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Determination of Resistance to Broomrape and Yield Performances of IMI Type Sunflower Hybrids(*)

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is the most widely cultivated oilseed crop in Türkiye. However, sunflower production is severely constrained by broomrape (*Orobanche cumana* Wallr.). Herbicide-tolerant sunflower cultivars resistant to imazamox (IMI) play a crucial role in controlling broomrape and other weeds. In Türkiye, newly emerging broomrape races are currently present in almost all sunflower-growing areas. This study aimed to evaluate the yield performance and broomrape resistance of IMI-tolerant hybrid sunflower cultivars developed within the scope of TARI's National Sunflower Project. Field experiments were conducted in four locations in 2024. Experimental design was a randomized complete block design with four replications. Weed control was achieved by applying imazamox (40 g L^{-1}) at a rate of 1.25 L ha^{-1} at the 6-8 leaf stage. Statistical analyses were performed using the JMP software. Broomrape resistance was evaluated under both field conditions in Keşan and artificial inoculation tests in pots. In field trial, plots with two replicates. Each plots consisted 32 plants. Infection frequency, infection intensity, and aggressiveness levels were assessed, and genotypes were classified as susceptible, tolerant, or resistant. The results showed that TTAE IMI 23-130 and TTAE IMI 23-135 exhibited superior seed yield, oil yield, and high tolerance to new broomrape races, and they were identified as the most promising hybrids for variety registration. The susceptibility of OR7 gene-carrying genotypes further indicates the emergence of new broomrape races in the region.

Keywords: Sunflower, broomrape, imazamox, inoculation, yield

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Introduction

Sunflower is one of the most extensively grown oilseed crops in Türkiye and exhibits a principal source of digestible vegetable oil. Due to its wide adaptability, sunflower can be successfully grown under both irrigated and rainfed conditions across many regions of the country. The growing global population has led to an increasing demand for food. Consequently, the need for vegetable oils has risen both globally and nationally. In Türkiye, the high consumer preference for sunflower oil magnifies this demand, emphasizing the importance of maximizing yield per decare. Despite its strong adaptive capacity, sunflower production often can not reached to desired levels by cause of various limiting factors.

Sunflower (*Helianthus* spp.), which known as native American, covers 51 species, including 14 annual and 37 perennial species. Sunflower was initially cultivated as an ornamental plant. Its use as an oil crop began in the 17th century, after which it rapidly spread throughout Europe (Fick and Miller, 1997).

Following World War II, sunflower cultivation was introduced to Thrace region, Türkiye by migrants from the Balkans and its cultivation has been expanded across the country (Kaya, 2021).

Oilseed sunflower is among the most widely cultivated oil crops worldwide due to its high oil content and exceptional adaptability. The interaction between genotype, environmental conditions and cultivation methods form yield, yield-related traits, and quality characteristics. Average seed yield generally ranges between 2000 and 3500 kg ha^{-1}, and appropriate irrigation, sowing time, and fertilization can significantly enhance productivity (Evci et al., 2012). Seed oil content mostly varies between 40% and 50%, depending on genetic structure. Adequate water and nutrient during the seed-filling period improve oil biosynthesis (Flagella et al., 2002). Plant height ranges from 120 to 180 cm, depending on nitrogen fertilization, planting density, and genotype (Kıllı, 2004). Head diameter usually varies between 15 and 25 cm and shows a positive correlation with seed number and yield (Gholinezhad et al., 2009). Thousand-seed weight, which is affected by environmental factors, ranges from 50 to 80 g in oilseed sunflower (Hassan et al., 2013).

Sunflower production is inhibited by several abiotic and biotic factors such as diseases, weeds, and broomrape (*Orobanche cumana* Wallr.) in Türkiye. Although breeding programs have strenghten genetic resistance to these stresses, resistance is getting weaker over time has caused new challenges for farmers. Downy mildew (*Plasmopara halstedii* (Farlow) Berlese et de Toni), one of the most important sunflower diseases, is spreaded throughout sunflower-growing regions in Türkiye and has caused severe yield losses during epidemic years.

Weed management in sunflower starts prior to sowing and continues after emergence. The best practice is achieved through an integrated approach combining cultural, mechanical, and chemical methods. Chemical control practices include pre-plant integrated, pre-emergence, and post-emergence applications, performed when sunflower plants reach the 4-6 leaf stage. Major weed species such as cocklebur (*Xanthium strumarium*), wild oat (*Avena sterilis*), goosefoot (*Chenopodium album*), barnyard grass (*Echinochloa crus-galli*), wild mustard (*Sinapis arvensis*), tumbleweed (*Amaranthus albus*, *A. retroflexus*), black nightshade (*Solanum nigrum*), and thornapple (*Datura stramonium*) are suppressed by these strategies efficiently (Beres et al., 2005).

In both Türkiye and globally, the cultivation of sunflower varieties resistant to IMI (Imazamox) and SU (75% tribenuron-methyl) herbicides has become increased. These technologies enable effective weed management and also providing efficient control of broomrape through imazamox applications.

Broomrape is an obligate parasitic plant belonging to the Orobanchaceae family and roots a serious threat to sunflower production in many regions. *Orobanche cumana* weakens photosynthetic ability and parasitizes sunflower roots. It represents a major constraint to sunflower cultivation, especially in the Black Sea basin and Spain (Molinero-Ruiz et al., 2013).

Each broomrape flower patterns a capsule containing approximately 600 to 5,000 seeds, with a single plant capable of producing up to 500,000 seeds (Habimana et al., 2014). These seeds can remain viable in the soil for up to 20 years. Optimal soil temperatures for seed germination range from 20 to 25°C, and around 30-60 days after germination, flowering takes place (Pathak and Kannan, 2014).

Recent studies have reported the emergence of a new broomrape race (race H) in Romania (Pacureanu-Joita et al., 2009), Russia (Gontcharov, 2009; Antonova et al., 2011), northeastern Ukraine (Maklyak et al., 2018), and Türkiye (Kaya et al., 2009). Currently, broomrape races F, G, and H are known to exist in Türkiye, although the races were not clearly identified (Kaya et al., 2004; Molinero-Ruiz et al., 2015; Bilgen et al., 2019; Uludağ et al., 2021). A new race has emerged in sunflower fields in Adana and has also begun to infect known resistant sunflower lines. Additionally, a distinct infection pattern observed in the Şahinköy region of Thrace has led to the identification of a new race, designated as race I (Yonet et al., 2018).

At present, new broomrape races are spotted in nearly all sunflower-growing areas of the Thrace–Marmara region equals to almost half of the national sunflower production areas. However, the development of genetically resistant and IMI-tolerant sunflower varieties has significantly reduced the impact of broomrape in recent years (Kilic et al., 2016; Kaya, 2020).

This study investigated the yield performance of candidate hybrid sunflower varieties developed within an institutional breeding program, alongside commonly cultivated registered varieties, across multiple locations. Resistance to broomrape was estimated under both natural field conditions and artificial inoculation.

Materials and Methods

Materials

The materials used in this study were IMI-resistant hybrid sunflower varieties developed within the scope of the National Sunflower Project of the Thrace

Agricultural Research Institute. Twelve IMI-tolerant oilseed sunflower candidate varieties (TTAE IMI 23-22, TTAE IMI 23-54, TTAE IMI 23-90, TTAE IMI 23-123, TTAE IMI 23-124, TTAE IMI 23-130, TTAE IMI 23-132, TTAE IMI 23-135, TTAE IMI 23-142, TTAE IMI 23-150, TTAE IMI 23-154, TTAE IMI 23-155) were tested. Some of the most commonly grown commercial varieties (LG 50550 CLP, P64 LP130, P64 LC108, SUN 2259 CL) in the region were used as control varieties.

Field Trials

Field trials were conducted at four locations (Edirne, Çorlu, Keşan, and Kırklareli) using a randomized complete block design with four replications and four-row plots. Rows were 7.5 m in length, with 70 × 30 cm plant spacing (Figure 1a and Figure 1b). Four widely cultivated commercial hybrids were included as check varieties (Table 1). Weed control was achieved by applying imazamox (40 g L^{-1}) at a rate of 1.25 L ha^{-1} at the 4–6 or 6–8 leaf stage (Figure 1a). Phytotoxicity observations were recorded at 7 and 14 days after application. Statistical analyses were performed using the JMP software package.

Broomrape Field Tests

Field trial of broomrape test was located in Kesan (Figure 1c). The experimental design was Randomized Complete Block Desing with 2 replicates. Plots with two rows were 4-m long and plant spacing was 70 x 25 cm. Each plots consisted 32 plants. The location was selected according to the observations on high broomrape intensity of the field between the seasons of 2020-2023. There was no herbicide (imazamox) applications to have a better understanding of variety's resistance to broomrape. Frequency of infection (F), intensity of infection (I), levels of aggression (A) were examined for each genotype. Frequency of infection was obtained by calculating the percentage of infected plants. The data of Intensity of infection was gathered by counting the broomrapes per infected plants. Levels of aggression was calculated with this formula: (Frequency of Infection x Intensity of Infection) / 100. Hyrids, which have 0-10% F score and 0-1 A score, were considered as resistant-tolerant hybrid (Pustovoit, 1975).

Broomrape Inoculation Tests

The resistance of material to broomrape was tested in pots with full of artificially infected soil by broomrape. Broomrape seeds were obtained from different locations in the Thrace region. In the climate chamber, 1-2 g broomrape seeds were mixed into the soil in each plastic cup. 35 days after planting, the plants in cups were removed, the roots were washed, the tubers of the rootstock were counted and the degree of resistance was determined (Figure 1d). It is evaluated as susceptible, tolerant and resistant according to the tubers on the roots (TARI, 2012).

Results and Discussion

An analysis of variance was performed using the data obtained from the field experiments. Seed yield per decare varied significantly among locations. Edirne recorded the lowest yield values, whereas Keşan and Kırklareli were identified as the highest-yielding locations. A similar trend was observed for oil content, with the Edirne location showing lower average oil percentages compared to the other test environments (Table 1). These findings are in agreement with the study conducted by Skoric (2009) in Serbia, who reported that prolonged drought conditions affect sunflower growth and development negatively, and it leads to yield reductions and causes serious challenges for sunflower production under dry environments.

When seed yield performance was evaluated by location, the candidate varieties TTAE IMI 23-54 (1018 kg ha^{-1}) and TTAE IMI 23-150 (1021 kg ha^{-1}) exhibited remarkable performance in Edirne. In Çorlu, TTAE IMI 23-155 achieved the highest yield (1522 kg ha^{-1}), followed by TTAE IMI 23-154 (1415 kg ha^{-1}), TTAE IMI 23-123 (1354 kg ha^{-1}), TTAE IMI 23-135 (1275 kg ha^{-1}), TTAE IMI 23-124 (1269 kg ha^{-1}), TTAE IMI 23-150 (1234 kg ha^{-1}), TTAE IMI 23-130 (1226 kg ha^{-1}), and TTAE IMI 23-54 (1205 kg ha^{-1}), all of which exceeded the yield levels of the standard varieties. In Keşan, no statistically significant differences were detected among varieties; however, TTAE IMI 23-90 (2149 kg ha^{-1}), TTAE IMI 23-54 (2134 kg ha^{-1}), TTAE IMI 23-130 (2109 kg ha^{-1}), TTAE IMI 23-142 (2103 kg ha^{-1}), and TTAE IMI 23-154 (2101 kg ha^{-1}) emerged as the most promising genotypes. In Kırklareli, the highest yields were recorded for TTAE IMI 23-54 (2347 kg ha^{-1}), TTAE IMI 23-22 (2307 kg ha^{-1}), and TTAE IMI 23-123 (2278 kg ha^{-1}) (Table 1).

Evaluation of oil content revealed that in Edirne, the candidate varieties TTAE IMI 23-130 (39.9%), TTAE IMI 23-142 (39.2%), and TTAE IMI 23-132 (38.7%) surpassed the average oil content of the standard varieties (38.4%). In the Çorlu location, TTAE IMI 23-142 (43.8%), TTAE IMI 23-130 (43.3%), and TTAE IMI 23-135 (42.6%) were identified as the highest oil-yielding genotypes. Results from Keşan indicated that a considerable number of candidate varieties exceeded the mean oil content of the standard cultivars (41.9%). Among all tested genotypes, including the standards, TTAE IMI 23-155 (44.1%), TTAE IMI 23-130 (44.0%), TTAE IMI 23-142 (44.0%), and TTAE IMI 23-154 (43.7%) exhibited the highest oil content values. In Kırklareli, TTAE IMI 23-142 (43.0%), TTAE IMI 23-

154 (42.5%), TTAE IMI 23-130 (42.3%), and TTAE IMI 23-155 (42.3%) exceeded the average oil content of the standard varieties (42.1%) and were ranked among the leading genotypes (Table 1).

Overall evaluation of the experimental results demonstrated yield differences among all locations, showing strong agreement with the findings reported by Cetin and Ozturk (2018) in their study conducted in the Altınekin, Çumra, and Obruk locations of Konya Province.

Based on field-based broomrape resistance assessments, the candidate varieties TTAE IMI 23-90, TTAE IMI 23-130, TTAE IMI 23-135, TTAE IMI 23-142, TTAE IMI 23-150, TTAE IMI 23-154, and TTAE IMI 23-155 were identified as tolerant to the broomrape parasite. Results obtained from artificial inoculation trials further confirmed that TTAE IMI 23-90, TTAE IMI 23-130, TTAE IMI 23-135, TTAE IMI 23-142, TTAE IMI 23-154, and TTAE IMI 23-155 exhibited high levels of tolerance, while TTAE IMI 23-22, TTAE IMI 23-132, and TTAE IMI 23-150 were classified as tolerant genotypes. Combined evaluation of both field and inoculation results revealed the resistance of genotypes, although certain genotypes carrying the OR7 resistance gene displayed susceptibility. These observations are coherent with previous reports indicating the emergence of new broomrape races (H race) in Türkiye (Kaya et al., 2009) and the identification of a distinct infection pattern in the Şahinköy region of Thrace, which has been designated as race I (Yonet et al., 2018).

Conclusions

As a results of this study, it is seen that genotypes coded TTAE IMI 23-130, TTAE IMI 23-135, TTAE IMI 23-142, and TTAE IMI 23-155 exhibit remarkable performance in terms of grain yield and oil content in all 4 locations. Tolerance to broomrape races of genotypes is also determined as an outcome of tests. Although TTAE IMI 23-54 produced the highest yield values, it was susceptible to broomrape. Herbicide applications are not the main option especially for the fields without severe weed pressure. In order to prevent yield losses caused by broomrape, herbicide-tolerant varieties that have strong genetic tolerance, is essential in sunflower cultivation. Resistance evaluation results indicated that genotypes carrying the OR7 resistance gene were susceptible, and these results are proof of the presence of new broomrape races in the region. Based on a combined assessment of yield, oil content, broomrape resistance, and stability analysis (Figure 2), TTAE IMI 23-130 and TTAE IMI 23-135 were identified as the most suitable candidates for variety registration.

Acknowledgments

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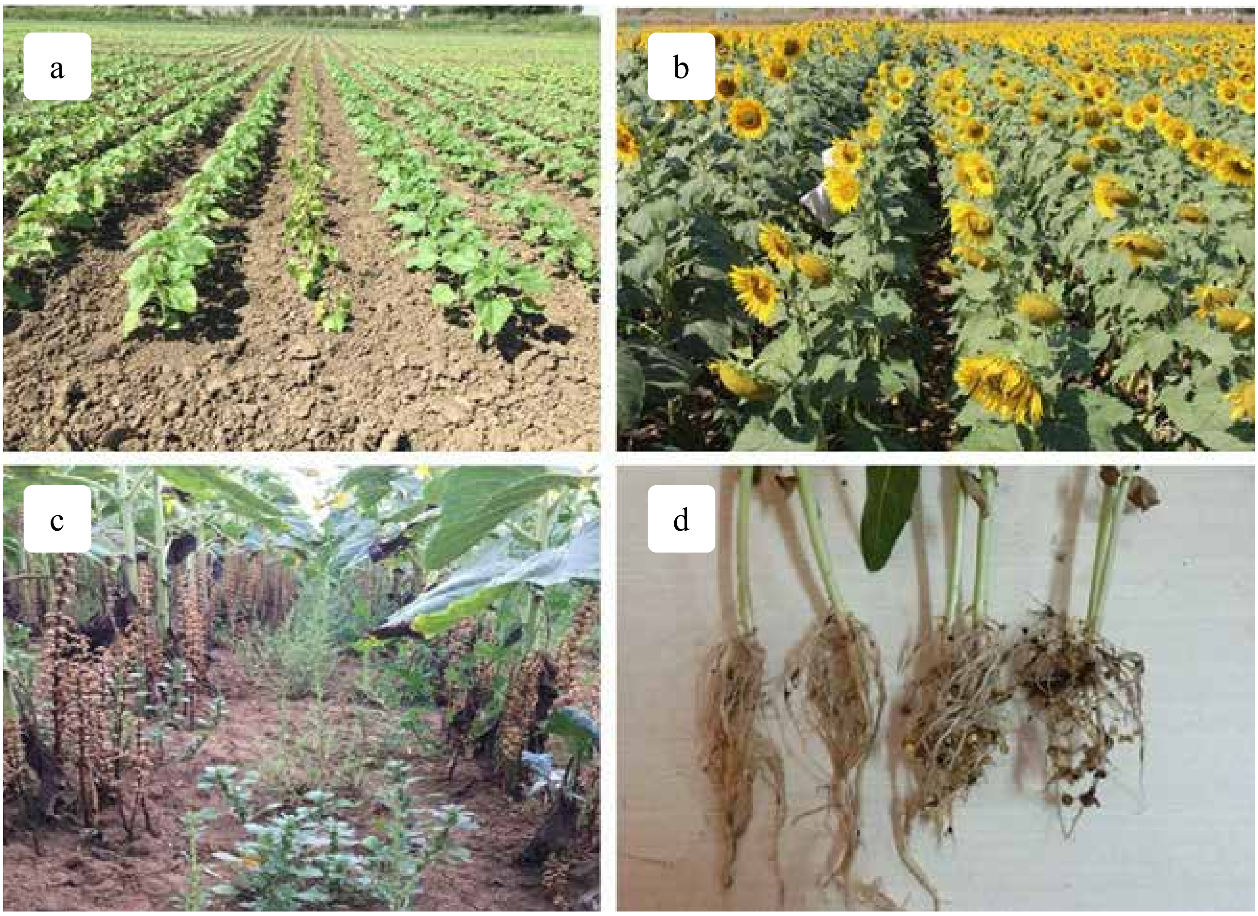

Figure 1. Sunflower yield trial, Edirne location (a-b), broomrape field tests, Keşan location (c) and (d) broomrape inoculation tests (Original).

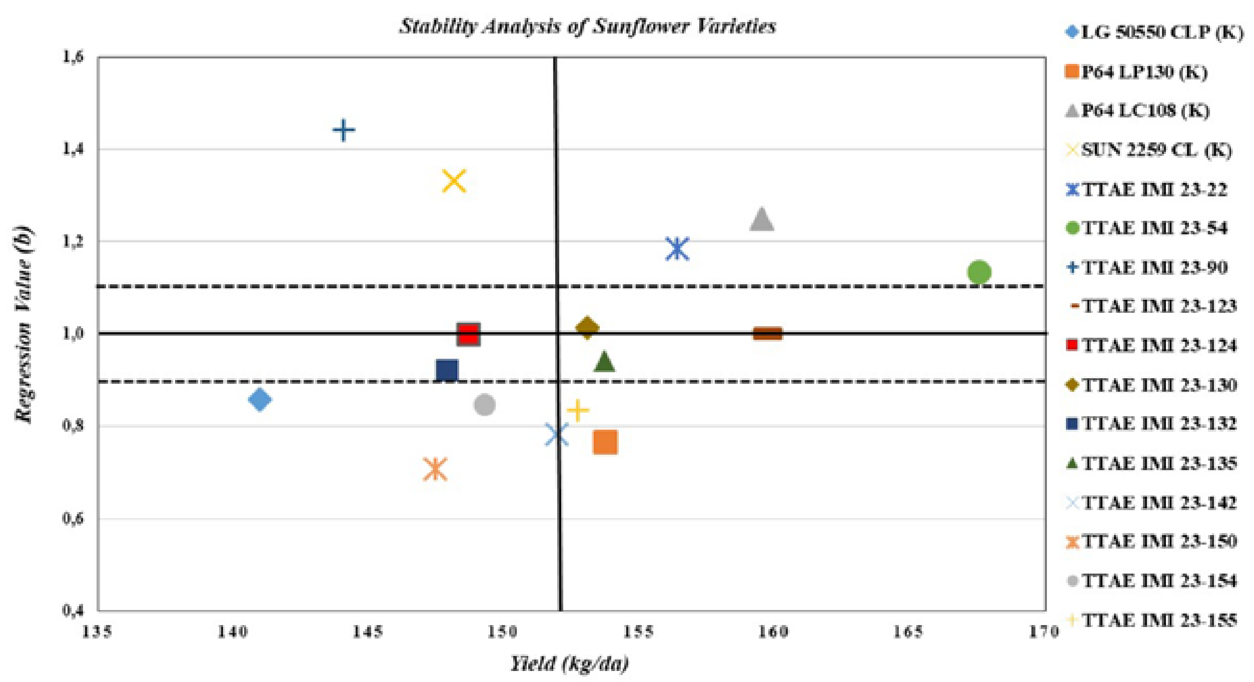

Figure 2. Stability analysis of sunflower varieties.

Table 1. Yield Trial, Field Broomrape Tests and Inoculation Broomrape Tests Observations and Results.

No	Varieties	Edirne		Çorlu		Keşan		Kırklareli		Yield Avg. (kg/ha)	SOC Avg. (%)	Yield Rank	FBT			IBT
		Yield (kg/ha)	SOC (%)	Yield (kg/ha)	SOC (%)	Yield (kg/ha)	SOC (%)	Yield (kg/ha)	SOC (%)				F	I	A	
1	LG 50550 CLP(C)	859^{bc}	38,9	1132^{b}	42,7	1688^{ab}	42,6	1959^{ef}	41,7	1410^{b}	41,5	16	0	0	0	R
2	P64 LP130 (C)	1194^{a}	39,1	1083^{b}	43,5	1578^{b}	43,7	2296^{ab}	44,0	1538^{ab}	42,6	5	0	0	0	R
3	P64 LC108 (C)	846^{bc}	38,2	1095^{b}	42,1	2364^{a}	41,2	2076^{ad}	41,0	1595^{ab}	40,6	2	3,1	1	0	R
4	SUN 2259 CL (C)	562de	37,5	1143^{b}	40,0	2027^{ab}	40,4	2194^{ad}	41,8	1481^{ab}	40	12	6,2	1	0,1	R
5	TTAE IMI 23-22	803^{bc}	37,8	1184^{b}	41,9	1961^{ab}	42,3	2307^{ab}	41,5	1564^{ab}	40,9	4	6,2	1	0,1	T
6	TTAE IMI 23-54	1018^{ab}	35,1	1205^{ab}	38,3	2134^{ab}	41,3	2347^{a}	40,0	1676^{a}	38,6	1	66	3,1	2	S
7	TTAE IMI 23-90	379^{e}	36,2	1167^{b}	38,0	2149^{ab}	39,7	2067^{ad}	39,8	1440^{b}	38,4	15	0	0	0	R
8	TTAE IMI 23-123	899^{bc}	36,9	1354^{ab}	37,9	1840^{ab}	42,6	2278^{ac}	41,3	1593^{ab}	39,6	3	100	3,9	3,9	S
9	TTAE IMI 23-124	774^{cd}	36,7	1269^{ab}	37,8	1987^{ab}	42,1	1919^{df}	39,4	1487^{ab}	39	11	53	3,3	1,8	S
10	**TTAE IMI 23-130**	**859^{bc}**	**39,9**	**1226^{ab}**	**43,3**	**2109^{ab}**	**44,0**	**1930^{df}**	**42,3**	**1531^{ab}**	**42,4**	**7**	**0**	**0**	**0**	**R**
11	TTAE IMI 23-132	900^{bc}	38,7	1166^{b}	41,0	1792^{ab}	42,5	2058^{ad}	40,1	1479^{ab}	40,6	13	31	2,3	0,7	T
12	**TTAE IMI 23-135**	**901^{bc}**	**37,7**	**1275^{ab}**	**42,6**	**1979^{ab}**	**41,4**	**1992^{be}**	**39,2**	**1537^{ab}**	**40,2**	**6**	**0**	**0**	**0**	**R**
13	TTAE IMI 23-142	957^{bc}	39,2	1337^{ab}	43,8	2103^{ab}	44,0	1679^{ef}	43,0	1519^{ab}	42,5	9	0	0	0	R
14	TTAE IMI 23-150	1021^{ab}	34,3	1234^{ab}	37,9	1957^{ab}	40,4	1686^{ef}	38,5	1475^{ab}	37,8	14	0	0	0	R
15	TTAE IMI 23-154	812^{bc}	37,0	1415^{ab}	41,8	2101^{ab}	43,7	1646^{f}	42,5	1493^{ab}	41,2	10	0	0	0	R
16	TTAE IMI 23-155	811^{bc}	36,1	1522^{a}	41,7	1900^{ab}	44,1	1876^{df}	42,3	1527^{ab}	41,1	8	0	0	0	R

Edirne CV (%): 16,6 LSD: 235
Çorlu CV (%): 19,1 LSD: 337
Keşan CV (%): 25,6 LSD: 723
Kırklareli CV (%): 11,3 LSD: 325
Avarage CV (%): 20,5 LSD: 234

SOC (%)=Seed Oil Content
FBT=Field Broomrape Tests
IBT=Inoculation Broomrape Tests

F (%)=Frequency of Infection
I (Unit)=Intensity of Infection
A (F x A/100)=Levels of Aggression

T : Tolerance
R : Resistant
S : Susceptible

References

Antonova, T. S., Araslanova, N. M., Strelnikov, E. A., Ramazanova, S. A., Tchelustnikova, T. A., & Guchetl, S. Z. (2011). Screening of wild *Helianthus* species for resistance to highly virulent *Orobanche cumana* affecting sunflower in the Rostov region of the Russian Federation. *Helia, 34*(55), 115-124. https://doi.org/10.2298/HEL1155115A

Beres, I., Szente, D., Gyenes, V., & Somlyay, I. (2005). Weed control in sunflower (*Helianthus annuus* L.) with post-emergent herbicides. *Communications in Agricultural and Applied Biological Sciences, 70*(3), 475-479.

Bilgen, B. B., Barut, A. K., & Demirbaş, S. (2019). Genetic characterization of *Orobanche cumana* populations from the Thrace region of Turkey using microsatellite markers. *Turkish Journal of Botany, 43*, 38-47. https://doi.org/10.3906/bot-1807-71

Çetin, K., & Öztürk, Ö. (2018). Determination of yield and yield characteristics of some hybrid sunflower cultivars. *Selcuk Journal of Agriculture and Food Sciences, 32*(3), 281-288. https://doi.org/10.15316/SJAFS.2018.95

Evci, G., Pekcan, V., Yılmaz, M. İ., & Kaya, Y. (2012). Determination of the relationships between oil content and important yield traits in sunflower. *Proceedings of the 18th International Sunflower Conference*, 1, 185.

Fick, G. N., & Miller, J. F. (1997). Sunflower breeding. A.A., Schneiter (Edt.), *Sunflower technology and production* (ss. 395-439). Soil Science Society of America, Inc.

Flagella, Z., Rotunno, T., Tarantino, E., Di Caterina, R., & De Caro, A. (2002). Changes in seed yield and oil fatty acid composition of high oleic sunflower (*Helianthus annuus* L.) hybrids in relation to sowing date and water regime. *European Journal of Agronomy, 17*(3), 221-230.

Gholinezhad, E., Aynaband, A., Ghorthapeh, A. H., Noormohamadi, G., & Bernousi, I. (2009). Effects of drought stress on yield, yield components, and harvest index of sunflower hybrid Iroflor at different nitrogen levels and plant populations. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37*(2), 85-94. https://doi.org/10.15835/nbha3723255

Gontcharov, S. V. (2009). Sunflower breeding for resistance to a new broomrape race in the Krasnodar region of Russia. *Helia, 32*(51), 75-80. https://doi.org/10.2298/HEL0951075G

Habimana, S., Nduwumuremyi, A., & Chinama, R. J. D. (2014). Management of *Orobanche* in field crops: A review. *Journal of Soil Science and Plant Nutrition, 14*(1), 43-62. https://doi.org/10.4067/S0718-95162014005000004

Hassan, S. F., Iqbal, M. S., Rabbani, G., Naeem-ud-Din, N. U. D., Shabbir, G., Riaz, M., & Noorka, I. R. (2013). Correlation and path analysis for yield and yield components in sunflower (*Helianthus annuus* L.). *African Journal of Biotechnology, 12*(16), 1968-1971. https://doi.org/10.5897/AJB12.817

Kaya, Y. (2020). Sunflower production in the Black Sea region: Situation and problems. *International Journal of Innovative Approaches in Agricultural Research, 4*(1), 147-155. https://doi.org/10.29329/ijiaar.2020.238.15

Kaya, Y. (2021). Ayçiçeğinin ülkemiz ve dünyadaki durumu, kökeni ve tarihi. *Ayçiçeği tarımı* (ss. 8-18). Nobel Yayıncılık.

Kaya, Y., Evci, G., Pekcan, V., & Gucer, T. (2004). Determining new broomrape-infested areas and resistant lines and hybrids in the Trakya region of Turkey. *Helia, 27*(40), 211-218. https://doi.org/10.2298/HEL0440211K

Kaya, Y., Evci, G., Pekcan, V., Gucer, T., & Yilmaz, İ. M. (2009). Evaluation of broomrape resistance in sunflower hybrids. *Helia, 32*(51), 161-169. https://doi.org/10.2298/HEL0951161K

Kıllı, F. (2004). Influence of different nitrogen levels on productivity of oilseed and confection sunflower (*Helianthus annuus* L.) under varying plant populations. *International Journal of Agriculture and Biology, 6*, 594-598.

Kılıç, Y., Sezgin, M., & Kaya, Y. (2016). Determining new aggressive broomrape infestations in the Mediterranean region of Turkey. *Proceedings of the 19th International Sunflower Conference* (pp. 728-733), Edirne, Turkey.

Maklyak, E., Kyrychenko, V. V., & Pacureanu-Joita, M. J. (2018, July). Race composition and phenology of sunflower broomrape (Orobanche cumana Wallr.) in Ukraine. *In Proceedings of the 4th International Symposium on Broomrape in Sunflower* (pp. 67-78), Bucharest, Romania.

Molinero-Ruiz, L., García, C. A. B., Collado, R. M., Raranciuc, S., Domínguez, J., & Melero, V. J. M. (2013). Pathogenic and molecular diversity in highly virulent populations of the parasitic weed *Orobanche cumana* from Europe. *Weed Research, 54*, 87-96. https://doi.org/10.1111/wre.12056

Molinero-Ruiz, L., Delavault, P., Pérez-Vich, B., Pacureanu-Joita, M., Bulos, M., Altieri, E., & Domínguez, J. (2015). History of the race structure of *Orobanche cumana* and breeding of sunflower for resistance: A review. *Spanish Journal of Agricultural Research, 13*(4), e10R01. https://doi.org/10.5424/sjar/2015134-8080

Pacureanu-Joita, M., Fernandez-Martinez, J. M., Sava, E., & Raranciuc, S. (2009). Broomrape (*Orobanche cumana* Wallr.), the most important parasite in sunflower. *Analele I.N.C.D.A. Fundulea, 77*, 49-56.

Pathak, A., & Kannan, C. (2014). A cost-effective method for quantification of *Orobanche* seed bank in soil. *Indian Journal of Weed Science, 46*(2), 151-154.

Pustovoit, V. S. (1975). Main trends in breeding research. Selection of sunflower for resistance to broomrape [*Orobanche cumana*] and moth [*Homoesoma nebulella*]. *Kolos*, 153-159.

TARI, Trakya Agricultural Research Institute. (2012). *Investigation of genetic resistance resources to Orobanche and breeding of broomrape-resistant sunflower lines (Research Projects Report).* TARI, Edirne, Turkey. https://arastirma.tarimorman.gov.tr/ttae/Belgeler/FaaliyetRaporlari/2012_faaliyet_raporu.pdf

Skoric, D. (2009). Sunflower breeding for resistance to abiotic stresses. *Helia, 32*(50), 1-16. https://doi.org/10.2298/HEL0950001S

Uludağ, A., Üremiş, İ., & Kaya, Y. (2021). Ayçiçeğinde yabancı otlar ve mücadelesi. Y. Kaya (Ed.), *Ayçiçeği tarımı* (pp. 101-125). Nobel Yayıncılık.

Yonet, N., Aydin, Y., Evci, G., & Uncuoglu, A. A. (2018). Genomic evaluation of sunflower broomrape (*Orobanche cumana*) germplasm by KASP assay. *Helia, 41*(68), 57-72. https://doi.org/10.1515/helia-2017-0016

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