Erzincan Üniversitesi
Fen Bilimleri Enstitüsü Dergisi
2025, 18(1), 229-247
ISSN: 1307-9085, e-ISSN: 2149-4584
Araştırma Makalesi

Erzincan University
Journal of Science and Technology
2025, 18(1), 229-247
DOI: 10.18185/erzifbed.1586325
Research Article

Investigation of Weeds Problematic in Agricultural Areas of Adana Province and Chemical Control Status

Ramazan Gürbüz[1], Ayşe Usanmaz Bozhüyük[2*], Harun Alptekin[3], Ramazan Taşkın[4]

[1,3,4] Department of Plant Protection, Faculty of Agriculture, Igdir University, Igdir, Türkiye
[2*]Department of Chemistry and Chemical Processing Technologies, Vocational School of Technical Sciences, Igdir University, Igdir, Türkiye

Received: 16/11/2024, **Revised:** 26/02/2025, **Accepted:** 01/03/2025, **Published:** 28/03/2024

Abstract
This study was conducted in Adana province and its districts in 2021 to investigate the weed species that pose problems in agricultural areas, the status of chemical control in both agricultural and non-agricultural areas, and the presence of herbicide-resistant weeds. Face-to-face surveys were conducted with 100 licensed dealers of Plant Protection with the Adana Directorate of Agriculture and Forestry. As a result of the research, 61% of the dealers stated that there was a severe weed problem in agricultural fields. The most common weed species identified were *Avena sterilis* (80%), *Echinochloa crus-galli* (79%), and *Sorghum halepense* (76%). The major crops affected by weed problems were wheat (78%), maize (76%), and peanut (61%), leading to the highest intensity of chemical herbicide use in these crops. The most commonly used herbicide active ingredients in agricultural areas were Glyphosate Potassium Salt (72%), Clethodim (65%), and Pendimethalin (62%). Additionally, 62% of the dealers reported a significant herbicide resistance problem in the region, stating that certain weed species cannot be controlled despite herbicide applications. The leading herbicide-resistant weed species were *Avena sterilis* (58%), *Convolvulus arvensis* (37%), and *Avena rigidum* (32%). Furthermore, 66% of the dealers stated that total weed control was implemented, with herbicides containing Glyphosate Isopropylamine Salt and Diquat Dibromide being the most frequently used. The study shows that weeds are a major problem in both agricultural and non-agricultural areas in Adana province. In addition, herbicide resistance is becoming an increasing problem due to the intensive and frequent use of herbicides for weed control.

Keywords: Adana, survey, resistance, herbicide, weed management

Adana İli Tarım Alanlarında Sorun Olan Yabancı Otların Araştırılması ve Kimyasal Mücadele Durumu

Öz
Araştırma 2021 yılında Adana il ve ilçelerinde tarım alanlarında sorun olan yabancı ot türlerini, tarım ve tarım dışı alanlarda kimyasal mücadele durumunu ve herbisitlere dayanıklı yabancı ot durumunu belirlemek amacıyla yürütülmüştür. Adana Tarım ve Orman Müdürlüğüne bağlı ruhsatlı 100 Bitki Koruma Ürünleri bayileri ile yüz yüze anketler yapılmıştır. Araştırma sonucunda, bayilerin %61'i tarım alanlarında yoğun bir yabancı ot probleminin olduğunu belirtmişlerdir. Sorun teşkil eden bu yabancı otların başında sırasıyla; %80 *A. sterilis*, %79 *E. crus-galli* ve %76 *S. halepense* yabancı ot türlerinin geldiğini bildirmişlerdir. Kültür bitkilerinde en büyük yabancı ot sorununun buğday (%78), mısır (%76) ve yer fıstığı (%61) ekim alanlarında görüldüğünü ve en yoğun bu ürünlerde kimyasal herbisit kullanımının olduğunu belirtmişlerdir. Tarım alanlarında en fazla Glyphosate Potasyum Tuzu (%72), clethodim (%65) ve pendimethalin (%62) aktif maddeli herbisitlerin kullanıldığını ifade etmişlerdir. Buna ek olarak, bayilerin %62'si bölgede ciddi bir dayanıklılık problemin olduğunu ve herbisit kullanılmasına rağmen bazı yabancı ot türlerinin kontrol altına alınmasının mümkün olmadığını belirtmişlerdir. Bu yabancı otların başında da sırasıyla; *A. sterilis* (%58), *C. arvensis* (%37) ve *A. rigidum* (%32) türlerinin geldiğini bildirmişlerdir. Ayrıca, bayilerin %66'sı total yabancı ot kontrolünün yapıldığını ve en fazla glyphosate isopropylamin tuzu ve Diquat Dibromide aktif maddeli herbisitlerin kullanıldığını belirtmişlerdir. Çalışma, yabancı otların Adana ilinde hem tarımsal hem de tarım dışı alanlarda önemli bir sorun olduğunu göstermektedir. Ayrıca, yabancı ot kontrolü için herbisitlerin yoğun ve sık kullanımı nedeniyle herbisit direnci giderek artan bir sorun haline gelmektedir.
Anahtar Kelimeler: Adana, anket, dayanıklılık, herbisit, yabancı ot yönetimi

*Corresponding Author: ayseusanmaz@hotmail.com
Ramazan GÜRBÜZ, https://orcid.org/0000-0003-3558-9823
Ayşe USANMAZ BOZHÜYÜK, https://orcid.org/0000-0003-2450-6850
Harun ALPTEKİN, https://orcid.org/0000-0001-9319-311X
Ramazan TAŞKIN, https://orcid.org/0000-0003-2004-453X

1. Introduction

Nicknamed the "Pearl of the Mediterranean," Adana is the seventh most populous city in Türkiye. According to TUIK (2021), the Mediterranean region ranks fourth in Türkiye in terms of agricultural land, and Adana ranks first among the provinces in this region in terms of agricultural area. The province, which has a total surface area of 14,030 km², has 4,869,874 da of agricultural land, including 3,576,151 da of cereals and other crops, 78,930 da of fallow land, 313,213 da of vegetables, 900,310 da of other crops such as orchards, and 1,270 da of ornamental plants [1].
With its vast and fertile agricultural lands, Adana is one of Türkiye's most important agricultural provinces, making a significant contribution to the national economy. Thanks to favorable climatic conditions, land suitable for irrigation, and advancements in technology, agricultural diversity and yield per unit area have increased considerably since the 1960s [2]. However, despite these improvements, many factors still reduce agricultural productivity.

Weeds are among the most significant factors negatively affecting the yield and quality of cultivated crops in agricultural areas [3-5]. Chemical control methods are generally preferred for weed management [6]. Today, chemical control is applied more frequently due to its rapid results, ease of application, and cost-effectiveness.
Chemical control against weeds started to be widely used after the Second World War [7]. Herbicides account for 47% of pesticide use in the world [8]. In Türkiye, 53 672 tons of pesticides were used in 2020, of which 24.68% were herbicides [1]. While herbicides are used in the first place in the World [8], in Türkiye they rank second after fungicides [1].

The use of herbicides is increasing day by day due to their rapid effect, ease of application, and low cost. However, the intensive and improper use of herbicides negatively impacts the environment, as well as human and animal health [9-11]. The effects of herbicides include acute and chronic toxicity in humans and warm-blooded animals, lethal effects on fish, side effects on insects (especially bees), negative impacts on soil microorganisms and invertebrates, disruptions in host-parasite relationships in plants, and alterations in higher plants [12, 13]. Herbicides can also cause toxicity in cultivated plants [14-16]. Applying herbicides at excessive doses or with an inappropriate number of applications, as well as using unsuitable herbicide mixtures, can lead to toxicity. Herbicide toxicity may cause symptoms that resemble plant diseases. Damage can appear on leaves, stems, flowers, and fruits, with symptoms such as interveinal chlorosis, spotted chlorosis, yellow spotting, leaf bruising, necrosis, and stem death. As a result, plants become weakened and more vulnerable to pathogens, pests, and unfavorable environmental conditions, leading to increased yield losses.
This study was carried out to determine the weed species that are problematic in agricultural areas and cultivated plants in Adana province, the chemical control status in agricultural and non-agricultural areas and the herbicide resistant weed status in the province.

2. Material and Methods

The study was conducted as a face-to-face survey with Plant Protection Products and Agricultural Control Tools and Machinery Dealers affiliated to Adana Provincial Directorate

of Agriculture and Forestry in 2021. There are 372 BKÜ dealers affiliated to the Adana Provincial Directorate of Agriculture and Forestry, and 100 of them were randomly selected for face-to-face interviews and a 16-question survey.
The number of BKÜ dealers in Adana province and its districts is given in Table 1.

Table 1. BKÜ dealers in Adana province and its districts

Districts	Number of dealers
Center	47
Aladag	0
Ceyhan	53
Cukurova	5
Feke	1
İmamoglu	10
Karaisalı	7
Karatas	8
Kozan	29
Pozantı	3
Saimbeyli	0
Sarıcam	15
Seyhan	57
Tufanbeyli	1
Yumurtalık	3
Yuregir	133
Total	372

To the dealers through a survey study;

- Distribution of the respondents according to age groups, educational status and how many years they have been dealers?
- Weed density level in Adana province?
- Weed species found intensively in the agricultural areas of Adana province?
- Crops with high weed density?
- Weed species that are problematic in the agricultural areas of Adana province and according to the cultivated plant?
- Crops where herbicides are used intensively?
- Herbicide application periods according to cultivated plants?
- Herbicides used extensively in agricultural areas?
- Whether there are weed species that cannot be controlled with herbicides?
- Areas where total chemical control is carried out?
- When producers come and apply to BKÜ dealers?
- How the BKÜ dealers decide on chemical control?
- In general, whether pre-emergence or post-emergence herbicides are used?
- Whether both pre-emergence and post-emergence herbicides were used?
- Whether there are herbicide resistant weeds in herbicide treated areas?
- Whether chemical control is practiced in non-agricultural areas?

Questions were asked on issues such as.

Data Analysis

The results of the data obtained as a result of the survey were evaluated using the SPSS 20.0 statistical package program. Results; findings are expressed as frequency and percentage distribution.

3. Results and Discussion

The frequency and percentage values of the responses to the questions regarding the participants' age groups, educational background, and years of experience as dealers are presented in Table 2.

Table 2. Age range, education level and how many years they have been a dealer

Age	F	%	Education Status	F	%	How Many Years Dealer	F	%
20-30	13	15	University	85	85	1-5	16	16
31-40	37	37	Master's degree	15	15	5-10	36	36
41-50	29	29				10-15	23	23
50+	21	31				15+	25	25
Total	100	100	Total	100	100	Total	100	100

When we look at the distribution of the participants according to age groups, 13 (15%) people between the ages of 20-30, 37 (37%) people between the ages of 31-40, 29 (29%) people between the ages of 41-50 and 21 (31%) people over the age of 50 (Table 2). Regarding the educational status, 85 people have university degrees and 15 people have master's degrees. It is seen that 16 of the dealers participating in the research are 1-5 years old, 36 of them are 5-10 years old, 23 of them are 10-15 years old and 25 of them are 15 years old or more (Table 1). The percentage (%) values of the answers given to the question of weed density level in Adana province asked to the dealers are given in Figure 1.

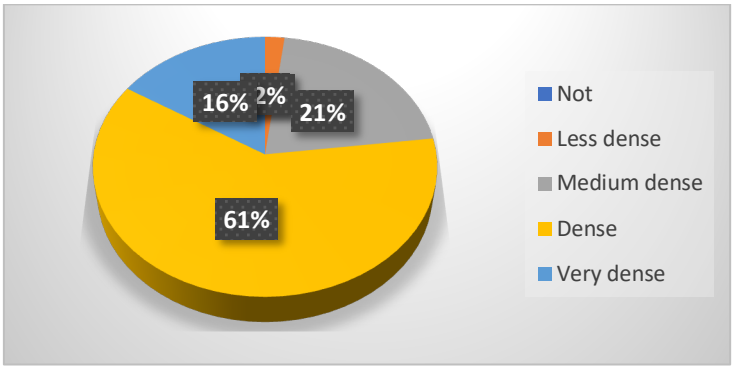

Figure 1. Weed density level in Adana province

When BKÜ dealers were asked about the level of weed density in their province, 61% of them reported that it was dense, 21% medium dense, 16% very dense and 2% low density (Graph 1). The frequency and percentage (%) values of the answers given to the question of weed species found intensively in agricultural areas are given in Table 3.

Table 3. Weed species found intensively in agricultural areas

Latin name	English name	Frequency	Percentage (%)
Sorghum halepense (L.) Pers.	Johnsongrass	76	76
Amaranthus retroflexus L.	Redroot pigweed	67	67
Sinapis arvensis L.	Wild mustard	75	75
Avena sterilis L.	Wild oat	80	80
Alopecurus myosuroides Huds.	Black-grass	22	22
Xanthium strumarium L.	Common cocklebur	44	44
Portulaca oleraceae L.	Common purslane	51	51
Echinochloa crus-galli (L.) P.Beauv.	Barnyard Grass	79	79
Convolvulus arvensis L.	Field bindweed	38	38
Cyperus rotundus L.	Purple nutsedge	20	20
Chenopodium album L.	Common lambsquaters	18	18
Other		24	24

* Total exceeds 100% due to more than one option being marked

When BKÜ dealers were asked about the most common weed species in the agricultural areas of Adana province, the dealers who participated in the research stated that the most common weed species in the agricultural areas are 80% Wild oat (*Avena sterilis* L.), 79% Barnyard Grass (*Echinochloa crus-galli* (L.) P. Beauv.), 76% Johnsongrass (*Sorghum halepense* (L.) Pers.), %75 Wild mustard (*Sinapis arvensis* L.), 67% Redroot pigweed (*Amaranthus retroflexus* L.), 51% Common purslane (*Portulaca oleraceae* L.), 44% Common cocklebur (*Xanthium strumarium* L.), 38% Field bindweed (*Convolvulus arvensis* L.), 24% other weeds, 22% Black-grass (*Alopecurus myosuroides* Huds.), 20% Purple nutsedge (*Cyperus rotundus* L.) and 18% Common lambsquaters (*Chenopodium album* L.) (Table 3). In a study conducted in the corn fields of Adana region; Java-grass (*Cyperus rotundus* L.), Jungle rice (*Echinochloa colonum* (L.) Link) and Wild melon (*Cucumis melo* var. *agrestis* Naudin) weeds were found to be important problems [17]. In another study conducted in Adana province, it was reported that *Convolvulus*

arvensis, *Chenopodium album* and *Sinapis arvensis* weed species were the most common in sunflower surveys [18]. These studies are similar to the results we obtained.

The frequency and percentage (%) values of the answers given by the BKÜ dealers to the question of the crops where weeds are dense are presented in Table 4.

Table 4. Crops with high weed density

Cultivated plant	Frequency	Percent (%)
Citrus	54	54
Maize	76	76
Cotton	58	58
Onion	25	25
Spinach	5	5
Sunflower	22	22
Wheat	78	78
Peanut	61	61
Radish	3	3
Soya beans	46	46
Pomegranate	8	8
Potato	10	10
Melon and watermelon	19	19
Banana	4	4
Other	4	4

* Total exceeds 100% due to more than one option being marked

When asked about the cultivated areas where weeds are most concentrated in Adana province, the dealers reported the following: 76% in corn, 78% in wheat, 61% in peanut, 58% in cotton, 54% in citrus, 46% in soybean, 25% in onion, 22% in sunflower, 19% in melon and watermelon, 10% in potato, 8% in pomegranate, 5% in spinach, and 4% in banana and other cultivated areas (Table 4).

According to previous studies, *Avena sterilis* L. and *Sinapis arvensis* L. [19] are common in wheat cultivation areas in Adana. In corn fields, the dominant weed species include *Cyperus rotundus* L., *Echinochloa colonum* L., and *Cucumis melo* var. *agrestis* Naudin [17]. Similarly, in citrus fields, prevalent weed species include *Cyperus rotundus* L., *Amaranthus viridis* L., *Portulaca oleracea* L., *Cynodon dactylon* (L.) Pers., *Amaranthus retroflexus* L., *Chenopodium album* L., *Sorghum halepense* (L.) Pers., *Avena sterilis* L., *Chrysanthemum* sp. and *Convolvulus arvensis* L. [20]. The literature data align with the findings of our study, confirming high weed densities in wheat, maize, and citrus cultivation areas.

The frequency and percentage (%) values of the answers given to the question of weed species in density according to crop plants asked to the BKÜ dealers are presented in Table 5.

Table 5. Weed species according to cultivated plants

Weeds	Wheat		Corn		Cotton		Peanut		Sunflower		Soybeans		Onion		Sp
	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F
Abutilon theophrastii Medik.	-	-	3	3	6	6	4	4	-	-	2	2	-	-	-
Agropyron repens (L.) Beauv.	-	-	-	-	-	-	-	-	-	-	2	2	2	2	2
Alopecurus myosuroides Huds.	15	15	10	10	4	4	2	2	4	4	-	-	-	-	-
Amaranthus retroflexus L.	-	-	29	29	6	6	15	15	6	6	12	12	6	6	-
Avena sterilis L.	80	80	13	13	-	-	-	-	9	9	-	-	8	8	-
Chenopodium album L.	2	2	15	15	8	8	2	2	13	13	2	2	-	-	10
Cyperus rotundus L.	2	2	17	17	28	28	30	30	-	-	19	19	10	10	-
Cucumis melo var. *agrestis* Naudin	-	-	-	-	18	18	22	22	2	2	13	13	-	-	-
Cuscuta sp.	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-
Convolvulus arvensis L.	12	12	62	62	10	10	8	8	12	12	10	10	-	-	2
Descurainia sophia (L.)	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-
Echinochloa crus-galli (L.) Beauv	-	-	26	26	8	8	27	27	2	2	35	35	10	10	2
Fumaria officinalis L.	18	18	6	6	-	-	-	-	-	-	-	-	-	-	-
Orobanche spp	-	-	-	-	-	-	-	-	15	15	-	-	-	-	-
Prosopis farcta (Banks& Sol.) J.F.Mac.	-	-	3	3	-	-	-	-	8	8	-	-	-	-	-
Portulaca oleraceae L.	-	-	8	8	4	4	37	37	-	-	2	2	8	8	8
Setaria verticillata (L.) P.Beauv.	-	-	-	-	6	6	2	2	-	-	8	8	-	-	-
Sinapis arvensis L.	72	72	24	24	-	-	-	-	2	2	2	2	5	5	2
Sorghum halepense (L.) Pers	-	-	65	65	36	36	38	38	6	6	32	32	-	-	9
Solanum nigrum L.	-	-	-	-	25	25	-	-	-	-	3	3	-	-	-
Vicia sativa L.	19	19	-	-	-	-	-	-	-	-	-	-	-	-	-
Xanthium strumarium L.	-	-	13	13	17	17	-	-	2	2	9	9	-	-	-

*Since more than one option was marked, the total exceeds 100%.

When the BKÜ dealers who participated in the research were asked about the dominant weed species in cultivated plants grown in Adana province and its districts, their responses were analyzed. Regarding problematic weed species in wheat cultivation areas, the dealers identified eight significant species. Among these, *Avena sterilis* (80%) and *Sinapis arvensis* (72%) were the most frequently reported. These were followed by *Vicia sativa* (19%), *Fumaria officinalis* (18%), *Alopecurus myosuroides* (15%), *Convolvulus arvensis* (12%), *Chenopodium album* (2%), and *Cyperus rotundus* (2%). The weed species mentioned by the dealers as problematic in wheat cultivation areas show similarities with those reported in previous studies, including *A. sterilis*, *S. arvensis*, *A. myosuroides*, and *V. sativa* [21]. In maize cultivation areas, the dealers reported a high density of weed species, with the three most common being *Sorghum halepense* (65%), *Convolvulus arvensis* (62%), and *Amaranthus retroflexus* (29%). Survey studies conducted in maize cultivation areas in the Cukurova region have also identified 12 weed species that have become prevalent in these fields [21, 22, 23]. These findings suggest that the studies complement each other.

It was reported that 14 weed species were intensive in cotton cultivation areas and the top five weed species were *S. halepense* 36%, *C. rotundus* 28%, *S. nigrum* 25%, *C. melo* 18% and *X. strumarium* 17%. It was determined that 84% *S. halepense*, 64% *P. oleracea,* 60% *X. strumarium*, 60% *C. arvensis* and 44% *S. nigrum* weeds took the first five places in the cotton cultivation areas of Iğdır province [24]. In a survey study conducted on cotton in Kahramanmaraş province, it was found that the most important weeds were *X. strumarium* (85.71%) and *S. halepense* (85.71%) followed by *Setaria* spp. (71.42%) and others [25]. In a survey study performed in cotton cultivation areas in Kahramanmaraş province, it was determined that the most important weed was *S. halepense* followed by *C. arvensis* [26]. In our survey, similarities were found between the weeds stated by the dealers and the studies conducted. In Türkiye, 79% of the peanut cultivation area and 81% of the production is realized in Adana and Osmaniye.Adana has the highest yield with 3.8 tons/ha. This province is followed by Osmaniye with 3.4 tons/ha [27]. Therefore, yield and quality of peanuts are important. They stated that 11 weed species were found intensively in the peanut cultivation areas of the dealers and 38% *S. halepense*, 37% *P. oleraceae*, 30% *C. rotundus* and 27% *E. crus-galli* were seen in the first four rows. In studies conducted with peanuts, *Sorghum halepense* (L.) Pers., *Xanthium strumarium* L., *Convolvulus arvensis* L., *Amaranthus retroflexus* L. and *Portulaca oleracea* L. were found to occupy a significant area.

Although the prevalence and density of these weeds vary, they are important weeds in peanuts [28-35]. In our survey, it was observed that the weeds *S. halepense* and *P. oleraceae* mentioned by the dealers were similar to the weeds in the previous studies. In sunflower cultivation areas, dealers reported that 13 weed species were problematic. The most common weeds were *Orobanche* spp. (15%), *C. album* (13%) and *C. arvensis* (12%). In studies conducted in sunflower cultivation areas in Osmaniye, Adana, Mersin and Osmaniye provinces of Cukurova region, it was found that the most common weed species was *Chenopodium album* L. with a frequency of 67.74% and the species with the highest percentage coverage was *Convolvulus arvensis* L. with a coverage of 3.71% [5]. It is seen that the weeds identified in the study overlap with the weeds in our study. Considering soybean cultivation areas; BKÜ dealers determined that 14 weeds were problematic. However, *E. crus-galli* (35%), *S. halepense* (32%), *C. rotundus*

(19%), *C. melo* (13%) and *A. retroflexus* (12%) weeds were found intensively. In a study conducted with industrial crops in the Mediterranean region, it was reported that *C. arvensis* (58.10%) and *I. triloba* (16.2%) weeds were found in soybean [36]. In the onion cultivation areas, the dealers stated that 7 weed species were found intensively, and the first 3 weed species were *C. rotundus* and *E. crus-galli* (10%), *A. sterilis* and *P. oleraceae* (8%), *A. retroflexus* (6%). It was determined that our findings were similar to the weed species that [37] and [38] determined as high frequency in their studies. It was reported that 7 important weed species were found in spinach cultivation areas. Among these, 10% *C. album*, 9% *S. halepense*, 8% *P. oleraceae* and 2% *A. repens*, *C. arvensis*, *E. grus-galli*, *S. arvensis* weed species are in the first place. In a study conducted in spinach cultivation areas; the most important species were *Veronica hederifolia* L. + *Veronica persica* Poiret., *Fumaria officinalis* L., *Stelleria media* (L.) Vill, *Sinapis arvensis* L. and *Cirsium arvense* (L.) Scop. in the fall period; *S. media*, *Lamium amplexicaule* L. + *Lamium purpureum* L., *Chenopodium album* L. and *Amaranthus retroflexus* L. [39]. It can be said that some of the weed species in the study overlap with our study.

The dealers stated that 14 weed species were found intensively in citrus cultivation areas, with the five most common being *Echinochloa crus-galli* (52%), *Setaria verticillata* (38%), *Portulaca oleracea* (37%), *Sorghum halepense* (36%) and *Descurainia sophia* (30%). In a study conducted in citrus orchards in Antalya province, the most prevalent weed species were *Xanthium strumarium* (64%), *Portulaca oleracea* (60%), *Sorghum halepense* (60%), *Cyperus rotundus* (50%), and *Echinochloa crus-galli* (45%) [40]. The findings of that study align closely with the weed species identified in our research. The dealers also reported that 11 weed species were found intensively in melon and watermelon cultivation areas, with the three most common being *Sorghum halepense* (22%), *Portulaca oleracea* (9%), and *Amaranthus retroflexus* (8%) followed by *Chenopodium album*. In a study conducted in watermelon cultivation areas, the most common weeds were *Chenopodium album*, *Amaranthus retroflexus*, *Heliotropium europeum*, *Chenopodium botrys* and *Atriplex hortensis* [41]. The results of that study also show similarities with our findings.

Table 6 presents the frequency and percentage (%) values of the answers given to the question of when the producer comes to you.

Table 6. When does the producer come to you?

Time	Frequency	Percentage (%)
Before planting the crop	52	52
After planting and before emergence	28	28
After product release	37	37
After weed emergence	69	69
After weed infestation	15	15

* Total exceeds 100% due to more than one option being marked

When the question directed to the dealers was analyzed in terms of chemical control, 69% of the dealers stated that they came to the dealers after the weed emerged, 52% before planting the crop, 37% after the crop emerged, 28% after planting the crop but before emergence and 15% after the weed infestation (Table 6).

The frequency and percentage (%) values of the answers given to the question "How do you decide on chemical control?" are presented in Table 7.

Table 7. How do you decide on chemical control?

Decision making on chemical control	Frequency	Percentage (%)
By walking around in the field myself	67	67
By looking at samples and photos brought by producers	28	28
According to the manufacturer's request	74	74
Looking at the surrounding fields	9	9
Depending on the previous crop	4	4

* Total exceeds 100% due to more than one option being marked

When the dealers were asked how they decide on chemical control, 74% stated that they decide on chemical control according to the request of the producer, 67% by walking around the field myself, 20% by looking at the samples and photographs brought by the producers, 9% by looking at other fields in the vicinity and 4% depending on the previous crop (Table 7).

The frequency and percentage (%) values of the answers given to the question about the crops where herbicides are intensively used are given in Table 8.

Table 8. Cultivated plants where herbicides are intensively used

Cultivated plant	Frequency	Percentage (%)
Citrus	62	62
Corn	76	76
Cotton	57	57
Onion	13	13
Spinach	2	2
Sunflower	16	16
Wheat	73	73
Peanut	68	68
Soybeans	42	42
Pomegranate	6	6
Potato	4	4
Melon-watermelon	5	5
Banana	1	1
Other	3	3

* Total exceeds 100% due to more than one option being marked

In the survey, when asked about the crops where herbicides are used intensively, the dealers responded as corn cultivation areas with a rate of 76%. Afterwards, 73% of the dealers reported wheat, 68% peanut, 62% citrus, 57% cotton, 42% soybean, 16% sunflower, 13% onion, 6% pomegranate, 5% melon and watermelon, 4% potato, 3% other, 2% spinach, 1% banana plantations (Table 7). [42], in their study, when the dealers were asked about the proportion of cultivated plants for which the most plant protection products were sold in our province, 28% of them stated that cotton, 23% wheat, 17% corn, 13% lentils, 10% pistachios, and 9% vegetables, and it can be said that the study data are in parallel with our results.

The frequency and percentage (%) values of the answers given to the question of herbicide application periods according to crop plants asked to the BKÜ dealers are given in Table 9.

Table 9. Herbicide application periods according to cultivated plants

Cultivated plant	Pre-exit		Post-exit		Pre-exit + Post-exit	
	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Citrus	21	21	52	52	13	13
Corn	73	73	73	73	52	52
Cotton	67	67	51	51	43	43
Onion	24	24	17	17	11	11
Spinach	1	1	-	-	-	-
Sunflower	25	25	16	16	7	7
Wheat	27	27	74	74	13	13
Peanut	69	69	63	63	57	57
Radish	-	-	1	1	-	-
Soybeans	51	51	46	46	34	34
Pomegranate	2	2	5	5	1	1
Potato	4	4	3	3	-	-
Melon-watermelon	1	1	8	8	1	1
Other	2	2	1	1	-	-

* Total exceeds 100% due to more than one option being marked

When the BKÜ dealers participating in the research were asked about the herbicide application periods according to the crops, 29% of them stated that they used pre-emergence herbicide and 71% used post-emergence herbicide. 81% of the dealers stated that they used herbicides in both pre-emergence and post-emergence periods and 19% stated that they did not use herbicides. It is seen that post-emergence herbicides are mostly used in cultivated plants (Table 9). The crops where dealers used post-emergence herbicides the most were wheat plantations with 74%. After that, they used 73% in maize, 63% in peanut, 52% in citrus, 51% in cotton, 46% in soybean, 17% in onion, 16% in sunflower, 8% in melon and watermelon, 5% in pomegranate, 3% in potato and 1% in radish and other crops. Among the crops for which they used pre-emergence herbicides, 73% of the crops were corn and 69% were peanuts. These were followed by cotton with 67%, soybean with 51%, wheat with 27%, sunflower with 25%, onion with 24%, citrus with 21%, potato with 4%, pomegranate and other crops with 2%, spinach and melon-watermelon with 1% (Table 8). They stated that there were 10 crops for which both pre-emergence and post-emergence herbicides were used, 52% of which were peanut plantations, 52% corn, 43% cotton, 34% soybean, 13% wheat and citrus, 11% onion, 7% sunflower, 1% pomegranate and melon-watermelon plantations.

The frequency and percentage (%) values of the answers given to the question of herbicides used intensively in agricultural areas, which was asked to the BKÜ dealers, are given in Table 10.

Table 10. Herbicides used intensively in agricultural areas

Active Substance	Product Used	Frequency	Percentage (%)
S-Metolachlor + Terbuthylazine	Sunflower, Corn, Chickpea, Cotton, Sweet Corn	26	26
Isoxaflutole + Thiencarbazone-methyl + Cyprosulfamide	Corn	58	58
Glyphosate Potassium Salt	Citrus, Vineyard, Hazelnut, Olive, Cultivated Crop Areas	72	72
Pendimethalin	Onion, Cotton, Sunflower, Corn, Beans, Tobacco, Carrot	62	62
Mesotrione + Nicosulfuron	Corn	38	38
Mesosulfuron-methyl + Thiencarbazone-methyl + Iodosulfuron-methyl-sodium + Mefenpyr-diethyl	Wheat	56	56
Dimethenamid-p	Corn	11	11
Clethodim	Cotton, Tomato, Red Lentil, Potato, Onion, Sugar Beet	65	65
Nicosulfuron	Corn	28	28
İndaziflam	Citrus, Vineyard, Apple, Peach	16	16
Halauxifen-methyl+Pyroxsulam + Cloquintocet-acid (Safener)	Wheat	18	18
Dicamba+Triasulfuron	Wheat, Barley	9	9
Glyphosate Isopropylamin Salt	Citrus	7	7
Quizalofop-p-ethyl	Sunflower, Vineyard, Tomato, Canola, Red Lentil, Chickpea, Cotton, Soybean, Sugar Beet	6	6
Diquat dibromide	Apple	3	3
Mesotrione + Nicosulfuron	Corn	5	5
S-Metolachlor + Benoxacor	Cotton, Tomato	8	8
Mesotrione + Nicosulfuron	Corn	4	4
Other		35	35

***** Total exceeds 100% due to more than one option being marked

When asked about the herbicides commonly used in agricultural areas, 72% of the dealers stated that Glyphosate Potassium Salt is intensively used in citrus, vineyard, hazelnut, olive and non-cultivated areas in Adana province and districts (Table 10). Subsequently, 65% of the dealers used clethodim in cotton, tomato, red lentil, potato, onion and sugar beet crops, and 62% used pendimethalin in onion, cotton, sunflower, maize, bean, tobacco and carrot crops, 58% used isoxaflutole + thiencarbazone-methyl + cyprosulfamide herbicide in maize, 56% used Mesosulfuron-methyl + Thiencarbazone-methyl + Iodosulfuron-methyl-sodium + Mefenpyr-diethyl herbicide in wheat, 38% used Mesotrione + Nicosulfuron in maize. [43], in his survey study, stated that 46% of the producers used herbicides in the GAP Region, 55% in Diyarbakır, 51% in Mardin, 51% in Şanlıurfa and 34% in Şanlıurfa.

The frequency and percentage (%) values of the answers given to the question of weed species that cannot be controlled with herbicides asked to the BKÜ dealers are given in Table 11.

Table 11. Weed species that could not be controlled with herbicides

Latin name	English name	Frequency	Percentage (%)
Avena sterilis L.	Wild oat	58	58
Convolvulus arvensis L.	Field bindweed	37	37
Asyneuma rigidum (Willd.) Grossh. subsp. *rigidum*	Broom grass	32	32
Echinochloa crus-galli (L.) P.Beauv.	Barnyard grass	15	15
Cyperus rotundus L.	Purple nutsedge	26	26
Amaranthus retroflexus L.	Redroot pigweed	13	13
Sorghum halepense (L.) Pers.	Johnsongrass	24	24
Malva sylvestris L.	High mallow	4	4
Portulaca oleraceae L.	Common purslane	11	11
Prosopis farcta (Banks& Sol.) J.F.Mac.	Prosopis	6	6
Cucumis melo var. *agrestis* Naudin	Wild Melon	7	7
Other		5	5

* Total exceeds 100% due to more than one option being marked

In the study, 62% of the dealers answered "yes", and 38% answered "no" to the question of whether there were weed species that could not be controlled after the use of herbicides. Those who answered "yes" were then asked which weed species remained uncontrolled despite herbicide application. In response, 58% of the dealers mentioned *Avena sterilis*, 37% *Convolvulus arvensis*, 32% *Alopecurus rigidum*, 26% *Cyperus rotundus*, 24% *Sorghum halepense*, 15% *Echinochloa crus-galli*, 13% *Amaranthus retroflexus*, 11% *Portulaca oleracea*, 7% *Cucumis melo*, 6% *Prosopis farcta*, 5% other species, and 4% *Malva sylvestris* (Table 10).

Additionally, during interviews with the dealers, they stated that the problem of herbicide resistance is becoming increasingly serious due to the intensive and improper use of herbicides, leading to weeds becoming uncontrollable.

It was reported that the weed species identified by dealers as resistant to herbicides include *Sorghum halepense*, *Amaranthus retroflexus*, *Echinochloa colonum*, *Echinochloa crus-galli*, *Sinapis arvensis*, *Avena sterilis*, and *Xanthium strumarium* worldwide, while in Türkiye, the primary resistant species were *Avena sterilis*, *Echinochloa crus-galli*, and *Sinapis arvensis* [44].

The frequency and percentage (%) values of the answers given to the question “Areas where total chemical control is practiced” asked to the BKÜ dealers are presented in Table 12.

Table 12. Areas where total chemical control was carried out

Area	Frequency	Percentage (%)
Garden	50	50
Irrigation Canals	16	16
Park	5	5
Hard floor	5	5
Other	9	9

*More than one option is marked

When BKÜ dealers who participated in the survey were asked whether total chemical control is practiced, 66% of the dealers answered yes and 34% answered no. Those who answered yes

to this question were asked in which areas do you carry out chemical control? 50% of the dealers stated that they apply chemical control in gardens, 16% in irrigation canals, 9% in other areas, and 5% in parks and hard surfaces (Table 12).

The frequency and percentage (%) values of the answers given to the question of the herbicides used intensively in total weed control and the licensed products are presented in Table 13.

Table 13. Herbicides used intensively in total weed control and licensed products

Active Substance	Licensed Products	Frequency	Percentage (%)
Glyphosate Isopropylamin Salt	Citrus	58	58
Diquat Dibromide	Citrus, Apple, Apricot, Cultivated Crop Areas	23	23
Oxyfluorfen	Pear, Sunflower, Cauliflower, Citrus, Onion	11	11
Glufosinate Ammonium Salt	Fruit, Vineyard, Citrus	7	7
Glyphosate Ammonium Salt	Citrus, Vineyard, Hazelnut and Olive	13	13
Sonrount	Citrus, Vineyard, Hazelnut, Fruit Gardens, Crop-free Areas	3	3
Knockdown	Citrus, Vineyard, Hazelnut, Fruit Gardens, Crop-free Areas	3	3
Other		9	9

*More than one option is marked

When asked about the herbicides used intensively in total weed control, 58% of the BKÜ dealers used glyphosate isopropylamine salt active ingredient herbicide licensed in citrus areas, 23% used Diquat dibromide licensed in citrus, apple, apricot and non-cultivated areas, 13% used Diquat dibromide licensed in citrus, vineyard, glyphosate ammonium salt in hazelnut and olive, 11% used Oxyfluorfen in pear, sunflower, cauliflower, citrus and onion, 9% used herbicides with other active ingredients, 3% used Sonrount and Knockdown herbicides in citrus fruits, vineyards, hazelnuts, orchards and areas where cultivated plants are not grown (Table 13).

4. Conclusion

In this study, a questionnaire survey was conducted with licensed BKÜ dealers affiliated to Adana Provincial Directorate of Agriculture and Forestry in order to determine the weeds that are problematic in agricultural areas and cultivated plants in Adana province and districts, the chemical control status in agricultural and non-agricultural areas and the status of herbicide resistant weeds. More than half of the dealers (61%) stated that the weed level in their agricultural areas was 'dense'. They reported that although weed species in agricultural areas varied according to the cultivated plants, the most problematic weed species were *A. sterilis* (80%), *E. crus-galli* (79%), *S. halepense* (76%) and *S. arvensis* (75%). The crops with the highest weed densities were wheat (78%), corn (76%), peanut (61%) and cotton (58%). They stated that post-emergence herbicides were mostly used in agricultural areas and the most chemical control was carried out in wheat with 74%, followed by 73% in maize and 63% in peanut cultivation areas. Additionally, they noted that the most commonly used herbicides contained the active ingredients glyphosate potassium salt (72%), clethodim (65%), and

pendimethalin (62%). The dealers also emphasized that 62% of them observed a herbicide resistance problem in the agricultural areas of Adana province and its districts. Despite herbicide applications, they reported that *Avena sterilis* (58%), *Convolvulus arvensis* (37%), *Alopecurus rigidum* (32%), and *Cyperus rotundus* (26%) were the most resistant weed species and could not be effectively controlled. They warned that herbicide resistance is increasing due to the intensive and improper use of herbicides. Furthermore, 66% of the dealers stated that total weed control was applied, with herbicides containing glyphosate isopropylamine salt and diquat dibromide being the most frequently used. In order to overcome the development of herbicide resistance and to promote sustainable agriculture, it is recommended that farmers implement an Integrated Weed Management (IWM) strategy. This involves a reduction in the reliance on herbicides, with the incorporation of cultural, mechanical, and biological control methods. In addition, the rotation of herbicide modes of action is to be encouraged. Diversifying the range of crops grown and utilising cover crops are effective strategies for weed control, thereby reducing the amount of herbicide required. Regular monitoring of weed populations for resistance is essential. It is incumbent upon policy makers to fortify programmes for the management of herbicide resistance, to advocate research into non-chemical control methodologies, and to furnish farmers with the requisite training. Nevertheless, the implementation of more stringent regulations pertaining to the use of herbicides, incentives for the adoption of sustainable practices, and an enhancement in the level of cooperation among the various stakeholders involved have the potential to facilitate the achievement of long-term and sustainable weed management objectives through the effective implementation of weed control methodologies.

Ethics in Publishing

In order to determine the Weed Problem and Chemical Control Status in Adana Province, it was decided that the surveys to be conducted through face-to-face interviews with dealers selling Plant Protection Products in Adana province were in compliance with scientific research and publication ethics in accordance with Article 10/1 of the Iğdır University Scientific Research and Publication Ethics Directive and an ethics document was prepared.

Author Contributions

R. Gürbüz planned the study; R. Taşkın collected the data; H. Alptekin made the tables, graphics and SPSS analyses; A. Usanmaz Bozhüyük evaluated and wrote the results.

References

[1] Tuik (2021). Turkish Statistical Institute (http//www.tuik.gov.tr) Access date (17.03.2021).

[2] Sen, B., (2009). Determination of possible effects of climate change on 1st and 2nd crop maize yield in Cukurova region using regional climate models. PhD Thesis, Cukurova University, Institute of Science, Department of Agricultural Structures and Irrigation, Adana.

[3] Thobatsi, T. J., (2009). Growth and yield responses of maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) in an intercropping system. University of Pretoria (South Africa).

[4] Gokalp, O., & Uremis, İ., (2015). Determination of weed species, prevalence and density in Mardin wheat planting areas. Mustafa Kemal University Faculty Journal of Agricultural Sciences, 20(1): 13-22.

[5] Karabacak, S., & Uygur, F. N. (2017). Problematic weed species and densities in sunflower cultivation areas of Cukurova Region. Turkish Journal of Weed Science, 20(2): 46-54.

[6] Uludag, A., Uremis, İ., Rusen, M., Tursun, N. (2017). Possible uses of allelopathy in weed control in organic farming in Türkiye. Acta Herbologica, 26 (2): 87-93.

[7] Vats, S., (2015). Herbicides: history, classification and genetic manipulation of plants for herbicide resistance. In Sustainable agriculture reviews, 153-192.

[8] Fao (2021). Food and Agriculture Organization. www.fao.org. (Access date: 18.05.2021.)

[9] Cullen, M. G., Thompson, L. J., Carolan, J. C., Stout, J. C., & Stanley, D. A. (2019). Fungicides, herbicides and bees: A systematic review of existing research and methods. PloS one, 14(12), e0225743.

[10] Silva, V., Mol, H. G., Zomer, P., Tienstra, M., Ritsema, C. J., & Geissen, V. (2019). Pesticide residues in European agricultural soils–A hidden reality unfolded. Science of the Total Environment, 653: 1532-1545.

[11] Jabłońska-Trypuć, A., Wydro, U., Wołejko, E., & Butarewicz, A. (2019). Toxicological effects of traumatic acid and selected herbicides on human breast cancer cells: In vitro cytotoxicity assessment of analyzed compounds. Molecules, 24(9): 1710.

[12] Guncan, A., (1977). Side Effects of Herbicides on the Living World. Ataturk University Journal of Agricultural Faculty, 8:2-3.

[13] Henderson, A. M., Gervais, J. A., Luukinen, B., Buhl, K., Stone, D., Strid, A., ... & Jenkins, J. (2010). Glyphosate Technical Fact Sheet; National Pesticide Information Center, Oregon State University Extension Services. Retrieved October, 20, 2013.

[14] Greenland, R. G. (2003). Injury to vegetable crops from herbicides applied in previous years. Weed technology, 17(1): 73-78.

[15] Charles, G., (2013). Herbicide Damage Symptoms Guide. Cotton Reaserch and Development Corporations. Section J2, October 2013.

[16] Derr, J., (2016). Plant Injury From Herbicide Residue. Virginia Cooperative Extension. Virginia Tech, 2016.

[17] Hancerli, L., & Uygur, F. N. (2017). Weed species in corn plantations in Cukurova region. Turkish Journal of Weed Science, 20(2): 55-60.

[18] Ozkil, M., Torun, H., Eymirli, S., Uremis, İ., & Tursun, N. (2019). Determination of the prevalence and density of weeds in sunflower (*Helianthus annuus* L.) cultivation areas

of Adana province. Mustafa Kemal University Faculty Journal of Agricultural Sciences, 24(2): 87-96.

[19] Tunk, S., & Uygur, F. N. (2020). Investigation of whether the weed species included in the labels of herbicides recommended for wheat cultivation areas in Cukurova Region are main pests, harmful or beneficial. Turkish Journal of Weed Science, 23(1):24-33.

[20] Oksar, M., & Uygur, F.N., (2000). Weeds in Cukurova and their biological control possibilities, Cukurova University, Institute of Science, Department of Plant Protection, Master Thesis, Adana, 86 p.

[21] Orel, E., & Uygur, F.N., (1996). Determination of weed Species that maybe indicators of some ecological factors in wheat and corn plantations in Cukurova region. Cukurova University, Institute of Science, Department of Plant Protection, Master Thesis, Adana, 133p.

[22] Gönen, O., & Uygur, F.N., (1999). Germination biology of summer weed species in Cukurova region and determination of their morphological characters for computer-aided diagnosis. Cukurova University, Institute of Science, PhD Thesis, Adana, 233 p.

[23] Gungor, M., & Uygur, F.N., (2005). Investigation of the ımportance of chemical control applied against weeds in maize plantations in Adana province and the emerging problems. Cukurova University, Institute of Science, Master Thesis, Adana, 171 p.

[24] Sahin, S., Gurbuz, R., & Coruh, I. (2020). Determination of weed species seen in cotton production areas of Igdir province and investigation of the effects of some herbicides on weed control and cotton yield. Journal of Agriculture, 3(2): 40-48.

[25] Tursun, N., & Seyithanoglu, M. (2006). Determination of important weed species causing problems in important crop plants in Kahramanmaraş province and the most commonly used herbicides in combating them. Kahramanmaras Sütcü Imam University Journal of Engineering Sciences, 9(2): 116-120.

[26] Tursun, N., Tursun, A. Ö., & Kacan, K. (2004). Determination of problematic weeds in cotton fields in Kahramanmaraş province and its districts. Kahramanmaras Sütcü Imam University Journal of Engineering Sciences, 7(1): 92-96.

[27] Arıoglu, H. H., (2014). Peanut Cultivation and Breeding, Oil Crops Textbook, 1999, Çanakkale University Faculty of Agriculture Publications, GY No: 220, Y. No: A-70, P, 74.

[28] Ulug, E., Kadıoglu, I., & Uremis, I. (1993). Weeds of Turkey and some of their characteristics. TKB Adana Agricultural Control Research Institute, Pub., 78:513, Adana.

[29] Kadıoglu, I., Ulug, E., & Uremis, I., (1993). Research on weeds in cotton fields in the Mediterranean region. 1st Turkish Herbology Congress (3-5 February 1993, Adana) 151-156.

[30] Uygur, S., (1997). Investigation of weed species in Cukurova region, disease agents hosted by these species, their distribution and the possibilities of using disease agents in biological control. PhD Thesis, Cukurova University, 148 p, Adana.

[31] Arslan, M., & Uremis, I., (2003). Yield loss caused by sorghum (*Sorghum halepense* (L.) Pers.) problem in peanut cultivation and determination of the most effective control method. 5th Turkish Field Crops Congress (13-17 October 2003, Diyarbakır) Volume I, 579-583.

[32] Arslan, M., Uremis, I., & Uludag, A. (2006). The critical period of weed control in double-cropped soybean. Phytoparasitica, 34: 159-166.

[33] Günes, E., Uludag, A., & Uremis, I. (2008). Economic impact of johnsongrass (*Sorghum halepense* [L.] Pers.) in cotton production in Turkey. Journal of Plant Diseases and Proctection, Supplement, 21: 515-520.

[34] Erturk, Y.E., Uremis, I., & Uludag, A., (2012). The economic impact of weeds and their control in Turkey. International Symposium: Current Trends in Plant Protection (25-28 September 2012, Belgrade, Serbia) Proceedings: 79-85.

[35] Uludag, A., Uremis, I., Tursun, N., & Bukun, B., (2012). A review on critical period for weed control in Turkey. The 6th International Weed Science Congress (17-22 June 2012, Hangzhou, China), 37.

[36] Özkil, M., & Uremis, I., (2020). Prevalence and density of evening primrose (*Ipomoea* spp.) and Field Ivy (*Convolvulus* spp.) species found in agricultural areas of the mediterranean region. Journal of Agriculture Faculty of Ege University, 57(2): 229-238.

[37] Yasar, S., (2012). Determination of important weed species, their densities and frequencies in onion growing areas of Tekirdağ province. Namık Kemal University, Institute of Science, Master's Thesis, 38p.

[38] Kaya, H., & Uremis, I., (2019). Determination of the prevalence and density of weeds in onion fields of Hatay province. Mustafa Kemal University Journal of Agricultural Sciences, 24(1): 21-30.

[39] Ozaslan, C., Onen, H., & Ozer, Z. (2002). Determination of problematic weeds in spring and autumn spinach (Spinacia oleracea L.) cultivation in Tokat-Kazova. Turkish Journal of Weed Science, 5(1): 52-61.

[40] Arıkan, L., Kitis, Y. E., Uludag, A., & Zengin, H. (2015). Determination of the prevalence and density of weeds in citrus orchards in Antalya province. Turkish Journal of Weed Science, 18(2): 12-22.

[41] Gul, P., & Gurbuz, R. (2023). The effects of different biodegradable mulches on weed population and fruit yield in watermelon production field. Pakistan Journal of Botany, 55(2): 1–7.

[42] Yetkin, C., Arslan, Z.F., & Bilgili, A., (2013). Determination of the usage status and problems of plant protection products in Şanlıurfa Province. 1st Plant Protection Products and Machinery Congress (2-5 April 2013, Antalya). Ministry of Food, Agriculture and Livestock, General Directorate of Food and Control Publications, Ankara, 1: 295-307.

[43] Kaplan, E., (2014). Determination of problems related to plant protection applications in Gap region. Dicle University, Institute of Science, Master's Thesis, Department of Plant Protection, Diyarbakır, 53p.

[44] Heap, I., (2021). The International Herbicide-Resistant Weed Database. Onlin