ARPP

Journal of Applied Research in Plant Protection

University of Tabriz Press
https://arpp.tabrizu.ac.ir/

Research Article

Efficacy of Terbuthylazine and Isoxaflutel + Thiencarbazone in comparison with common herbicides on weed control in corn, *Zea mays*

Noushin Nezamabadi✉[1], Rasoul Fakhari[2], Peyman Sabeti[3], Sajjad Moharramnejad[4], Ghorban Didehbaz Moghanlo[2]

Open Access

[1] Iranian Research Institute of Plant Protection (IRIPP), Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran
[2] Plant Protection Research Department, Ardabil Agricultural and Natural Resources Research and Education Center, (AREEO), Moghan, Iran
[3] Plant Protection Research Department, Kermanshah Agricultural and Natural Resources Research and Education Center, (AREEO), Kermanshah, Iran
[4] Crop and Horticultural Science Research Department, Ardabil Agricultural and Natural Resources Research and Education Center, (AREEO), Moghan

Corresponding author
✉nezamabadi_n@yahoo.com

Keyword

Broadleaves, Density, Dry weight, Terbuthylazine herbicide

Received: 19 November 2023
Revised: 8 July 2024
Accepted: 22 July 2024

Available online: 14 October 2024

Abstact

Experiments were performed from 2021 to 2022 in Ardabil, Alborz, and Kermanshah province, Iran, to evaluate the efficiency of Terbuthylazine and Isoxaflutel + Thiencarbazone on controlling weeds in corn feilds. Examined herbicides included Terbuthylazine (A-Maize-ing 50% SC), Isoxaflutel + Thiencarbazone (Adango SC 46.5%), Mesotrione + S-metolachlor (Lumax 53.75% SE), 2. 4, D + MCPA (67.5% SL), Bromoxynil + MCPA (Bromicide MA 40% EC), Bromoxynil + MCPA (Bromicide MA 40% EC) + Nicosulfuron (Cruze 4% SC). The results showed that application of A-Maize-ing, Adengo, Lumax, 2. 4, D + MCPA, Bromicide MA, and Bromicide MA + Cruze herbicides affected weed density and dry weight (more than 85%), increasing the corn yield in all three provinces. A-Maize-ing and Adengo were as effective as other commonly used herbicides in corn fields of Iran; therefore, the use of these herbicides can be recommended. Redroot pigweed and common lambsquarters weed plants were sensitive to A-Maize-ing and Adengo herbicides.

Cite this article:
Nezamabadi N, Fakhari R, Sabeti P, Moharramnejad S, Didehbaz Moghanlo G, 2025. Efficacy of Terbuthylazine and Isoxaflutel + Thiencarbazone in comparison with common herbicides on weed control in corn, *Zea mays*. *Journal of J Appl Res Plant Prot* 14 (1): 1–11.
https://dx.doi.org/10.22034/arpp.2024.18639

Introduction

Corn ranks the first globally in terms of yield and production and the second most cultivated crop after wheat in terms of acreage (FAO 2021). Among various methods of weed control, the use of herbicides plays a crucial role in weed management due to their effectiveness and cost efficiency (Zand *et al*. 2021). Currently, it is widely accepted that the use of herbicides has been successful (Fetyukhin *et al*. 2022), leading to increased production in major crop plants and increasingly proposing new compounds for chemical control of weeds every year (Moshaver *et al*. 2011). New compounds may include new or previous active ingredients blended together in new formulations with optimal ratios (Saberali *et al*. 2008). Weeds are the main factors reducing corn yield in Iran, and herbicide application is the main method to manage them. In Iran, few herbicides are available for use in corn fields. Commonly used herbicides for weed control in Iran include 2.4,D + MCPA, Eradican, Atrazine, Cyanazine, Acetochlor, Bromoxynil + MCPA, Foramsulfuron, Nicosulfuron, Rimsulfuron. Some of these herbicides have been used in Iranian corn fields for years, raising a high risk of weed resistance to some of them (such as atrazine) in addition to the environmental risks (Teymoori *et al*. 2012). Herbicides such as Atrazine (Gesaprim) and EPTC + safener (Eradicane) are old (registered since 1968), and the recommended dose of Eradicane used is very high (6-4 liters of commercial product per hectare) (Rezvani *et al*. 2011). Although herbicides like Nicosulfuron (Cruze) and Nicosulfuron + Rimsulfuron (U46 Combifluid) and other ALS-inhibiting herbicides registered for corn do not have a long history of use, they have a high resistance risk, particularly after consecutive five-year use (Zand *et al*. 2019). Therefore, the limited mechanism of action of the recommended herbicides for corn fields and the risks associated with consecutive use of herbicides with similar mechanisms of action are among the main reasons for the introduction and registration of herbicides with a wide control spectrum, especially with diverse target sites, to manage weed in Iranian corn fields.

Overall, due to the low number and diversity of registered herbicides for weed control in Iranian corn fields, this research aims to evaluate the effects of new and commonly used herbicides on annual broadleaf weeds in corn fields.

Materials and Methods

Three separate field trials were conducted in the Research Centers of Ardabil, Alborz, and Kermanshah provinces, Iran. All locations were uniformly infested with high densities of redroot pigweed (*Amaranthus retroflexus* L.) and common lambsquarters (*Chenopodium album* L.). The details of the experimental regions are provided in Table 1.

Table 1. Agricultural information related to the regions in the year of the experiment.

Area	Geographical coordinates of the regions	Average rainfall (mm)	Average temperature (C°)	Soil texture
Ardabil	39.42° N, 47.59° E	298	15	Caly loam
Alborz	35.45° N, 50.57° E	247	14.4	Loam
Kermanshah	34.8° N, 46.26° E	397	12.5	Caly loam

The experimental procedures for all locations were the same, and corn (SKC 704 cultivar) seeds were sowed in the middle of the first half of June. The plot size for each treatment was 3 m wide by 8 m long, arranged in a randomized complete block design with four replications. Each test plot was divided into two parts in length. The upper part of each plot was not sprayed and was regarded as a control separately, while the lower part of the plot underwent treatment with herbicides (Table 2).

Spraying was performed based on the treatments provided in the lower half of each plot and recommended in the growth stage, using a backpack sprayer equipped with a flat fan nozzle at a pressure of 2-2.5 bars, calibrated based on a water amount of 300 liters per hectare. A 50 by 75 cm quadrat (i.e., half a meter in length, one row) was randomly placed in sprayed and unsprayed sections of each plot thirty days after spraying, followed by counting all weeds in each plot's quadrats by species. Then, they were placed in an oven at 72 C for 48 hours to determine the dry weight. Also, visual weed control was recorded at 15 and 30 DAT on a scale of 0% to 100%, with 0% representing no control compared to nontreated plots and 100% indicating plant death (Table 3) (Thomas *et al*. 2014).

Table 2. Characteristics of treatments.

Treatments	Trade name	Common name	Dosage
1	A-Maize-ing	Terbuthylazine (500 g. L^{-1})	1 L. ha^{-1}
2	A-Maize-ing	Terbuthylazine	1.2 L. ha^{-1}
3	A-Maize-ing	Terbuthylazine	1.5 L. ha^{-1}
4	A-Maize-ing	Terbuthylazine	1.8 L. ha^{-1}
5	A-Maize-ing	Terbuthylazine(500 g. L^{-1})	2 L. ha^{-1}
6	Adango	Isoxaflutole (225 g. L^{-1}) + Thiencarbazone (90 g. L^{-1})+ Ciprosulfamide safener (150 g. L^{-1})	0.55 L. ha^{-1}
7	Lumax	Mesotrione (125.5 g. L^{-1}) + S-metolachlor (375 g. L^{-1}) + terbuthylazine (37 g. L^{-1})	4.5 L. ha^{-1}
8	U46 Combi Fluid	2. 4, D (360 g. L^{-1}) + MCPA (315 g. L^{-1})	1.5 L. ha^{-1}
9	Bromicide MA	Bromoxynil (200 g. L^{-1}) + MCPA (200 g. L^{-1})	1.5 L. ha^{-1}
10	Bromicide MA + Cruze	Bromoxynil (200 g. L^{-1}) + MCPA (200 g. L^{-1}) + Nicosulfuron (40 g. L^{-1})	1.5 + 0.5 L. ha^{-1}
11	hand weeding	-	-

Table 3. Criteria for weeds response assessment to applied herbicides.

Weed's reaction		Score
Description	**Weed control (%)**	
Complete weed control	100	1
Excellent controlled	96.5- 99	2
Good controlled	93.5- 96	3
Fairly controlled	87.5- 93	4
Rather desirable controlled	80.5- 87	5
Undesirable controlled	70.5- 80	6
Weakly controlled	50.5- 70	7
Poorly controlled	1- 50	8
Quite ineffective	0	9

The percentage reduction in weed density in each plot compared to the control plot (unsprayed section) was calculated based on Equation 1.
Equation 1:

$$\% \, Density = 100(\frac{Nospray - spray}{Nospray})$$

In the Density equation, No Spray and Spray represent the number of weeds counted in the quadrats in the unsprayed and sprayed sections, respectively, indicating the percentage reduction in weed density. Equation 1 is used to calculate the percentage reduction in dry matter of weeds (with the difference that no Spray and Spray represent the dry weight of weeds in the unsprayed and sprayed quadrats, respectively).

For the corn harvest, the yield of each section of the plot (at least from an equivalent area of 2 m^2) was separately harvested (sprayed and unsprayed sections), and the yield amount for each plot was calculated. Furthermore, the decrease in yield was calculated using Equation 2.
Equation 2:

$$\% \text{ Yield} = 100\ (\frac{Yield\ spray}{Yield\ no\ spray})$$

In this equation, yield spray and yield no spray represent the yield of harvested grains associated with the partially sprayed and unsprayed halves of each plot, respectively. The data obtained from the experiment were analyzed using SAS 9.4 software. Arcsine transformations were used on percent weed control data when needed to mitigate the skewness of the data and meet the requirements of normality for analysis. The means were compared using the Duncan's multiple range test at a significance level of 5%, performed using the same software.

Results and Discussion

Ardabil province

Redroot pigweed density: based on the results obtained from the density of redroot pigweed in this experiment, controlling this weed with treatments of 1.2, 1.5, 1.8, and 2 liters of A-Maize-ing, Adengo, Lomax, U46 Combo Fluid, Bromicide MA, and Bromicide MA+Cruze was satisfactory, with over 90% effectiveness (Table 4). On the other hand, using one liter of commercialized A-Maize-ing showed poor efficiency in controlling this weed (Table 4).

Common lambsquarters density: weed density reduction percentage showed a significant difference between herbicide treatments, as indicated by the ANOVA results (data not shown). The results revealed that the herbicide treatments of 1.2, 1.5, 1.8, and 2 liters of A-Maize-ing, Adengo, Lumax, U46 combi fluid, Bromicide MA, and Bromicide MA + Cruze significantly reduced weed density of common lambsquarters by over 90% (Table 4). Observing the percentage reduction in weed density, it can be seen that the one liter of A-Maize-ing commercial product had poor effectiveness in controlling this weed, resulting in a 72% reduction in weed density (Table 4).

Redroot pigweed dry weight: the ANOVA results for the percentage reduction in dry weight of redroot pigweed showed that the applied treatments had a significant effect on this characteristic (data not shown). The results from the Ardabil region highlighted that among the applied treatments, the best efficacy in controlling the dry weight of redroot pigweed was achieved by the treatments of 1.2, 1.5, 1.8, and 2 liters of A-Maize-ing, Adengo, Lumax, U46 combi fluid, Bromicide MA, and Bromicide MA + Cruze, respectively (over 95% control). However, the treatment of one liter of A-Maize-ing commercial product could not effectively reduce the dry weight of the mentioned weed. In other words, this herbicide dose caused a reduction in the growth of redroot pigweed but did not sufficiently reduce its dry weight (67% efficacy), resulting in the possibility of its re-growth in the field (Table 4).

Common lambsquarters dry weight

The ANOVA results showed a significant difference between the herbicide treatments in terms of the percentage reduction in dry weight of common lambsquarters (data not shown). The results obtained for the percentage reduction in dry weight of common lambsquarters indicated that the treatments of 2.1, 1.5, 1.8, and 2 liters of A-Maize-ing, Adengo, Lumax, U46 combi fluid, Bromicide MA, and Bromicide MA + Cruze could reduce the dry weight of common lambsquarters by over 90% (Table 4). On the other hand, one liter of A-Maize-ing commercial product had a significantly lower efficiency in controlling this weed (Table 4).

Kermanshah province

Redroot pigweed density

The analysis of variance of the data obtained from the application of different herbicides on the percentage reduction in redroot pigweed density in the Kermanshah region after 30 days of spraying showed a significant difference between the treatments (data not shown). Regarding the reduction in redroot pigweed weed density, it can be observed that the use of 1.5, 1.8, and 2 liters of A-Maize-ing and Bromicide MA resulted in more than 90% reduction, while lumax resulted in more than 85% reduction in the density of this weed (Table 4). The lowest efficacy was observed for the treatment using one liter of commercial A-Maize-ing herbicide (Table 4).

Common lambsquarters density

The ANOVA results showed a significant difference in common lambsquarters density among the different herbicide treatments (data not shown). The results indicated that the treatments using 1.5, 1.8, and 2 liters of A-Maize-ing and Bromicide MA resulted in a more than 90% reduction in common lambsquarters density. The treatment using lumax also resulted in more than 85% reduction in the density of this weed (Table 5). The lowest efficacy was observed for the treatment using one liter of commercial A-Maize-ing herbicide (Table 5). Overall, the treatments with 1.8 and 2 liters of A-Maize-ing, Bromicide MA, and Lumax had the highest control efficacy in reducing the density of this weed, while the treatments with 1, 1.2, and 1.5 liters of commercial A-Maize-ing had poor efficacy (less than 70%) in controlling this weed (Table 5).

Table 4. Mean comparison of chemical control on the percent reduction in density and dry weight of weeds (compared to the control of no spraying), 30 days after spraying in experimental areas.

Treatments	Areas							
	Density reduction percentage				Dry weight reduction percentage			
	Ardabil		Kermanshah		Ardabil		Kermanshah	
	Redroot pigweed	Common lambsquarters	Redroot pigweed	Common lambsquarters	Redroot pigweed	Common lambsquarters	Redroot pigweed	Common lambsquarters
A-Maize-ing 1 L	67.95[b]	72.38[b]	51.25[c]	28.75[e]	66.74[b]	70.07[b]	53.1[b]	52.75[c]
A-Maize-ing 1.2 L	93.88[a]	92.26[a]	80.0[b]	41.25[d]	95.33[a]	92.95[a]	80.4[a]	68.75[b]
A-Maize-ing 1.5 L	94.79[a]	94.09[a]	90. 0[ab]	63.75[c]	95.61[a]	95.44[a]	80.1[a]	83.25[a]
A-Maize-ing 1.8 L	100[a]	100[a]	93.75[a]	71.25[bc]	100[a]	100[a]	88.4[a]	87.25[a]
A-Maize-ing 2 L	100[a]	100[a]	93.75[a]	77.50[b]	100[a]	100[a]	86.0[a]	90.25[a]
Adango 0.55 L	91.42[a]	92.85[a]	80.0[b]	92.50[a]	92.22[a]	92.81[a]	80.3[a]	83.0[a]
Lumax 4.5 L	100[a]	100[a]	85.0[ab]	95.0[a]	100[a]	100[a]	79.2[a]	89.75[a]
U46 Combi Fluid	100[a]	100[a]	80.0[b]	61.25[c]	100[a]	100[a]	81.7[a]	83.75[a]
Bromicide1.5 L	100[a]	100[a]	90.0[ab]	90.0[a]	100[a]	100[a]	88.9[a]	90.0[a]
Bromicide 1.5 L+ Cruze 0.5 L	100[a]	100[a]	81.25[b]	66.25[c]	100[a]	100[a]	82.5[a]	83.75[a]

The means with similar letter did not show significant differences (Duncan P≤0.05).

Redroot pigweed dry weight

The analysis of variance showed a significant difference in the percentage reduction of dry weight of redroot pigweed among the different herbicide treatments in the Kermanshah region (data not shown). Based on the results obtained from the dry weight of redroot pigweed in this experiment, the treatments with 1.2, 1.5, 1.8, and 2 liters of A-Maize-ing, Adengo, Lumax, U46 combo fluid, Bromicide MA, and Bromicide MA + Cruze reduced more than 80% of the dry weight of this weed and did not have a statistically significant difference (Table 5). On the other hand, the treatment with one liter of commercial A-Maize-ing had poor efficacy in controlling this weed (Table 5).

Common lambsquarters dry weight

The analysis of variance showed a significant difference in the percentage reduction of dry weight of common lambsquarters among the different herbicide treatments in the Kermanshah region (data not shown). Based on the results obtained from the dry weight of common lambsquarters in this experiment, treatments with 1.2, 1.5, 1.8, and 2 liters of A-Maize-ing, Adengo, Lumax, U46 combo fluid, Bromicide MA, and Bromicide MA + Cruze reduced more than 80% of the dry weight of this weed and did not have a statistically significant difference (Table 5). On the other hand, the treatment with one liter of commercial A-Maize-ing had poor efficacy in controlling this weed (Table 5).

Alborz province

The analysis of variance revealed a significant difference in the percentage reduction of total weed density and dry weight among the different herbicide treatments (data not shown). Comparing the average data obtained from the different treatments indicated that in Alborz Province, the worst efficacy was associated with the application of 1, 1.2, and 1.5 liters of the new herbicide, A-Maize-ing, reducing the total weed density by approximately 53% and the dry weight by 52%. Other applied treatments did not show a significant difference in reducing the density and dry weight of these weeds (Table 5).

Table 5. Mean comparison of chemical control on the percent reduction in density and dry weight of weeds (compared to the control of no spraying), 30 days after spraying in in experimental areas.

Treatments	Areas					
	Density reduction percentage			Dry weight reduction percentage		
	Ardabil	Kermanshah	Alborz	Ardabil	Kermanshah	Alborz
A-Maize-ing 1 L	63.60^{e}	76.25^{e}	46.4^{c}	62.88^{e}	76.4^{e}	53.1^{b}
A-Maize-ing 1.2 L	87.15^{d}	85.0^{cde}	52.4^{c}	88.72^{d}	76.6^{c}	47.0^{b}
A-Maize-ing 1.5 L	89.77^{cd}	95.0^{ab}	62.2^{bc}	90.39^{cd}	88.4^{abc}	57.6^{b}
A-Maize-ing 1.8 L	96.95^{ab}	96.25^{a}	87.5^{a}	96.72^{ab}	90.8^{ab}	90.9^{a}
A-Maize-ing 2 L	99.21^{a}	98.75^{a}	91.8^{a}	99.23^{a}	95.8^{a}	92.1^{a}
Adango 0.55 L	92.09^{bcd}	77.25^{de}	89.8^{a}	92.93^{bc}	79.2^{bc}	91.6^{a}
Lumax 4.5 L	94.29^{abc}	90.09^{abc}	88.8^{a}	94.95^{ab}	80.1^{bc}	97.5^{a}
U46 Combi Fluid 1.5 L	98.03^{ab}	82.58^{cde}	77.3^{ab}	98.47a	85.8^{abc}	82.8^{a}
Bromicide MA 1.5 L	98.99^{a}	86.25^{bcd}	89.3^{a}	98.14^{a}	83.3^{abc}	89.1^{a}
Bromicide MA 1.5 L+ Cruze 0.5 L	98.99^{a}	85.08^{cde}	90.3^{a}	99.10^{a}	83.9^{abc}	92.5^{a}

The means with similar letter did not show significant differences (Duncan $P \leq 0.05$).

Based on the descriptive and inferential evaluation of herbicide efficacy in the tested regions, the use of A-Maize-ing herbicide applied at 1 to 1.5 L.ha^{-1} as a pre-emergence application after corn planting showed lower efficacy in weed control, so its application is not recommended. A-Maize-ing herbicide is an electron transfer inhibitor in the target site receptor of photosystem II and belongs to the triazine chemical family, mainly absorbed through the roots. This herbicide controls several broadleaf weeds in corn fields, such as redroot pigweed (*A. hybridus* L.), common purslane (*Portulaca oleracea* L.), and hairy nightshade (*Solanum sarrachoides* Sendtn.) (Anonymous 2021). The tolerance of maize to this chemical family is due to its binding with glutathione. A-Maize-ing herbicides can be mixed with glyphosate and simazine herbicides and have also been registered for weed control in citrus, grape, apple orchards, fallow lands, and industrial areas in different quantities worldwide (Anonymous 2021). The waiting period between spraying operations with this herbicide and safe entry into the field without protective equipment is 8 days. Heavy rainfall after herbicide application, which leads to water accumulation in the field, can cause damage to corn, so it is recommended to its application one to two days before heavy rainfall. Besides, sensitive vegetables and soybeans should not be planted in the field for up to three months after using this herbicide (Anonymous 2021). Based on the evaluation criteria (weed density, biomass, and visual assessment of phytotoxicity) and the need to reduce herbicide consumption to minimize undesirable environmental effects, the use of Adengo herbicide at a rate of 0.55 liters per hectare is recommended for weed control in corn fields. It is evident that the use of this herbicide is preferred compared to other herbicides at higher recommended rates, particularly Lumax at a rate of 4.5 liters per hectare. In general, the herbicide U46 combi fluid (a combination of 360 grams per liter of 2,4. D + 315 g per liter of MCPA herbicide) has been previously registered as effective for controlling broadleaf weeds in corn fields and can provide a wider spectrum of control when used in combination. Additionally, the mixture of two herbicides, Nicosulfuron and Bromoxynil + MCPA, had a desirable effect on weed control. It has also been reported that the mixture of Bromoxynil + MCPA and Nicosulfuron in corn fields increases the herbicidal spectrum and effectively controls dominant weeds in the field. One solution to broaden the spectrum of Nicosulfuron herbicide in controlling broadleaf weeds is to mix it with other broadleaf herbicides (Dobbels and Kapusta 1993; Baghestani *et al*. 2007b). Bromicide MA herbicide is a combination of Bromoxynil and MCPA herbicides, acting differently from nicosulfuron and successfully controling a wide range of broadleaf weeds. The mixture of these two herbicides not only enhances the herbicidal spectrum but may also reduce the required dosage for achieving the desired control level compared to the recommended doses of each herbicide alone (Dobbels & Kapusta 1993; Mamnoei *et al*., 2023; Sheibany *et al*. 2009). In conclusion, it is recommended to use herbicide combinations, such as A-Maize-ing, for weed control after corn cultivation and before corn emergence. Other treatments such as Adengo herbicide can be used with more confidence after the first and before the second irrigation if the emerged weeds in the field match the list of weeds examined in this experiment.

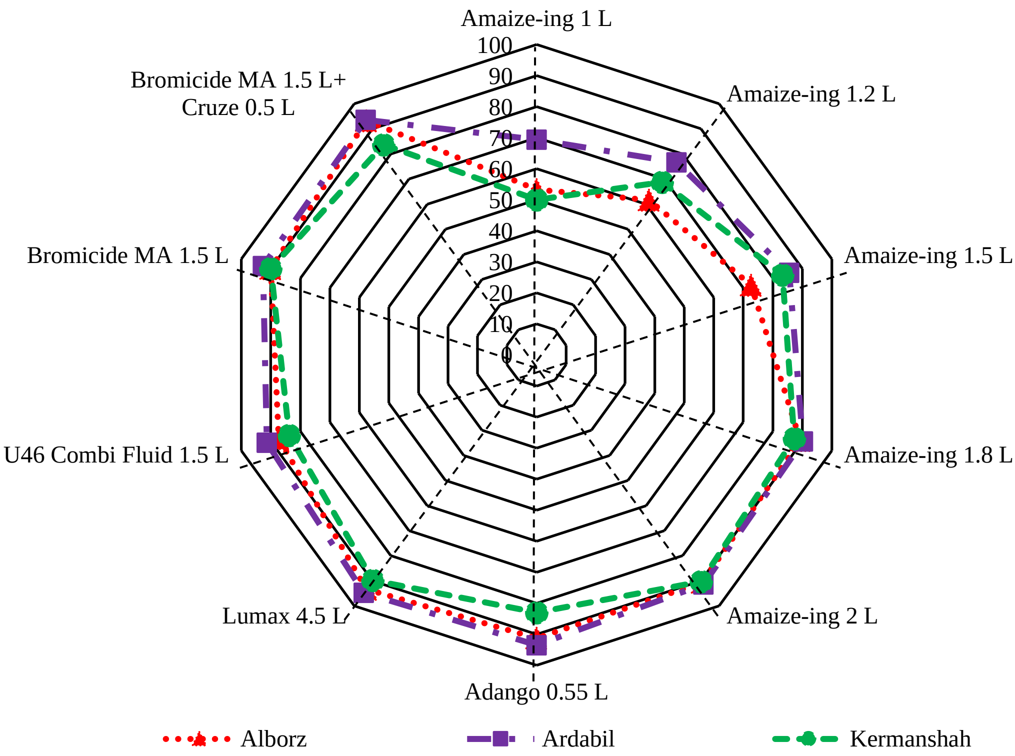

Figure 1. Visual scoring of herbicide damage on weeds in different test areas (percentage of control infected with weeds).

Effect of treatments on corn yield

Ardabil province

The ANOVA results showed a significant difference between treatments in terms of corn grain yield at a 1% level (data not shown). The results of the comparison of mean values revealed that treatments with 1.8 and 2 liters of A-Maize-ing per hectare had the highest grain yield with a 33% increase compared to the control. These results confirm the findings of the percentage reduction in weed density and dry weight, as these treatments had the highest reduction compared to other treatments (Table 6). Among the herbicide treatments, the highest corn grain yield was associated with treatments of 1.8 and 2 liters of A-Maize-ing, Bromicide MA + Cruze, and Bromicide MA, which did not show a statistically significant difference compared to the control (Table 6). The use of these herbicides resulted in a 20-30% increase in corn yield for variety 704 (Table 6).

Kermanshah province

The ANOVA results regarding the effect of herbicides on corn grain yield indicate a significant difference between treatments at a 1% level (data not shown). The results of mean comparisons showed that regardless of the weed free treatment, the highest maize grain yield was associated with treatments of 1.8 and 2.1 liters of A-Maize-ing, Adengo, Lumax, U46 Combo, Bromicide MA, and Bromicide MA + Cruze (Table 6). The application of the mentioned top treatments led to a 22-29% increase in maize grain yield (Table 6). Furthermore, the use of A-Maize-ing herbicide at rates of 1.8 and 2 liters per hectare resulted in a 26% increase in the yield of maize variety 703 (Table 6).

Alborz province

The analysis of variance conducted on the impact of herbicides on maize grain yield showed a significant difference between treatments at a 1% significance level (data not shown). The mean comparison results revealed that the hand weeding treatment had the highest maize grain yield, with approximately 9 tons per hectare, and did not have a statistically significant difference from all treatments except for the use of 1 and 2.1 liters per hectare of the A-Maize-ing herbicide (Table 6). The treatments of 1.8 and 2 liters of A-Maize-ing herbicide also had a favorable effect on grain yield and yield efficiency of corn varieties, with no significant differences, which could be attributed to effective weed control in competition with corn plants. In terms of percentage increase in yield, all treatments, except for 1 liter per hectare of A-Maize-ing herbicide, resulted in an increase in maize grain yield compared to the weed-infested control and did not have a statistically significant difference. These treatments led to a 5-24% increase in the yield of maize variety 401 (Table 6).

Table 6. Mean comparison the effect of chemical control of the weeds on yield of corn in experimental areas.

Treatments	Areas					
	Ardabil		Kermanshah		Alborz	
	Seed yield (ton. ha^{-1})	Percentage yield compared to the weedy check	Seed yield (ton/ha)	Percentage yield compared to the weedy check	Seed yield (ton/ha)	Percentage yield compared to the weedy check
A-Maize-ing 1 L	5.94^{e}	87.4^{e}	7.60^{c}	116.0^{e}	6.91^{c}	94.5^{b}
A-Maize-ing 1.2 L	6.91^{d}	110.2^{cd}	7.94^{c}	118.0^{de}	7.37^{bc}	108.4^{ab}
A-Maize-ing 1.5 L	6.93^{d}	113.1^{cd}	8.42^{b}	121.4^{cde}	8.02^{a}	105.4^{ab}
A-Maize-ing 1.8 L	7.60^{ab}	120.8^{a-d}	8.64^{ab}	126.4^{bc}	8.84^{a}	123.3^{a}
A-Maize-ing 2 L	7.77^{ab}	122.4^{abc}	8.57^{ab}	126.6^{bc}	8.97^{a}	123.7^{a}
Adango 0.55 L	7.09^{c}	112.2^{cd}	8.62^{ab}	126.9^{bc}	8.8^{a}	123.1^{a}
Lumax 4.5 L	7.01^{c}	102.3^{de}	8.8^{ab}	129.4^{ab}	8.9^{a}	123.7^{a}
U46 Combi Fluid 1.5 L	7.03^{c}	107.0^{d}	8.45^{ab}	123.9^{bc}	8.42^{ab}	117.7^{ab}
Bromicide MA 1.5 L	7.81^{a}	127.8^{ab}	8.44^{ab}	122.5^{cd}	8.85^{a}	124.0^{a}
Bromicide MA 1.5 L+ Cruze 0.5 L	7.88^{a}	130.8^{a}	8.58^{ab}	125.0^{bc}	8.95^{a}	124.8^{a}
Hand weeding	8.03^{a}	133.4^{a}	8.97^{a}	134.0^{a}	9.04$^{\backslash}$	128.2^{a}

The means with similar letter did not show significant differences (Duncan *P≤0.05*).

As can be observed in Table 6, manual weeding and weeding application resulted in an average increase of approximately 32% in corn grain yield compared to the control (weedy check) in the Ardabil, Kermanshah, and Alborz regions. The comparison of the average data obtained from the percentage changes in yield in the test areas indicates that treatments with 1.8 and 2 liters of A-Maize-ing, with herbicides Adengo, Lomax, U46 Combifluid, Bromicide MA, and Bromicide MA + Cruze had the highest yield. Most treatments were placed in the same statistical group as the control with manual weeding (Table 6). The high yield in these treatments can be attributed to their effective performance in controlling the existing weeds in the experiment. On the other hand, the application of 1, 1.2, and 1.5 liters of A-Maize-ing showed the lowest efficiency in controlling the existing weeds in these regions and resulted in the least increase in corn yield. The lack of significant differences among the test treatments in terms of yield variation could be attributed to the relatively low weed density in the experimental plots, resulting in the inability of the weed to exert sufficient competitive pressure on corn and making the effects of the treatments on yield less apparent. Baghestani *et al*. (2007a) concluded in their experiment that chemical control and reduction of weeds could lead to increased corn yield compared to the control with uncontrolled weeds. Johnson and Haverstad (2002) and Nurs *et al*. (2006) also reported that weed control could increase crop yield compared to the control with uncontrolled weeds, which agree with the findings of this study.

Since old herbicides are widely used in Iran to control corn weeds, this study aimed to replace these herbicides with new ones to address some of the problems associated with herbicide use, including risks in subsequent crops and environmental pollution. Overall, the herbicides used in the experiment were effective in controlling weeds, all indicaing a significant effect on weed control compared to the control treatment. Based on the results of different regions, A-Maize-ing herbicide, at doses ranging from 1.8 to 2 liters per hectare, had a desirable efficacy in controlling weeds and increasing maize yield, without significant differences compared to other registered herbicides for grain maize. Although the use of 2 liters of A-Maize-ing herbicide showed higher efficacy in weed control compared to a dose of 1.8 liters, its use is not recommended due to the lack of statistical difference. Therefore, based on the results of this experiment, the use of 1.8 liters of A-Maize-ing herbicide is recommended for corn, especially in terms of sustainable weed management and chemical control hazards.

Overall, the results of this research demonstrated that considering the dominance of weed species in the experimental regions of Alborz, Ardabil, and Kermanshah, the use of A-Maize-ing herbicide had a very high effectiveness in weed control. Due to the greater sensitivity of weed seedlings to herbicides, the application of doses of this herbicide had a greater inhibitory effect on weed density and dry weight in the early stages of growth. In such conditions, the prevention of early-season interference of weeds with corn, minimized their competitive effects on the crop, and the application of even lower amounts of herbicides (even less than 2 liters of commercial product per hectare) had very positive results in increasing crop yield. In summary, the experimental results indicated that treatments with a a higher percentage of weed density and dry weight control shifted the competitive conditions towards the cultivated crop, leading to an increase in leaf area and photosynthetic capacity, ultimately resulting in increased corn grain yield.

Based on the results of this experiment, A-Maize-ing herbicide (50%) at a rate of 1.8 liters of commercial product in pre-emergence (after corn sowing and before weed emergence) and Adengo herbicide (46.5% SC) at a rate of 0.55 liters of commercial product in early post-emergence (between the first and second irrigation) can effectively control broadleaf weeds in corn fields and enhance the yield of corn plants without imposing negative effects.

References

Anonymous, 2021. Available from: https://www.sipcam-oxon.com. Products plant protection herbicides terbuthylazine. [Accessed 8th July 2021].

Baghestani MA, Zand E, Soufizadeh S, Beygi MA, 2007b. Evaluation of different empirical models of crop/weed competition to estimate yield and LAI losses from common lambsquarters (*Chenopodium album* L.) in maize (*Zea mays* L.). *Pakistan Journal of Biological Sciences* 10(21): 3752–3761.

Baghestani MA, Zand E, Soufizadeh S, Eskandari A, PourAzar R, *et al*., 2007a. Efficacy evaluation of some dual purpose herbicides to control weeds in maize (*Zea mays* L.). *Crop Protecion* 26: 936–942.

Dobbels AF, Kapusta G, 1993. Postemergence weed control in corn with nicosulfuron combinations. *Weed Technology* 7: 844–850.

Faostat, 2022. Available from: https://www.fao.org/faostat/en/#data/QCL [Accessed 8th January 2022].

Fetyukhin IV, Popov AS, Tolpinskii VV, 2022. Weed control in the cultivation of corn (*Zea mays* L.) on irrigation. *Environmental Science & Technology* 10: 12–47.

Mamnoie E, Izadi-Darbandi E, Rastrgoo M, Baghestani MA, Khayyat MH, 2023. The effect of adjuvants on nicosulfuron efficacy for controlling *Amaranthus retroflexus*, *Chenopodium album*, and *Echinochloa crus-galli*. *Journal of Crop Protection* 12(4): 379–388.

Moshaver E, Zand E, Miri HR, Ghezeli FD, 2011. Effect of separate and tank-mix treatments of herbicides on weed control and yield of corn (*Zea mays* L.). *Research on Crops* 12(1): 23–26.

Nurs R, Swanton C, Francois T, Sikkema PH, 2006. Weed control and yield are improved when glyphosate is preceded by a residual herbicide in glyphosate-tolerant maize (*Zea mays*). *Crop Protection* 25: 1174–1179.

Rezvani M, Zaefarian F, Aghaalikhani M, Rahimian Mashhadi H, Zand E, 2011. Investigation corn and soybean intercropping advantages in competition with redroot pigweed and jimsonweed. *World Academy of Science, Engineering & Technology* 81: 350–352.

Saberali SF, Baghestani MA, Zand E, 2008. Influence of corn density and planting pattern on the growth of common lambsquarters (*Chenopodium album* L.). *Weed Biology & Management* 8(1): 54–63.

Sheibany K, Baghestani Meybodi MA, Atri A, 2009. Competitive effects of redroot pigweed (*Amaranthus retroflexus*) on the growth indices and yield of corn. *Weed Biology & Management* 9(2): 152–159.

Teymoori M, Baghestani MA, Zand E Madani H, Mafakheri S, 2013. Weed management in maize field by chemical, mechanical and cultural methods. *Research on Crops* 14(3): 729–735.

Thomas K, Christos A, Ioannis G. 2014. Herbicide mixtures for control of water smartweed (*Polygonum amphibium*) and wild buckwheat (*Polygonum convolvulus*) in potato. *Weed Technology* 28(2): 401–407.

Zand A, Kashtkar A, Mousavi SK, Heidari A, 2021. Herbicides and their application technology. Mashhad University Press. 816 pp (in Persian).

پژوهش‌های کاربردی در گیاه‌پزشکی ۱۴ (۱): ۱۱-۱ (۱۴۰۴)
مقاله پژوهشی

بررسی کارایی تربوتیلازین و ایزوکسافلوتل+ تین‌کاربازون در مقایسه با علف‌کش‌های رایج در کنترل علف‌های‌هرز ذرت دانه‌ای *Zea mays*

نوشین نظام آبادی[1]✉، رسول فخاری[2]، پیمان ثابتی[3]، سجاد محرم نژاد[4]، قربان دیده باز مغانلو[2]

[1] بخش تحقیقات علف‌های هرز، موسسه تحقیقات گیاه پزشکی کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، تهران، ایران

[2] بخش تحقیقات گیاهپزشکی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی استان اردبیل، سازمان تحقیقات، آموزش و ترویج کشاورزی، مغان، ایران

[3] بخش تحقیقات گیاهپزشکی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی استان کرمانشاه، سازمان تحقیقات، آموزش و ترویج کشاورزی، کرمانشاه، ایران

[4] بخش تحقیقات علوم زراعی و باغی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی استان اردبیل، سازمان تحقیقات آموزش و ترویج کشاورزی، مغان، ایران

نویسنده مسئول: nezamabadi_n@yahoo.com✉

دریافت: ۱۴۰۲/۰۸/۲۸ بازنگری: ۱۴۰۳/۰۴/۱۸ پذیرش: ۱۴۰۳/۰۵/۰۱

چکیده

به منظور ارزیابی کارایی تربوتیلازین و ایزوکسافلوتل + تین‌کاربازون در کنترل علف‌های‌هرز ذرت، آزمایشاتی در مزارع ذرت استان‌های اردبیل، البرز و کرمانشاه طی سال زراعی ۱۴۰۱-۱۴۰۰ انجام گرفت. تیمارها شامل کاربرد علف‌کش تربوتیلازین (اِمیزینگ ٪۵۰ SC) در مقادیر ۱، ۱/۲، ۱/۵، ۱/۸ و ۲ لیتر در هکتار، ایزوکسافلوتل+ تین‌کاربازون + ایمن‌کننده سیپروسولفامید (آدنگو ٪۴۶/۵ SC) ۰/۵۵ لیتر در هکتار، مزوتریون + اس‌متالاکلر + تربوتیلازین (لوماکس ٪۵۳/۷۵ SE) ۴/۵ لیتر در هکتار، توفوردی + ام‌ث‌پ‌آ (یو۴۶ کمبی فلوئید ٪۶۷/۵ SL) ۱/۵ لیتر در هکتار، بروموکسینیل + ام‌ث‌پ‌آ (برومایسید ام‌آ ٪۴۰ EC) ۱/۵ لیتر در هکتار و بروموکسینیل + ام‌ث‌پ‌آ (برومایسید ام‌آ ٪۴۰ EC) ۱/۵ لیتر در هکتار + نیکوسولفورون (کروز ٪۴ SC) ۱/۵ لیتر در هکتار بودند. نتایج نشان داد کاربرد علف‌کش امیزینگ در مقدار ۱/۸ و ۲ لیتر، آدنگو، لوماکس، یو۴۶ کمبی فلوئید، برومایسید ام آ و برومایسید ام‌آ + کروز، تراکم و وزن خشک علف‌های‌هرز را بیش از ۸۵ درصد کاهش دادند و سبب افزایش عملکرد ذرت در مناطق مغان، کرمانشاه و البرز شدند. علف‌کشِ امیزینگ و علف‌کش آدنگو همانند سایر علف‌کش‌های رایج در مزارع ذرت ایران موثر بودند، بنابراین می‌توان استفاده از این علف‌کش‌ها را توصیه کرد. همچنین علف‌های هرز تاج‌خروس ریشه‌قرمز و سلمه‌تره به علف‌کش‌هایِ امیزینگ و آدنگو حساس بودند.

کلمات کلیدی: پهن‌برگ، تراکم، علف‌کش تربوتیلازین، وزن خشک