Bitki Koruma Bülteni / Plant Protection Bulletin

http://dergipark.gov.tr/bitkorb

Original article

Wild mustard (*Sinapis arvensis* L.) resistance to tribenuron methyl in wheat fields of Diyarbakır province, Türkiye

Diyarbakır ili buğday tarlalarında yabani hardalın (*Sinapis arvensis* L.) tribenuron methyle karşı dayanıklılık durumu

Erdal ATEŞ[a*], İslam Emrah SÜER[a], İlhan ÜREMİŞ[b], Nihat TURSUN[c]

https://orcid.org/0000-0002-3708-3407, https://orcid.org/0000-0003-3297-6860, https://orcid.org/0000-0001-5937-9244, https://orcid.org/0000-0002-8765-0326

[a]*Diyarbakır Plant Protection Research Institute, Diyarbakır, Silvan Highway 7. km. Sur, Diyarbakır*

[b]*Hatay Mustafa Kemal University, Faculty of Agriculture, Department of Plant Protection, Tayfur Sökmen Campus, Antakya, Hatay*

[c]*Malatya Turgut Ozal University, Faculty of Agriculture, Department of Plant Protection, Kirkgöz Street No: 82 B Battalgazi, Malatya*

ARTICLE INFO

Article history:
DOI: 10.16955/bitkorb.1470158
Received : 18-04-2024
Accepted : 10-06-2024

Keywords:
acetolactate synthase (ALS) inhibitor, herbicide resistance, *Triticum aestivum* L.

* Corresponding author: Erdal ATEŞ
erdal.ates@tarimorman.gov.tr

ABSTRACT

Chemical weed control is unavoidable in the fields where weeds cause problems in wheat production. However, resistance problems in weeds arise a few years later especially using herbicides with the same mode of action continuously. Frequent and inappropriate use of herbicides leads to various environmental, health and economic issues, as well as labour losses. Recently, growers complained that tribenuron-methyl (acetolactate synthase - ALS), commonly used to control wild mustard (*Sinapis arvensis* L.-SINAR), which is causing problems in the wheat fields of Diyarbakır province, is ineffective. To determine the extent of the problem, wild mustard seeds were collected from 56 suspected wheat fields in 16 districts of Diyarbakır. As a result of applications carried out with the method under controlled conditions, resistance was suspected in the population of 28 fields. The results of the dose-response experiments indicated that no resistance ($RI<3$) was observed in 20 biotypes, low resistance ($3 \leq RI<5$) was detected in 5 biotypes, and moderate resistance ($5 \leq RI<10$) was detected in 3 biotypes.

INTRODUCTION

Wheat is the most widely grown crop in the world. According to the FAO, in 2020 about 760 million tonnes of wheat were produced in 123 countries on an area of about 242 million hectares. In terms of production volume, China ranks first with 17.6% of total wheat production, followed by India (14.1%), Russia (11.3%) and the USA (6.5%). Türkiye ranks 10th with wheat production of 20.5 million tonnes and a production rate of 2.7% (FAO 2022).

Although the wheat plant is highly adaptable, its yield can vary according to ecological and climatic conditions. In addition, the size and characteristics of farms, access to irrigation water and inputs and equipment used in agricultural production, producers' education level, and their attitudes and behaviours in carrying out agricultural activities are also important factors affecting wheat yield (Ateş 2022). Additionally, biotic and abiotic factors can also affect wheat yield during production Depending on the climate, weeds, especially biotic factors, can cause productivity losses of up to 52% (Ateş 2022, Chaudhary et al. 2008). Yield losses have been reported to be as high as 100% when broadleaf weeds, such as *Sinapis arvensis* L. (SINAR), completely cover the wheat plant and prevent harvest in seasons of heavy infestation (Ateş and Üremiş 2020). SINAR is one of the species that is widely distributed in the wheat-growing areas of Türkiye and has a large coverage area (Ateş and Üremiş 2020, Gökalp and Üremiş 2015, Gürbüz et al. 2018, Özaslan 2011). Herbicides with different modes of action are used to control SINAR in wheat fields. There have been complaints in recent years regarding the failure of chemical applications to yield the intended outcomes. Although the basis of these complaints was the method and timing of application, there have been reports that SINAR is a species susceptible to developing resistance to herbicides (Gherekhloo et al. 2018, Gürbüz et al. 2018). According to the International Herbicide-Resistant Weed Database, 901 cases of herbicide resistance in weeds have been reported in 72 countries and more than 40% of these reports come from wheat fields. Six cases were recorded in SINAR species, with five attributed to tribenuron-methyl (Heap 2024). Tribenuron methyl belongs to the group of acetolactate synthase (ALS) enzyme inhibitors. ALS herbicides inhibit the biosynthesis of branched-chain amino acids such as valine, leucine, and isoleucine, which are required for the synthesis of some essential proteins in the chloroplasts of plants. Without essential amino acids, no proteins can be made and the plant slows down or dies (Ateş 2021, Ross and Lembi 1999). Weed resistance to herbicides can occur because the herbicide cannot bind to the target site due to mutation. After all, the herbicide cannot bind to the target site due to intense protein synthesis in the enzyme region, or because the plant metabolises the herbicide very rapidly and tolerates the phytotoxic effect of the herbicide (Preston and Mallory-Smith 2001). Particularly in areas where monoculture has been practiced for many years, weed resistance to herbicides can result from continuous use of herbicides with the same mode of action. This study aimed to determine, under controlled greenhouse and laboratory conditions, resistance to tribenuron-methyl, one of the ALS-inhibitor herbicides approved in Türkiye and widely used in the wheat-growing areas of Diyarbakır province to control SINAR.

MATERIALS AND METHODS

The field studies were conducted in 2015-2016 in the wheat-growing areas of Bağlar, Bismil, Çermik, Çınar, Dicle, Eğil, Ergani, Hani, Hazro, Kayapınar, Kocaköy, Kulp, Lice, Silvan, Sur and Yenişehir districts of Diyarbakır province, Türkiye (Figure 1).

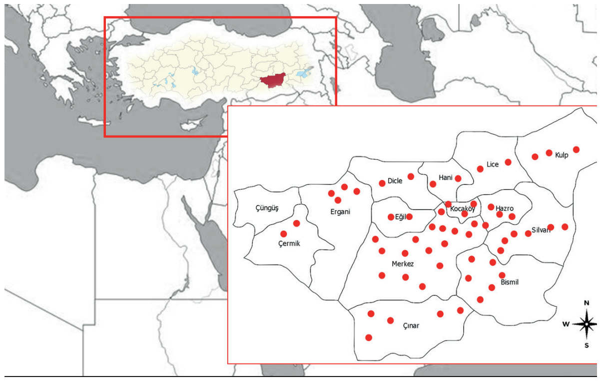

Figure 1. Survey areas where SINAR seeds were collected

SINAR seed samples were taken from the first wheat field seen at random every 5 km along the selected routes (Yıldız et al. 2017). During sampling, 20 plants that had reached seed maturity were pulled from the soil at different points in the field and placed with their root zone in fine-meshed polyethylene bags. The sensitive populations used for the study were collected from the mountainous, non-agricultural area of the Kulp district (Table 1). The plants were transported to the laboratory and dried under shade. Seed populations were obtained from the plants using mechanical methods.

Screening tests

Each population of SINAR seeds collected from wheat fields was placed in a 50% NaOH solution for 10 minutes to break the seed dormancy. The seeds were then kept in a 3% NaClO solution for 1 min, washed with sterile pure water, and surface sterilised (Ateş et al. 2017). The planting medium, a mixture of peat, sand, and soil (1:1:1), was placed in 10x12 cm pots. A total of 20 pots were planted with three seeds each. The herbicide was applied at a rate of 10 g per hectare (licensed dose) of the active herbicide tribenuron-methyl (75%) using a flat fan nozzle type delivering 300 litres per hectare at 3 atm at a height of 50 cm from the pot surface in a spraying cabinet when the SINAR had 2-4 true leaves. After herbicide application, the pots were watered regularly, taking into account the moisture status of the pots. The pots were watered regularly, taking into account the moisture status of the pots. The trials were terminated on day 28 after herbicide application (HRAC GLOBAL 2024).

Dose-response experiments

Dose-response experiments were conducted on 28 populations suspected of resistance. A total of ten seeds were collected from each suspected resistance seed population. Pre-germinated three seeds were placed in each pot. After thinning at the cotyledon stage, one healthy plant was retained in each pot.

Table 1. Location information of SINAR populations collected from wheat fields in Diyarbakır province

Sampling codes	Districts	Coordinates	Sampling code	Districts	Coordinates
Bağ3	Bağlar	37.908171, 40.160361	Kay86	Kayapınar	37.937161, 40.162938
Bağ55	Bağlar	37.904104, 40.172790	Koc18	Kocaköy	38.291128, 40.498953
Bis37	Bismil	37.493837. 40.403873	Koc36	Kocaköy	38.289713, 40.530035
Bis39	Bismil	37.828221, 40.541256	Koc38	Kocaköy	38.314969, 40.499111
Bis40	Bismil	37.812369, 40.345241	Kul25	Kulp	38.493768, 41.007043
Bis59	Bismil	38.146033, 41.205882	Kul80	Kulp	38.636018, 41.164378
Bis61	Bismil	37794465, 40.773310	Kul82*	Kulp	38.468816, 40.935940
Bis87	Bismil	37.808958, 40.436701	Lic12	Lice	38.486006 40.994365
Çer5	Çermik	38.146531, 39.480153	Lic33	Lice	38.453055, 40.634566
Çer30	Çermik	38.202427, 39.587638	Sil1	Silvan	38.110976, 41.125367
Çın10	Çınar	37.627298, 40.493062	Sil13	Silvan	38.133068, 40.887937
Çın24	Çınar	37.751097, 40.389226	Sil16	Silvan	38.194642, 40.148446
Çın29	Çınar	37.732933, 40.406822	Sil21	Silvan	38.137349, 40.820672
Çın34	Çınar	37.808977, 40.439482	Sil56	Silvan	38.154770, 40.992443
Çın72	Çınar	37.749450, 40.391478	Sil84	Silvan	38.123469, 41.148979
Çın81	Çınar	37.728519, 40.416556	Sur32	Sur	37.923603, 40.296891
Dic7	Dicle	38.352431, 40.070774	Sur42	Sur	37.946437. 40.313619
Dic88	Dicle	38.382999, 40.300850	Sur44	Sur	38.018615, 40.480798
Eği2	Eğil	38.232212, 40.061278	Sur50	Sur	38.127997, 40.441455
Eği16	Eğil	38.194642, 40.148446	Sur51	Sur	37.911120, 40.239542
Erg20	Ergani	38.146968, 39.862059	Sur52	Sur	38.127977, 40.441468
Erg48	Ergani	38.253701, 39.726081	Sur53	Sur	37.870004, 40.304166
Erg57	Ergani	38.273173, 39.845364	Sur62	Sur	37.932387, 40.386099
Erg63	Ergani	38.284300 39.899219	Sur75	Sur	38.005128, 40.448022
Han47	Hani	38.408129, 40.354200	Yen6	Yenişehir	37.994626, 40.221267
Han79	Hani	38.410715, 40.387970	Yen17	Yenişehir	37.990666, 40.161969
Haz.11	Hazro	38.152238. 40.747905	Yen26	Yenişehir	37.962431, 40.222597
Haz. 15	Hazro	38.218530, 40.768873	Yen41	Yenişehir	37.956476, 40.223880
Kay71	Kayapınar	37.943461, 40.140090			
		Total	16 Districts	57 Fields	

*Sensitive population

The development of the plant was monitored regularly. New-generation seeds were collected from plants that had reached harvest maturity. Dose-response studies were carried out with seeds of a new generation (F2) obtained from populations of doubtful resistance (Serim et al. 2022). Application doses were prepared at 0, 0.25, 0.5, 1, 2, 4, 8, 16, and 32 times the labelled field rate of 10 g ha-1 for tribenuron-methyl (75%). After adding 0.1% litter adjuvants (Trend 90 EC) to the post-sowing, herbicide applications were made when SINAR had 2-4 true leaves. All trials were replicated 4 times and repeated. Plants in pots were harvested at the point closest to the soil surface on the 28th day after herbicide application, and dried in an oven at 60 °C for 72 hours then weighed (Durigon et al. 2020). Dry biomass weight was determined by weighing on a precision scale and the data was recorded.

Dose-response analyses were evaluated using the log-logistic analysis model with the following formula. GR50 values were determined for each biotype (Equation 1).

$Y = C + ((D–C) / (1 + exp(b^0 (log(X) – log(GR_{50})$ (Equation 1)

Where Y is the response, C is the lower limit, D is the upper limit, b is the slope of the dose-response curve at the GR_{50} point, X is the herbicide dose, GR_{50} refers to the herbicide dose at which the dry biomass weight of the plants is reduced by 50% (Seefeldt et al. 1994). All data were calculated and analysed using the R package programme. As a result of the analysis, the biotypes were accepted as resistant to twice the recommended dose according to the GR_{50} value. In addition, the resistance index (RI) was determined by dividing the GR_{50} of the resistant biotypes by the GR_{50} of the susceptible biotype (Mennan et al. 2012) (Equation 2).

$Resistance\ index(RI) = GR_{50}\ (Resistant)/GR_{50}\ (Susceptible)$ (Equation 2)

The resistance levels of the SINAR populations to tribenuron-methyl were defined according to a standard (Yang et al. 2021). This standard was as follows: no resistance (RI < 3), low resistance (3 ≤ RI < 5), moderate resistance (5 ≤ RI < 10), and high resistance (RI ≥ 10).

RESULTS AND DISCUSSION

As a result of the study conducted to determine the resistance of SINAR to tribenuron methyl, it was determined that 28 out of 56 populations exhibited suspected resistance (Table 2). The results of dose-response experiments conducted with F2 biotypes of SINAR populations with suspected resistance are presented in Table 3.

The results of the dose-response experiments showed that no resistance (RI<3) was observed in 20 biotypes, low resistance (3≤ RI<5) in 5 biotypes and moderate resistance (5 ≤ RI<10) in 3 biotypes (Table 3). 16.6% of the samples from Bismil district exhibited low resistance, while 16.6% displayed moderate resistance. In Çınar district, 33.3% showed low resistance, 11.1% showed low resistance and 22.2% showed moderate resistance, while in Sur district, 22.2% showed low resistance and 25% showed moderate resistance (Figure 2).

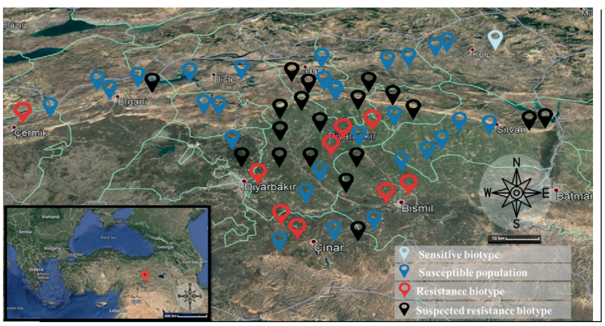

Figure 2. Resistance status in areas where SINAR was sampled

Table 2. Number of SINARs sampled and number of populations with suspected resistance

Districts	Sampling numbers	Number of suspected populations
Bağlar	2	1
Bismil	6	4
Çermik	2	1
Çınar	6	3
Dicle	2	0
Eğil	2	1
Ergani	4	1
Hani	2	1
Hazro	2	2
Kayapınar	2	1
Kocaköy	3	2
Kulp	2	0
Lice	2	0
Silvan	6	2
Sur	9	5
Yenişehir	4	4
Control (Kulp)	1	0
Total	57	28

In the wheat fields of Diyarbakır, tribenuron-methyl is the active ingredient most preferred by growers because it has low phytotoxicity in tank-mixes with monocotyledonous herbicides and is more economical than herbicides with other modes of action. Wheat cultivation in Diyarbakır province is usually done to utilise dry agricultural land. As monoculture is prevalent in the province, herbicide rotation is quite limited, which can naturally lead to cases of resistance. Many studies report that SINAR, which occurs in almost all regions of the world except the poles and has invasive potential in many ecologies, is causing problems in agricultural areas and developing resistance to herbicides (Christoffers et al. 2006, Gherekhloo et al. 2018, Gürbüz et al. 2018, Ntoanidou et al. 2017, Peniuk et al. 1993, Şin 2022, Topuz 2007, Turgut 2023, Veldhuis et al. 2000). In Southeast Anatolia, no study has been reported on SINAR's herbicide resistance. Şin (2021) found that 13 (Amasya 2, Çorum 1, Tokat 7 and Yozgat 3) out of 310 populations collected from wheat fields in the

Table 3. The mean number of the sum of drosophilid individuals captured per trap with different colours in the study period (individuals/trap/study period)

Biotypes	I. experiment			II. experimets			Resistance Categories
	GR_{50}	SE±	Resistance Index (RI)	GR_{50}	SE±	Resistance Index (RI)	
Bağ55	0.22	0.03	1	0.53	0.17	1	no resistance
Bis37	0.96	0.6	4	1.92	1.1	4	low resistance
Bis40	0.4	0.05	1	0.86	0.32	1	no resistance
Bis59	0.11	0.03	1	0.38	0.08	1	no resistance
Bis87	1.22	1.21	5	2.54	0.82	5	moderate resistance
Çer5	0.47	0.3	2	1.06	0.21	2	no resistance
Çın29	0.06	0.04	1	0.19	0.07	0	no resistance
Çın72	0.67	0.09	3	1.39	0.24	3	low resistance
Çın81	0.71	0.13	3	1.49	0.23	3	low resistance
Eği2	0.23	0.08	1	0.53	0.23	1	no resistance
Erg20	0.02	0.02	1	0.24	0.1	1	no resistance
Han47	0.36	0.07	1	0.53	0.13	1	no resistance
Han79	0.12	0.04	1	0.38	0.1	1	no resistance
Haz11	0.17	3.47	1	0.48	2.19	1	no resistance
Kay86	0.11	0.04	1	0.34	0.19	1	no resistance
Koc18	0.33	0.08	1	0.48	0.15	1	no resistance
Koc38	0.15	0.09	1	0.38	0.02	1	no resistance
Sil39	0.08	0.02	1	0.24	0.05	1	no resistance
Sil84	0.25	0.05	1	0.62	0.15	1	no resistance
Sur44	0.14	0.04	1	0.38	0.3	1	no resistance
Sur50	0.77	0.29	3	1.42	3.4	3	low resistance
Sur51	1.51	1.83	6	3.07	2.2	6	moderate resistance
Sur62	0.39	0.11	1	0.38	0.26	1	no resistance
Sur75	1.15	1.02	5	2.41	2.9	5	moderate resistance
Yen6	0.79	0.14	3	1.44	0.16	3	low resistance
Yen26	0.3	0.05	1	0.53	0.11	1	no resistance
Yen41	0.02	0.04	1	0.14	0.09	0	no resistance
Yen65	0.35	0.03	1	0.34	0.03	1	no resistance
Sensitive	0.25	0.01	-	0.48	0.06	-	Susceptible

*RI < 3: no resistance, 3 ≤ RI < 5 low resistance, 5 ≤ RI < 10 moderate resistance, RI ≥ 10: high resistance

Black Sea region developed resistance to tribenuron-methyl. That finding supports our study. Regarding SINAR's ability to develop resistance to ALS group herbicides, Topuz (2007) detected resistance to chlorsulfuron in 4 biotypes in wheat fields in Balıkesir and Çanakkale provinces. In the Çukurova region, Gürbüz et al. (2018) found resistance to pyroxsulam + cloquintocet sodium in 22 populations and to mesosulfuron-methyl + iodosulfuron-methyl sodium in 26 populations in Adana. The resistance status of SINAR to these compounds, which belong to the same class (ALS) as tribenuron-methyl, is similar to the results obtained in our study in Diyarbakır province. As a result of the resistance study conducted by Turgut (2023) on a total of 139 SINAR populations from wheat fields in Samsun, Amasya and Çorum provinces, resistance to 2,4-D+dicamba was detected in 9 biotypes and to 2,4-D+florasulam in 16 biotypes. These studies show that SINAR has developed resistance to several modes of action in Türkiye. Tribenuron-methyl of SINAR, a problem in wheat fields in Iran, was detected in 18 biotypes of 38 populations in Kermanshah province in studies conducted in different regions (Mehdi et al. 2017). Another study detected it in 30 biotypes of 80 populations in the same region (Khaledi et al.

2019). They discovered resistance in 14 biotypes out of 33 populations in Gulistan province (Gherekhloo et al. 2018), and 3 biotypes out of 16 populations in Ramiyan province (Heravi et al. 2018). Herbicide resistance is assumed to occur at the field level rather than at the regional level in these studies. In the study we conducted in Diyarbakır province, resistance was not observed in all fields of the districts where resistance was found, and in this respect, it is similar to the studies of Gherekhloo et al. (2018), Heravi et al. (2018), and Mehdi et al. (2017). These data indicate that the effectiveness of the herbicide containing the active ingredient tribenuron-methyl in controlling wild mustard in wheat fields does not cause problems and that there are problems with resistance in regions where growers' complaints are particularly severe. It is recommended to raise awareness among producers about overcoming weed problems by organizing workshops, informational meetings, field days, and similar educational activities on issues such as the decision-making process for herbicide applications, herbicide selection, maintenance and calibration of tools and equipment used in applications.

ACKNOWLEDGEMENTS

This study was supported by the Republic of Türkiye, Ministry of Agriculture and Forestry, Directorate General of Agricultural Research and Policy (No. TAGEM–BS–12/12-01/04-01).

Author's Contributions
Authors declare the contribution of the authors is equal.

Statement of Conflict of Interest
The authors have declared no conflict of interest.

ÖZET

Buğday tarımında yabancı otların sorun oluşturduğu alanlarda kimyasal mücadele kaçınılmazdır. Ancak aynı etki mekanizmasına sahip herbisitlerin uzun yıllar kullanılması sonucunda yabancı otlarda dayanıklılık sorunu ortaya çıkabilmektedir. Herbisitlerin sık ve yanlış kullanılması çeşitli çevre ve sağlık sorunlarının yanı sıra iş gücü ve ekonomik kayıpların da yaşanmasına yol açmaktadır. Diyarbakır ili buğday alanlarında sorun oluşturan yabani hardalın (*Sinapis arvensis* L.- SINAR) kontrolünde yoğun kullanılan tribenuron-methyl (asetolaktat sentaz - ALS)'in etkisiz olduğu üreticiler tarafından bildirilmektedir. Bu bildirimlerin boyutlarını belirlemek amacıyla Diyarbakır'ın 16 ilçesinde buğday ekim alanlarından 56 SINAR tohum popülasyonu toplanmıştır. Kontrollü koşullarda klasik test metoduyla yapılan uygulamalar sonucunda 28 tarlaya ait popülasyonda dayanıklılık şüphesi tespit edilmiştir. Doz-etki denemeleri sonucunda SINAR'ın 20 biyotipinde dayanıklılık (RI<3) görülmezken, 5 biyotipte düşük seviyede (3≤ RI<5), 3 biyotipte ise orta düzeyde dayanıklılık (5 ≤ RI<10) tespit edilmiştir.

Anahtar kelimeler: acetolactate synthase (ALS) inhibitörü, herbisit dayanıklılığı, *Triticum aestivum* L.

REFERENCES

Ateş E., 2021. Herbisitlerin etki mekanizması. Weed Science Current Issues. Iksad Publishing House, 387-438, ISBN: 978-625-8061-67-3

Ateş E., 2022. Determination of the critical period of weed control in wheat (*Triticum aestivum* L.) and investigation of the control methods of wild mustard (*Sinapis arvensis* L.). Malatya Turgut Özal University, Graduate Education Institute, Unpublished Doctoral Thesis, 130 p., Malatya.

Ateş E., Üremiş İ., 2020. Determination of weed species and their frequency and density in wheat cultivation areas of Şanlıurfa province, Türkiye. Harran Tarım ve Gıda Bilimleri Dergisi, 24 (1), 33-43. doi:10.29050/Harranziraat.612049

Ateş E., Süer İ.E., Üremiş İ., 2017. Germination biology of wild mustard (*Sinapis arvensis*). 3rd ASM International Congress of Agriculture and Environment, 16-18 November 2017, Antalya, Türkiye, 57 p.

Chaudhary S.U., Hussain M., Ali M.A., Ali M.A., Iqbal J., 2008. Effect of weed competition period on yield and yield components of wheat. Journal of Agricultural Research, 46 (1), 47-53.

Christoffers M.J., Nandula V.K., Howatt K.A., Wehking T.R., 2006, Target-site resistance to acetolactate synthase inhibitors in wild mustard (Sinapis arvensis). Weed Science, 54, 191-197.

Durigon M.R., Cechin J., Mariani F., da Silva G.B.P., Vargas L., Chavarria G., 2020. Growth of canola hybrids resistant and sensitive to herbicides. Semina: Ciências Agrárias, 41 (6Supl2), 2911-2922.

FAO, 2022. The Food and Agriculture Organization of the United Nations. FAO Statistics, Production Indices. https://www.fao.org/faostat/en/#data/QI

Gherekhloo J., Hatami Z. M., Cruz R.A., Sadeghipour H.R., Prado R.D., 2018. Continuous use of tribenuron-methyl selected for cross-resistance to acetolactate synthase–inhibiting herbicides in wild mustard (*Sinapis arvensis*). Published Online by Cambridge University Press: 23 July.

Gökalp Ö., Üremiş İ., 2015. Determination of weed seeds in wheat grain in Mardin province of Turkey. Journal of Agricultural Faculty of Mustafa Kemal University, 20 (1), 23-30. https://dergipark.org.tr/tr/pub/mkuzfd/issue/19637/209638

Gürbüz R., Uygur S., Uygur F.N., 2018. Determination of segetal flora in wheat growing areas of Ağri province. Turkish Journal of Weed Science, 21 (1), 8-18.

Heap I., 2024. The international herbicide-resistant weed database. Annual Report Online. www.weedscience.org

Heravi M., Gherkhloo J., Siahmarguee A., Kazemi H., Hassanpour B.S., 2018. Investigating the resistance of wild mustard (*Sinapis arvensis* L.) biotypes to tribenuron methyl herbicide in wheat fields of Ramiyan Township. Weed Research Journal, 10 (1), 46-59.

HRAC GLOBAL, 2024. Synthetic auxin resistance in wild mustard. http://Hracglobal.Com/Files/Wild-Mustard-Fact-Sheet-June-2024.Pdf, (accessed date: 21.05.2024).

Khaledi R., Fayaz F., Kahrizi D., Talebi R., 2019. PCR-based identification of point mutation mediating acetolactate synthase-inhibiting herbicide resistance in weed wild mustard (*Sinapis arvensis*). Molecular Biology Reports, 46, 5113–5121.

Mehdi A., Ali G., Mehdi R., Javid G., Goodarz A., 2017. Investigating resistance of wild mustard (*Sinapis arvensis* L.) populations to tribenuron-methyl herbicide. Journal of Crop Ecophysiology (Agriculture Science) Spring, 11 (1), 127-141.

Mennan H., Doğan M.N., Yılmaz N.D.K., Çankaya S., Gönen O., 2012. Çeltik ekim alanlarında sorun olan önemli bazı yabancı otların genetik çeşitliklerinin belirlenmesi ve ALS-Accase inhibitörü herbisitlere dayanıklı biyotiplerinini moleküler ve bioassay yöntemlerle saptanması. TÜBİTAK Conclusion Report (108O371), Samsun.

Ntoanidou S., Madesis P., Diamantidis G., Eleftherohorinos I., 2017.Trp574 substitution in the acetolactate synthase of *Sinapis arvensis* confers cross-resistance to tribenuron and imazamox. Medicine, Biology, Pesticide Biochemistry and Physiology, doi:10.1016/J.Pestbp.2016.12.008Corpus ID: 8009705

Özaslan C., 2011. Determination of weed species creating problem in cotton and wheat fields of Diyarbakır with fungal factors they host and research on their bio-activity potentials. Selçuk University, Institute of Science, Unpublished Doctoral Thesis, 229 p., Konya.

Peniuk M.G., Romano M.L., Hall J.C., 1993. Physiological investigations into the resistance of a wild mustard (*Sinapis arvensis* L.) biotype to auxinic herbicides. Weed Research, 33 (6), 431-440. doi.Org/10.1111/J.1365-3180.1993. Tb01959.X

Preston C., Mallory-Smith C.A., 2001. Biochemical mechanisms, inheritance and molecular genetics of herbicide resistance in weeds. In: Herbicide Resistance in World Grains. Powles S.B., Shaner D.L. (Eds.). Boca Raton, CRC Press, 23-60.

Ross M.A., Lembi C.A., 1999. Applied weed science. 2nd Edition. Prentice-Hall Inc., New Jersey, 07458.

Seefeldt S.S., Gealy D.R., Brewster B.D., Fuerst E.P., 1994. Cross-resistance of several diclofop-resistant wild oat (*Avena fatua*) biotypes from the Willamette Valley of Oregon. Weed Science, 42, 430-437.

Serim A.T., Budak İ., Asav Ü., 2022. Isparta ili elma bahçelerinde glyphosate'a dayanıklı pire ot (*Conyza canadensis* (L.) Cronquist)'larının belirlenmesi. Bilecik Şeyh Edebali Üniversitesi Fen Bilimleri Dergisi, 9 (1), 564-573. https://doi.org/10.35193/bseufbd.1106196

Şin B., 2021. The determination of tribenuron methyl resistance of wild mustard (*Sinapis arvensis* L.) collected from wheat fields located in Amasya, Çorum, Tokat and Yozgat provinces. Tokat Gaziosmanpaşa University, Graduate Education Institute, Unpublished Doctoral Thesis 199 p., Tokat.

Topuz M., 2007. Researches on sulfonylurea herbicide resistance in wild mustard *Sinapis arvensis* L. in wheat fields in the Marmara region of Turkey. Ege University, Institute of Science, Unpublished Doctoral Thesis, 202 p., İzmir.

Turgut N.Ç., 2023. Determination of the herbicide resistance status of wild mustard (*Sinapis arvensis* L.), a problem in wheat culturements of the central black sea region, and its growth biology. Ondokuz Mayıs University, Graduate Education Institute, Unpublished Doctoral Thesis, 239 p., Samsun.

Veldhuis L.J., Hall L.M., O'Donovan J.T., Dyer W., Hall C., 2000. Metabolism-based resistance of a wild mustard (*Sinapis arvensis* L.) biotype to ethametsulfuron- methyl. Journal of Agricultural and Food Chemistry, 48, 2986-2990.

Yang Q., Yang X., Zhang Z., Wang J., Fu W., Li Y., 2021. Investigating the resistance levels and mechanisms to penoxsulam and cyhalofop-butyl in barnyardgrass (*Echinochloa crus-galli*) from Ningxia province, China. Weed Science, 69 (4), 422-429.

Yıldız Ş., Koç İ., Yardım E.N., 2017. Investigation on nematode faunal structures in pastures of Muş province. Yuzuncu Yıl University Journal of Agricultural Sciences, 27 (2), 197-203. https://doi.org/10.29133/yyutbd.282164

Cite this article: Ateş, E., Süer, İ. E., Üremiş, İ., Tursun, N. (2024). Wild mustard (*Sinapis arvensis* L.) resistance to tribenuron methyl in wheat fields of Diyarbakır province, Türkiye. Plant Protection Bulletin, 64-3. DOI: 10.16955/bitkorb.1470158

Atıf için: Ateş, E., Süer, İ. E., Üremiş, İ., Tursun, N. (2024). Diyarbakır ili buğday tarlalarında yabani hardalın (*Sinapis arvensis* L.) tribenuron methyl'e karşı dayanıklılık durumu. Bitki Koruma Bülteni, 64-3. DOI: 10.16955/bitkorb.1470158