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The efficiency of some post-emergence herbicides for controlling problematic weeds of lawn areas

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This study was carried out to determine the effectiveness of some herbicides on weed species and weed population in the landscape area of Iğdır University Şehit Bülent Yurtseven Campus in 2021. In the study, herbicides with active ingredients, 2,4-D amine, Bromoxynil + MCPA, 2,4-D tri-isopropyl amine salt + Picloram, dicamba + triasulfuron, 2,4-D EHE + florasulam, Halosulfuron-methyl and Fluazifop-p-butyl as well as Bromoxynil + MCPA + dicamba + triasulfuron and 2,4-D amine + Fluazifop-p-butyl herbicide mixtures were used. The percentage effects of the herbicides applied in the study on weed dry weights, weed species, and the percentage effects of herbicides on these weed species were determined according to the 3 counts made at certain intervals for the weed species with a density of 1 weeds/m^2 and above in the census.
As a result of the study, a total of 14 weed species belonging to 8 families were determined in the trial area. Of these detected weed species, *Trifolium repens* L. (5.49 weed/m^2), *Cynodon dactylon* (L.) Pers. (3.24 weed/m^2), *Trifolium pratense* L. (1.23 weed/m^2), *Melilotus albus* Medik. (1.07 weed/m^2) and *Convolvulus arvensis* L. (1.03 weed/m^2), the density of 5 of them was determined as 1 weeds/m^2 and above. As a result of the study, the lowest weed dry weights (2.12 g/m^2) and the highest percentage effect (94.50%) were obtained in the 2,4-D tri-isopropyl amine salt + Picloram plots. The percentage effects of the herbicides applied in the study on the weed species varied according to the weed species and the herbicides used.

Keywords: turfgrass, weeds, herbicide, chemical control, *Trifolium repens*, *Cynodon dactylon*

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Эффективность некоторых послевсходовых гербицидов для борьбы с проблемными сорняками на газонах

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Исследование проводилось для определения эффективности некоторых гербицидов в отношении видов сорняков и популяции сорняков в ландшафтной зоне кампуса Бюлента Юрцевена Ыгдырского университета в 2021 г. В исследовании использовались гербициды с активными ингредиентами: 2,4-D-амин, бромоксинил +MCPA, соль 2,4-D триизопропиламина + пиклорам, дикамба + триасульфурон, 2,4-D EHE + флорасулам, галосульфурон-метил и флуазифоп-П-бутил, а также смеси гербицидов бромоксинил + MCPA + дикамба + триасульфурон и 2,4- D-амин + флуазифоп-П-бутиловый. Процентное воздействие примененных гербицидов на сухой вес сорняков, виды сорняков и процентное воздействие гербицидов на эти виды сорняков были определены в соответствии с тремя подсчетами, проведенными через определенные промежутки времени для видов сорняков с плотностью 1 сорняк/м^2 и выше.

В результате исследования на пробной площади было определено в общей сложности 14 видов сорняков, относящихся к восьми семействам. Из этих видов сорняков плотность пяти определялась как 1 сорняк/м^2 и выше: *Trifolium repens* L. (5,49 сорняк/м^2), *Cynodon dactylon* (L.) Pers. (3,24 сорняк/м^2), *Trifolium pretense* L. (1,23 сорняк/м^2), *Melilotus albus* Medik. (1,07 сорняк/м^2) и *Convolvulus arvensis* L. (1,03 сорняк/м^2). В результате исследования наименьший сухой вес сорняков (2,12 г/м^2) и наибольший процентный эффект (94,50%) были получены на участках с применением гербицида 2,4-D триизопропиламиновая соль + пиклорам. Процентное воздействие гербицидов, примененных в исследовании, на виды сорняков варьировалось в зависимости от вида сорняков и используемых гербицидов.

Ключевые слова: дерновая трава, химическая защита, *Trifolium repens*, *Cynodon dactylon*

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Introduction

With the dense construction that emerged as a result of rapid population growth, green areas in cities are decreasing and the longing for nature gradually increases. One of the most important elements of green areas is grass covers (Kuşvuran, 2012). Turfgrass areas form the basic structure of the urban green spaces (Oral, Açıkgöz, 2001). Turfgrass sward areas within the urban green area system, more importantly than providing aesthetic beauty, form a green cover conducive to sports, playing and resting (Yılmaz, Hurmanlı, 2016). Green lawn area plants, which form an important part of outdoor spaces, are used in terms of architecture and aesthetics and create the resting environment that people need. Turfgrass is an oxygen reservoir and the 225 m^2 turfgrass area provides the daily oxygen need of a family of 4 members (URL: https://www.ulusoyseed.com.tr/teknik/bunlari-biliyor-musunuz). By wrapping the soil surface like a carpet, it prevents the soil from causing pollution in the form of dust and mud with wind and precipitation. The turfgrass green area ensures that the humidity and temperature of the environment remain in balance. It prevents water and wind erosion by keeping the fertile top layer of the soil as a whole. In addition, grass fields with dense root structure and developed above-ground parts act as a filter on the ground, preventing the contamination of soil and underground water by precluding harmful substances and chemicals from going deep into soil layers (URL: https://www.ulusoyseed.com.tr/teknik/bunlari-biliyor-musunuz).

Today, keeping the turfgrass sward healthy is more important than establishing it, because there are many factors that limit the development of these plants and lose their attractive color. One of them is weeds, which are very often a problem in the lawn. Weed infestation in lawn areas most likely reflects the low competitiveness of the lawn. Therefore, it is necessary to keep the growth of weeds under control (Larsen et al., 2004). Weeds on lawns are undesirable and are generally considered one of the most important and common problems here (Raikes et al., 1994). Every year, weeds become an serious challenge in such turfgrass areas as golf courses, race tracks, and sports fields (Fischer, Larsen, 2002). The establishment of turfgrass areas is quite expensive. For this reason, weed control is very important for the protection and longevity of these areas. If left uncontrolled, weeds can weaken the turfgrass swards in competition for the water and nutrients in the plant root zones. As a result, if the weeds formed after planting in the turfgrass areas cannot be competed, turfgrass can spread in a short time and completely cover the area. In fact, weeds in lawn areas that are established with difficulty not only reduce the purpose of area use, but also shorten the life span of the turfgrass. Some weed species dominate the environment over time and cause the loss of the turfgrass quality of the environment. They decrease the aesthetic appearance and increase maintenance costs (Şanlıtürk, 2009). According to the growing periods, there are annual and perennial weeds in the turfgrass areas. Broad-leaved weeds are especially very dominant in turfgrass fields (Şanlıtürk, 2009). In turfgrass areas, mostly biennial or perennial weeds with a deep root system and rosette form pose a serious problem (Kitiş, 2011). The most problematic weeds in turfgrass areas are: *Taraxacum officinale* F.H. Wigg (dandelion), *Chenopodium album* L. (fat-hen), *Capsella bursa-pastoris* (L.) Medik. (shepherd's purse), *Plantago lanceolata* L. (buckhorn plantain), *Convolvulus arvensis* L. (field bindweed), *Trifolium* spp. (clover species), and *Amaranthus retroflexus* L. (redroot pigweed) (URL: https://www.almanac.com/content/common-garden-weeds) – they can be given as examples.

In small home gardens, after emergence, weeds are removed manually or with different tools and can be controlled easily. However, manual weed control in large areas is difficult and expensive. As for controlling weeds by mowing, tall annual weed species are easy to be controlled by cutting with different machines when they are in bloom. However, the mowing method is not very useful in controlling weeds which grow close to the ground, and it is not cost-effective (Açıkgöz, 1993; Tepe, 1998). Because of these negative reasons, the use of herbicides against weeds in turfgrass areas is more important. The control of weeds, which are troublesome in lawn plant areas, is largely based on the use of herbicides (Watschke, 1985). Thus, although mechanical and other cultural control techniques are applied in lawn areas, chemical control methods are emphasized, since weeds are not sufficiently controlled (Turgeon et al., 1994; Watschke et al., 1995).

The objective of the present study was to determine the effectiveness of some herbicides and herbicide mixtures against weeds that are a problem in turfgrass areas. Thus, it is aimed to develop a successful chemical control strategy against weeds and, as a result, to implement an effective spraying program correctly in order to develop a more effective and economical control method.

Materials and methods

The study was carried out on the turfgrass areas in the landscape land of Iğdır University Şehit Bülent Yurtseven Campus in 2021. In this area where the experiment was carried out, there is an existing lawn area of previously established 145 hectares. The province of Iğdır is located between 39°39' and 40°07' north latitudes and 43°17' and 44°49' east longitudes. The lawns were established two years before the experiment, on 15th of March 2019, with the hydroseeding system. Turfgrass mixtures and proportions in the experiment area were as follows: 25% of perennial ryegrass (*Lolium perenne* L.), 45% of tall fescue (*Festuca arundinacea* Schreb.), 10% of Kentucky bluegrass (*Poa pratensis* L.), and 20% of red fescue (*Festuca rubra* L. subsp. *rubra)*. The texture of the experimental soils was sandy loam; pH (8.37), organic matter (1.95%), lime (10.51%), saturation (71.55%). K_2O (139.79 kg/da), P_2O_5 (1917.60 kg/da) and total salt (0.04%) were as given here. The mean of long years (MLY) and the climate data of 2021 for the months in which the study was carried out are presented in Table 1.

The experiment was set up as a total of 36 plots according to the randomized complete blocks design with 9 characters in 4 replications. In addition, safety strips were drawn around the area and warning signs were hung in order to prevent entrances to the experiment area. Fertilizers containing NPK (nitrogen, phosphorus, and potassium) were sprinkled on the experiment area 20 days before the parcelization. Three days before the experiment was set up, the turfgrass (lawn) was mowed around 3 cm mowing heights (Fagerness, 2001). Afterwards, parcelization was done and 7.5 m^2 (3 × 2.5 m) wide strips of 1 m were left between the parcels and 1 m between the blocks. The trial area was 457.5 m^2 in total. Stakes were fixed to the ground for parcelization and rope was used in the strips. Weed species in each parcel were determined according to the Flora of Turkey (Davis, 1965-1985).

In the study, herbicides were applied on May 16, 2021. A backpack sprayer with a 25 liter tank capacity and a gasoline engine flat fan nozzle with a 2.5 working width was used

Table 1. Meteorological data of the research area in 2021 and MLY (URL: https://www.mgm.gov.tr/2020)

Таблица 1. Метеорологические данные в зоне изучения в 2021 г. и в среднем за многолетний период (URL: https://www.mgm.gov.tr/2020)

	Mean temperature (°C)		Total rainfall (mm)		Mean relative humidity (%)	
Months	2021	MLY (1941–2021)	2021	MLY (1941-2021)	2021	MLY (1941–2021)
April	17.4	13,0	18.4	33.8	43.6	49.9
May	21.1	17.7	42.1	46.5	46.3	51.5
June	26.8	22.1	0.7	32.0	33.9	47.3
July	27.4	25.9	32.4	13.7	45.7	45.3
August	27.4	25.3	8.3	9.7	40.6	47.1
September	22.2	20.4	11.5	11.5	44.8	46.2
October	12.7	13.1	18.5	26.3	60.0	48.53
November	13.5	6.0	6.2	18.6	80.7	80.2

Note: MLY – mean of long years
Примечание: MLY – в среднем за многолетний период

for herbicide application. Herbicides were applied broadcastly onto the surface of lawns. Herbicides with 2,4-D amine, Bromoxynil + MCPA, 2,4-D tri-isopropyl amine salt + Picloram, dicamba + triasulfuron, 2,4-D EHE + florasulam, Halosulfuron-methyl, and Fluazifop-p-butyl active ingredient, plus Bromoxynil + MCPA + dicamba + triasulfuron and 2,4-D amine + Fluazifop-p-butyl herbicide mixtures and untreated control plots were used in the experiment. The experiment area was irrigated with a sprinkler irrigation system 24 hours after the herbicides application.

Determination of the effects of herbicides on weeds

In order to assess the effect of herbicides on weeds, the weed count in the plots was conducted before the application using a 1 m^2 frame by randomly throwing into each plot and counting the weeds in the frame (TAGEM..., 2020). Thus, weeds in 1 m^2 of each plot were determined and their density was assessed. Assessment of the density of weeds was made on the basis of the arithmetic mean. Weed densities (plant/m2) were calculated by dividing the total number of plants per m^2 in the surveys, taking into account the number of surveys, and the densities of each species were calculated using the following formula (Odum, 1971):

$$\text{Density (plant/m}^2\text{)} = B/m,$$

where B is the total number of individual plants in the samples;

m is the total number of samples.

The effects of the herbicides applied in the study on weeds were measured in 3 assessments after post-emergence herbicide applications onto turfgrass fields according to the weed standard herbicide application methods of the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies (TAGEM). The first assessment was done 7 days after the treatment (DAT) on May 23, 2021, the second assessment was done 21 DAT on June 6, 2021, and the third assessment was done 50 DAT on July 5, 2021 (TAGEM..., 2020). Weed species densities of 1 weeds/m^2 and above were handled one by one, and the reductions in them compared to the control were recorded by expressing the percentage of the area covered with weeds, shortening in height or damaged. The percentage of reduction in the weed population was determined by comparing the treated plots with the control ones.

Effects of herbicides on the dry weight of weeds

In the study, after the last assessment of the weeds, the weeds in each plot were cut with scissors close to the soil surface, and they were collected and put into separate paper bags. They were brought to the Department of Herbology. After being kept in an oven at 70°C for 24 hours, they were removed, their dry weights were measured separately (Travlos et al., 2020), and numerical data were recorded. Afterwards, the percentage effects of herbicides on weed dry weights were assessed, based on the control plots of the weed dry weights obtained in the herbicide-applied plots.

Statistical analysis

All the herbicides were applied in a randomized complete block design with four replicates and nine experimental treatments (eight herbicides and their mixtures, and an untreated control). For all the herbicide applications, the weed dry weights for each weed species were recorded separately on 7 DAT, 21 DAT and 50 DAT, expressed as percentages of the corresponding values recorded for the untreated control plots. The Tukey test was applied in the SPSS 17.0 Package Program and the statistical analysis was done, and the difference between the separate applications was determined (Efe et al., 2000). In addition, the results of the assessment were determined using the Abbott formula, the effect on the weeds at the species level and the effects on all weeds (Snedecor, Cochran, 1967):

$$\text{Herbicide effects (\%)} = \frac{\text{(Weeds in control – Weeds in treatment)}}{\text{Weeds in control}} \times 100$$

Results and discussion

A total of 14 weed species belonging to 8 families were assessed in the trial area. The experiment was carried out in 2021 on the grass field located in the Şehit Bülent Yurtseven Campus of Iğdır University (Table 2).

Table 2. Scientific name, common names and life cycles of the weed species (P = perennial, A = annual)

Таблица 2. Научное название, общепринятое название и жизненные циклы видов сорняков (P = многолетний вид, A = однолетний)

Familya	Scientific name	Common name	Life cycle
Narrow-leaved			
Plantaginaceae	*Plantago lanceolata* L.	Buckhorn plantain	P
	Plantago major L.	Broad-leaved plantain	P
Poaceae	*Cynodon dactylon* (L.) Pers.	Bermuda grass	
	Phragmites australis (Cav.) Trin. ex St.	Common reed	P
Broad-leaved			
Amaranthaceae	*Ceratocarpus arenarius* L.	Ceratocarpus	A
Asteraceae	*Cirsium arvense* (L.) Scop.	Canada thistle	P
	Lactuca serriola L.	Prickly lettuce	P
	Taraxacum officinale F.H. Wigg.	Dandelion	P
Convolvulaceae	*Convolvulus arvensis* L.	Field bindweed	P
Fabaceae	*Melilotus albus* Medik.	Honey clover	A
	Trifolium pratense L.	Red clover	P
	Trifolium repens L.	White clover	P
Malvaceae	*Malva sylvestris* L.	Mallow	P
Polygonaceae	*Rumex crispus* L.	Curly dock	P

Among the weed species detected in the experiment area, 4 types of narrow-leaved weeds and 10 types of broad-leaved ones were identified. Among the 8 families identified, Fabaceae (3), Asteraceae (3), Poaceae (2) and Plantaginaceae (2) were the highest in terms of weed numbers, and 1 species belonging to the remaining families was found (see Table 2). N. G. Şanlıtürk (2009) identified 26 weed species in his study, most of which belong to Fabaceae family, and also *Trifolium* spp., *Sorghum halapense* (L.) Pers., *Taraxacum officinale*, *Trifolium repens*, *Malva sylvestris* L., and *Convolvulus arvensis*. In addition, C. D. G. Maciel et al. (2008) determined a total of 45 weed species belonging to 15 families in their study in the turfgrass fields in Brazil, and stated that the most common weed family was Asteraceae. M. D. Kamal-Uddin et al. (2009) identified 79 weed species in their study. Similarly, A. C. Xing et al. (2000) found 24 weed families and 74 weed species in their study in China. These studies were similar to current study. In this study, weed densities in the experiment area were determined after the parcelization process. The density of 5 species among the weed species measured as a result of the surveys was determined as 1 weeds/m^2 and above (Table 3).

Weed species with densities of 1 weeds/m^2 and above in the experiment area were as follows; *Trifolium repens* (5.49 weeds/m^2), *Cynodon dactylon* (3.24 weeds/m^2), *Trifolium pratense* (1.23 weeds/m^2), *Melilotus albus* Medik. (1.07 weeds/m^2) and *Convolvulus arvensis* (1.03 weeds/m^2) (see Table 3). Taştan and Erçiş (1994) stated that the weed species with the highest density in their study were *Trifolium repens* (13.78 weeds/m^2), *Taraxacum* spp. (11.47 weeds/m^2) and *Trigonella* spp. They determined it as 1.54 weeds/m^2. Şanlıtürk (2009) established that *Sorghum halapense* (1.44 weeds/m^2) *Trifolium* spp. (0.49 weeds/m^2), *Taraxacum officinale* (0.31 weeds/m^2), *Cardaria draba* (L.) Desv. (0.16 weeds/m^2), *Trifolium bocconei* Savi (0.11 weeds/m^2), *Conyza canadensis* (L.) Cronq. (0.06 weeds/m^2), *Trifolium campestre*

Table 3. Densities of weed species in the experiment area

Таблица 3. Плотность видов сорняков на экспериментальной территории

Weeds	Density	Weeds	Density
Ceratocarpus arenarius L.	0.003	*Phragmites australis* (Cav.) Trin. Ex St.	0.36
Cirsium arvense (L.) Scop.	0.12	*Plantago lanceolata* L.	0.68
Convolvulus arvensis L.	1.03	*Plantago major* L.	0.66
Cynodon dactylon (L.) Pers.	3.24	*Rumex crispus* L.	0.37
Lactuca serriola L.	0.81	*Taraxacum officinale* F.H. Wigg.	0.5
Malva sylvestris L.	0.12	*Trifolium pratense* L.	1.23
Melilotus albus Medik.	1.07	*Trifolium repens* L.	5.49

Schreb. (0.06 weeds/m^2), and *T. fragiferum* L. (0.09 weeds/m^2) had the highest density. In another study, *Anagallis arvensis* L., *Chenopodium album* L., *Convolvulus arvensis*, *Matricaria chamomilla* L., *Plantago lanceolata*, *Polygonum* spp. and *Trifolium repens*, *Erigeron canadensis* L., *Medicago sativa* L. and *Plantago major* L. weeds were identified (Altınışık, Kadıoğlu, 2003). There were similarities between these studies and the weed species and densities that we detected in the present study. The reason for some differences is that different weeds were encountered in grass areas at different times due to their development in different periods (Sözeri et al., 1998).

In the effects of the applied herbicides on the dry weight of weeds in the turfgrass fields according to the results of Tukey test there was a statistically 1% difference between $F = 210.91$ and $P = 0.00 < 0.01$ (Table 4).

mined that the percentage effects of herbicide applications in terms of weed dry weights varied between 94.5% and 23.57%. Compared to the control plots, the highest percentage effects was detected in the plots with 2,4-D tri-isopropyl amine salt + Picloram (94.50%), 2,4-D amine + Fluazifop-p-butyl (92.09%), and 2,4-D amine (87.02%). In the study, the lowest percentage effect in terms of weed dry weight was obtained in the Bromoxynil + MCPA (23.57%) plots compared to the control plots (see Table 4). As a result of his study, N. G. Şanlıtürk (2009) stated that the dry weight of weeds in the parcels in the experiment area varied between 0.6 g/m^2 and 17.5 g/m^2, and the percentage effects varied between 96.69% and 15.9%. The percentage effects of the herbicides we used in the study on the weeds detected in the trial area were determined (Table 5). The percentage effects varied depending on the weed species and herbicides or their mixtures used.

Table 4. Effects of herbicides on weed dry weights

Таблица 4. Влияние гербицидов на сухую массу сорняков

Applications	Weed dry matter (gr)	Effect (%)
Control	38.6a	0.00
2,4-D amine	5.01d	87.02
2,4-D EHE + Florasulam	6.19d	83.96
2,4-D amine + Fluazifop-p-butyl	3.05d	92.09
2,4-D tri-isopropyl amine tuzu + Picloram	2.12d	94.50
Bromoxynil + MCPA + dicamba + triasulfuron	16.8c	56.47
Dicamba + triasulfuron	19.2c	50.25
Bromoxynil + MCPA	29.5b	23.57
Halosulfuron-methyl	24.7b	36.01
F	210.91	
P	0.00	
R^2: 0,984		

In the study, the lowest weed dry weights were registered on the plots with 2,4-D tri-isopropyl amine salt + Picloram (2.12 g), 2,4-D amine + Fluazifop-p-butyl (3.05 g) and 2,4-D amine (5.01 g). The highest weed dry weights were obtained on the Bromoxynil + MCPA (29.5 g) plots (see Table 4), contrary to the study of L. Khan et al. (2016), who used five methods to control weeds in lawn areas, including mowing and hand weeding, herbicides with 2 active ingredients (fluroxypyr + MCPA and bromoxynil + MCPA), and weed control treatment. According to the measurements made before and after the herbicide application in the study, the lowest weed density per square meter was obtained on the bromoxynil + MCPA (12.99 units/m^2) and fluroxypyr + MCPA (28.95 units/m^2) plots. As a result, they stated that herbicides gave the highest effect on weeds in lawn areas. We believe that this was likely caused by the effectiveness of other different herbicides used in the study. In the present study, it was deter-

The 2,4-D amine herbicide affected 9 species out of 14 weed species detected in the trial area. Among these weeds, the highest effect was seen in *Lactuca serriola* L. and *Malva sylvestris* weeds with the 100% effect rate. The 2,4-D EHE + Florasulam herbicide affected 9 weed species detected in the trial area and did not affect 5 weed species. The highest effect was observed against *Cirsium arvense* (L.) Scop. (100%). The 2,4-D amine + Fluazifop-p-butyl herbicide affected 13 weed species detected in the trial area. *Melilotus albus*, *Malva sylvestris* and *Cynodon dactylon* had the highest effect on weeds with the 100% effect rate. The 2,4-D tri-isopropyl amine salt + Picloram herbicide affected 13 species out of 14 weed species detected in the trial area. Among these weed species, *Cynodon dactylon*, *Trifolium repens*, *T. pratense*, *Convolvulus arvensis*, *Rumex crispus* L., *Plantago lanceolata*, *P. ma-*

Table 5. The percentage effects of the applied herbicides on weed species

Таблица 5. Процентное воздействие применяемых гербицидов на виды сорняков

Weeds	2,4-D amine	2,4-D EHE +Florasulam	2,4-D amine + Fluazifop-p-butyl	2,4-D tri-isopropyl amine tuzu + Picloram	Bromoxynil + MCPA + dicamba + triasulfuron	Dicamba + triasulfuron	Bromoxynil + MCPA	Halosulfuron-methyl
Trifolium repens	82	71	78	100	35	0	10	0
Cynodon dactylon	0	0	100	100	0	0	0	25
Trifolium pratense	76	62	72	100	38	0	10	0
Convolvulus arvensis	68	72	57	100	15	10	5	0
Melilotus albus.	98	68	100	48	14	0	0	0
Rumex crispus	67	58	45	100	38	15	10	0
Lactuca serriola	100	76	96	64	54	35	10	0
Plantago lanceolata	0	0	42	100	0	0	0	15
Plantago major	0	0	28	100	0	0	0	20
Taraxacum officinale	58	47	52	98	12	8	10	0
Phragmites australis	0	0	24	100	0	0	0	0
Cirsium arvense	56	100	54	96	100	100	5	0
Malva sylvestris	100	64	100	72	10	5	0	0
Ceratocarpus arenarius	0	0	0	0	0	0	0	0

jor and *Phragmites australis* (Cav.) Trin. ex St. showed the highest effect with the 100% effect rate. Bromoxynil + MCPA + dicamba + triasulfuron affected 9 of the weed species detected in the trial area. *Cirsium arvense* (100%) showed the highest effect among weed species. The Dicamba + triasulfuron herbicide affected 7 weed species detected in the trial area. The highest effect was recorded for *C. arvense* (100%). It was observed that the Bromoxynil + MCPA herbicide had a low effect against 7 weed species detected in the trial area. It was determined that the highest effect was against *Trifolium repens*, *T. pratense*, *Rumex crispus*, *Lactuca serriola* and *Taraxacum officinale* weeds with the 10% effect rate. It was observed that the Halosulfuron-methyl herbicide affected 3 weed species detected in the trial area. It was observed that this herbicide affected weeds of *Cynodon dactylon* (25%), *Plantago major* (20%) and *P. lanceolata* (15%) (see Table 5). N. Altınışık and İ. Kadıoğlu (2003) stated in their study that the percentage (%) effects of herbicides on weed species ranged from 85% to 100%. These values vary according to the weed species and the herbicides used. Similar results were obtained by K. Hockemeyer et al. (2019), who stated that the herbicides with different active ingredients used in their study generally controlled the weeds in the lawn areas, and the highest weed control was observed in the plots where the herbicide with the 2,4-D + dicamba + MCPA active substance was applied.

In the study, 5 weed species with densities of 1 weed/m^2 and above were identified. These weed species were: *Trifolium repens* (5.49 weed/m^2), *Cynodon dactylon* (3.24 weed/m^2), *Trifolium pratense* (1.23 weed/m^2), *Melilotus albus* (1.07 weed/m^2) and *Convolvulus arvensis* (1.03 weed/m^2) (see Table 3). In order to determine the effects of the herbicides applied in the study on these weed species, the percentage effects obtained in the three assessments were evaluated (Figure).

The percentage effects of the herbicides and weed densities varied according to the weed species of 1 weed/m^2 and above and the herbicides used. It was observed that 6 herbicides applied in the study affected *Trifolium repens* and the highest effect was shown by 2,4-D tri-isopropyl amine salt + Picloram (100%) in the last count. N. Altınışık and İ. Kadıoğlu (2003) stated that the effects of the herbicides they used on *T. repens* varied between 90% and 98%. As a result of the study of the 3 herbicides used on *Cynodon dactylon*, it was observed that the highest effect was recorded for the 2,4-D amine + fluazifop-p-butyl and 2,4-D tri-isopropyl amine salt + Picloram herbicides with the 100% effectiveness. Six

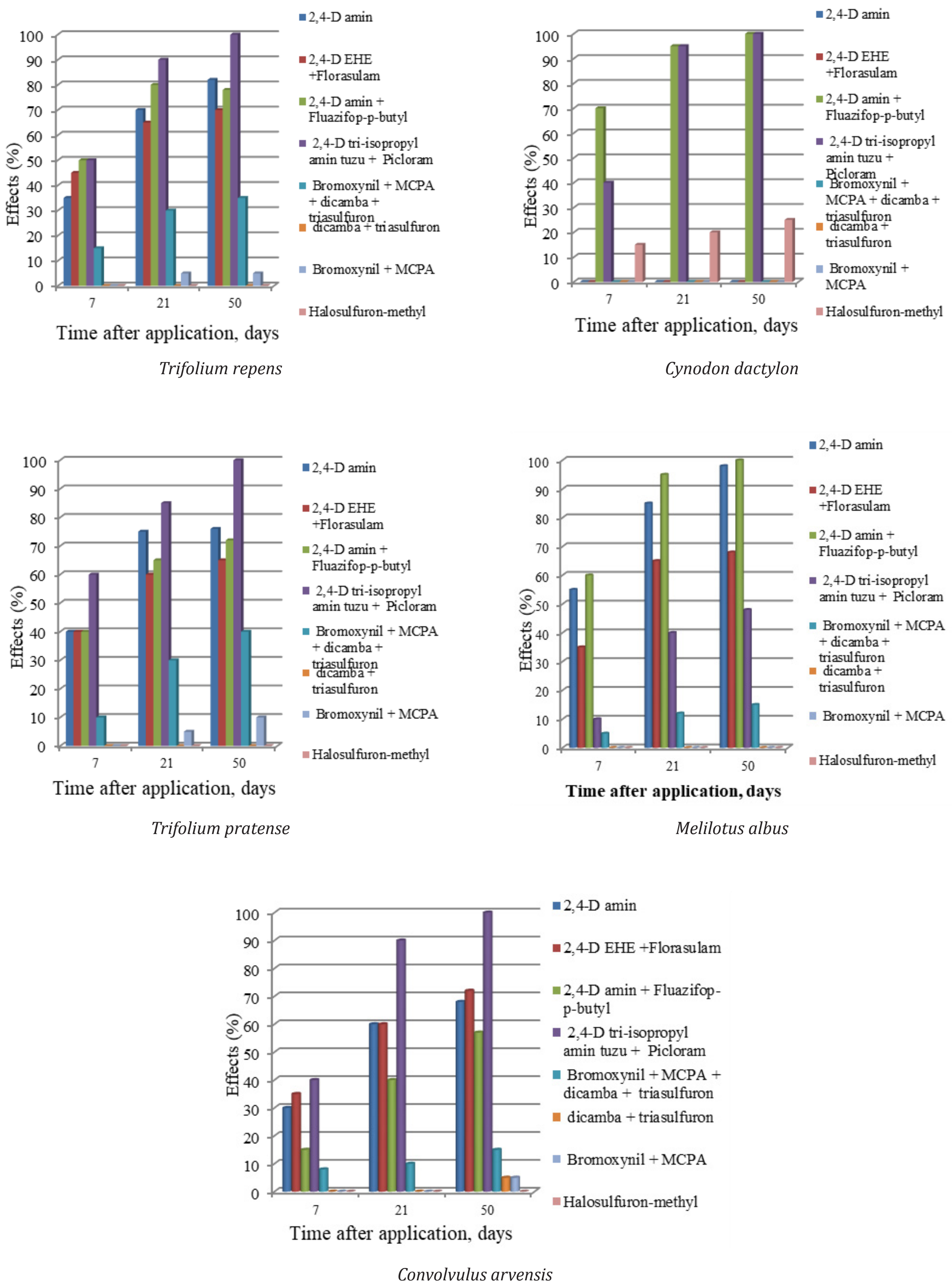

Figure. **Percentage effects of herbicides applied in three assessments at different times on 5 weed species (*Trifolium repens* L., *Cynodon dactylon* (L.) Pers., *Trifolium pratense* L., *Melilotus albus* Medik., and *Convolvulus arvensis* L.) whose densities were determined as 1 plant/m² and above**

Рисунок. **Процентное воздействие гербицидов, примененных в трех подсчетах в разное время на 5 видов сорняков (*Trifolium repens* L., *Cynodon dactylon* (L.) Pers., *Trifolium pratense* L., *Melilotus albus* Medik., *Convolvulus arvensis* L.), чья плотность определялась как 1 растение/м² и выше**

herbicides were effective against *Trifolium pratense*, and the highest effect was obtained in the 2,4-D tri-isopropyl amine salt + Picloram (100%) plots. When the percentage effects of the applied herbicides on *Melilotus albus* were evaluated, the highest effect was observed in the 2,4-D amine + Fluazifop-p-butyl (100%) plots. Seven of the herbicides used in the study were effective on *Convolvulus arvensis*. As a result of the study, it was observed that the highest effect was observed in the 2,4-D tri-isopropyl amine salt + Picloram plots with the 100% effect rate. According to the results of the current study, it can be concluded that most of the tested herbicides affected most of the troublesome weeds that were present in the experiment fields. Similar results were shown by J. J. Henderson (2021) who stated in his study that the highest weed control was obtained in the plots where herbicides were applied.

Conclusion

As a result of our study, a total of 14 weed species belonging to 8 families were identified in the experiment area. These weed species were in the first 5 order in terms of their densities: *Trifolium repens* (5.49 weed/m^2), *Cynodon dactylon* (3.24 weed/m^2), *Trifolium pratense* (1.23 weed/m^2), *Melilotus albus* (1.07 weed/m^2) and *Convolvulus arvensis* (1.03 weed/m^2). The lowest weed dry weight (2.12 g) and high percentage effect (94.50%) were observed in the 2,4-D tri-isopropyl amine salt + Picloram plots. The 2,4-D amine + Fluazifop-p-butyl and 2,4-D tri-isopropyl amine salt + Picloram herbicides used in the study affected 13 weed species detected in the trial area. The 2,4-D amine, 2,4-D EHE + Florasulam and Bromoxynil + MCPA + dicamba + triasulfuron herbicides were effective against 9 weed species, Dicamba + triasulfuron and Bromoxynil + MCPA herbicides against 7 weed species, and Halosulfuron-methyl herbicide against 3 weed species. In addition, it was observed that the herbicides used in the study did not affect the *Ceratocarpus arenarius* L. weed species.

Considering the percentage effects of herbicides on these species according to the counts of the first 5 weed species with the highest density in the study, the percentage effects of the applied herbicides on *Trifolium repens* in the last count with the 100% effect rate were observed in the plots where 2,4-D tri-isopropyl amine salt + Picloram had been applied. It was shown that the 2,4-D amine + Fluazifop-p-butyl and 2,4-D tri-isopropyl amine salt + Picloram herbicides affected *Cynodon dactylon* with the 100% effect rate. When the percentage effects of the applied herbicides on *T. pratense* were evaluated, in the last count it was determined that the highest effect rate was demonstrated by the 2,4-D tri-isopropyl amine salt + Picloram (100%) herbicide. It was also determined that the highest percentage effect against *Melilotus albus* was shown by 2,4-D amine + Fluazifop-p-butyl (100%). When the percentage effects of the applied herbicides on *Convolvulus arvensis* were evaluated, in the last assessment it was observed that the 2,4-D tri-isopropyl amine salt + Picloram herbicide had the highest percentage effect on *C. arvensis*. Considering the results of the study, it was concluded that 2,4 D and its mixtures can be used effectively and economically for the control of most broad-leaved weeds found in turfgrass. Ultimately, it can be stated that herbicides can be the most significant solution for suppressing weed populations in highly infested turfgrass areas, if there are no other alternative control options effective against weeds in turfgrass. Further research is needed to assess herbicide effects on other weed species and in turfgrass fields established with different species.

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