



Effect of Bentazone Herbicide Application on Weed Species Associated with Broad Bean (*Vicia faba* L.)

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Abstract

An experiment was conducted at the Research Station field - Department of Field Crops, College of Agriculture, Tikrit University, through winter season of (2024–2025). The aim was to evaluate the Effectiveness of Bentazone herbicide on weeds that grow with the broad bean crop (*Vicia faba* L.). The study had 18 experimental units, each unit consist three rows of broad beans, with weed seeds sown between the crop rows. The experiment designed with a Randomized Complete Block (RCBD) with three replications, using a factorial arrangement of two variables: first, crop varieties (Iraqi and Egyptian varieties). The second factor comprised three dosage levels of Bentazone herbicide: a non-treated control (0 L ha^{-1}), the standard recommended rate of 3 L ha^{-1} (100%), and a supra-optimal dose of 4.5 L ha^{-1} (150% of the prescribed rate).

The results Shown significant effects of herbicide concentrations across all studied traits. As for the control percentage of *Eruca sativa* (Arugula) and *Raphanus raphanistrum* (Wild Radish) weeds, no significant differences were recorded between the varieties. But, the 150% concentration treatment achieved the highest control rates, reaching 70.54% for *E. sativa* and 74.70% for *R. raphanistrum*, compared to 0.00% in control treatment.

About the crop growth and yield traits, the recommended concentration (100%) was superior, recording the highest values for plant height trait (65.25 cm), leaf number (13.60 leaves/plant), branch number (4.80 branches/plant), dry weight (31.25 g/plant), pod number (6.23 pods/plant).

On the other hand, the 150% concentration caused a significant Decrease in all studied traits, especially in the Iraqi variety which recorded the lowest values. While the Egyptian variety exhibited relatively higher tolerance to the phytotoxicity resulting from the herbicide overdose (150%).

The study cleared that applying Bentazone herbicide at the 100% recommended concentration is Ideal for best Performance in growth and yield for both broad bean varieties, with a Need to avoid excessive doses, particularly for the sensitive Iraqi variety. The findings Focus on Specific herbicide management to balance weed control with crop safety.

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1. Introduction

Broad bean (*Vicia faba* L.) is an Essential crop cultivated worldwide to its high nutritional value. it was a main food for the Ancient Egyptians, Babylonians, Greeks, and Romans. In Iraq it considered one of the primary and strategic Legumes Belonging to the Fabaceae family, it seeds within green pods are rich with carbohydrates, proteins, and essential minerals. Productivity and nutrient concentrations differ by variety, in general containing about 31.83% protein, 51.50% carbohydrates, 3.47% ash, 1.24%

fat, and 11.96% fiber. Furthermore, it contains various sugars also essential amino acids like ascorbic acid, aspartic acid, glycine, and proline. Beyond human food uses, the vegetative parts are utilized as animal fodder. also, the crop plays a crucial role in improving soil properties through biological nitrogen fixation via root nodules in symbiosis with *Rhizobium* bacteria (Ray et al., 2015).^[15]

The exact center of origin for broad beans remains in debate among scientists. some of them suggest West Asia as the primary origin, while others mentioned it to Central Asia. The growth and development of *Vicia faba* are affected by some environmental factors, such as salinity, moisture levels, and temperature fluctuations, as well as agricultural methods as like as planting dates, sowing, fertilization, and seasonality. crop productivity is significantly Obstructed by weed interference, especially broadleaf species such as wild radish, mallow, arugula, and wild mustard. These species are among the most competitive weeds Common in broad bean fields. Weeds are defined as plants growing where they are not wanted, also causes productivity losses, they are competitive components of agroecosystems that compete with the main crop for essential resources (light, nutrients, water, etc.) often leading to their dominance within the ecosystem. worldwide there are approximately 8,000 weed species representing nearly 3% of the total plant kingdom (Kumbhar & Dharmistha, 2016)^[11].

Weeds are also defined as critical pests that inflict damage on most crops. symbolizing a perennial challenge in agriculture and one of the most difficult obstacles facing farmers (Samad et al., 2008)^[18]. Growing of weeds within crop stands is a main factor leading to reduce productivity by inter-species competition. This competition go's to essential growth factors, specifically nutrients, water, light, soil resources, and space. Weed competition significantly impacts crop growth, development, and qualitative characteristics (Al-Mubarak, 2008).

Furthermore, weeds are causing substantial losses, such as yield reductions ranging from 30% to 50% in some cases reaching up to 70%, depending on some factors like weed density and the dominant species (Heather et al., 2007)^[8]. These reductions in growth and yield are a direct outcome of competition for water, light, nutrients, and space. Therefore researchers have focused on various weed management strategies to reduce these risks with chemical herbicides emerging as a highly effective method for minimizing weed related damage (Steven et al., 2010)^[22].

Garrity et al. (1999)^[9] referred to weed control as a fundamental practice for enhancing yield. Furthermore, certain varieties have the ability to Inhibit weed growth. a trait of significant importance for Integrated Weed Management in field crops. In this context taller varieties tend to be more competitive against weeds compared to shorter ones.

The success of any weed control program depends on several factors, such as weed density, species composition, the severity of the resulting damage and the prevailing climatic conditions in the region (Boyall, 1983)^[4].

Effective weed management through chemical herbicides ensure that essential requirements for crop growth are provided. This allows for the accumulation of Abundance dry matter from net photosynthesis within various plant organs such as stems, leaves, and roots. A portion of these reserves

is subsequently transferred to the seeds during the grain-filling stage, thereby positively impacting the final yield and its components (Ismail et al., 2002; Al-Mubarak, 2008).

Herbicides represent an effective and reliable way for managing weeds associated with broad bean crops. they significantly reduce weed density which in turn positively affect plant growth and yield enhancement. And for achieving optimal results requires the selection of appropriate herbicides and precise timing of application within the framework of Integrated Management Programs to prevent the development of herbicide resistance and reducing environmental impact. This necessitates the use of high-Capability herbicides, such as Bentazone specifically targeted for controlling these broadleaf weed species. Harmful weeds remain one of the most common and severe constraints in crop production, as they compete with crops for the essential resources (Al-Khazali & Shati, 2016).

1.1. Bentazone Herbicide

Bentazone is one of the chemical herbicides widely employed for weed management across various agricultural crops. It is a selective herbicide belonging to the benzothiadiazinone group (often associated with the benzothiadiazole family). Applied post emergence. it targets a broad spectrum of broadleaf weeds in several grass and legume fields, including broad beans (*Vicia faba* L.) (Al-Mallah & Al-Jubouri, 2014). Ajirloo et al. (2014)^[1] explained that a single application of Bentazone one week after weed emergence, effectively eliminates approximately 70% of broadleaf weeds without causing phytotoxic damage to broad bean or lentil crops. recording, this treatment does not inhibit the subsequent germination of weed seeds. basically use for controlling broadleaf species. Bentazone is characterized as a specialized contact herbicide and requiring direct contact with plant tissues to be effective (Pan, Singh, et al., 2006)^[14].

Bentazone is a selective herbicide used to control a wide range of weeds associated with various crops. the application of this herbicide in agricultural fiels can lead to environmental impacts. as residues are frequently detected in both surface and groundwater (Lagana et al., 2002).

2. Materials and Methods

2.1. Experimental Site and Design

An experiment was conducted at the Research Station fields of Field Crops Department, College of Agriculture, Tikrit University. during the 2024–2025 season. The study aimed to determine the effect of Bentazone herbicide application on several broadleaf weeds growing with broad bean (*Vicia faba* L.).

The experiment was established according to the Random Complete Block Design (RCBD). And the field was prepared through plowing, leveling and then divided into three replications, each containing six experimental units. Each unit had an area of 3 m². with a total of 18 experimental plots. A row-planting system was spaced with a 15-cm intra-row. Three seeds were sown per hill, Later re-seeding (filling gaps) was applied after seedling emergence followed by thinning to one plant per hill two weeks later. Fertilization was applied using Triple Superphosphate (TSP) at a rate of 240 kg ha⁻¹ as a single basal dose during sowing (Al-Bahadli, 2015). Irrigation was controlled according to the crop's requirements throughout the experimental period.

2.2. Experimental Factors

The study was conducted as a factorial experiment with two primary factors. The first factor was two broad bean cultivars, the local Iraqi variety and the Egyptian variety. The second factor was the application of Bentazone herbicide at three distinct dosage levels (a non-treated control (zero application), the standard recommended rate of 3 L ha⁻¹ (100%), and an escalated dose of 4.5 L ha⁻¹, representing 150% of the prescribed concentration).

The herbicide was applied when the broadleaf weeds reached the 3–4 leaf stage. Performed by following the manufacturer's guidelines. The required dosage for each concentration was conducting based on a spray volume of 100 L water for dunam. Applications were carried out uniformly for each treatment using a manual sprayer under constant pressure with ensuring direct contact with the plants. To prevent drift to adjacent plots, and by using wooden barrier was utilized during the spraying process (Saleh, 2018).

2.3. Studied Traits

1. Weed Control Percentage (WCP)

The control effect for *Eruca sativa* (Arugula) and *Raphanus raphanistrum* (Wild Radish) was calculated using the following formula (Al-Jumaily et al., 2014):

$$WCP (\%) = \frac{(\text{Weed count before treatment}) - (\text{Weed count after treatment})}{(\text{Weed count before treatment})} * 100$$

2. Plant Height (cm)

Five plants were randomly selected from each experimental unit. Plant height was measured from the soil surface to the highest point of the plant using a graduated ruler, and the average height per treatment was recorded (Shaaban, 2010) [20].

3. Number of Leaves

The total number of leaves was counted for five plants per

treatment, and the average was calculated.

4. Number of Lateral Branches

The number of lateral branches was recorded for five plants per experimental unit, and the mean value was determined (Al-Hayani, 2015).

5. Dry Weight (g)

The vegetative dry weight of broad bean plants was determined after oven-drying the samples until a constant weight was achieved.

6. Number of Pods (pods plant⁻¹)

The average number of pods was recorded per plant for the selected samples.

2.3. Statistical Analysis

The data were analyzed according to a Randomized Complete Block Design (RCBD). Analysis of Variance (ANOVA) was performed using the SAS statistical software package. For mean separation, Duncan's Multiple Range Test (DMRT) was employed to compare treatment means at a probability level of 0.05. (Al-Rawi & Khalaf-Allah, 2000).

3. Results and Discussion

3.1. Control Percentage of Arugula (*Eruca sativa*) (%)

Statistical analysis results presented in Table (1) revealed no significant differences between the Iraqi and Egyptian varieties regarding the mean control percentage of *Eruca sativa*. Conversely, herbicide concentrations exerted a significant influence; the 150% dosage achieved the highest efficacy at 70.54%, significantly outperforming the recommended rate (42.57%). Furthermore, a significant interaction was observed between varieties and herbicide levels, reflecting a variation in the herbicide's effectiveness on weeds depending on the specific crop variety cultivated, as reported by Abadi et al. (2009).

Table 1: Effect of Bentazone herbicide, varieties and their interaction on the control percentage of Arugula (*Eruca sativa*).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	0.00 c	44.44 b	68.89 a	37.8 a
Egyptian	0.00 c	40.70 b	72.20 a	37.8 a
Mean	0.00 c	42.57 b	70.54 a	

*Treatments followed by the same letter do not differ significantly at the 5% probability.

3.2. Control Percentage of Wild (%)

Findings presented in Table (2) demonstrated that Bentazone concentrations significantly impacted the control efficacy of wild radish (*Raphanus raphanistrum*). (The 150% dosage yielded the highest control rate at 89.72%, significantly surpassing the 100% recommended rate which recorded 74.70%. Although no significant differences were observed between varieties as a general mean, the interaction between

varieties and herbicide levels was significant; this suggests that the herbicide's effectiveness in eliminating wild radish was co-dependent on both the cultivated variety and the applied dose.

The control percentage reflects the potency of the experimental treatments in reducing weed populations within the field. These results are in alignment with the findings of Al-Obaidi (2015) and Al-Kilani (2018).

Table 2: Effect of Bentazone spray, varieties and their interaction on the control percentage of wild radish (*Raphanus raphanistrum*) (%).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	0.00 c	87.78 a	90.28 a	59.4 a
Egyptian	0.00 c	61.50 b	89.17 a	50.2 a
Mean	0.00 c	74.70 b	89.72 a	

"Treatments followed by the same letter do not differ significantly at the 5% probability."

3.3. Plant Height (cm)

Data summarized in Table (3) revealed no significant differences between the varieties regarding plant height. On the other hand, the statistical analysis indicated significant variations among the herbicide concentration means. The 100% (recommended) concentration shows superiority reaching a maximum height of 65.25 cm. while the 150% dosage resulted in the lowest average height (36.05 cm), compared to 51.36 cm in the control treatment. The ideal height founded at the 100% concentration may attributed to the effective balance between weed control efficacy and crop safety. while the sharp decline in height at the 150% concentration is might likely due to the phytotoxic effects on the broad bean plants, despite successful weed suppression. for the control treatment, the reduced height compared to the

100% dose is a direct consequence of intense weed competition for growth resources. (Salih, 2020) [17].

As for the two-way interaction indicates the superiority of the Iraqi variety by treated with the 100% concentration recording the highest plant height (68.33 cm). This may cause by the efficacy of this concentration in eliminating environmental competition, which aligns with the results of Wakweya et al. (2017) [23] regarding the role of weed control in enhancing the crop's biological activities. In contrast, the 150% concentration caused severe growth inhibition in both varieties due to chemical stress leading to a significant reduction in plant height to its lowest levels. This may indicate that increasing the Bentazone dosage beyond the recommended rate exceeds the phytotoxicity threshold for the crop.

Table 3: Effect of Bentazone spray, varieties and their interaction on the plant height of broad bean (cm).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	52.74 c	68.33 a	37.25 d	52.77 a
Egyptian	49.97 c	62.18 b	34.86 d	49.00 a
Mean	51.36 b	65.25 a	36.05 c	

*Treatments followed by the same letter do not differ significantly at the 5% probability.

3.4. Number of Leaves (leaves plant⁻¹)

Results in Table (4) indicated that the evaluated varieties did not differ significantly in terms of leaf number. As for the herbicide concentrations showed a significant impact. The 100% (recommended) rate achieved the highest average (13.60 leaves plant⁻¹), It might be facilitated by effective weed suppression and the provision of an optimal growth environment. On the other had the 150% concentration recorded the lowest mean (6.12 leaves plant⁻¹). This drastic reduction is may likely attributable to the phytotoxic effect of the herbicide which caused vegetative damage and growth stunting. This negative impact surpassed the reduction has seeing in the control treatment (8.53 leaves plant⁻¹). where

the decline may be solely due to weed competition.

As for the two-way interaction, the Egyptian variety exhibited superiority at the 100% concentration by recording the maximum leaf count (13.90 leaves plant⁻¹). the Iraqi variety at the 150% dosage yielded the lowest value (5.45 leaves plant⁻¹). This substantial decline Confirms the findings of Singh and Wright (2019) [21], who mentioned that excessive Bentazone dosages induce phytotoxicity, which inhibits vital biological processes. Such inhibition may adversely impact leaf initiation and overall vegetative development.

Table 4: Effect of Bentazone spray, varieties and their interaction on the number of leaves (leaves plant⁻¹).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	9.65 b	13.30 a	5.45 d	9.47 a
Egyptian	7.41 c	13.90 a	6.80 cd	9.37 a
Mean	8.53 b	13.60 a	6.128 c	

*Treatments followed by the same letter do not differ significantly at the 5% probability

3.5. Number of Branches (branches plant⁻¹)

Statistical analysis results in Table (5) declares no significant differences between the varieties regarding the number of branches per plant. while herbicide concentrations had a significant impact by applying the 100% concentration was superior recording the highest mean of 4.80 branches plant⁻¹. This enhancement is may likely attributed to the herbicide's efficiency in eliminating weed competition, thereby providing ideal nutritional and light conditions that stimulated lateral branching. On the other hand, the 150% concentration yielded the lowest average (2.57 branches plant⁻¹). This decline is might due to the phytotoxicity of the overdose, which may inhibit photosynthetic efficiency and

restricts lateral bud activity. These results align with Khan et al. (2020) [10], who reported that supra-optimal doses of selective herbicides cause stunting and a reduction in branching within legume crops.

As for the two-way interaction, the Egyptian variety shows superiority for the trait at the 100% concentration, resulting the maximum branching rate (5.03 branches plant⁻¹). while the 150% dosage yielded the lowest values for both varieties. This superiority of the Egyptian variety within the interaction could be attributed to its high competitive ability and compatibility with the recommended dose, which made a better expression of its productive potential in branching compared to the Iraqi variety under same conditions.

Table 5: Effect of Bentazone spray, varieties and their interaction on the number of branches (branches plant⁻¹).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	3.067 b	4.567 ab	2.167 d	3.267 a
Egyptian	3.233 bc	5.033 a	2.967 cd	3.744 a
Mean	3.150 b	4.800 a	2.567 c	

*Treatments followed by the same letter do not differ significantly at the 5% probability

3.6. Dry Weight of Broad Bean (g plant⁻¹)

Results in Table (6) indicated no significant differences among the varieties regarding dry weight. while herbicide concentrations significantly influenced this trait. with the application of 100% (recommended) rate achieving the highest mean for the trait of 31.26 g plant⁻¹. This increase may reflect the vital role of weed management in enhancing dry matter accumulation by improving photosynthetic efficiency and carbohydrate distribution. As for the 150% concentration recorded the lowest average (10.13 g plant⁻¹).

This sharp decline is may cause by the severe phytotoxicity, which destroys chloroplast membranes and inhibits dry matter biosynthesis. These findings are similar with Senseman (2007)^[19], who observed that excessive Bentazone dosages cause extensive necrotic damage to the vegetative system.

As for the two-way interaction, the 100% concentration treatments for both Egyptian and Iraqi varieties achieved the highest dry weight values by recording 30.73 and 31.78 g plant⁻¹ respectively.

Table 6: Effect of Bentazone spray, varieties and their interaction on the dry weight of broad bean (g plant⁻¹).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	17.900 b	31.780 a	8.200 d	17.18 a
Egyptian	16.770 b	30.733 a	12.050 c	19.85 a
Mean	17.330 b	31.257 a	10.130 c	

*Treatments followed by the same letter do not differ significantly at the 5% probability.

3.7. Number of Pods (pods plant⁻¹)

Results in Table (7) refers for no significant differences between the varieties regarding the number of pods per plant. This suggests that pod number is more influenced by environmental factors and herbicide application than by the genetic makeup of the variety alone. while herbicide concentrations had a significant impact for the application of 100% concentration which achieved the highest pod count (6.23 pods plant⁻¹). while the 150% dosage resulted the lowest average (3.17 pods plant⁻¹). compared to 4.49 pods plant⁻¹ recorded by the control treatment. The superiority of the recommended dose may be attributed to enhanced vegetative growth and increased the count of branches, which may be positively influenced the number of flowering nodes as pods represent the final output of photosynthetic efficiency. As for the decline at the 150% concentration is might due to severe phytotoxicity that induced flower abortion and the shedding of newly formed pods. These results align with Saber et al. (2018)^[16], who noted that

herbicide toxicity reduces pod numbers in legumes by adversely affecting pollen fertility. The reduction in pod number within the control treatment may be attributed to early weed emergence and high weed density which intensified competition for environmental resources (nutrients, water, and light, etc.). This competition Drained the available carbohydrates required during the critical flowering stage and leading to flower abortion or failure of pod setting post-pollination, may cause reducing the final pod count. These observations are consistent with Jones et al. (1999)^[9].

As for the two-way interaction cleared a significant difference. The Egyptian and Iraqi varieties treated with the 100% concentration application achieved the highest pod numbers by recording 6.43 and 6.03 pods plant⁻¹ respectively. while the control treatment for the Iraqi variety recorded a reduction to 3.66 pods plant⁻¹ whereas the 150% concentration application treatments recorded the minimum values due to the herbicide's phytotoxic effects.

Table 7: Effect of Bentazone spray, varieties and their interaction on the number of pods of broad bean (pods plant⁻¹).

Variety	Bentazone Concentration %			
	0	100	150	Mean
Iraqi	3.663 c	6.03 a	3.143 d	4.279 a
Egyptian	5.320 b	6.433 a	3.187 d	4.980 a
Mean	4.492 b	6.232 a	3.165 c	

*Treatments followed by the same letter do not differ significantly at the 5% probability.

Conclusions

1. Applying Bentazone at the recommended rate (100%) achieved an ideal balance between controlling broadleaf weeds (*E. sativa* and *R. raphanistrum*) and crop safety providing enhanced growth and yield traits.
2. Applying Herbicide overdose (150% concentration) may Stimulated severe phytotoxicity, characterized by growth Inhibiting, reduced number of leaf and flower abortion, resulting in a significant decline in dry weight and yield components.

3. The Egyptian variety showed relatively higher tolerance to excessive doses compared to the Iraqi variety, which recorded greater sensitivity to chemical stress.

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