Efficiency of different herbicides on growth, yield and companion weeds of chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was implemented during the 2024 spring season at the University of Duhok to assess the efficacy of eight distinct herbicides on weed management and the agronomic performance of rain-fed chickpea (Cicer arietinum L.). The trial employed a randomized complete block design (RCBD) with nine treatments—eight herbicide formulations and an untreated control—each replicated three times. Results indicated significant treatment effects on all measured parameters. The herbicides Traxos and Madbon significantly enhanced plant height and pod number per plant. Madbon further achieved the highest values in critical yield components, including seeds per plant (18.47), 100-seed weight (51.09 g), and ultimate seed yield (2510.86 kg/ha), whereas the unweeded control yielded the lowest results across all metrics. The weed spectrum comprised twelve species (nine broad-leaf and three narrow-leaf). Totic was the most effective treatment in reducing overall weed density and dry biomass, while Axial selectively suppressed narrow-leaf species. This study confirms that targeted herbicide application is crucial for effective weed control in rain-fed chickpea production, with Madbon and Totic identified as the most promising options for enhancing productivity in the Duhok region

Key word: Chickpea, herbicides, Weeds, Yield.

Introduction

Chickpeas (Cicer arietinum L.) are considered to be one of the most significant grain legumes in the world. Because of its versatility, it is frequently used in both conventional and processed foods. Chickpeas are a great source of protein in terms of nutrition. It is mostly produced in the northern governorates of Iraq, such as Sulaymaniyah and Duhok, and is regarded as the second most important grain legume after faba bean. With 180,000 hectares under cultivation and 104,000 tons produced annually, it is the most important pulse crop [15]. Sulaimani, Duhok, Erbil, and Nineveh cover 14,000 hectares and produce 0.74 tons per hectare, according to the FAO [1]. Chickpea yield is still poor worldwide, particularly in Kurdistan, despite the crop's critical significance in daily nutrition and food processing [17]. The production and harvesting efficiency of chickpea crops are significantly hampered by weeds. Additionally, the percentage of chickpea yield declines that could be attributed to weeds ranges from 22% to 100%. In particular, weeds can reduce grain yield by up to 60% [16].

The current methods for controlling weeds in chickpeas include crop rotation, mechanical methods, hand weeding, and mostly the use of pre-emergence herbicides. In these cases, farmers typically decide to weed by hand. However, because to issues

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with cost and staff availability, they look for more economical weed management methods. Chickpeas are more vulnerable to herbicides than cereal crops [23]. According to research from Australia, Italy, and India, pre-emergence herbicides were generally more effective at controlling weeds than post-emergence herbicides and were not associated with plant damage [31], [38], and [23].

Chemical weed control is currently one of the most widely used methods of weed control and has been widely adopted throughout the world due to its capacity to provide quick and efficient weed management [13]. By using the right herbicides, yield declines can be prevented and early weed competition can be reduced. According to [21], herbicides provide selectivity, cost effectiveness, ease of application, and scheduling flexibility. On the other hand, chemical weed management significantly reduced plant height and grain output, yielding yields that were around 25% lower than those from manually weeded and untreated plots [5]. Similarly, [6] observed that herbicide-treated plots had shorter plant heights. Herbicides effectively inhibited the growth of weeds, but they also negatively impacted crop development by reducing plant height and other growth indicators. This study set out to determine how successfully pre or post-emergence herbicides affected the growth of related weeds as well as the development and yield of chickpea plants.

Material and Methods

Using chickpeas (*Cicer arietinum* L.) as the model crop, an agronomic field study was conducted in a rainfed system during the spring of 2024 at the University of Duhok's field crops research site. As indicated in Table 1, the study used a randomized complete block design (RCBD) with three replications and comprised nine treatments: an untreated control (weedy check) and eight herbicide treatments (Luxdor, Clean Field, Tayrex, Traxos, Madbon, Mega, Totic, and Axial). Each plot measured one meter by two meters. Manual sowing of a native Kabuli chickpea variety was done on 4 march 2024 by using a 0.25 m row spacing and a 0.12 m intra-row plant spacing.

Up until crop maturity, weed assessments were carried out on a regular basis. Following air-drying, the density and dry biomass of narrow-leaf and broad-leaf weeds were measured after weeds were sampled from a 1 m² quadrant each plot (Table 2). Also weed control percentage (density-based) [19] and Inhibition percentage (dry weight-based) according to [20] was calculated. Ten plants per plot were chosen at random to quantify yield and yield components at harvest. Plant height, lowest pod height, number of pods and seeds per plant, 100-seed weight, biological weight per plant, and seed production per hectare were among the parameters that were evaluated. Fisher's analysis of variance (ANOVA) was used to examine the data, and Duncan's Multiple Range Test was used to compare treatment means at a 5% probability level [14].

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Table (1): The experiment utilized several herbicides, for which the trade name, formulation type, dosage rate, and timing of application are all provided.

Trade name of herbicide	Active ingredient	Formulation	Recommended dose	Application time
Luxdor	Linurone	45 SC	2.5 l/ha	Post emergence (10-15 cm chickpea height)
Clean field	Tribenurone-methyl	75 D	40 g/ha	Pre planting & preemergence
Tayrex	Oxadiazone	250 EC	3 l/ha	After planting & before weed emergence
Traxos	Pinoxadan	50 EC	1 l/ha	Post emergence (for narrow leaf weeds)
Madbon	Bentazon	480 g/l SL	2.5 l/ha	Post emergence (Broad leaf weeds (2-3 leaves for weeds & 1-3 leaves for crop)
Mega	Clodinofop-proparjyl	8 EC	0.4 l/ha	Post emergence (for narrow leaf weeds)
Totic	Clodinofop-proparjyl (80 g/l) Glocoynosit mixyl (20 g/l)	10 EC	0.6 l/ha	Post emergence (for narrow leaf weeds)
Axial	Pinoxadan	50 EC	1.3 l/ha	Post emergence (for narrow leaf weeds) (3-4 leaves for crop)

Table (2): The main weeds that were present in chickpea fields in 2024 growing season.

	Scientific name	Family name	Growth habit	Types
1	*Phalaris minor* Retz.	Poaceae	Winter annual	Narrow-leaf
2	*Hordeum glaucum* Steud.	Poaceae	Winter annual	Narrow-leaf
3	*Avena fatua* L.	Poaceae	Winter annual	Narrow-leaf
4	*Polygonum arviculare* L.	Polygonaceae	Summer annual	Broad-leaf
5	*Aster subulatus*	Asteraceae	Winter annual	Broad-leaf
6	*Hypericum spp.*	Hypericaceae	Winter annual	Broad-leaf
7	*Carthamus oxycantha* Bieb.	Asteraceae	Winter annual	Broad-leaf
8	*Xanthium strumarium* L.	Asteraceae	Summer annual	Broad-leaf
9	*Vaccaria pyramidata* Medik.	Caryophyllaceae	Winter annual	Broad-leaf
10	*Sinapis arvensis* L.	Brassicaceae	Winter annual	Broad-leaf
11	*Lactuca serriola* L.	Asteraceae	Summer annual	Broad-leaf
12	*Convolvulus arvensis* L.	Convolvulaceae	Summer perennial	Broad-leaf

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Results and Discussion

Table 3 displays the influence of various herbicide treatments on chickpea growth traits, specifically plant height, lower pod height, and number of pods/plant. The results demonstrate significant differences across herbicide treatments for all parameters evaluated. The tallest plants were recorded in the Traxos treatment, which showed no statistically significant difference compared to the Madbon, Tayrex, and Totic treatments. In contrast, the control (untreated) group produced the shortest plants, with an average height of 30.14 cm. With respect to lower pod height, the highest value was observed in the Madbon treatment (15.55 cm), while the control recorded the lowest (10.95 cm). Concerning the number of pods/plant, the Madbon treatment yielded the highest count (19.44), though this was not significantly different from the results of the Traxos and Totic treatments. The control again showed the lowest value, with only 10.40 pods/plant. These findings align with previous research by [2], [25], and [24], who reported that herbicide applications significantly improved plant height, first pod height, and pod number per plant. Similarly, [35] and [13] documented notable increases in pods/plant, seeds/pod, and overall grain yield in chickpea following weed control treatments.

Table (3): Effect of studied herbicides on plant height, lower pod height, number of pods per plant in chickpea field.

Treatments	Plant height (cm)	Lower pod height (cm)	Number of pods/plant
Luxdor	33.33 c	11.55 cd	12.22 cd
Clean field	40.11 b	12.77 bcd	14.11 bc
Tayrex	43.22 a	12.89 bcd	15.77 b
Traxos	44.88 a	13.55 abc	18.11 a
Madbon	43.43 a	15.55 a	19.44 a
Mega	37.77 b	12.44 bcd	14.11 bc
Totic	42.78 a	14.55 ab	18.44 a
Axial	37.78 b	11.11 d	13.78 bc
Check	30.14 d	10.95 d	10.40 d

Based on DMRT, means with a common letter are not statistically different at 0.05.

The information in Table 4 shows how various herbicide treatments affect a number of chickpea yield components, such as seeds per plant, 100-seed weight (seed index),

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biological weight per plant, and seed yield. With 18.47 seeds per plant, a 100-seed weight of 51.09 g, a biological weight of 25.46 g per plant, and a seed yield of 2510.86 kg per hectare, Madbon continuously provided the highest values across all parameters among all treatments. These results are consistent with previous research by [3], [35], [40], [22], and [23], all of whom reported significant yield improvements in chickpea following herbicide application. Similarly, [37] and [33] noted that pre-emergence herbicides substantially increased seed yield, hay yield, and 100-seed weight. In contrast, the control (untreated) plot showed the poorest performance across all measured traits, with only 11.02 seeds per plant, a 100-seed weight of 41.05 g, a biological weight of 11.93 g per plant, and a seed yield of 1204.32 kg per hectare. This pattern aligns with observations [30], [18], and [32], who attributed low yields in unweeded plots to intense competition from weeds for resources such as space, water, and nutrients, which also restricted root development and overall plant growth. The findings are further supported by studies from [33], [32], [8], [12], and [4], which demonstrated that effective herbicide treatments not only enhanced weed control but also created more favorable growing conditions, leading to significant improvements in both grain and straw yield.

Table (4): Effect of studied herbicides on seed number per plant, seed index, biological weight and seed yield in chickpea field.

Treatments	Seed number /plant	Seed index (g)	Biological weight (g/plant)	Seed yield (kg/ha)
Luxdor	11.87 d	42.88 bcd	14.02 c	1356.31 d
Clean field	15.67 bc	42.36 cd	20.47 b	1766.93 c
Tayrex	15.73 bc	44.46 bcd	20.21 b	1866.48 c
Traxos	16.87 ab	48.20 ab	20.99 b	2165.12 b
Madbon	18.47 a	51.09 a	25.46 a	2510.86 a
Mega	14.93 c	46.52 abcd	18.90 b	1845.15 c
Totic	17.47 a	47.77 abc	21.99 b	2225.56 b
Axial	14.40 c	45.57 bcd	20.00 b	1749.16 c
Check	11.02 d	41.05 d	11.93 c	1204.32 d

Based on DMRT, means with a common letter are not statistically different at 0.05.

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Table 5 presents data on weed species found in the chickpea field and assesses the efficacy of different herbicide treatments on narrow- and broad-leaf weed density and biomass. A total of 12 weed species from seven families were identified, with eight winter-growing and four summer-growing weeds. Broadleaf species dominated with nine types, compared to only three narrow-leaf weeds (see Table 2). For narrow-leaf weeds, the Axial treatment resulted in the lowest density and dry weight (0.00), performing comparably to most other herbicides. The untreated control showed the highest narrow-leaf weed presence. In contrast, Axial produced the highest broadleaf weed count (144), similar to Luxdor and the control. Luxdor also yielded the highest broadleaf dry weight, not differing significantly from Axial. Totic was the most effective against broadleaf weeds, achieving the lowest density (1.33) and dry weight (1.85 g). Overall, Totic provided the best total weed control with the lowest weed number and biomass, while the control had the highest total weed count (181.33). These results support earlier findings by [9], who noted that effective weed management improves light distribution, microclimate conditions, and ultimately grain yield. The outcomes are consistent with multiple studies—including those by [39], [27], [34], and others—which found that both pre- and post-emergence herbicides successfully control annual broadleaf and grass weeds in chickpea. The highest weed control was observed with Totic (95.59%), followed by Madbon (94.12%) and Clean Field (83.09%), indicating these treatments were highly effective in reducing weed density and suppressing weed growth. Conversely, the lowest control was recorded in Luxdor (22.06%) and Axial (20.59%), demonstrating minimal effectiveness against weeds. Similarly, the strongest inhibition of weed biomass was achieved by Totic (95.90%), Madbon (93.54%), Clean Field (88.98%), and Traxos (88.01%). In contrast, Luxdor (-19.24%) and Axial (-9.50%) showed negative inhibition values, suggesting these treatments allowed greater weed biomass than the untreated control. This could result from treatment selectivity (controlling one group of weeds but allowing another to dominate) or treatment failure. Further support comes from researchers such as [11], and [29], and [28] who confirmed that herbicides significantly reduce weed biomass, particularly against annual species.

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Table (5): Effect of studied herbicides on weed number, weed dry weight, weed control (%) and inhibition (%) in chickpea field.

Treatments	Number of narrow-leaf weeds/ m^2	Dry weight of narrow-leaf weeds/ m^2	Number of broadleaf weeds/m^2	Dry weight of broadleaf weeds/ m^2	Total number of weeds/ m^2	Total dry weight of weeds/ m^2	Weed control (Density) %	Inhibition (Dry weight) %
Luxdor	4.00 C	8.87 e	137.33 A	1260.20 a	141.33 b	1269.07 a	22.06	-19.24
Clean field	24.00 B	53.80 c	6.67 D	63.47 c	30.67 de	117.27 d	83.09	88.98
Tayrex	5.33 C	9.63 e	96.00 bc	151.25 c	101.33 c	160.88 d	44.12	84.88
Traxos	33.33 B	89.67 b	4.00 D	37.93 c	37.33 d	127.60 d	79.41	88.01
Madbon	5.33 C	6.17 e	5.33 D	62.59 c	10.67 ef	68.76 d	94.12	93.54
Mega	5.33 C	20.00 de	84.00 C	803.27 b	89.33 c	823.27 c	50.74	22.65
Totic	6.67 C	41.76 cd	1.33 D	1.85 c	8.00 f	43.61 d	95.59	95.90
Axial	0.00 C	0.00 e	144.00 A	1165.47 a	144.00 b	1165.47 ab	20.59	-9.50
Check	62.67 A	135.33 a	118.67 ab	929.00 b	181.33 a	1064.33 b	0.00	0.00

Based on DMRT, means with a common letter are not statistically different at 0.05.

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