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WEED MANAGEMENT IN POTATO CROPS USING HERBICIDE METRIBUZIN IN INTEGRATION WITH AGRONOMIC OPERATIONS

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SUMMARY

This study proceeded in the spring of 2022 to assess the efficiency of Metribuzin herbicide alone and combined with some agricultural methods, such as mulching and hoeing, to control potato weeds. The effect of Metribuzin at a rate of 400 g ha^{-1} with mulching reduced the total weed density to 19.0 plants m^{-2}, similar to Metribuzin at a rate of 800 g ha^{-1} (16.0 plants m^{-2}). The efficiency of Metribuzin herbicide at 400 g ha^{-1} combined with one or two hoeings reduced the number of weed densities by 19.3 and 10.6 plants m^{-2} for one hoeing and two hoeings, respectively. The effect positively manifested in plant heights, the number of leaves, the foliage dry weight, and its reflection on the potato yield weight.

Keywords: Potato (*Solanum tuberosum* L.), Solanaceae, weed management, Metribuzin, mulching, hoeing, weed population

Key findings: Metribuzin herbicide treatment at a rate of 800 g ha^{-1} alone or in combination with mulching or hoeing was effective in controlling weeds. It manifested in the yield and chemical properties of the potato. Integration between mulching or hoeing with 400 g ha^{-1} of Metribuzin significantly controlled the weeds and the studied potato traits.

INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the Solanaceae family. It is one of the most valuable crops worldwide due to its abundant yield and diversity of growth in different conditions (El-Ganainy *et al*., 2022). It ranks third as a strategic and economic crop after

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wheat and rice (Eriksson *et al*., 2016; Nurul-Afza *et al*., 2023; Siregar *et al*., 2023). It constitutes the daily diet of more than 90% of countries' diets (Duguma *et al.,* 2019).

Although the environmental conditions in Iraq may be suitable for the crop's growth, crop productivity is still low. The reason for this is the farmers' lack of knowledge in crop management, especially in the field of weed control. Pests, pathogens, weeds, and arthropods caused significant losses in potato farms (Adhab and Alkuwaiti, 2022). The weeds specifically cause notable losses, often leading to entire crop loss, depending on the type and density of the weeds in the field. Most researchers have confirmed that weeds caused substantial losses in the percentage of the total yield, reaching 30%–50%, and may sometimes reach 70% (Al-rajbo *et al*., 2022).

The weeds compete with the potato crop for light, water, nutrients, and production affecting the tuber quality, as the weeds cause holes and deformations in potato tubers and produce smaller sized tubers undesirable for the consumer. Consequently, it causes great losses to farmers, and some weeds secrete toxic substances that cause crop damage and contribute significantly to the production's decline in quantity and quality (Xie *et al*., 2021).

Potato crop cultivation at the global level faces many problems, including weeds, as control is a fundamental and necessary process to reduce the adverse effects of competition with the potato crop to achieve high productivity and quality (Skiba *et al*., 2021). The control of weeds in crops, especially in potato fields, is insufficient. It does not prevent the subsequent growth of the weeds during the flowering period and, thus, may be a cause of transmission of viral diseases or the emergence of their spread in the following years (Li *et al.*, 2019).

The chemical control method of weeds is a common approach by farmers in Iraqi potato fields using one of the recommended herbicides, including Metribuzin, which is ineffective. In addition, the continuous use of specific herbicides in potato fields helped develop some weed resistance. Therefore, integrating mechanical and chemical methods is best for improving weed control and reducing the herbicide amount. Its reflection is evident in the environment, especially the residue in the soil, and its effects on subsequent crops (Caputo, 2021). It was apparent that using Metribuzin, combined with one hoeing and covering with wheat residue, reduced the weed number percentage and reflected in the potato percentage of dry weights and total yield (Gupta *et al*., 2019). The efficiency of Metribuzin used as pre-emergence and covering with paddy straw mulch was more effective in controlling weeds in the potato than using the pesticide alone (Shafiq and Kaur, 2021). This article sought to probe the effect of a combination of mulching with black plastic (mulch) or hoeing with Metribuzin in controlling the weeds in the potato crop and its influence on several vegetative and productive characteristics compared with using Metribuzin alone.

MATERIALS AND METHODS

The experiment materialized in a potato farm in the Anbar Governorate for spring 2022. The chief goal was to study the efficiency of the Metribuzin pesticide alone and when combined with some agricultural methods (mulching and hoeing) in controlling weeds in potato fields on the variety Arizona and the role of weed control methods in increasing some vegetative characteristics and yields. The soil preparation comprised homogeneously plowing, smoothing, and dividing into three blocks, consisting of 13 units in each replicate. Each experimental unit contains four planting lines, with a distance of 75 cm between lines and 25 cm between plants, leaving 0.75 m between the experimental units. The area of the experimental unit was 4.5 m × 4 m = 18 m^2. The experiment employed a randomized complete block design (RCBD), with a comparison using the least significant difference (LSD) test at 5% (Farhan *et al*., 2023). Potato seeds of the Arizona variety produced by Agrico Company, Class: Elite commenced planting on January 1, 2022, in the sandy loam soil texture. The potato field experiment fertilization applied poultry manure

with chemical fertilizer (NPK 15:15:15). After planting, nitrogen fertilizer application in urea form was in two batches: the first was after complete germination and the second at the beginning of the tuber formation. The treatment with Metribuzin ensued before the emergence at a rate of 400 and 800 g ha^{-1}, with some agricultural practices, such as black plastic mulch (thickness of 8.0 microns) and hoeing.

Weed type and density

The types of weeds that prevailed in each treatment bore diagnosis, calculating the total numerical density of the total weeds within one square meter at the end of the growing season. Using a wooden square with 100 cm × 100 cm dimensions, progressed to four separate locations from each experimental unit at random.

The percentage of weed control determination employed the following equation:

$$\text{Weedcontrol \%} = \frac{\text{No. of weeds in control treatment} - \text{No. of weeds in herbicide treatment}}{\text{No. of weeds in control treatment}}$$

The weeds dried naturally had the percentage of weed inhibition determined according to the following equation:

$$\text{Inhibition rate \%} = 100 - \frac{A}{B} \text{ X } 100$$

A: dry weight of the weeds in the treatments.
B: dry weight of the weeds in the control treatment.

Yield and yield components

Selecting three plants from each block had their data recorded on the potato vegetation measurements, including leaf length, leaf number, stem number, vegetable dry weight, tuber number, weight of tubers per plant, tuber weight, and total yield.

RESULTS AND DISCUSSION

Diagnosis of the weeds

The types of weeds noted to spread in the potato crop during the spring growing season reached 13 weed species, i.e., *Lolium rigidum* L., *Melilotus indicus* Mill, *Raphanus raphanistrum* L., *Carthamus oxyacanthus, Malva rotunbifolia* L, *Amaranthus retroflexus* L., *Cardaria dropa* Desv, *Cynodon dactylon* L, *Chenopodium album* L., *Lolium temulentum , Avena fatua* L., *Digitaria sanguinalis* L., and *Convolvulus arvensis* L.

Effects of Metribuzin and agricultural methods

The number of weeds significantly decreased for all treatments compared with the weedy treatment of 194.2 plants m^{-2} (Table 1). It reduced with the combination of mulching with Metribuzin at a rate of 400 g ha^{-1} by giving the lowest number of weeds at 19.0 plants $m^{-2,}$ and reflecting on the control percentage of 90.2%, respectively, compared with Metribuzin at the recommended rate (800 g ha^{-1}) and half recommended (400 g ha^{-1}) without mulching (16 and 96 plants m^{-2} and 91.7% and 50.5%, respectively). As for hoeing, it significantly decreased weeds by the integrated treatment of one and two hoeings with Metribuzin at half the recommended rate, with the number of weeds amounting to 19.3 and 10.6 plants m^{-2}, and the control rate of 90.0% and 94.5%, respectively. They did not differ significantly from the treatment of the two hoeing without herbicides (7.3 plants m^{-2} and 96.2%).

This result indicates the effectiveness of the herbicide Metribuzin alone or with mulching and hoeing methods, which affects the vital activities of the weeds and the subsequent growth processes in plants. Mulching the soil with black plastic is an essential agricultural process. It blocks the light, sterilizes the soil, and homogenizes the ground moisture under the cover (Pathak and

Singh, 2021). The hoeing process is also helpful and practical for getting rid of weeds in crop fields and successfully controlling annual and biennial weeds, as this method does not leave any root trace of the weed in the soil, preventing it from growing again (Shehata *et al*., 2019).

Weeds dry weight

The results in Table 1 show that the dry weight of weeds was 28.7 and 43.0 g m^{-2} in the treatment combination of mulching with Metribuzin at a rate of 800 and 400 g ha^{-1}, respectively, and its reflection on the percentage of inhibition had a rate of 95.9% and 91.9% compared with Metribuzin without mulching (29.7 and 204.5 g m^{-2} and 70.5% and 95.7%, respectively). It differed from mulching only (184.7 g m^{-2}), and the inhibition rate was 73.3%. The results also indicated a significant decrease with the hoeing treatment plus Metribuzin at half the recommended rate, giving a dry weight of 30.0 and 24.3 g m^{-2} and an inhibition rate of 95.4% and 96.8% for the one and two hoeing treatments, respectively. It differed from the treatment of one and two hoeings only (182.0 and 21.7 g m^{-2}), and the inhibition rate is 73.3% and 97.0%. The dry weight of the weeds is clear evidence of a decrease in their competitiveness compared with the crop ability. The low dry weight strongly indicates the effectiveness of these treatments and their impact on the vital activities of the weeds. The herbicide Metribuzin affects many changes in the physiological processes within the plant body. The chief effect is the inhibition of photosynthesis. It inhibits the water photolysis step (Hill reaction). The results show Metribuzin significantly affects agricultural operations by reducing the weed's dry weight and ability to compete with the crop. It is a pure reflection of the high relative efficiency of weed control in potato fields. This finding agrees with Barbaś *et al.* (2020) and Bongaarts (2021).

Effects of Metribuzin and agricultural methods on potato traits

Plant height

Compared with the weedy treatment, which had the lowest value of 54.6 cm (Table 2), the Metribuzin treatment affected the plant height, stand-alone or with mulching and hoeing. The treatments of Metribuzin (800 g ha^{-1}) with mulching outperformed others, giving a plant height of 84.3 and 82.3 cm for the herbicide (400 g ha^{-1}). The results also indicated the superiority of Metribuzin herbicide with the one

Table 1. Effects of the herbicide Metribuzin alone or in combination with mulching and hoeing on weed density and its dry weight.

Treatments	Weed growth characteristics			
	Total weed density m^{-2}	Control (%)	Dry weight (g)	Inhibition rate in dry weight (%)
Control	194.2	0.0	693.3	0.0
Hand weeding	0.0	100	0.0	100
Metribuzin 800 g ha^{-1}	16.0	91.7	29.7	95.7
Metribuzin 400 g ha^{-1}	96.0	50.5	204.0	70.5
M.800 g ha^{-1} + mulch (black plastic)	5.3	97.2	28.7	95.9
M.400 g ha^{-1} + mulch (black plastic)	19.0	90.2	43.0	91.9
M. 800 g ha^{-1} + 1 hoeing	6.00	96.7	18.0	97.4
M.400 g ha^{-1} + 1 hoeing	19.3	90.0	30.0	95.4
M.800 g ha^{-1} + two hoeing	4.00	97.9	11.7	98.3
M.400 g ha^{-1} + two hoeing	10.6	94.5	24.3	96.8
One hoeing	73.6	61.1	182	73.7
Two hoeing	7.3	96.2	21.7	97.0
Mulch (black plastic)	62.3	67.9	184.7	73.3
$LSD_{0.05}$	4.3	———	15.0	———

Table 2. Effects of Metribuzin alone or combined with mulching and hoeing on some potato plant growth vegetative characteristics.

Treatments	Vegetative characteristics of potato plant growth			
	Plant height (cm)	Stem number plant^{-1}	Leaf number plant^{-1}	Vegetative dry weight (g)
Control	54.6	2.0	45.7	41.3
Hand weeding	84.6	3.0	132.0	75.0
Metribuzin 800 g ha^{-1}	79.0	2.3	123.7	60.3
Metribuzin 400 g ha^{-1}	69.3	4.0	52.0	39.7
M.800 g ha^{-1} + mulch (black plastic)	84.3	3.0	99.3	65.0
M.400 g ha^{-1} + mulch (black plastic)	82.3	2.6	125.0	63.3
M. 800 g ha^{-1} + 1 hoeing	77.3	3.0	105.0	58.7
M.400 g ha^{-1} + 1 hoeing	73.6	3.0	106.3	57.3
M.800 g ha^{-1} + two hoeing	73.0	2.3	110.0	66.7
M.400 g ha^{-1} + two hoeing	70.6	2.3	117.3	53.0
One hoeing	61.6	2.0	64.3	44.7
Two hoeing	67.3	2.3	89.3	53.0
Mulch (black plastic)	64.0	3.0	47.0	50.3
$LSD_{0.05}$	8.2	N.S	29.1	11.8

and two-hoeing processes (Table 2). They gave a height of 77.3 and 73.0 cm for herbicide treatment of 800 g ha^{-1} with one and two hoeings, respectively, and 73.6 and 70.6 cm for an herbicide of 400 g ha^{-1} with one and two hoeings, respectively, versus using only one hoeing (61.6 cm) and two hoeings only (67.3 cm). All treatments had higher average plant heights than the weedy treatment because using the herbicide alone or combined with other farming methods made it harder for the weeds to compete with potato plants for their primary growth needs. It made the potato plants grow taller.

Leaves per plant and dry weight

The outcomes implied Metribuzin treatments (800 g ha^{-1}) with mulching were superior. It gave the number of leaves plant^{-1} and the vegetative dry weight at 99.3 leaves plant^{-1} and 65.0 g, respectively, and 125.0 leaves plant^{-1} and 63.3 g, respectively, for the herbicide treatment (400 g ha^{-1}). The application using plastic alone only gave 47.0 leaves plant^{-1} and 50.3 g, respectively (Table 2), compared with the herbicide at the recommended rate (123.7 leaves plant^{-1} and 60.3 g, respectively).

The results also indicate that effects in the hoeing treatments combined with the herbicide (Metribuzin at 800 g ha^{-1}) increased significantly with 105.0 leaves plant^{-1} and 58.7 g per hoeing and 110.0 leaf plant^{-1} and 66.7 g for two hoeings, respectively. The herbicide treatment (400 g ha^{-1}) combined with one and two hoeings gave the number of leaves at 106.3 and 117.3 leaves plant^{-1} and the total vegetative dry weight of 57.3 and 53.0 g, respectively. They did not differ significantly from the treatment of the two hoeings without the herbicide (89.3 leaves plant^{-1} and 53.0 g). Without weeds, its lack of competition for the potato crop allowed crop plants to grow and obtain the requirements for growth without stress. It then increases the outputs of the photosynthesis process, which positively reflected in an increase in the vegetative growth of the plant, represented by the plant height and the dry weight of the plant, compared with what the weedy treatment provided (Pathak and Singh, 2021; Abdallah *et al*., 2021). The increase in the dry weight of the vegetative total in the experimental treatments may refer to a significant increase in the accumulation of processed materials inside the plant, which helped raise the dry weight rate in the plant (Farrag *et al*., 2016).

Effects of Metribuzin and agricultural methods on yield

The findings showed that the treatments of Metribuzin at a dose of 800 g ha^{-1} coupled with mulching were superior by giving a high tuber weight and the yield of one plant amounting to 128.2 g and 933.6 g $plant^{-1}$, respectively. The amount of 120.2 g and 774.9 g $plant^{-1}$ emerged for the herbicide treatment (400 g ha^{-1}) and for the treatment with plastic only (125.4 g, 682.6 g $plant^{-1}$) (Table 3). It did not differ significantly from the herbicide treatment at the recommended rate (139.0 g and 848.4 g $plant^{-1}$). It manifested in the total yield of the potato crop (t ha^{-1}), which gave a yield weight of 49.4 and 41.1 t ha^{-1} for herbicide treatment according to the rate of 800 and 400 g ha^{-1} used with plastic mulch, respectively, and the herbicide treatments without mulching gave 44.9 and 32.6 t ha^{-1}, respectively.

The outcomes also signified the superiority of Metribuzin herbicide used with one-hoeing and two-hoeing processes by giving the tuber weight and the yield of one plant at 160.5 g and 980.3 g $plant^{-1}$ for the herbicide treatment at a rate of 800 g ha^{-1} with one hoeing and 152.6 g and 878.0 g $plant^{-1}$ with two hoeings respectively. It did not differ significantly from the herbicide at a rate of 400 g ha^{-1} with 158.0 g and 774.1 g $plant^{-1}$ with one hoeing and 144.6 g and 864.4 g $plant^{-1}$ with two hoeings. However, it differed remarkably from using one hoeing only (123.7 g and 656.1 g $plant^{-1}$) but did not differ considerably from the two hoeing only (157.1 g and 872.1 g $plant^{-1}$). It was evident in the total yield of the potato crop (t ha^{-1}), which gave a yield weight of 51.9 and 45.8 t ha^{-1} for the herbicide according to the rates of 800 and 400 g ha^{-1} with one hoeing, respectively, and 46.5 and 45.8 t ha^{-1} with the two hoeing.

Metribuzin herbicide alone or combined with the mulching and hoeing processes in controlling potato weeds reduced competition for nutritional and light requirements, making it confined only to plant nutrition. It was distinct in an increase in the crop root system's ability to absorb water and mineral elements and an increase in the accumulated carbohydrates and their transfer to the leaves, then to the tuber as the prime consumer (Yadav *et al.,* 2015). The increase in the tuber weight in the experimental treatments is attributable to the increase in the leaf area of the potato plant and its positive reflection on the activity of photosynthesis, which leads to an upsurge in the manufacture of carbohydrates transferred to the tubers, raising their weight (Javaheri *et al*., 2012). This finding is analogous to the reports by Yadav *et al*. (2015), Shafiq and Kaur (2021), and Gupta *et al*. (2019) on the possibility of controlling weeds accompanying the potato crop by using Metribuzin and integrating with some agricultural operations.

Table 3. Effects of Metribuzin alone or in combination with black plastic mulching and hoeing on the total yield and its components of potato plants.

Treatments	Total yield and its components for potato crop			
	Tuber number $plant^{-1}$	Tuber weight (g)	Plant yield (g)	Plant yield (t ha^{-1})
Control	5.8	70.0	472.2	25.0
Hand weeding	6.2	173.0	1123.3	59.5
Metribuzin 800 g ha^{-1}	6.1	139.0	848.4	44.9
Metribuzin 400 g ha^{-1}	6.0	103.0	616.7	32.6
M.800 g ha^{-1} + mulch (black plastic)	6.9	128.2	933.6	49.4
M.400 g ha^{-1} + mulch (black plastic) M. 800	6.9	120.2	774.9	41.1
g ha^{-1} + 1 hoeing	5.8	160.5	980.3	51.9
M.400 g ha^{-1} + 1 hoeing	5.8	158.0	774.1	41.0
M.800 g ha^{-1} + two hoeing	7.6	152.6	878.0	46.5
M.400 g ha^{-1} + two hoeing	5.7	144.6	864.4	45.8
One hoeing	5.2	123.7	656.1	34.7
Two hoeing	5.6	157.1	872.1	46.2
Mulch (black plastic)	5.3	125.4	682.6	36.1
$LSD_{0.05}$	n.s	19.0	85.9	4.5

CONCLUSIONS

A low dose (400 g ha^{-1}) of Metribuzin and mulching with black plastic or hoeing worked well to control weeds by the studied traits during the growing season of the potato crop. The treatment of the two hoeing alone efficiently and successfully controlled weeds in the above-studied characteristics.

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