areas problematic for broomrape and weeds, for use together with sunflower cultivars genetically resistant to broomrape.

Key words: sunflower, weed, resistance to herbicide, imidazolinone, sulfonylureas, broomrape

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the important oil crops in the world and Turkey. Trakya region, i.e., the European part of Turkey, holds 75% of the entire sunflower production in Turkey (Kaya, 2003a). Broomrape and some weeds are important problems in the sunflower production of that region. About 80% of the sunflower production area is infected by new races of *Orobanche cernua* Loeffl. Broomrape epidemics break out each 20 years (1960, 1980, 2000) and overcome the resistance of sunflower cultivars grown in the region (Bulbul *et al*,. 1991; Kaya, 2003b).

Broomrape resistance in sunflower is controlled by only one gene, *Or* gene, but the new races of *Orobanche* other than A,B,C,D,E showed additive dominant allelic reaction (Sukno *et al*., 1999). New broomrape races were observed in Spain and Turkey over last eight years. However, Turkish F race is more virulent than those

* Corresponding author, e-mail: yalcinkaya@ttae.gov.tr

from other countries and there are additionally probably one or two more races in the region that have not been identified. Although resistant and tolerant sunflower hybrids are planted, these cultivars become susceptible after a couple of years due to high virulence of these new races. *Orobanche* resistance breeding program in sunflower had been started and is conducted on national-wide basis by Trakya Agricultural Research Institute-Edirne,Turkey (TARI) ever since 1955. Based on periodic changes in race, several resistant parental lines and hybrids have been developed within the National Sunflower Research Program (Anonymous, 2002). BR populations developed by Jan were resistant to F race but they showed segregation. BR-1 was a female inbred line of oil type, BR-2 was a restorer line of oil type, BR-3 was a confectionery female line and BR-4 was a restorer line of confectionery type (Jan *et al*., 2000).

Some herbicide-resistant plants were discovered in wild sunflowers found in a field in Kansas, USA, and imidazolinone (IMI) and sulfonylurea (SURE) herbicide-resistant lines of the cultivated type were developed in the USDA sunflower breeding program by using classical back-crossing breeding methods (Alonso *et al*., 1998; Alkhatib *et al*., 1998; Miller and AlKahatib, 2000; Miller, 2002). After USDA discovered sources of IMI resistance in sunflower, extensive research continued by TARI and private companies in Turkey on the control of *O. cernua* with post emergence herbicides IMI, Imazamox and Imazapyr.

Besides, some weed species such as *Xanthium strumarium* L., *Sinapis arvensis* L., *Chenopodium album* L., *Cirsium arvense* (L) Scop., *Convolvulus arvensis* L., *Avena* spp., *Datura stramonium* and *Amaranthus* spp. cause important problems in the sunflower production in this area. Therefore, herbicide application to control both weeds and broomrape is so important to increase sunflower yields. Some weeds, especially *X. strumarium* L., are a big problem in the sunflower production areas in Trakya region. Use of IMI herbicides in problem areas to control both weeds and broomrape will bring more profit to farmers (Alonso *et al*., 1998; Malid_a, 2003). CLEARFIELD System® developed by BASF Company (Anonymous, 2003) and IMI resistant sunflower hybrid were sold to farmers widely in 2003. The herbicide Intervix [Imazamox+Imazapyr (33+15 g/l)] was registered by BASF Company to control both *O. cernua* and key weeds in sunflower production at 1.25 l/ha. One IMI resistant sunflower hybrid from Syngenta Seed Co. obtained production permission for Turkey in 2003 (Yucer, 2003).

Chlorsulfuron herbicides from SURE group were used for controlling broomrape in tobacco, so their use in sunflower could be another solution for controlling *Orobanche* and different weed species (Yordanova *et al.,* 2001). The goals of the National Program are first genetic control of broomrape, by getting resistance genes into parental lines and hybrids, and then chemical control of both *O.cernua* and other weeds using IMI and other herbicide groups.

MATERIAL AND METHODS

BR populations developed by Jan were tested under artificially infested conditions at fields of TARI in 2002. Broomrape seeds collected from different infested fields of Trakya region were placed in holes opened in the field before planting. Several broomrape seeds were placed 3 cm below ground, at the same depth as sunflower seeds. Each BR population was planted in four rows and sixty plants at 0.7 × 0.35 m plant density. Sunflower plants were irrigated to get high broomrape germination. Resistant BR plants from 2002 planting season and BR populations were planted in naturally infested fields in 2003.

Due to germination problem under artificial conditions at TARI fields, all broomrape tests were repeated under conditions of natural infestation in 2003. Locations were Karabulut-Edirne, Yanibedir-Luleburgaz and Malkara-Tekirdag. In each location there were 770 rows including controls. Row length was 4 m and about 12 plants were planted in each row with 1 m × 0.35 m plant density. Control was SANBRO hybrid from Syngenta Co. and broomrape observations were made after flowering stage. A total of 154 female CMS inbred lines (60 lines belonging to TARI, 94 lines belonging to Novi Sad Institute, Yugoslavia), 48 TARI restorer inbred lines, 440 experimental hybrids (151 TARI, 156 Aegean Agricultural Research Institute-Izmir-Turkey; 39 ProAgro Seed Co., India, 35 Fundulea Agricultural Research Institute-Romania; 23 Maisador Seed Co., France; 15 Seed 2000 Co., USA, and 21 hybrids belonging to other private companies) were tested for reaction to broomrape. However, the results from Yenibedir and Karabulut locations were not good due to hot and dry summer season. Low broomrape germination was obtained in Yenibedir location due to extremely dry conditions. In Karabulut location, distribution of broomrape was not even and germination of broomrape plants was low too. Therefore, reliable results were obtained only in Malkara and the results from this location were evaluated widely in this research.

Broomrape observations were evaluated as frequency (F), intensity (I) and attacking rate (AR) based on Pustovoit's method. The plants having 0-10% frequency and 0-1 AR values were considered as resistant (Vranceanu *et al.*, 1980; Pacureanu-Joita *et al.*, 1998).

% of plant with *Orobanche*

$$F = \frac{\text{The plant number infested by } \textit{Orobanche}}{\text{Total plants in the row}} \times 100$$

The number of *Orobanche* in one infested plant

$$I = \frac{\text{Total } \textit{Orobanche}}{\text{Total plants infested by } \textit{Orobanche} \text{ in the row}}$$

The number of *Orobanche* in one plant in the row

$$AR = \frac{F \times I}{100}$$

IMI and SURE herbicide resistance program started in TARI in 1999. Crossing TARI inbred lines with IMI and SURE resistant populations, IMI resistant lines will be developed in 2004 and SURE resistant ones in subsequent years.

RESULTS AND DISCUSSION

In 2003 in Turkey, broomrape was controlled effectively genetically, using resistant and tolerant hybrids, and chemically, using IMI resistant hybrids and IMI herbicide. The herbicide INTERVIX that belongs to IMI group and controls some weeds such as *Xathium strumarium* L., *Avena sterilis* L., *Chenopodium album* L., *Echinochloa cruss*-galli (L) P.Beauv., *Sinapis arvensis* L., *Amaranthus albus* L., *A. retroflexus* L., *Solanum nigrum* L. and *Datura stramonium* L. was used by farmers at the dose of 1.25 l/ha without any problem in the 2003 season. The best time to control both broomrape and weeds is 6-8 leaf stage in sunflower (Demirci *et al*, 2003). Work on IMI resistant hybrid breeding and development of new lines continues at TARI and some private seed companies.

SURE resistance could be another option to manage weeds in sunflower production. It was observed that a chlorsulfuron herbicide from SURE group controlled broomrape gradually in some trials in the sunflower resistance breeding program of TARI in 2003.

Four BR populations were planted in a field of TARI in 2002 and tested under artificial conditions for reaction to new broomrape races collected from different parts of Trakya region (Table 1). BR populations resistant to F race showed more segregation in irrigated conditions and resistant plants were selected from these populations. Fourteen plants from BR-1, 8 from BR-2, 14 from BR-3 and 13 from BR-4 showed resistance. These resistant plants were selected and self-pollinated by covering their heads with cloth bags. These plants and also BR populations were again planted under natural infestation conditions with broomrape in 2003.

Table 1: Broomrape observations in BR populations planted in Edirne in 2002

Entry Name	Plant #	Plant # with *Orobanche*	*Orobanche* number	Frequency (%)	Intensity	Attack rate
BR-1	60	46	75	76.7	1.6	1.3
BR-2	60	52	86	86.7	1.7	1.4
BR-3	60	46	74	76.7	1.6	1.2
BR-4	60	47	76	78.3	1.6	1.3

Table 2: Broomrape observations in BR populations planted in Karabulut and Malkara in 2003

Entry name		Plant number	Plant # with *Orobanche*	*Orobanche* number	Frequency (%)	Intensity	Attack rate
Karabulut-Edirne	BR-1	8	1	1	12.5	1.0	0.1
	BR-2	9	2	2	22.2	1.0	0.2
	BR-3	9	1	4	11.1	4.0	0.4
	BR-4	5	1	11	20.0	11.0	2.2
Malkara-Tekirdag	BR-1	4	0	0	0.0	0.0	0.0
	BR-2	5	0	0	0.0	0.0	0.0
	BR-3	5	1	1	20.0	1.0	0.2
	BR-4	3	0	0	0.0	0.0	0.0

Table 3: Broomrape observations in BR resistant plants planted in Malkara in 2003

Entry name	Plant number	Plant # with *Orobanche*	*Orobanche* number	Frequency (%)	Intensity	Attack rate
BR1-B1	8	1	1	12.5	1.0	0.1
BR1-B2	8	3	6	37.5	2.0	0.8
BR1-B3	5	1	3	20.0	3.0	0.6
BR1-B4	6	2	4	33.3	2.0	0.7
BR1-B5	4	0	0	0.0	0.0	0.0
BR1-B6	7	0	0	0.0	0.0	0.0
BR1-B7	6	1	1	16.7	1.0	0.2
BR1-B8	8	1	1	12.5	1.0	0.1
BR1-B10	6	2	3	33.3	1.5	0.5
BR1-B11	8	1	3	12.5	3.0	0.4
BR1-B12	6	1	2	16.7	2.0	0.3
BR1-B13	5	0	0	0.0	0.0	0.0
BR1-B14	2	0	0	0.0	0.0	0.0
BR2-B1	4	1	2	25.0	2.0	0.5
BR2-B2	4	1	2	25.0	2.0	0.5
BR2-B3	4	0	0	0.0	0.0	0.0
BR2-B4	4	1	2	25.0	2.0	0.5
BR2-B5	7	1	2	14.3	2.0	0.3
BR2-B7	9	2	3	22.2	1.5	0.3
BR2-B8	8	1	1	12.5	1.0	0.1
BR3-B1	8	0	0	0.0	0.0	0.0
BR3-B2	9	1	4	11.1	4.0	0.4
BR3-B3	3	0	0	0.0	0.0	0.0
BR3-B4	8	1	3	12.5	3.0	0.4
BR3-B5	9	0	0	0.0	0.0	0.0
BR3-B6	8	0	0	0.0	0.0	0.0
BR3-B7	4	1	1	25.0	1.0	0.3
BR3-B8	6	0	0	0.0	0.0	0.0
BR3-B9	7	3	3	42.9	1.0	0.4
BR3-B10	6	0	0	0.0	0.0	0.0
BR3-B11	7	0	0	0.0	0.0	0.0
BR3-B12	9	1	4	11.1	4.0	0.4
BR3-B13	6	0	0	0.0	0.0	0.0
BR3-B14	6	0	0	0.0	0.0	0.0
BR4-B1	10	1	1	10.0	1.0	0.1
BR4-B2	6	1	18	16.7	18.0	3.0
BR4-B3	4	2	2	50.0	1.0	0.5
BR4-B4	4	2	13	50.0	6.5	3.3
BR4-B5	5	3	20	60.0	6.7	4.0
BR4-B6	8	3	7	37.5	2.3	0.9
BR4-B7	9	4	10	44.4	2.5	1.1
BR4-B8	5	2	5	40.0	2.5	1.0
BR4-B9	8	0	0	0.0	0.0	0.0
BR4-B10	6	0	0	0.0	0.0	0.0
BR4-B11	5	1	2	20.0	2.0	0.4
BR4-B12	6	0	0	0.0	0.0	0.0
BR4-B13	4	1	6	25.0	6.0	1.5

BR populations showed susceptibility in Karabulut but resistant in Malkara under natural infestation conditions in 2003 (Table 2). However, the part of the field planted to BR populations in Malkara location did not have even distribution of broomrape so we could not observe enough broomrape germination due to dry conditions. The reaction of broomrape to BR population resistant to F race is the proof of existence of one or two more new races in the region. The resistant BR plants selected last year were planted under conditions of natural infestation in 2003 and their observations at Malkara location were given in Table 3.

Four rows of BR-1, 1 of BR-2, 9 of BR-3 and 3 rows of BR-4 were free from broomrape (Table 3). Based on these results obtained under natural conditions, BR-3 showed higher tolerance than the other BR populations and BR-2 showed lower tolerance than the others. Additionally, population BR-3 had higher tolerance than others in some other studies conducted in the region (personal communication).

The female inbred lines of TARI and Novi Sad Institute tested in Malkara in 2003 broomrape trial showed less tolerance than restorer lines of TARI (Table 4). The highest broomrape number was observed in experimental hybrids after the control rows. The hybrids had higher average frequency and intensity than inbred lines and controls. However, the female lines had higher attacking rate than the others.

Table 4: Summary of broomrape observations in Malkara-Tekirdag in 2003

Entry name	Plant number		Plant # with *Orobanche*		*Orobanche* number		Frequency (%)		Intensity		Attack rate	
	Avg	Range	Avg	Range	Avg	Range	Avg	Range	Avg	Range	Avg	Range
Control (Sanbro)	9.7	7-13	5.2	1-10	25.3	1-78	53.9	7.7-100.0	4.4	1.0 - 9.8	2.6	0.1-7.8
Female lines	7.0	1-14	2.8	0-9	11.9	0-62	43.6	0.0-100.0	3.4	0.0-15.0	2.0	0.0-14.4
Restorer lines	7.6	2-14	2.4	0-11	7.7	0-47	30.8	0.0-100.0	2.6	0.0-18.0	1.0	0.0-5.0
Experimental hybrids	8.6	2-14	5.0	0-13	24.9	0-76	56.9	0.0-100.0	4.4	0.0-20.7	2.8	0.0-11.3
Commercial cultivars	6.8	2-10	2.1	0-16	5.6	0-26	28.3	0.0- 66.7	1.8	0.0-4.3	0.7	0.0-2.9
TOTAL	7.9	1-14	3.5	0-16	15.1	0-78	42.7	0.0-100.0	1.7	0.0-20.7	1.8	0.0-14.4

The broomrape observations of female and restorer inbred lines of TARI in Malkara location are given in Tables 5 and 6. 2517-A, 3018-A, 6388-A, BAH4-A, HA89-5-A and HA-89-A were found to be resistant to broomrape in Malkara location in 2003. 2517-A has shown resistance in previous years and it was A line of registered TARSAN-1018 hybrid resistant to the new races in some locations. It was interesting to note that HA-89-A showed resistance. The reason could be the uneven broomrape distribution in the field or HA-89-A does have resistance genes for this

Table 5: Broomrape observations in sunflower female lines planted in Malkara-Tekirdag in 2003

Line name	Plant number	Plant #with *Orobanche*	*Orobanche* number	Frequency (%)	Intensity	Attack rate
Control (Sanbro)	7	7	21	100.0	3.0	3.0
0043-A	9	5	8	55.6	1.6	0.9
0043-A	9	5	8	55.6	1.6	0.9
0046-A	9	7	14	77.8	2.0	1.6
0704-A	11	2	3	18.2	1.5	0.3
0821-A	6	4	8	66.7	2.0	1.3
1159-A	13	3	10	23.1	3.3	0.8
195-A	8	1	2	12.5	2.0	0.3
2453-A	10	6	14	60.0	2.3	1.4
2478-A	8	1	1	12.5	1.0	0.1
2517-A	0	0	0	0.0	0.0	0.0
3002-A	14	1	2	7.1	2.0	0.1
3009-A	7	3	7	42.9	2.3	1.0
3018-A	4	0	0	0.0	0.0	0.0
4155-A	9	1	3	11.1	3.0	0.3
4156-A	11	3	13	27.3	4.3	1.2
583-A	13	2	5	15.4	2.5	0.4
6163-A	9	2	2	22.2	1.0	0.2
62001-A	12	3	7	25.0	2.3	0.6
62003-A	9	3	5	33.3	1.7	0.6
6388-A	7	0	0	0.0	0.0	0.0
6397-A	3	3	20	100.0	6.7	6.7
6398-A	11	6	15	54.5	2.5	1.4
6522-A	8	2	7	25.0	3.5	0.9
6535-A	11	9	25	81.8	2.8	2.3
65371-A	10	2	2	20.0	1.0	0.2
65373-A	8	1	1	12.5	1.0	0.1
6545-A	9	3	7	33.3	2.3	0.8
66241-A	1	1	1	100.0	1.0	1.0
66244-A	9	5	17	55.6	3.4	1.9
6626-A	9	4	23	44.4	5.8	2.6
67375-A	10	8	5	80.0	0.6	0.5
6765-A	5	4	14	80.0	3.5	2.8
BAH-2-A	10	1	1	10.0	1.0	0.1
BAH-3-A	10	2	6	20.0	3.0	0.6
BAH-4-A	10	0	0	0.0	0.0	0.0
BAH-5-A	9	4	10	44.4	2.5	1.1
BAH-I-A	12	2	2	16.7	1.0	0.2
HA-64-A	10	5	16	50.0	3.2	1.6
HA-821-A	10	2	5	20.0	2.5	0.5
HA-850-A	10	2	2	20.0	1.0	0.2
HA-89-1-A	9	2	6	22.2	3.0	0.7
HA-89-2-A	7	3	8	42.9	2.7	1.1
HA-89-3-A	3	1	6	33.3	6.0	2.0
HA-89-4-A	9	4	10	44.4	2.5	1.1
HA-89-5-A	6	0	0	0.0	0.0	0.0
HA-89-6-A	8	1	1	12.5	1.0	0.1
HA-89-7-A	8	1	7	12.5	7.0	0.9
HA-89-A	7	0	0	0.0	0.0	0.0

Table 6: Broomrape observations in sunflower restorer lines planted in Malkara-Tekirdag in 2003

Line name	Plant number	Plant # with *Orobanche*	*Orobanche* number	Frequency (%)	Intensity	Attack rate
Control (Sanbro)	11	10	45	90.9	4.5	4.1
010018-R	9	1	1	11.1	1.0	0.1
010019-R	8	6	28	75.0	4.7	3.5
0525-R	11	8	20	72.7	2.5	1.8
0536-R	12	1	1	8.3	1.0	0.1
0595-R	11	4	17	36.4	4.3	1.5
0708-R	10	2	3	20.0	1.5	0.3
0845-R	4	0	0	0.0	0.0	0.0
1001-R	10	3	7	30.0	2.3	0.7
1095-R	5	2	10	40.0	5.0	2.0
1739-R1	8	5	12	62.5	2.4	1.5
1749-R	7	2	9	28.6	4.5	1.3
2274-R	9	7	32	77.8	4.6	3.6
2280-R	10	3	7	30.0	2.3	0.7
2284-R	10	4	15	40.0	3.8	1.5
2557-R	9	5	25	55.6	5.0	2.8
2562-R	5	4	16	80.0	4.0	3.2
25711-R	14	2	3	14.3	1.5	0.2
25712-R	2	1	1	50.0	1.0	0.5
2644-R	4	1	5	25.0	5.0	1.3
2881-R	11	2	4	18.2	2.0	0.4
2916-R	9	2	5	22.2	2.5	0.6
29331-R	4	3	15	75.0	5.0	3.8
29332-R	9	3	7	33.3	2.3	0.8
2956-R	11	11	47	100.0	4.3	4.3
2958-R	5	4	12	80.0	3.0	2.4
33701-R	7	5	17	71.4	3.4	2.4
33702-R	7	2	6	28.6	3.0	0.9
3473-R	7	2	6	28.6	3.0	0.9
3600-R	10	6	4	60.0	0.7	0.4
4177-R	8	5	6	62.5	1.2	0.8
4327-R	5	1	4	20.0	4.0	0.8
48312-R	11	2	6	18.2	3.0	0.5
48315-R	10	3	5	30.0	1.7	0.5
5257-R	7	2	6	28.6	3.0	0.9
62302-R	8	6	20	75.0	3.3	2.5
62303-R	12	4	17	33.3	4.3	1.4
63461-R	11	2	5	18.2	2.5	0.5
63462-R	3	0	0	0.0	0.0	0.0
6973-R	11	2	5	18.2	2.5	0.5
70351-R	11	6	20	54.5	3.3	1.8
70352-R	7	3	8	42.9	2.7	1.1
7069-R	11	2	15	18.2	7.5	1.4
7487-R	3	0	0	0.0	0.0	0.0
7794-R	7	5	17	71.4	3.4	2.4
7818-R	8	7	16	87.5	2.3	2.0
7820-R	4	4	9	100.0	2.3	2.3
7873-R	10	3	9	30.0	3.0	0.9
7877-R	3	2	13	66.7	6.5	4.3

race, because it showed resistance last year too. HA-89-5-A was the only resistant line among the HA-89-A lines. The line 3002-A also had improved resistance level.

From restorer lines of TARI, only 0845-R 7487-R and 63462-R were free from broomrape in the 2003 broomrape trials (Table 6). However, 0536-R restorer line of registered TARSAN-1018 hybrid also showed a resistance level to broomrape in Malkara location in 2003. TARI restorer lines showed less tolerance than inbred female lines in this *Orobanche* test trial and resistant ones will be included in broomrape differential set in subsequent years.

P-4223 and P-4028, which belong to Pioneer Seed Co., were the only resistant hybrids in the 2003 regional trials (Table 7). However, P-4028 had high yield only in Muratli location, but P-4223 showed high performance under both heavy and less intensive broomrape conditions. Sunflower hybrids were affected more under conditions heavy broomrape infestation in Muratli location. Although some commercial hybrids such as TR-1018 (TARSAN-1018), SANBRO, AYDIN, C-70165, COBAN and TR-9426 showed susceptibility to broomrape, the seed yields of these hybrids were not reduced too much. From experimental hybrids, TR-9426 showed tolerance to broomrape in Muratli location, but it showed no resistance in broomrape trials in Malkara location.

Some inbred lines (62003-A, 62001-A, 6522-A) showed different levels of tolerance in different locations. In some areas, a few broomrape plants were observed in the resistant Pioneer hybrid PR-64-A95 and differential reactions were observed in BR populations and some inbred lines. Sunflower lines and hybrids resistant in one location in previous years could show susceptibility in subsequent years. It means that new broomrape races change their reactions depending on year and location. It is not easy to determine how many races we could find in Trakya Region, what their limits and infestation areas are and which hybrids could be used in the broomrape differential set. There could be new races or sub-races and molecular methods are needed to differentiate these races. However, we know that P-4223 is resistant to all races, since it has only several broomrape plants in a sunflower crop, and the sunflower hybrid TARSAN-1018, the female inbred lines 62003-A, 62001-A and 6522-A and the restorer line 63462-R have resistance capabilities in some regions. These sunflower hybrids and lines can be included in the broomrape differential set. It was also observed by researchers that sunflower hybrids showed more stability than inbred lines regarding the resistance to new races of broomrape in Trakya region (personal communication).

CONCLUSIONS

The Pioneer hybrid P-4223 was resistant in all locations tested in 2003 but the resistance of this hybrid could be broken in some areas in Trakya region. This result shows how high and serious the virulence of the new broomrape race is. The resistance of the hybrid TARSAN-1018, some inbred lines and BR populations in some locations in the region is a proof of existence of at least one or more new broomrape races in addition to the F race. Besides, these new races spread out easily and quickly year-by-year. We do not know yet if the new races exist or not in

Table 7: Broomrape observations and seed yields of the hybrids in the 2003 regional trials

Cultivars	Seed yield / location						Broomrape observations / location								
	Edirne		Luleburgaz		Muratli		Karabulut			Malkara			Muratli		
	Kg/da	VS	Kg/da	VS	Kg/da	VS	F	I	AR	F	I	AR	F	I	AR
TR - 1018	222.7	9	153.3	24	154.3	5	10.0	1.0	0.1	0.0	0.0	0.0	98.3	5.7	5.6
AYDIN	232.7	3	164.9	16	149.8	6	9.1	1.0	0.1	0.0	0.0	0.0	100.0	6.3	6.3
MERICF1	203.2	24	165.7	15	95.3	21	7.7	2.0	0.2	14.3	1.0	0.1	100.0	7.8	7.8
TR-3080	192.9	26	192.3	3	88.5	22	25.0	2.7	0.7	16.7	4.0	0.7	100.0	9.9	9.9
TR-6149	213.7	16	170.5	12	104.9	14	18.2	1.5	0.3	28.6	3.5	1.0	100.0	11.0	11.0
COBAN	213.1	17	179.0	5	134.5	9	0.0	0.0	0.0	30.0	3.3	1.0	100.0	5.4	5.4
SANBRO	239.3	2	193.5	2	162.0	3	20.0	1.0	0.2	14.3	1.0	0.1	100.0	8.2	8.2
ISERA	227.8	5	186.9	4	140.7	8	-	-	-	-	-	-	100.0	8.1	8.1
P-4028	210.6	18	121.0	27	180.1	2	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1.8	0.1
P-4223	248.5	1	174.9	8	182.5	1	0.0	0.0	0.0	25.0	1.0	0.3	2.8	4.0	0.1
ALHAJA	216.7	10	158.5	19	98.5	20	9.1	1.0	0.1	44.4	2.5	1.1	100.0	8.4	8.4
SIRENA	215.0	13	157.7	20	112.1	13	8.3	1.0	0.1	40.0	2.0	0.8	100.0	8.0	8.0
AS-6310	209.0	22	169.9	13	84.0	24	-	-	-	-	-	-	100.0	10.3	10.3
VANKO	209.8	19	177.5	7	84.9	23	0.0	0.0	0.0	37.5	4.0	1.5	100.0	10.2	10.2
C-70165	227.0	6	197.3	1	155.6	4	-	-	-	-	-	-	100.0	10.5	10.5
TR-7237	216.2	11	167.7	14	122.5	11	0.0	0.0	0.0	87.5	8.3	7.3	100.0	7.1	7.1
TR-9102	209.4	21	172.5	11	103.2	18	9.1	1.0	0.1	75.0	4.2	3.1	100.0	8.3	8.3
TR-9163	199.2	25	154.2	23	66.83	26	0.0	0.0	0.0	28.6	2.5	0.7	100.0	10.3	10.3
TR-9173	208.5	23	177.7	6	104.9	15	0.0	0.0	0.0	25.0	1.5	0.4	100.0	10.1	10.1
TR-9190	214.9	14	160.6	17	77.1	25	0.0	0.0	0.0	33.3	4.0	1.3	100.0	9.0	9.0
TR-9198	192.5	27	155.4	21	101.8	19	0.0	0.0	0.0	60.0	2.5	1.5	100.0	10.9	10.9
TR-9206	224.8	7	173.9	9	114.5	12	0.0	0.0	0.0	40.0	3.0	1.2	100.0	10.0	10.0
TR-9313	228.9	4	135.9	26	103.6	17	0.0	0.0	0.0	66.7	3.8	2.5	100.0	9.2	9.2
TR-9322	216.0	12	160.6	18	127.0	10	8.3	1.0	0.1	22.2	17.5	3.9	98.9	5.3	5.2
TR-9426	214.8	15	146.3	25	147.1	7	0.0	0.0	0.0	40.0	2.5	1.0	73.1	1.5	1.1
RIMI	209.8	20	173.6	10	63.9	27	55.6	2.0	1.1	66.7	1.0	0.7	100.0	15.1	15.1
ZOLTAN	223.0	8	154.4	22	104.5	16	-	-	-	-	-	-	100.0	12.3	12.3
Average	216.3	-	166.5	-	117.2	-	-	-	-	-	-	-	-	-	-
SD	12.8	-	17.1	-	32.8	-	-	-	-	-	-	-	-	-	-
LSD(0.05)	32.8	-	37.9	-	26.6	-	-	-	-	-	-	-	-	-	
CV (%)	10.9	-	14.5	-	13.9	-	-	-	-	-	-	-	-	-	-

other parts of Turkey. Some resistant hybrids could show susceptibility in following years in some areas of the region. Molecular methods could be used for the determination of new races in addition to the use the broomrape differential set. Besides using genetically resistant sunflower cultivars by farmers, use of IMI herbicide resistant cultivars in the sunflower production could bring more profit in the areas of the region infested by broomrape and weeds. Developing SURE herbicide resistant hybrids and their use in the production is also another option to increase the spectrum of weed and broomrape control.

REFERENCES

Al-Khatib, K., J.R. Baumgartner, D.E. Petersen and R.S. Curie, 1998. Imazethhapyr resistance in common sunflower (*Helianthus annuus* L.). Weed Science 46: 403-407.

Alonso, L.C., M.I. Rodriquez-Ojedo, J. Fernedez-Escobar, G. Lopez-Ruiz-Calero, 1998. Chemical control of broomrape (*Orobanche cernua* Loeffl.) in sunflower (*Helianthus annuus* L.) resistant to imazethapyr herbicide. Helia 29: 45-54.

Anonymus, 2002. Trakya Agricultural Research Institute Sunflower Research Project Report. Edirne.

Anonymus, 2003. CLEARFIELD® Production System, BASF Company. www.clearfieldsystem.com

Bulbul, A., M. Salihoglu, Ç. Sari, and A. Aydin, 1991. Determination of broomrape (*Orobanche cumana*. Wallr.) races of sunflower in the Thrace region of Turkey. Helia 14(15): 21-26.

Demirci, M., Y. Nemli and Y. Kaya, 2003. Effect of soil temperature on *Orobanche cernua* Loeffl. growing stages and control strategies. Proc. European Weed Research Society (EWRS) 7th Mediterranean Symposium, 6-9 May. Cukurova University, Adana, Turkey, 151-152.

Jan, C.C., J.A. Ruso, J. Munoz-Ruz and J.M. Fernandez, 2000. Resistance of sunflower (*Helianthus*) perennial species, interspecific amphidiploids and backcross progeny to broomrape *Orobanche cumana Wallr.* races. In: Proceedings of the 15th Int. Sunflower Conf. Toulouse, France. June 12-15. J: pp. 14-19.

Kaya, Y., 2003a. Aycicek Tarimi. Tarim Istanbul. 84: 24-25.

Kaya, Y., 2003b. Ayciceginde Orobans ve Mucadelesi. Tarim Istanbul. 84: 26-28.

Malidza, G., S. Jocić, and D. Škorić. 2003. Weed and broomrape (*Orobanche cernua)* control in Clearfield in Sunflower. Proc. European Weed Research Society (EWRS) 7th Mediterranean Symposium, 6-9 May. Cukurova University, Adana, Turkey: pp. 51-52.

Miller, J.F. and K. Al-Khatib, 2000. Development of Herbicide Resistant Germplasm in Sunflower. In Proc. of the 15th Int. Sunflower Conf. Toulouse, France. June 12-15: pp. 37-41.

Miller, J.F., 2002. Cross-Resistance of Two Sulfonylurea-Resistant Sunflower Sources to Selected Als Herbicides. Proceedings of Sunflower Research Workshop, January 24, Fargo, ND, USA

Pacureanu-Joita, M., A.V. Vranceanu, G. Soare, A. Marinescu and I. Sandu, 1998. The evaluation of the parasite-host interaction system (*Helianthus annuus* L.-*Orobanche cumana Wallr.)* in Romania. Proceedings of 2nd Balkan Symposium on Field Crops. 16-20 June, 1998. Novi Sad, Yugoslavia: pp. 153-155.

Sukno, S., J.M. Melero-Vara, and J.M. Fernandez-Martinez, 1999. Inheritance of resistance to *Orobanche cernua* Loeffl. in six sunflower lines. Crop Science 39: 674-678.

Vranceanu, A.V., V.A. Tudor, F.M. Stonescu and N. Pirvu, 1980. Virulence groups of broomrape (*Orobanche cumana Wallr.)* differential hosts and resistance sources and genes in sunflower. In: Proceedings of the 9th International Sunflower Conference. Torremolinos. Spain. June 8-13: pp 74-81.

Yordanova, E., N. Gorinova, and A. Atanassov, 2001. Use of Cytochrome P450 monooxygenase genesto introduce herbicide tolerance in tobacco. Biotechnology & Biotechnol. Eq. 2/ 2001/15. Suplement, Turkish-Bulgarian Workshop on Plant Biotechnology. 27-30 May. TUBITAK, MRC, RIGEB-NCAS, Agrobio Institute, Bulgaria: pp. 49-55.

Yucer. M., 2003. Tarim Ilaclari. Registered Agrochemicals in Turkey. Hasad Yayincilik. pp. 283.

JOPO DE GIRASOL (*Orobanche cernua* Loeffl.) Y RESISTENCIA A HERBICIDAS EN GIRASOL (*Helianthus annuus* L.) EN TURQUÍA

RESUMEN

Las nuevas razas de jopo de girasol afectan la producción de girasol en Turquía. El híbrido P-4223 de la Compañía Pioneer, era resistente en todas las partes del país, mientras los híbridos TARSAN-1018 y ciertas líneas consanguíneas eran resistentes en ciertas zonas de la región de Trakya, en la cual está presente por lo menos una nueva raza más de jopo de girasol, aparte de la raza F. U 2003. Los granjeros aplicaban con éxito Clearfield System® sin cualquier tipo de problemas, utilizando herbicidas del grupo de imidazolinonas y el híbrido resistente. En los anos venideros, aparte de cultivar las variedades de girasol genéticamente resistentes a jopo de girasol, este sistema será el modo preferido de lucha contra ese patógeno, entre granjeros, sobre todo en las regiones problemáticas, en las cuales el jopo de girasol está presente junto con las malas hierbas.

OROBANCHE (*Orobancce cernia* Loeffl.) ET RÉSISTANCE AUX HERBICIDES DANS LES LIGNES CULTIVÉES DE TOURNESOL (*Helianthus annuus* L.) EN TURQUIE

RÉSUMÉ

Les nouvelles races d'orobanche mettent en danger la production de tournesol en Turquie. L'hybride P-4223 de la compagnie "Pioneer" s'est présenté résistant dans toutes régions du pays, tandis que l'hybride TARSAN-1018 et certaines lignes cultivées étaient résistantes sur les terrains délimités en Thrace. Dans cette région il existe au moins encore une ou plusieurs nouvelles races d'orobanche à côté de la race F. En 2003 l'usage de l'herbicide du groupe "imidazolinone" et les herbicides résistants ont été mis en œuvre. Les fermiers ont utilisé les herbicides du "Clearfield System®" sans problèmes. Dans les années suivantes les fermiers choisiront ce "Clearfield System®" comme protection contre l'orobanche et les mauvaises herbes dans les régions problématiques où ce phénomène apparaît.