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PERFORMANCE OF SOME FABA BEAN CULTIVARS UNDER NUMEROUS BROOMRAPE CONTROL TREATMENTS

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ABSTRACT

A-two experiments were conducted at Sakha Agricultural Research Station during the 2023/2024 and 2024/2025 seasons to assess the effect of different control methods on broomrape infestation in some faba bean cultivars to improve seed yield and net return in areas with high levels of broomrape infestation. The study involved combining four faba bean cultivars (Misr 3, Misr 1, Giza 843 and Sakha4) with four control methods (glyphosate twice, glyphosate once + bio-fertilizer once, bio-fertilizer twice, and untreated control), arranged in a split-plot design with three replications. The cultivars were randomly assigned to the main plots, while control methods were allocated in sub plots. Misr 1 and Misr 3 faba bean cultivars showed better tolerance to broomrape infestation fouled by Giza 843, as compared to Sakha 4. Using glyphosate once + bio-fertilizer once and glyphosate at a twice resulted in lower broomrape spike numbers and weights per m^2 compared to other treatments. Misr 3 and Misr 1 cultivars also showed higher seed yield and yield components compared to other cultivars. Application glyphosate once +bio-fertilizer once resulted in number of pods per plant, seed yield per plant, and seed yield per hectare compared to other control methods. Application with glyphosate once +bio-fertilizer once resulted in higher seed yield and yield components for Misr 3 and Misr 1 compared to other treatments. There was a high negative correlation between the number and dry weight of broomrape spikes per m^2, and each of the number of pods per plant, seed yield per plant, and seed yield per hectare. Misr 3 and Misr 1 showed the highest profitability with the application of glyphosate once and bio-fertilizer once. Growing faba bean cultivars Misr 3 and Misr 1 with application of application with glyphosate once + bio-fertilizer once reduced number and dry weight of broomrape spikes and improved their yields achieving higher profitability under naturally infested soil with broomrape.

Key words: ***Faba bean cultivars, Broomrape infestation, Control methods, correlation, Net return.***

INTRODUCTION

Faba bean is recognized as a valuable source of protein, starch, cellulose, and essential micro nutrients for human consumption in developing nations and as feed for livestock in developed countries (Haciseferogullari *et al* 2003 and Crépon *et al* 2010). However, the cultivated area of faba beans in Egypt decreased to, approximately 47,000 hectares in 2023, with an average yield of 3.42tons per hectare (Bulletin of Statistical Cost Production and Net Return, 2023).

The productivity of faba bean highly decreases because of broomrape infestation, with 50% reduction in severe infestations (Mesa-Garcia and Garcia-Torres, 1984). Hassanein *et al* (1998) indicated that one

Orobanche spike/plant can reduce faba bean seed yield by 15%, and four spikes / plant can reduce seed yield by 55%.

However, faba bean varieties vary in their response to broomrape infestation. Nassib (1982) indicated that *Orobanche* infested faba bean plants were lower in Giza 402 cultivar compared to Rebaya 40, Giza 2 and Giza 4 cultivars which exhibited more tolerance to broomrape infestation. Khalil (1983) proved that Giza 402 cultivar was tolerant to *Orobanche* infestation with almost one metric ton of seed/ha. Gadalla *et al* (2010) found that Giza 3 was susceptible cultivar while Giza 843 was tolerant to *Orobanche* infestation. Amer *et al* (2012) revealed that faba bean varieties differed significantly in yield and yield attributes. Ismail (2013) found that Misr1 faba bean variety Misr1 reduced the dry weight of *Orobanche* spikes by about 17.0%, while Ghalwach *et al* (2008) reported that the sane variety reduced the spikes by about 27.00 – 43.00%, weight of broomrape spikes/ m^2 by about 20%; spikes length by20% and number of capsules/spikes by 28.00 - 42.65%. Also, faba bean variety, Misr 1 recorded the highest values of yield and its components followed by Giza 843 variety as compared to Sakha 2 variety. Eid *et al* (2017) found that faba bean varieties; Misr 3 and Giza 843 exhibited significant decrease in numbers and weight of broomrape spikes, and both varieties exhibited higher faba bean yield and yield components as compared to Giza 3.

Broomrape infestation can cause complete crop failure in heavily affected areas of Middle and Upper Egypt, with *Orobanche* spp. infestation rates reaching 90 to 100% (Anonymous, 2004). Therefore, it is crucial to address this problem as Egypt has limited land and water resources.

Various studies have demonstrated effective methods to combat broomrape in faba bean production, including the use of tolerant cultivars, mineral nitrogen (N), glyphosate, or algae fertilizer. By implementing these strategies, farmers in Egypt can increase yields and minimize the negative impact of broomrape on faba bean yield. Using tolerant cultivars is a cost-effective and eco-friendly way to control broomrape. Studies by Elsakhawy *et al* (2016) and Abdel-Wahab and Abdel-Wahab (2021) emphasize the importance of using tolerant faba bean cultivars to manage broomrape

infestations. Also, Tantawy *et al* (2022) found that faba bean cultivar Giza 843 exhibited significantly higher tolerance to broomrape compared to other cultivars, with fewer broomrape spikes per m^2 and lower dry weight of broomrape spikes per m^2. Giza 843 consistently demonstrated exceptional qualities in both seasons. In contrast, Giza 716 was highly susceptible to broomrape infestation. Meanwhile, adding 10 and 20 kg N/fed decreased broomrape infestation by 22.3 and 43.9%, respectively, according to Ismail (2013). On the other hand, the optimal yield of broad bean pods was achieved with two or three applications of 150 g/ha glyphosate (Jacobsohn and Kelman, 1980). Also, Tantawy *et al* (2022) revealed that foliar spraying with glyphosate on faba bean leaves significantly reduced broomrape infestation (spikes/m^2) and dry weight of broomrape spikes (g/m^2), resulting in superior outcomes compared to other control methods in both seasons. With respect to algae fertilizer, it release allopathic compounds that directly affect broomrape plants by inhibiting germination and attachment, leading to a decrease in the number of broomrape plants parasitizing faba bean crops (Rubiales *et al* 2009).

Therefore, the aim of this study was to assess the effect of different control methods on broomrape infestation in some faba bean cultivars to improve seed yield and net return in areas with high levels of broomrape infestation. Determining the most effective approach, farmers can increase their yields and improve overall faba bean production.

MATERIALS AND METHODS

The experiments took place at the Sakha Research Station, Agricultural Research Center (ARC) during the 2023/2024 and 2024/2025 seasons. The aim of this study was to assess the effect of different treatments on *Orobanche* in faba bean to improve seed yield and net return. Four faba bean cultivars Misr 3, Misr 1, Giza 843 and Sakha 4 were used (Table 1) the treatments of *Orobanche* were (glyphosate twice, glyphosate once + bio-fertilizer once, bio-fertilizer twice and untreated control). The treatments were laid out in a split plot design with three replications. Faba bean cultivars were randomly assigned to the main plots, and *Orobanche* treatments were allocated in sub-plots. Each plot had an area of was 10.5 m^2 contains five rows 3.5 m length and 60 cm apart. Names and

pedigrees of the faba bean cultivars under investigation were provides at Table (1).

Table 1. Common names and pedigrees of the studied faba bean cultivars

Common name	Pedigree	*Orobanche spp* reaction
Misr 3	**L.667 X (C. 241 X G. 461)**	**Tolerant**
Misr 1	**Derived from (Giza 3 x 123A/45/76) x (62/1570/66/G.2) x (Romi x Habashi)**	**Tolerant**
Giza 843	**Cross 461 x Cross 561**	**Tolerant**
Sakha 4	**Sakha 1 x Giza 3**	**Susceptible**

Soil samples were collected from each location at a depth of 0–30 cm in areas with high levels of broomrape infestation. Mechanical and chemical properties of the soil (Table 2) were conducted following the methodology outlined by Black (1965).

Table 2. Mechanical and chemical properties of the soil at the experimental site in both seasons.

Seasons	Particle size distribution			Soil texture	Chemical analyses					
	Sand%	Silt%	Clay%		EC (dsm^{-1}) (1:5)	pH (1:1)	Organic matter%	Available (mg kg^{-1})		
								Total N (%)	P (ppm)	K (ppm)
2023/24	**9.18**	**27.26**	**63.56**	**Clay**	**2.22**	**7.79**	**1.62**	**25.66**	**9.11**	**261**
2024/25	**9.02**	**25.94**	**65.04**	**Clay**	**2.27**	**7.87**	**1.35**	**26.10**	**8.98**	**237**

The faba bean cultivars were planted on October 20th and 18th in 2023/24 and 2024/25, respectively. The plants were grown in one row in 60 cm wide ridges with two plants per hill spaced 25 cm apart. Furrow irrigation was utilized in the region, and all recommended cultural practices were followed.

***Orobanche* control treatments were as follows**

1- Glyphosate 48% WSC, at a rate of 178.5 cm^3/hectare, applied twice. The first application was done at the beginning of flowering faba bean and the second application was done 21 days later.

2- Glyphosate at a rate of 178.5 cm^3/hectare, applied once at the beginning of flowering faba bean followed by the application of bio-fertilizer by 1.0 cm per liter, with a total of 4.76 liters per hectare, at 50 days after planting.
3- Bio-fertilizer by 1.0 cm per liter, with 4.76 liters per hectare, twice, at 30 and 50 days after sowing.
4- Untreated (control)

Biogreen Power "Egyptian Algae Tech". This fertilizer is made from pure algae. For foliar spraying, concentrations of the plants from each treatment were sprayed. One bottle of Egyptian Algae Tech contains N "0.8%", P_2O_5 "1.5%", K_2O"1.5%", CaO "0.4%", MgO "0.25%", S "0.8%", Fe "1000 ppm", Zn "1000 ppm", Mn "500 ppm", Cu "100 ppm", B "100 ppm", and Mo "250 ppm".

The recorded data

1. **Broomrape infestation**

- Broomrape spike length (cm).
- Number of broomrape spikes/m^2.
- Dry weight of broomrape spikes/m^2 (g).

2. **Seed yield and yield components**

At harvest, five plants of faba bean were chosen randomly from each plot to estimate the following traits:

- Plant height (cm).
- Number of pods per plant.
- Seed yield per plant (g).
- Seed yield per plot (kg), which was adjusted to ton per hectare.

3. **Correlation coefficients**

Simple correlation coefficients were calculated among the number and dry weight of broomrape spikes per plot and faba bean traits following the method outlined by Draper and Smith (1966).

4. **Economic evaluation**

Farmers' profits were used to compare costs and returns amongst broomrape control treatments. Production costs of faba bean per hectare were estimated according to Bulletin of Statistical Cost Production and Net Return (2023).

- **Financial costs (USD/ha):** land preparation, seeding & planting, irrigation, labor and crop field service treatment, cost of harvesting, transporting the crop were estimated. Costs of bio-fertilization, mineral-N fertilization and glyphosate were computed.

- **Gross returns (USD/ha)** = (yield (ton/fed) x price of ton) + (Straw yield (ton/fed) x price of ton (L.E.))

- **Net returns (USD/ha)** were calculated by subtracting the cost of plant protection along with other costs (USD/ha) from the gross returns.

- **Benefit cast (B: C ratio) =** [gross returns (USD/ha)/financial costs (USD/ha)] x 100.

5. Statistical analysis:

- The measured variables were analyzed by ANOVA using the MSTATC statistical package (Freed, 1991). The least significant differences (L.S.D) test at a significance level of 5% (Gomez and Gomez, 1984) was calculated.

RESULTS AND DISCUSSION

Effect of faba bean cultivars on broomrape

Tolerance levels, as indicated by the spikes length (cm), number of broomrape spikes/$m^2$and dry weight of broomrape spikes /m^2, varied significantly among the faba bean cultivars in both seasons (Table 3).Misr 3 and Misr 1 exhibited lower number of broomrape spikes/m^2 and dry weight of broomrape spikes /m^2, followed by Giza 843, as compared to Sakha 4 in both seasons (Table 3).

Cultivars Misr 3, Misr 1 and Giza 843 recorded the highest reduction percentages on broomrape spikes length, No. of broomrape spike/ m^2, and broomrape dry weight (g/m^2) in both sowing seasons. Which recorded for broomrape spikes length by (25.98, 19.03 and 5.99%), No. of broomrape spikes/ m^2 by (62.41, 57.02 and 35.06%) and broomrape dry weight by (66.82,62.78 and 46.76%), in the first season, respectively, as compared with the susceptible cultivar Sakha 4.The results had the same trend in the second season. The deficiency may be due to the lateness of *Orobanche* attachment to faba bean plants and its delay germination above soil surface and consequently partially escaped from the injury of broomrape.

Table 3. Effect of faba bean cultivars on broomrape spikes during 2023/24 and 2024/25 seasons

Cultivars	Spikes Length (cm)		No spikes m^{-2}		Dry weight spikes (g m^{-2})	
	First season	Second season	First season	Second season	First season	Second season
Misr 3	**74.87**	**63.5**	**27.25**	**33.50**	**113.12**	**82.00**
Misr 1	**81.9**	**78.8**	**31.16**	**30.58**	**126.91**	**80.91**
Giza 843	**95.09**	**91.5**	**47.08**	**36.75**	**181.55**	**87.08**
Sakha 4	**101.15**	**105.7**	**72.50**	**64.08**	**341.02**	**161.87**
L.S.D.$_{0.05}$	**6.71**	**5.98**	**7.18**	**19.59**	**64.05**	**59.16**

Further investigation is required to identify the specific factors contributing to this difference in susceptibility. Meanwhile, the field showed high and consistent levels of broomrape infestation with Sakha 4, indicating potential vulnerability of these cultivars to the parasite. Misr 3 and Misr1 can offer better tolerance to broomrape infestation compared to Giza 843 and Sakha 4. These results are in accordance with Safina (2017) who found that faba bean cultivar Giza 843 was infested by the lower number of broomrape than Giza 2 cultivar. Also, Abdel-Wahab and Abdel-Wahab (2021) found that faba bean cultivar Nubaria 2 was infested by the lower number of broomrape than Nubaria 1 cultivar.

Effect of weed control methods on broomrape

Data in Table (4) showed that control methods significantly affected spikes length (cm), number of broomrape spikes/m^2 and dry weight of broomrape spikes /m^2, in both seasons. Application of glyphosate once + bio-fertilizer once and glyphosate twice and bio-fertilizer twice resulted in lower spikes length (cm), number of number of broomrape spikes/m^2 and dry weight of broomrape spikes /m^2 as compared to the untreated control treatment in both seasons.

The view in the number of *(O. crenata)* spikes/plant was observed with application of glyphosate once + bio-fertilizer once and the glyphosate twice as compared to the control treatment in both seasons. In first season the reduction in No. of broomrape/$m^2$was significant and amounted to (38.74, 56.67, 45.18 and 58.62%) for of glyphosate once + bio-fertilizer

once and (26.14, 29.15, 30.89 and 51.44%) for glyphosate twice treatment as compared to untreated control, respectively. The results had the same trend in the second season. These findings indicate that glyphosate treatment has immediate effects on broomrape when it is in its underground stage. Glyphosate disrupts the parasite's growth by inhibiting the production of essential amino acids. Additionally, incorporating bio-fertilizer into faba bean plants enhances resistance to broomrape infestation and promotes overall plant growth. This integrated approach offers a sustainable solution for managing broomrape in faba bean crops. Glyphosate, being a systemic herbicide, is absorbed by the plant and distributed throughout its tissues, effectively eliminating the broomrape. Furthermore, the use of biological fertilizer improves nutrient uptake and soil health in faba bean plants. This combined strategy not only directly targets the parasite but also boosts the plant's ability to withstand future infestations. These results are in harmony with Abd-El-Haleem *et al* (2019) who found that fertilizers reduced significantly broomrape infestation by decreasing number and dry weight of spikes per plot. Also, revealed that glyphosate at rate twice and glyphosate once rate + Salicylic acid once decreased number and dry weight of spikes per plot.

Table 4. Effect of weed control treatments on broomrape spikes during 2023/24 and 2024/25 seasons.

Treatments	Spikes Length (cm)		No of spikes m^{-2}		Dry weight spikes (g m^{-2})	
	First season	Second season	First season	Second season	First season	Second season
Glyphosate 48% WSC) twice, with 178.5 cm/hectare	77,4	74.7	43.53	37.52	170.98	92.63
Glyphosate 48% WSC) once, with 178.5 cm/hectare + Bio-fertilizer once, with 4.76 liters/hectare	64.2	66.7	34.53	34.93	145.68	83.30
Bio- fertilizer, twice, with 4.76 liters/hectare	94.2	92.3	55.46	39.79	261.97	100.06
Untreated (control)	104.8	101.7	62.99	73.99	352.11	185.40
L.S.D.$_{0.05}$	7.35	6.39	8.71	13.04	37.83	37.39

The interaction between faba bean cultivars and control methods on broomrape:

Table (5) indicated that the interaction between faba bean cultivars and control methods significantly affected spikes length (cm), number of broomrape spikes/m^2 and dry weight of broomrape spikes/m^2in both seasons.

Table 5. Effect of interaction between faba bean cultivars and weed control treatments on broomrape Spikes during 2023/24 and 2024/25 seasons.

Cultivars	Treatments	Spikes length (cm)		No spikes (m^{-2})		Dry weight spikes (gm^{-2})	
		First season	Second season	First season	Second season	First season	Second season
Misr 3	Glyphosate 48% WSC twice	89.1	91.8	25.00	32.33	106.66	77.50
	Glyphosate once + Bio-fertilizer once	81.7	84.0	21.66	30.66	100.00	75.83
	Bio-fertilizer twice	108.4	94.8	29.66	33.33	119.16	80.50
	Untreated (control)	110.3	103.9	32.66	37.66	126.66	94.16
Misr 1	Glyphosate 48% WSC twice	82.2	82.8	31.00	28.33	123.33	76.50
	Glyphosate once + Bio-fertilizer once	84.3	79.6	27.33	27.33	110.00	70.50
	Bio-fertilizer twice	94.3	86.6	31.66	29.00	127.66	81.83
	Untreated (control)	102.2	96.3	34.66	37.66	146.66	94.83
Giza 843	Glyphosate 48% WSC twice	87.7	82.6	38.33	36.66	136.96	83.33
	Glyphosate once + Bio-fertilizer once	71.6	69.8	38.00	35.00	129.03	80.63
	Bio-fertilizer twice	85.9	80.6	43.66	36.66	160.00	86.33
	Untreated (control)	97.8	82.7	68.33	38.66	300.23	98.03
Sakha 4	Glyphosate 48% WSC twice	83.8	87.2	61.66	48.66	244.66	121.66
	Glyphosate once + Bio-fertilizer once	72.7	69.7	39.00	45.00	208.40	104.16
	Bio-fertilizer twice	79.7	76.2	91.00	50.00	374.03	140.00
	Untreated (control)	96.2	99.5	98.33	112.66	537.00	281.66
L.S.D.$_{0.05}$		23.24	22.14	0.882	31.25	94.19	90.90

Application glyphosate once + bio-fertilizer once and glyphosate twice resulted in lower spikes length (cm), number of broomrape spikes/m^2 and dry weight of broomrape spikes/m^2on faba bean cultivars Misr 3 and Misr 1 compared to other treatments. In contrast, the untreated control treatment on faba bean cultivars Sakha 4 showed higher spikes length (cm), number of broomrape spikes/m^2 and dry weight of broomrape spikes /m^2, than the other treatments. These findings suggest that the combination of glyphosate and bio-fertilizer could be an effective method for controlling broomrape in faba bean cultivars Misr 3 and Misr 1. Further research may be necessary to explore alternative methods for managing broomrape in faba bean cultivars Sakha 4. Overall, the results indicate that different cultivars may exhibit varying responses to different control methods for broomrape.

Effect of faba bean cultivars on yield and its components

Results in Table (6) showed that faba bean cultivars exhibited significant differences in seed yield and yield components in both seasons. Misr 3 and Misr 1 cultivars showed higher values for plant height, number of pods per plant, seed yield per plant, and seed yield per hectare compared to other faba bean cultivars in both seasons. Misr 3 had plant heights of 125.83 and 122.50 cm in the first and second seasons, respectively, while Misr 1 had heights of 121.66 and 117.08 cm in the first and second seasons, respectively. These results may be attributed to genetic variations that influence the number of nodes and internode length throughout the growing seasons.

In terms of the number of pods per plant, Misr 3 had 6.31 and 7.24 pods in the first and second seasons, respectively, while Misr 1 had 6.11 and 6.12 pods in the first and second seasons, respectively.

For seed yield per plant, Misr 3 produced 14.66 and 16.90 g in the first and second seasons, respectively, while Misr 1 yielded 13.95 and 14.05 g in the first and second seasons, respectively.

Regarding seed yield per hectare, Misr 3 yielded 3.95 and 4.53 tons in the first and second seasons, respectively, while Misr 1 yielded 3.42 and 4.23 tons in the first and second seasons, respectively. Giza 843 ranked second in performance, while Sakha 4 cultivars had lower values for these traits in both seasons. Misr 3 and Misr 1 outperformed Sakha 4 in terms of

seed yield and yield components, with Giza 843 also showing strong performance. This superiority is attributed to the tolerance of Misr 3, Misr 1, and Giza 843 to broomrape infestation, resulting in better growth, development, and higher seed yield per hectare.

Table 6. Effect of faba bean cultivars on yield and its components during 2023/24 and 2024/25 seasons.

Cultivars	Plant height (cm)		Number of pods/ plant		Seed yield/plant (g)		Seed yield/hectare (ton)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Misr 3	125.83	122.50	6.31	7.24	14.66	16.90	3.95	4.53
Misr 1	121.66	117.08	6.11	6.12	13.95	14.05	3.42	4.23
Giza 843	118.32	114.16	4.63	4.40	11.76	8.96	3.30	3.98
Sakha 4	89.58	76.25	2.60	2.01	6.67	4.55	1.06	1.18
$L.S.D._{0.05}$	7.86	8.59	1.17	2.00	1.54	4.73	0.43	0.30

The genetic makeup of these cultivars may play a key role in their consistent high seed yield across different seasons. Further research could explore the specific genetic factors that contribute to the superior performance of Misr 3, Misr 1, and Giza 843 compared to Sakha 4. Conversely, Sakha 4 consistently showed lower values due to higher broomrape infestation, which hindered their growth and development, resulting in lower seed yield per hectare. The differences in performance among cultivars underscore the importance of selecting broomrape-tolerant cultivars for optimal productivity in faba bean cultivation. These results are in harmony with Abdel-Wahab and Abdel-Wahab (2021) who found that Nubaria 2 had higher seed yield and yield components than Nubaria 1. Also, Abo-Hegazy and Darwish (2022) found that the performance of the tested faba bean cultivars varied significantly in terms of seed yield and yield components.

Effect of weed control methods on yield and its components

Control methods had a significant impact on seed yield and yield components in both seasons, except for plant height in the second season (Table 7). The application with glyphosate once + bio-fertilizer once

resulted in higher numbers of pods per plant, seed yield per plant, and seed yield per hectare as compared to other control methods in both seasons. This combination showed positive effects on the number of pods per plant. Specifically, this combination led to a 17.58, 52.11, and 75.84% increase in the number of pods per plant compared to the application with glyphosate twice, the application of bio-fertilizer at rate twice, and the untreated control treatment, respectively, in the first season.

Table 7. Effect of weed control treatments on yield and its components during 2023/24 and 2024/25 seasons.

Treatments	Plant height (cm)		Number of pods per plant		Seed yield/plant (g)		Seed yield/hectare (ton)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Glyphosate 48% WSC) twice, with 178.5 cm/hectare	120.99	101.66	4.89	4.32	12.32	10.95	2.96	3.41
Glyphosate 48% WSC) once, with 178.5 cm/hectar + Bio-fertilizer once, with 4.76 liters per hectare	115.33	104.33	5.75	5.87	14.36	13.05	3.13	3.68
Bio-fertilizer twice, with 4.76 liters per hectare	110.66	104.33	3.78	4.07	8.38	9.37	2.17	2.63
Untreated (control)	104.99	103.33	3.27	3.55	7.89	6.94	1.90	2.44
L.S.D.$_{0.05}$	4.92	Ns	0.78	1.04	1.58	2.92	0.35	0.18

In the second season, these increases were 35.87, 44.22%, and 65.35% compared to the same control methods. Application glyphosate once + bio-fertilizer once also resulted in a 16.55, 71.36, and 82.00% increase in seed yield per plant compared to the glyphosate twice, the application of bio-fertilizer twice and the untreated control treatment, respectively, in the first season. In the second season, these increases were 19.17, 39.27%, and 88.04% compared to the same control methods. Overall, Application glyphosate once + bio-fertilizer once rate significantly

improved seed yield per plant compared to application of glyphosate twice, application of bio-fertilizer twice, and the untreated control treatments in both seasons. Additionally, Application glyphosate once + bio-fertilizer once led to a 5.74, 44.23, and 64.73% increase in seed yield per hectare compared to the application glyphosate twice, the application of bio-fertilizer twice and the untreated control treatment, respectively, in the first season.

In the second season, these increases were 7.91, 39.92, and 50.81% compared to the same control methods. These results highlight the positive impact of combining glyphosate and bio-fertilizer on seed yield per hectare over multiple seasons. The findings suggest that a one-time application of both products can significantly increase the number of pods per plant and seed yield per plant, ultimately improving overall crop productivity. The application with glyphosate at rate twice did not increase faba bean yield, suggesting that the herbicides were still causing physiological disorders in the plant that counteracted the positive effects of broomrape control on faba bean performance. Previous studies by López-Bellido *et al* (2019) and Tantawy *et al* (2022) have shown that glyphosate application can actually increase faba bean seed yield.

Effect of interaction between faba bean cultivars and control methods on yield and its components

Results in Table (8) indicated that the interaction between control methods and faba bean cultivars had a significant impact on seed yield and yield components in both seasons. Application glyphosate once + bio-fertilizer once resulted in higher seed yield and yield components for Misr 3, also, Misr 1 showed improved seed yield and yield components when treated with this combination, as compared to untreated control. These results were attributed to a lower number and dry weight of broomrape spikes per m^2 (Table 3), which was caused by glyphosate, and the enhancement of nutrient uptake and growth of faba bean cultivars Misr 3 and Misr 1 by the bio-fertilizer in combination with glyphosate. Giza 843, also demonstrated promising results, suggesting increased productivity potential with this combination. In contrast, faba bean cultivars Sakha 4 exhibited lower seed yield and yield components under all control methods.

These findings suggest that Sakha 4 may not respond as favorably to the combination of glyphosate and bio-fertilizer as Misr 3, Misr 1, and Giza 843, beside the other control methods. Further research may be necessary to determine the most effective treatment for these specific cultivars.

Table 8. Effect of interaction between cultivars and weed control treatments on yield and its components during 2023/24 and 2024/25 seasons.

Cultivars	Treatments	Plant height (cm)		Number of pods per plant		Seed yield/plant (g)		Seed yield/hectare (ton)	
		First season	Second season	First season	Second season	First season	Second season	First season	Second season
Misr 3	Glyphosate 48% WSC twice	131.66	125.00	6.47	6.60	15.26	19.80	4.34	4.48
	Glyphosate once + Bio fertilizer once	125.00	118.33	7.26	9.93	15.73	19.93	4.33	4.99
	Bio-fertilizer twice	126.66	130.00	6.27	6.50	14.53	14.80	3.74	4.40
	Untreated (control)	120.00	116.66	5.24	5.93	13.13	13.06	3.37	4.25
Misr 1	Glyphosate 48% WSC twice	126.66	113.33	6.20	6.33	13.73	15.23	3.66	4.33
	Glyphosate once + Bio-fertilizer once	120.00	128.33	7.10	6.96	15.06	16.10	3.69	4.48
	Bio-fertilizer twice	120.00	110.00	5.73	5.73	13.63	13.96	3.29	4.11
	Untreated (control)	120.00	116.66	5.43	5.46	13.36	10.93	3.05	4.02
Giza 843	Glyphosate 48% WSC twice	121.66	103.33	5.33	4.60	12.13	9.03	3.37	4.11
	Glyphosate once + Bio-fertilizer once	121.66	123.33	5.59	5.33	17.83	10.43	4.06	4.16
	Bio-fertilizer twice	113.33	106.66	4.33	4.00	8.76	8.46	2.95	3.88
	Untreated (control)	116.66	123.33	3.26	3.66	8.34	7.93	2.81	3.79
Sakha 4	Glyphosate 48% WSC twice	95.00	80.00	3.40	1.58	10.25	4.35	1.81	2.08
	Glyphosate once + Bio-fertilizer once	91.66	63.33	4.40	3.53	11.56	8.73	1.85	2.26
	Bio-fertilizer twice	90.00	86.66	1.33	1.65	2.44	3.65	0.44	0.30
	Untreated (control)	81.66	75.00	1.26	1.30	2.43	1.50	0.16	0.09
L.S.D.$_{0.05}$		12.03	13.13	1.88	2.72	3.48	5.34	0.62	0.45

Correlation coefficient

The correlation coefficients among the number and weight of broomrape spikes/$m^2$and faba bean traits are presented in Table (9). The results indicate a high positive correlation between the number of broomrape spikes/m^2 and the dry weight of broomrape spikes/m^2 (r = 0.939**).

Table 9. Correlation coefficients among the number and dry weight of broomrape spikes and faba bean traits, combined data of both seasons.

Traits	Number of broomrape spikes/m^2	Dry weight of broomrape spikes/m^2	Plant height	Number of pods per plant	Seed yield per plant	Seed yield per hectare
Number of broomrape spikes/m^2	**1**					
Dry weight of broomrape spikes/m^2	**0.939****	**1**				
Plant height	**-0.272**	**-0.369**	**1**			
Number of pods per plant	**-0.733***	**-0.787***	**0.416**	**1**		
Seed yield per plant	**-0.897****	**-0.921****	**0.383**	**0.927****	**1**	
Seed yield per hectare	**-0.851****	**-0.838****	**0.209**	**0.879****	**0.943****	**1**

*** and **: Significant at 0.05 and 0.01 probability level, respectively.**

There is a negative correlation between the number of broomrape spikes/m^2 and the number of pods per plant (r = -0.733*), as well as high negative correlations with seed yield per plant (r = -0.897**) and seed yield per hectare (r = -0.851**). These findings suggest that an increase in the number of broomrape spikes/m^2 significantly affects both the dry weight of broomrape spikes and faba bean traits, posing challenges for faba bean production. The number of broomrape spikes/m^2 was not significantly

correlated with plant height (r = -0.272). Furthermore, there is a negative correlation between the dry weight of broomrape spikes/m^2 and the number of pods per plant (r = -0.787*), as well as high negative correlations with seed yield per plant (r = -0.921**) and seed yield per hectare (r = -0.838**). These results suggest that broomrape infestation can have a significant impact on faba bean yield, particularly in terms of seed production. Effective management strategies to control broomrape spikes are essential for optimizing crop productivity in faba bean fields. The dry weight of broomrape spikes/m^2 was not significantly correlated with plant height (r = -0.369). Plant height showed no correlation with the number of pods per plant (r = 0.416), seed yield per plant (r = 0.383), or seed yield per hectare (r = 0.209). There is a high positive correlation between the number of pods per plant and both seed yield per plant (r = 0.927**) and seed yield per hectare (r = 0.879**). Additionally, there is a high positive correlation between seed yield per plant and seed yield per hectare (r = 0.943**). These results suggest that plant height does not significantly impact crop yield, while the number of pods per plant strongly influences both seed yield per plant and seed yield per hectare. Similar results were obtained by Fayed *et al* (2002), who found a significant and negative correlation between faba bean seed yield and the number and weight of *Orobanche* spikes/m^2 (r = -0.548**, -0.528**).

Economic evaluation

The study assessed faba bean genotypes for resistance to broomrape infestation using various control methods. Gross and net returns, as well as B:C ratios, varied among treatments (Table 10). Gross returns ranged from 52.8 USD per hectare for Sakha 4 with the control treatment to 1432.2 USD per hectare for Misr 3 with the application with glyphosate twice in the first season. In the second season, these values ranged from 29.7 USD per hectare to 1478.4 USD per hectare.

Net returns ranged from -723.1 USD per hectare for Sakha4 with the mineral-N treatment to 706.9 USD per hectare for Misr 3 with application with glyphosate once + bio-fertilizer once rate in the first season. In the second season, net returns ranged from -736.3 USD per hectare to 924.7 USD per hectare. B: C ratio ranged from 6.89 for Sakha4 with the untreated

control treatment to 197.90 for Misr 3 with application glyphosate once + bio-fertilizer once. In the second season, these values ranged from 3.87 to 228.07.

Table 10. Farmer's profits of the interactions between faba bean cultivars and control methods in both seasons.

Treatments		Gross returns (USD/ha)		Financial costs (USD/ha)		Net returns (USD/ha)		B:C ratio	
		First season	Second season	First season	Second season	First season	Second season	First season	Second season
Misr 3	Glyphosate twice	1432.2	1478.4	727	727	705.2	751.4	197.00	203.35
	G + B	1428.9	1646.7	722	722	706.9	924.7	197.90	228.07
	Bio-fertilizer twice	1234.2	1452.0	717	717	517.2	735.0	172.13	202.51
	Untreated (control)	1112.1	1402.5	766	766	346.1	636.5	145.18	183.09
Misr 1	Glyphosate twice	1207.8	1428.9	727	727	480.8	701.9	166.13	196.54
	G+B	1217.7	1478.4	722	722	495.7	756.4	168.65	204.76
	Bio-fertilizer twice	1085.7	1356.3	717	717	368.7	639.3	151.42	189.16
	Untreated (control)	1006.5	1326.6	766	766	240.5	560.6	131.39	173.18
Giza 843	Glyphosate twice	1112.1	1356.3	727	727	385.1	629.3	152.97	186.56
	G + B	1339.8	1372.8	722	722	617.8	650.8	185.56	190.13
	Bio-fertilizer twice	973.5	1280.4	717	717	256.5	563.4	135.77	178.57
	Untreated (control)	927.3	1250.7	766	766	161.3	484.7	121.05	163.27
Sakha 4	Glyphosate twice	597.3	686.4	727	727	-129.7	-40.6	82.15	94.41
	G + B	610.5	745.8	722	722	-111.5	23.8	84.55	103.29
	Bio-fertilizer twice	145.2	99.0	717	717	-571.8	-618	20.25	13.80
	Untreated (control)	52.8	29.7	766	766	-713.2	-736.3	6.89	3.87

G + B= Glyphosate once**+ bio-fertilizer once.**

These results indicate significant differences in net returns between control methods and cultivars, with Misr 3 showing the highest potential for profitability. Farmers should carefully consider their choice of cultivar and control method to maximize returns in both seasons. In both seasons, Misr 1 with application of glyphosate once + bio-fertilizer once closely followed these results, with B:C ratios ranging from 3.87 to 228.07. Overall, Misr 3 exhibited the highest B:C ratio in both seasons among all treatments evaluated.

CONCLUSION

It can be concluded that growing the faba bean cultivars Misr 3 and Misr 1 with application of with glyphosate once + biological fertilizer once controll broomrape infestation and improve seed yield and profitability under naturally infested soil conditions in North Egypt.

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أداء بعض أصناف الفول البلدى تحت العديد من معاملات مكافحة الهالوك

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أجريت تجربتان في محطة البحوث الزراعية بسخا– مركز البحوث الزراعية، محافظة كفر الشيخ، خلال موسمي ٢٠٢٣/٢٠٢٤م و٢٠٢٤/٢٠٢٥م لتقييم تأثير طرق مختلفة لمكافحة الهالوك في بعض أصناف الفول البلدى لتحسين الإنتاجية والعائد الصافي في المساحات الموبوءة طبيعيا بالهالوك. وتضمنت الدراسة أربعة أصناف من الفول البلدى (مصر ٣، مصر ١، جيزة ٨٤٣ و سخا ٤) مع أربعة طرق لمكافحة الهالوك (جليفوسات مرتين، جليفوسات مرة واحدة + سماد حيوي مرة واحدة، سماد حيوي مرتين، بالاضافة لمعاملة الكنترول) في تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات. حيث وضعت أصناف الفول البلدى في القطع الرئيسية، بينما وضعت طرق المكافحة في القطع الفرعية وكانت أهم النتائج كما يلى:. أظهر صنفى الفول مصر ١ ومصر ٣ قدرة أفضل على تحمل الإصابة بالهالوك مقارنةً بالأصناف جيزة ٨٤٣ وسخا ٤. أدى استخدام مبيد جليفوسات مرة واحدة + سماد حيوي مرة واحدة وجليفوسات مرتين إلى انخفاض أعداد وأوزان شماريخ الهالوك في كل قطعة تجريبية مقارنةً بالمعاملات الأخرى. كما أظهر صنفى مصر ٣ ومصر ١ إنتاجية بذور ومكونات محصول أعلى مقارنةً بالأصناف الأخرى. أدى استخدام جليفوسات مرة واحدة + سمادحيوي مرة واحدة إلى زيادة عدد القرون لكل نبات وإنتاجية البذور لكل نبات وإنتاجية البذور للهكتار مقارنةً بطرق المكافحة الأخرى. كما أدى استخدام مبيد جليفوسات مرة واحدة + سماد حيوي مرة واحدة إلى زيادة إنتاجية البذور ومكونات المحصول لمصر ٣ ومصر ١ مقارنةً بالمعاملات الأخرى. وجد ارتباط سالب كبير بين عدد شماريخ الهالوك ووزنها الجاف في كل قطعة تجريبية، وعدد القرون على النبات، ومحصول البذور في النبات، ومحصول البذور في الهكتار. وقد حقق صنفى مصر ٣ ومصر ١ أعلى ربحية عند استخدام مبيد جليفوسات مرة واحدة + السماد الحيوي مرة واحدة. وقد أدى زراعة صنفي الفول البلدى مصر ٣ ومصر ١، باستخدام مبيد جليفوسات مرة واحدة + السماد الحيوي مرة واحدة، إلى انخفاض عدد شماريخ الهالوك ووزنها الجاف، وتحسين إنتاجيتها، محققةً أعلى ربحية في التربة الموبوءة طبيعيًا بالهالوك في شمال مصر.

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