

Effect of cultivars, intercropping and glyphosate herbicide on broomrape (*Orobanche crenata* Forsk) and faba bean productivity

EL-Sherbeni A. E.^a, Hamed S. A.^a, Khaffagy Azza E.^{b*}, ELkmash Ranya A.^a

^aPlant Protection Department, Faculty of Agriculture, Tanta University, Egypt

^bWeed Control in Field Crop Research Department, Weed Research Central Laboratory, Agricultural Research Centre, Giza 12619, Egypt

Abstract

Two field trials were conducted in naturally infested fields with broomrape (*Orobanche crenata* Forsk.) at Sakha Agricultural Research Station, Kafr El-Shiekh, Egypt, during 2017/18 and 2018/19 winter growing seasons to study the effect of cultivars and some trap crops and herbicide on controlling broomrape, yield and its components. Results revealed that faba bean Giza 843 cultivar caused significantly decreasing on number of spike/m², fresh and dry weight of (g/m²), number of capsules /spike and spike length (cm) in both seasons. Faba bean Giza 843 cultivar decreased these characteristics by 26.7, 26.3, 21.4, 41.0 and 20.9% and 25.98, 29.14, 20.08, 40.9 and 21.3%, respectively, in 2017/2018 and 2018/2019 seasons as compared with faba bean Sakha 3 cultivar. For seed yield, faba bean Giza 843 increased by 4.88 and 2.79%, in both seasons higher than Sakha 3. The highest reduction percentage on number and dry of broomrape spikes obtained by garlic, fenugreek and hand pulling were (74.5, 72.6 and 67%) and (72.2, 69.9 and 61.3%), respectively, in both seasons, as compared with untreated plots. Seed yield increased by all broomrape control treatments, the highest values were obtained from glyphosate twice and once in both seasons by (66.4 and 64.6%) and (60.0 and 60.8%), in 2017/2018 and 2018/2019 seasons compared to the untreated plot. All trap crops gave the highest values of seed yield and its components than untreated check treatment in both seasons. This increase in seed yield (ardeb/feddan) (feddan = 4200 m² = 0.420 hectares = 1.037 acres, ardeb = 5.44 imperial or 5.619 U.S. bushels) for each of fenugreek, garlic, flax, parsley and turnip in the two seasons which were 44.9, 43.0, 33.2, 10.5 and 5.4%, respectively, in 2017/2018 season and 53.3, 51.8, 43.5, 24.2 and 20.0% in 2018/2019 season, compared to untreated plot. The interaction between cultivars and trap crops gave the highest reduction in the number and dry weight of broomrape spikes which reflected on yield and its components. The best seed yield was obtained from the interaction between faba bean cultivar Giza 843 with glyphosate once or twice and garlic as a trap crop seemed to be excellent treatments in controlling broomrape in faba bean fields.

Keywords: faba bean, intercropping, cultivars, broomrape, fenugreek, flax, parsley, turnip, garlic, herbicide, glyphosate.

*Corresponding author: Khaffagy Azza E.,
E-mail address: azzakhaffagy@yahoo.com

1. Introduction

Faba bean (*Vicia faba* L.) is critical grain legume, as a protein source for human and animal consumption. In addition, the faba bean also has a valuable agronomic function considering its high capacity for N₂ fixation and its ability to facilitate diversification of the agro-ecosystems by indirectly enhancing the associated diversity of wild fauna (Köpke and Nemecek, 2010). Faba beans (*V. faba* L.), one of the leguminous crops cultivated in Egypt, ranks the third country in the production of faba bean after China and Ethiopia (Kakahy et al., 2012). In 2018, the area of cultivated faba bean in Egypt reached about 45,445 ha⁻¹, which produced about 11,856 tons of dry seeds (FAO Stat 2018). Broomrape parasitic weed is a detrimental pest for the cultivation of faba bean in Egypt which cause significant losses in the yield of faba bean up to 80%. Some cases make farmers stop to growing faba bean under heavy infestation conditions. Up till now no single control measure is sufficient by itself to control this parasite in this crop. Thus, a successful strategy for broomrape management that depends on adopting of integral effects of the combination of tolerant cultivars and rationale chemical control measures and suitable cultural practices is necessary (Eid et al., 2017). Gadalla et al. (2010) proved that sakha3 was susceptible cultivar and Giza843 was tolerant to *Orobanche* infection, which had the lowest *Orobanche* tubercles/plant. Kakahy et al. (2012) found that the differences between cultivars significantly affected on growth, plant height, number of branches plant⁻¹, pod length and seed

pod⁻¹, respectively. On other hand, many researchers stated that glyphosate application twice at the rate of 178.7 cc/ha gave broomrape control by 96-99.1% and increased faba bean seed yield/faddan by 100-149.5 than untreated infested check (EL-Metwally et al., 2013; Ismail, 2013). The effects of Roundup on broomrape tubercle are attributable to its selective accumulation in the young parasite plant up to a level of three times as high as that in faba bean host root three days after spraying (Hassanein and Kholosy, 1997; Fernández-Aparicio et al., 2016). Intercropping is a method facilitating simultaneous crop production and soil fertility building. There is a renewed interest in intercropping linked to the need for reducing nitrogen cost and soil erosion. Intercropping is already used in regions of Africa as a low-cost technology for controlling the broomrapes (Oswald et al., 2002). Several crops were used a trap or catch crops such as flax, fenugreek, garlic and turnip. Abu-Shall and Raghe (2014) reported that the reduction in *O. crenata* emerged spikes reached 42% when the cultivar was intercropped with garlic, 59% with flax and 52% with fenugreek. Also, turnip reduced the number of *O. crenata* shoots by 35% and 31% (Aksoy et al., 2016). Hand pulling of *Orobanche* shoots 3-4 times per season before seed setting is advocated to reduce the maximum of its seed population for the coming years. Hand weeding although labour-intensive, is proper, particularly under light infestations and should be practiced as early as possible to avoid crop damage (Patel et al., 2017). For the above reasons, this investigation aimed to determine the best packages of broomrape control

treatments on the effect of combining some trap crops with the use of two faba bean cultivars under Kafr El- Sheikh Governorate conditions. The objectives of this study were to determine the integrated broomrape (*Orobanche crenata*) control on the two cultivars faba bean (*Vicia faba* L.) with intercropped faba bean with fenugreek, flax, parsley, turnip, garlic and herbicides.

2. Materials and methods

Two experiments were conducted on clay soil at the Sakha Agricultural Research Station Farm, Kafr El-Shiekh, Egypt, during the 2017/18 and 2018 /19 winter growing seasons. The objective of this work was to study the effect of intercropping faba bean with some field crops (trap crops) compared to spray with glyphosate herbicides on *Orobanche* and faba bean productivity. The field was naturally heavily and uniformly infested with *Orobanche crenata* plant seeds. The preceding crop was maize in both seasons. The mechanical and chemical analysis of the experimental site soil are presented in Table (1), according to Jackson (1967). Faba bean cultivars and trap crops were planted on the 26th and 29th of October in the first and second seasons. The faba bean seed was sown on one side of the ridge in a 2-seeds hill distanced 20 cm at the sole system. In intercropping system, Seeds of faba bean were planted on one side of the ridge. Seeds of flax at a rate of 50kg/feddan (feddan = 4200 m² = 0.420 hectares = 1.037 acres), parsley at the rate of 5kg/feddan, fenugreek at the rate of 2 kg/feddan, and garlic at the rate of 200

kg/feddan on the other side; except (turnip), which were sown distance on top of the ridge near the faba bean at a rate (5kg/feddan). The plots were irrigated immediately after planting. Garlic was sown after irrigation. All the recommended agricultural practices for faba bean production were applied at the proper time. In both seasons, calcium superphosphate fertilizer was used at 15.0 kg P₂O₅/feddan during land preparation. The treatments for each experiment were arranged in a split-plot design in four replications. The subplot area was 10.5 m² contained five rows 3.5 m in length and 60 cm apart as follow:

A-Main plots (cultivars):

- 1- Giza 843
- 2- Sakha

B-Sub plots (Trap crops):

T₁: Round up 48% WSC (glyphosate) at 36 g a.i./feddan, once at the beginning of faba bean flowering stage.

T₂: Roundup 48% WSC (glyphosate) at 36 g a.i./feddan, twice at the beginning of faba bean flowering stage, with 21 days interval between applications.

T₃: Hand pulling (twice) at 70 and 90 days from sowing.

T₄: Flax (*Linum usitatissimum* L.) cv. Sakha 5.

T₅: Parsley (*Petroselinum crispum* L.) cv. Balady.

T₆: Fenugreek (*Trigonella foenum-graecum* L.) cv. Balady.

T₇: Turnip (*Brassica rapa* subsp. *Rapa* L.) cv. Balady.

T₈: Garlic (*Allium sativum* L.) cv. Balady.

T₉: Untreated (control).

The herbicides in both experiments were

sprayed by knapsack sprayer Cp3 with a water volume of 200 liters/feddan. The nomenclature of herbicide is listed in Table (2).

Table (1): Physical and chemical properties of the soils (0-30 cm).

Seasons	Organic matter (%)	pH soil	Sand (%)	Silt (%)	Clay (%)	Texture class	N (ppm)	P (ppm)	K (ppm)
2017/18	1.30	7.5	20.7	30.5	48.8	Clay	32.0	2.42	244
2018/19	1.65	7.7	21.54	28.16	50.3	Clay	33.0	2.64	246

Table (2): Common, trade and chemical names of the tested herbicides.

Common name	Trade name	Chemical name
Glyphosate	Round up WSC 48%	N- (phosphonomethyl) glycine, isopropyl ammonium salt

2.1 Data recorded

2.1.1 On broomrape

Prior to faba bean harvesting, broomrape spike/m², broomrape fresh and dry weight of (g/m²), the number of capsules broomrape/spike and broomrape spike length (cm) were estimated. The percentage of reduction in all previous traits was calculated using the following equation:

$$\text{Reduction \%} = \frac{\text{Un weeded control} - \text{Treatment}}{\text{Un weeded control}} \times 100$$

2.1.2 Faba bean yield and its components

At harvest, 15th April, samples of ten plants were collected at random from the central rows of each plot to study the following criteria: plant height (cm), number of branches/plant, number of pods/plant, number of seed pods per plant, 100-seed weight (g), seed yield/plant (g), biological yield (g/m²) and biological yield ton/feddan.

2.2 Statistical analysis

The collected data were subjected to proper statistical analysis of split-plot

design according to the procedure outlined by Snedecor and Cochran (1980). The least significant differences (LSD) at a 5% significance level were calculated.

3. Results and Discussion

3.1 Effect of cultivars

3.1.1 Broomrape control

The data in Table (3) showed that tested two faba bean cultivars significantly differed in the number of broomrape spike/m², broomrape fresh and dry weight of (g/m²), number of capsules broomrape/spike and broomrape spike length (cm) in both seasons. Faba bean Giza 843 cultivar decreased these characteristics by 26.7, 26.3, 21.4, 41.0 and 20.9% and 25.98, 29.14, 20.08, 40.9 and 21.3%, respectively, in 2017/18 and 2018/19 seasons as compared with faba bean Sakha 3 cultivar (Figure 1). The results may be due to the death of broomrape plants under Giza 843 plants; or the difficulty of penetration of the haustorium into the host root, based on lignification, mechanical barriers formation, or inhibition of broomrape seed germination by allelochemicals substances

released by cereal roots. Therefore, it decreased the characters mentioned above of broomrape. This result is similar to that obtained by Briache *et al.* (2019).

Table (3): Effect of faba bean cultivars on broomrape in characters 2017/18 and 2018/19 seasons.

Characters	Number of broomrape spike /m ²	Broomrape fresh weight/ (g/m ²)	Broomrape dry weight/ (g/m ²)	Number of capsules /broomrape spike	Broomrape spike length (cm)
2017/18 season					
Cultivars					
Giza 843	24.85 ^b	87.18 ^b	60.07 ^b	20.11 ^b	49.28 ^b
Sakha 3	33.88 ^a	118.22 ^a	81.46 ^a	34.09 ^a	62.29 ^a
F Test	**	**	**	*	*
2018/19 season					
Giza 843	24.72 ^b	85.02 ^b	58.58 ^b	19.99 ^b	48.93 ^b
Sakha 3	33.40 ^a	114.16 ^a	78.66 ^a	33.80 ^a	62.15 ^a
F Test	**	**	**	*	*

* and ** indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using DMRT.

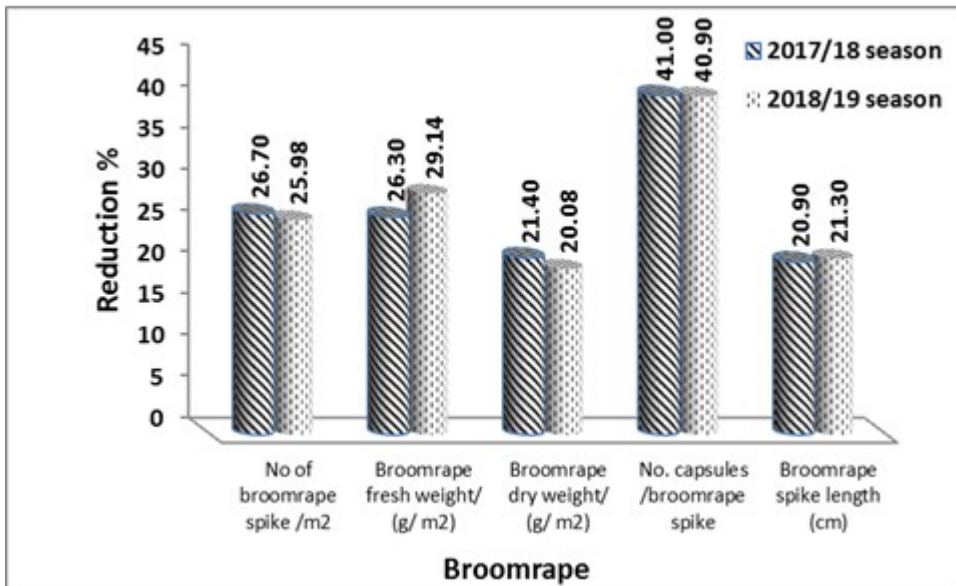


Figure (1): Percentage of reduction in broomrape characteristics in faba bean Giza 843 cultivar in both seasons.

Many previous studies have described the resistance of the Egyptian faba bean cultivar to *O. crenata*, such as Gadalla *et al.* (2010) who found that the Giza 3 was the susceptible cultivar, and Giza 843 was tolerant, which had the lowest *Orobanche* tubercles per plant. Also, Soliman *et al.* (2012) indicated that the cultivar Giza 843

is effectively shared in transmitting its high yield properties and its immense ability to resist broomrape. Moreover, Eid *et al.* (2017) found that using the best control package for growing faba bean in sandy soil infested with broomrape is by planting Misr 3 or Giza 843 cultivars through November with two sprays of

Roundup at a 30 kg/seeding rate in infested fields with broomrape in Ismailia area. Finally, Safina (2017) reported that Giza- 843 recorded the lowest value of the number of *Orobanche crenata* m⁻² and the highest values of yield and its attributes compared to Giza 2 cultivar.

3.1.2 Seed yield and its components

Data recorded in Table (4) show that faba bean Giza 843 and Sakha 3 cultivars significantly differed in all growth characters and seed yield (ardeb/feddan) in two seasons than faba bean Sakha 3 cultivar in both seasons. Faba bean Giza 843 cultivar recorded the highest values of plant height (cm), number of branches/plant, number of pods/plant, number of seeds/plant (g), 100- seed weight (g), seed yield (ardeb/feddan) and biological yield ton/feddan, as compared with Sakha 3 cultivar. The tallest faba bean plants belonged to cultivar Giza 843, taller by 13.19 and 13.20%, respectively, in both seasons compared to cultivar Sakha 3. The

highest numbers of branches/plant and pods/plant of faba bean belonged to the cultivar Giza 843, which recorded an increase in the number of pods/plant by 13.59 and 13.02% in the 2017/18 season and by 13.74 and 13.04% in 2018/19 season, respectively, as compared to Sakha 3 cultivar. The highest number of seeds/plant (g) and weight of seeds/plant (g) of faba bean belonged to the cultivar Giza 843 gave increases in number of seeds/plant by 13.31 and 13.30%, respectively, and the weight seeds/plant (g) by 13.37 and 13.11% in the 1st and 2nd season, respectively, higher than Sakha 3 cultivar. The heaviest 100-seed weight (g) of faba bean belonged to the cultivar Giza 843, which increased the weight of 100-seed by 9.61 and 18.34%, in the 1st and 2nd season, respectively, higher than Sakha 3. The highest seeds yield ardeb/feddan of faba bean resulted from the cultivar Giza 843, which gave increases in seed yield (ardeb/feddan) by 32.78 and 21.52%, in 2017/18 and 2018/19 seasons higher than cultivar Sakha 3.

Table (4): Effect of between the two faba bean cultivars on yield and its components in 2017/18 and 2018/19 seasons.

Characters Cultivars	Plant height (cm)	Number of branches/plant	Number of pods/plant	Number of seeds/plant	100-seed weight (g)	Seed yield/plant (g)	Seed yield (ardeb/feddan)	Biological yield (ton/feddan)
2017/18 season								
Giza 843	69.45 a	2.06 a	6.99 a	19.53 a	63.62 a	12.04 a	7.17 a	1.79 a
Sakha 3	60.29 b	1.78 b	6.08 b	16.93 b	57.79 b	10.43 b	4.82 b	1.21 b
F Test	*	*	*	*	*	*	**	**
2018/19 season								
Giza 843	70.83 a	2.11a	7.13 a	19.92 a	69.69 a	12.36 a	7.48 a	1.88 a
Sakha 3	61.49 b	1.82 b	6.20 b	17.27 b	56.91 b	10.74 b	5.87 b	1.47 b
F Test	*	*	*	*	**	*	**	**

* and ** indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using DMRT.

Also, gave the highest biological yield (ton/feddan) of Giza 843 cultivar by 32.4 and 21.81%, compared to Sakha 3 in both seasons. This increase of seed yield may be

due to the increased number of branches/plant, number of pods/plant, weight of pods (g/plant), seed weight (g/plant) and due to the decrease to the

number and dry weight of broomrape spikes. From the previous results depending on *Orobanche*, severity scale Sakha 3 was considered as a highly susceptible cultivar to *Orobanche* infection. These results are similar to those reported by Briache *et al.* (2019) and Eid *et al.* (2017).

3.2 Effect of trap crops and herbicide

3.2.1 Broomrape characters

Data recorded in Table 5 and Figures (2 and 3) revealed that all trap crops and herbicides significantly decreased the number, fresh and dry weight of broomrape spikes in both seasons. Glyphosate twice, glyphosate once, garlic, fenugreek, hand pulling twice, turnip, parley, and flax, significantly decreased

the number of broomrape spikes/m² by 89.0, 74.6, 74.5, 72.6, 59.5, 57.3 and 46.6%, respectively, in 2017/18 season and the second season the same trend of the characters mentioned above. The results indicated that all broomrape traits significantly differ under weed management in both seasons. Using glyphosate twice or once, garlic as a trap crop and hand pulling seemed to be excellent treatments in controlling broomrape in faba bean fields. The obtained data in Table (5) showed that spraying glyphosate twice resulted in the lowest number of broomrape spikes/m² (8.4 and 7.3), broomrape fresh weight (g/m²), (24.76 and 24.64 g/m²), broomrape dry weight g/m² (17.06 and 16.97 g/m²), capsules number/spike (3.09 and 3.03) and spike length with averages of (41.89 and 41.91 cm) in both seasons, respectively.

Table (5): Effect of trap crops and herbicide on broomrape control, of faba bean in 2017/18 and 2018/19 seasons.

Treatments	Number of broomrape spike/m ²		Broomrape fresh weight (g m ²)		Broomrape dry weight (g/m ²)		Number of capsules /broomrape spike		Broomrape spike length (cm)	
	Mean	Reduction (%)	Mean	Reduction (%)	Mean	Reduction (%)	Mean	Reduction (%)	Mean	Reduction (%)
2017/18 season										
Glyphosate once	18.71 ^d	74.6	68.25 ^d	71.9	47.02 ^d	71.9	20.00 ^b	73.8	47.11 ^{de}	50.3
Glyphosate twice	8.04 ^c	89.0	24.76 ^c	89.8	17.06 ^e	89.8	3.09 ^c	95.9	41.85 ^d	55.8
Hand pulling	24.28 ^{cd}	67.0	93.91 ^{bcd}	72.52	64.71 ^{bcd}	61.3	27.65 ^b	63.8	46.97 ^{cd}	50.4
Flax	39.33 ^b	46.6	132.45 ^b	61.3	91.26 ^b	45.4	22.28 ^b	70.8	47.70 ^{cd}	49.7
Parsley	31.47 ^{bc}	57.3	113.33 ^{bc}	53.3	78.08 ^{bc}	53.3	28.58 ^b	62.6	54.27 ^{bc}	42.7
Fenugreek	20.21 ^d	72.6	73.81 ^{cd}	69.6	50.85 ^{cd}	69.6	22.28 ^b	70.8	57.53 ^b	39.3
Turnip	29.81 ^{bcd}	59.5	107.71 ^{bcd}	55.6	74.22 ^{bcd}	55.6	22.20 ^b	70.9	60.19 ^b	35.5
Garlic	18.81 ^d	74.5	67.44 ^d	72.1	46.46 ^d	72.2	20.15 ^b	73.6	51.83 ^{bc}	45.3
Untreated control	73.63 ^a		242.67 ^a		167.20 ^a		76.38 ^a		94.77 ^a	
F Test	**		**		**		**		**	
2018/19 season										
Glyphosate once	18.59 ^d	74.6	67.91 ^c	69.12	46.79 ^c	69.1	19.91 ^b	73.8	47.19 ^{de}	48.6
Glyphosate twice	7.73 ^c	89.5	24.64 ^d	88.8	16.97 ^d	88.8	3.08 ^c	95.9	41.91 ^e	54.3
Hand pulling	24.18 ^{cd}	67.0	91.53 ^{bc}	58.4	64.07 ^{bc}	57.7	27.51 ^b	63.8	47.02 ^{de}	48.8
Flax	38.95 ^b	46.9	131.79 ^b	40.1	90.80 ^b	49.41	22.81 ^b	69.9	47.81 ^{de}	47.9
Parsley	30.89 ^{bc}	57.9	112.76 ^{bc}	48.7	77.69 ^{bc}	40.1	28.43 ^b	62.6	54.35 ^{bcd}	40.8
Fenugreek	20.14 ^d	72.5	73.44 ^c	66.6	50.60 ^c	66.6	22.16 ^b	70.8	57.59 ^{bc}	37.2
Turnip	29.39 ^{bcd}	59.9	107.18 ^{bc}	51.3	73.85 ^{bc}	51.3	22.09 ^b	70.9	60.32 ^b	34.3
Garlic	18.37 ^d	74.9	67.10 ^c	69.5	46.24 ^c	69.5	20.05 ^b	73.6	51.89 ^{cd}	43.5
Untreated control	73.30 ^a		219.98 ^a		151.57 ^a		75.99 ^a		91.77 ^a	
F Test	**		**		**		**		**	

* and ** indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using DMRT.

The superiority of spraying glyphosate twice in reducing all broomrape traits associated in all cases with the highest reduction ratios of these traits over the control. Also, the results revealed that spraying glyphosate once, followed by garlic as a trap crop and hand hoeing showed highly positive effects in reducing broom rape in faba bean in both studied seasons. These results are in agreement with those of Briache *et al.* (2019), Eid *et al.* (2017) and Safina (2017). This study indicated that spraying glyphosate twice significantly reduces all broomrape traits. Glyphosate disrupts the biosynthesis of aromatic amino acids inhibiting the key enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP). These findings agree with those reported by Lopez-Bellido *et al.* (2009) who reported applying an ultra-low glyphosate rate at an early broomrape parasitic phase, i.e., tubercle development is the most common control system. Within each tillage system, glyphosate application always reduced broomrape infestation and increased faba bean seed yield. Moreover, Ghalwash *et al.* (2012) reported that the foliar spray of Imazapic

and Glyphosate twice on faba bean recorded a less number and dry weight of broomrape spikes / m² than its spray one time. Ismail (2013) found that the application of glyphosate alone or with hand pulling gave a higher reduction in the number and weight of broomrape than the untreated check. Kandil *et al.* (2015) indicated that spraying Roundup® (glyphosate 48% WSC) twice where the first spraying was applied to begin the flowering while the second spraying was used after two weeks from the first treatment caused a significant reduction in the number and weight of broomrape as compared with other treatments. Zeid and hemied (2019) studied the effect of the number of glyphosate sprays, at the rate of 86 g a.i./ha, on the performance of a set of faba bean cultivars varying in their resistance to the parasite under farmer’s field conditions. They found a clear reduction in the number of broomrape emerged spikes from 18 to 49% and the amount of photo-assimilates accumulated by the parasite from 1 to 42%, depending on the cultivar and that was related to the number of sprays applied.

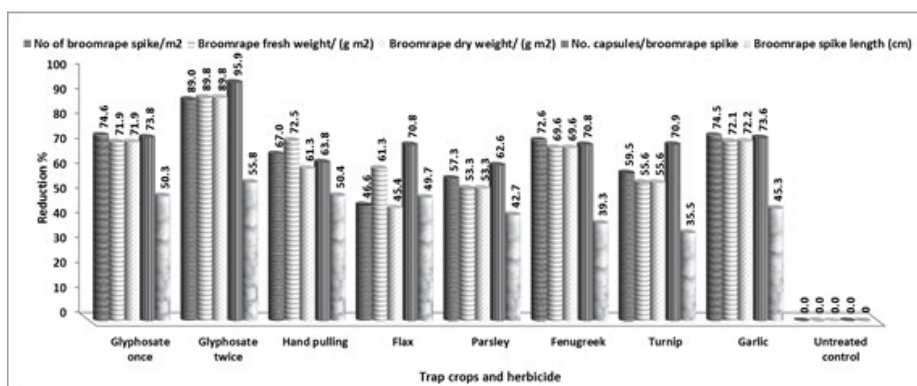


Figure (2): Percentage of reduction in broomrape of characters in faba bean as affected by broomrape control herbicide and trap crops in 2017/18 season.

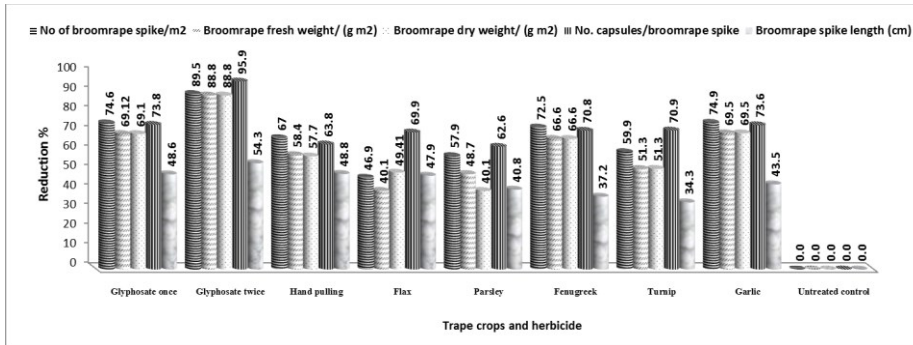


Figure (3): Percentage of reduction in broomrape of characters in faba bean as affected by broomrape control herbicide and trap crops in 2018/19 season.

3.2.2 Seed yield and its components

Table (6) indicated that all faba bean yield and its components significantly differ under all treatments. Glyphosate in both spraying numbers and hand pulling significantly exceeded all other used treatments in enhanced growth and yield of faba bean in both seasons. The results showed that the heaviest 100-seeds of faba bean were obtained under sprayed glyphosate twice (75.83 and 75.2 g) followed by sprayed glyphosate once (72.88 and 71.11 g) in the two studied seasons, respectively. Generally, the result showed that sprayed faba bean with glyphosate followed by hand pulling significantly increased all faba bean yield and its components. All broomrape control treatments and trap crops gave the highest values of plant height (cm), number of branches/plant, number of pods/plant, number of seeds (g/plant), seed weight (g/plant), 100-seed weight (g), seed yield (ardeb/feddan) and biological yield t/feddan than untreated check treatment in both seasons. Seed yield (ardeb/feddan) increased by all

broomrape control treatments, the highest values were obtained from glyphosate twice and once in both seasons by (66.4 and 64.6%) and (60.0 and 60.8%), respectively, in 2017/18 and 2018/19 seasons compared to untreated plot in Figure (4). As for, seed yield (ardeb/feddan) increased by all trap crops, the highest values were obtained from fenugreek, garlic, flax, parsley, and turnip in the 2017/18 season and 2018/19 season, which was 44.9, 43.0, 33.2, 10.5 and 5.4 %, respectively, in the first season and 53.3, 51.8, 43.5, 24.2 and 20.0 %, respectively, in the second season, compared to untreated plot. This increase of seed yield may be due to the increased number of branches/plant, number of pods/plant, weight of pods (g/plant), seed weight (g/plant) and due to the decrease to the number and dry weight of broomrape spikes. These results are in harmony with those reported by El-Degwy *et al.* (2010) found that increasing glyphosate doses from zero up to 75 cm³/feddan twice were associated with a significant increase in the number of pods/plant, the number of seeds/plant and seed yield/plant, seed

yield (ardeb/feddan). Also, Ghalwash *et al.* (2012) reported that the foliar spraying of glyphosate once or twice on faba bean significantly increased plant height, the number of branches, and pods/plant, 100-seed weight, seed yield/plant, seed, and biological yields/feddan of faba bean compared with untreated treatment in both

seasons. Moreover, Ismail (2013) found that the Application of glyphosate alone or with hand pulling gave a higher reduction in the number and weight of broomrape by 97.1, 97.1, 97.0, and 97.3%, respectively, as compared with untreated check, and improved seed yield of faba bean by 75.6 and 72.1%, respectively.

Table (6): Effect of trap crops and herbicide treatments on faba bean yield and its components in 2017/18 and 2018/19 seasons.

Treatments	Plant height (cm)	Number of branches/plant	Number of pods/plant	Number of seeds/plant	100-seed weight (g)	Seed yield /plant (g)	Seed yield (ardeb/feddan)	Biological yield (ton/feddan)
2017/18 season								
Glyphosate once	69.99 ^b	2.24 ^b	8.73 ^b	24.05 ^b	72.88 ^b	15.64 ^b	8.35 ^b	2.09 ^b
Glyphosate twice	86.75 ^a	3.25 ^a	10.42 ^a	29.17 ^a	75.83 ^a	20.47 ^a	9.95 ^a	45y67
Hand pulling	62.11 ^c	2.20 ^c	7.85 ^c	21.80 ^c	48.06 ^f	15.52 ^b	8.16 ^b	2.05 ^c
Flax	68.02 ^d	1.73 ^f	5.76 ^f	16.13 ^f	66.35 ^c	9.65 ^d	5.00 ^c	1.25 ^d
Parsley	69.02 ^c	1.63 ^g	4.97 ^g	13.93 ^g	57.38 ^e	7.15 ^f	3.73 ^e	0.93 ^e
Fenugreek	66.05 ^e	1.99 ^d	6.81 ^d	19.06 ^e	67.98 ^c	11.30 ^c	6.06 ^c	1.52 ^c
Turnip	56.19 ^g	1.30 ^g	4.19 ^h	11.73 ^h	59.183 ^{de}	6.29 ^g	3.53 ^e	0.89 ^e
Garlic	62.11 ^c	1.81 ^e	7.20 ^d	20.16 ^d	62.27 ^d	10.90 ^d	5.86 ^c	1.47 ^d
Untreated control	43.61 ^h	1.16 ⁱ	2.89 ⁱ	8.06 ⁱ	35.79 ^g	4.20 ^h	3.34 ^e	0.84 ^e
F Test	**	**	**	**	**	**	**	**
2018/19 season								
Glyphosate once	71.39 ^b	2.28 ^b	8.90 ^b	24.53 ^b	71.11 ^{ab}	15.96 ^b	8.78 ^b	2.20 ^b
Glyphosate twice	88.48 ^a	3.32 ^a	10.63 ^a	29.76 ^a	75.20 ^a	20.88 ^a	9.73 ^a	2.44 ^a
Hand pulling	63.35 ^f	2.25 ^c	8.01 ^c	22.24 ^c	58.16 ^e	15.83 ^b	8.67 ^b	2.17 ^b
Flax	69.38 ^c	1.77 ^f	5.87 ^f	16.45 ^f	64.09 ^{abc}	9.84 ^c	6.09 ^d	1.53 ^d
Parsley	70.39 ^c	1.66 ^g	5.07 ^g	14.21 ^g	55.93 ^f	7.29 ^f	4.54 ^e	1.14 ^e
Fenugreek	67.37 ^c	2.03 ^d	6.94 ^e	19.44 ^e	67.23 ^{abc}	11.53 ^c	7.37 ^c	1.85 ^c
Turnip	57.31 ^g	1.33 ^h	4.27 ^h	11.96 ^h	61.74 ^{bc}	6.41 ^g	4.30 ^e	1.08 ^e
Garlic	63.35 ^c	1.84 ^e	7.34 ^d	20.56 ^d	60.32 ^{bc}	11.12 ^d	7.14 ^c	1.79 ^d
Untreated control	44.44 ^h	1.19 ⁱ	2.94 ⁱ	8.22 ⁱ	45.48 ^d	5.08 ^h	3.44 ^f	0.86 ^f
F Test	**	**	**	**	**	*	**	**

* and ** indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using DMRT.

Also, fenugreek was intercropping and one hand pulling decreased Orobanche infestation 72.6 and 53.2%, improving faba bean seed yield by 34.7 and 57.9%, respectively. Kandil *et al.* (2015) indicated that spraying Roundup (glyphosate 48% WSC) twice where the first spraying was applied to begin the flowering while the second spraying was applied after two weeks from the first treatment at 180 cm³

(Roundup)/480 L (water)/ha, caused a significant increase of faba bean yield. Eid *et al.* (2017) found that round-up applied twice significantly increased faba bean yield and its components in both seasons compared with untreated check. The increases in seed yield (ardeb/feddan) were 89.1 and 86.3% in the first and second seasons, respectively, compared with untreated checks.

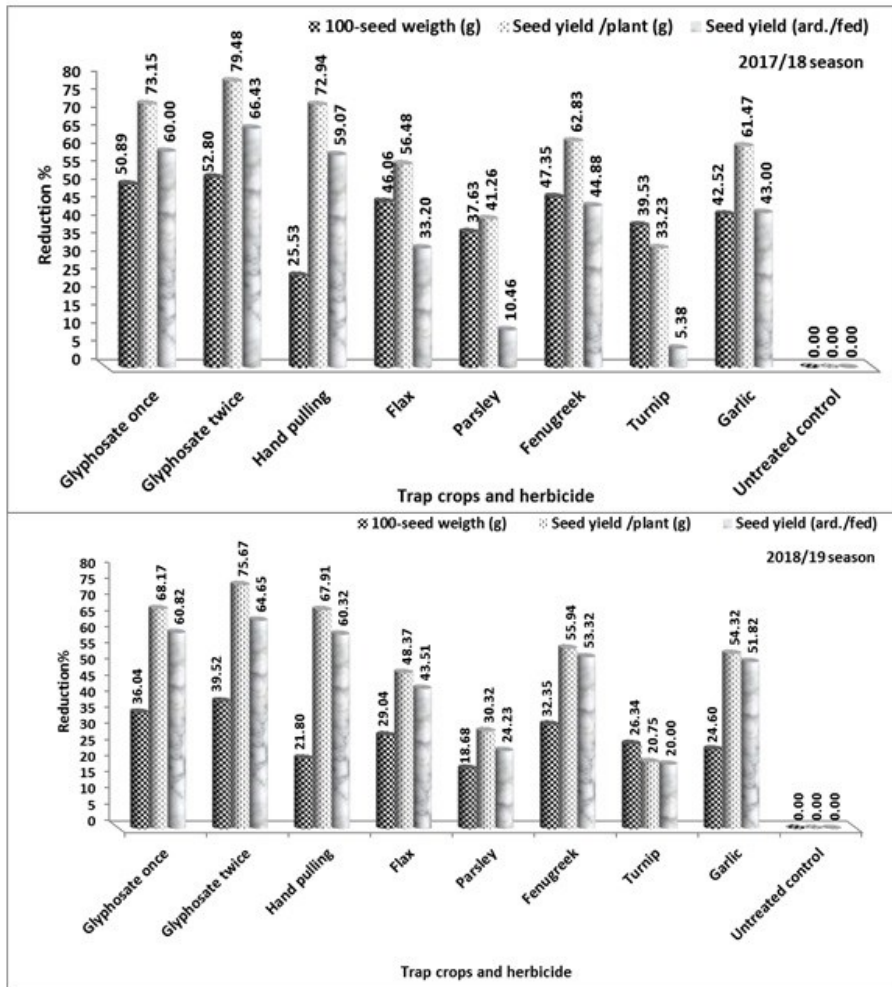


Figure (4): Percentage of reduction in faba bean yield, 100-seed weight and seed yield/ plant as affected by broomrape control herbicide and trap crops in 2017/18 and 2018/2019 season.

3.3 Effect of the interactions between faba bean cultivars, trap crops treatments and herbicide

3.3.1 Broomrape characters

Table (7) showed that all interactions between cultivars and trap crops treatments, and herbicides gave the highest reduction in the number of

broomrape spike/m², broomrape fresh and dry weight of (g/m²), number of capsules broomrape/spike and broomrape spike length (cm), in both seasons. The most significant reduction percentage by using glyphosate twice for the number, fresh and dry weight of broomrape spikes and the number of capsules broomrape/spike were obtained by the interaction between faba bean Giza 843 cultivar were 85.6, 95.2,

88.6 and 89.8 %, respectively, compared to faba bean Sakha 3 cultivar control treatments. All interactions between cultivars and trap crops increased the highest reduction in broomrape spike/m², broomrape fresh and dry weight of (g/m²), and the number of capsules broomrape/spike and broomrape spike length (cm), in both seasons. Garlic, fenugreek, hand pulling twice, turnip, flax, and parsley significantly decreased the number of broomrape spikes by 63.7, 60.3, 42.8, 40.8, and 39.3%, respectively, average in both seasons. The obtained data in Table (5) indicated that the faba bean cultivars Giza 843 that were sprayed twice with glyphosate showed the lowest number of broomrape spikes/m² (7.74 and 7.25), the lowest fresh spike weight/m² (19.25 and 19.16 g), dry spikes weight/m² (13.27 and 13.20 g) and spike lengths with averages lengths of 36.89 and 37.26 cm in both seasons, respectively. The effectiveness of this treatment was associated in all cases with high reduction ratios on all broomrape traits over the control. Giza 843 sprayed with glyphosate twice showed the lowest numbers of capsules/spike of 0.00 and 0.00 and reduction ratios of 100.00 and 100.00% in both seasons. Glyphosate also reduces all broomrape traits growing under Sakha 3 cultivar. All other weed treatments could be recommended in IPM with spraying glyphosate once more. Our findings revealed the highest reductions in broomrape growth under the faba bean Giza 843 sprayed with glyphosate twice.

3.3.2 Seed yield and its components

All interactions between cultivars and

broomrape control treatments increased yield and its components (Table 8) in both seasons. Faba bean Giza 843 cultivar recorded the highest values of plant height (cm), number of branches /plant, number of pods /plant, number of seeds /plant (g), 100- seed weight (g), seed yield (ardeb/feddan) and biological yield ton/feddan, as compared with Sakha 3 cultivar. The highest values were obtained from glyphosate twice and once in both seasons (66.4 and 64.6%) and (60.0 and 60.8%), respectively, in the 2017/18 and 2018/19 seasons compared to the untreated plot. All trap crops gave the highest values of plant height (cm), number of branches/plant, number of pods/plant, number of seeds (g/plant), seed weight (g/plant), 100-seed weight (g), seed yield (ardeb/feddan) and biological yield ton/feddan than untreated check treatment in both seasons. Seed yield (ardab/feddan) increased by all trap crops and the highest values were obtained from fenugreek, garlic, flax, parsley, and turnip in the 2017/18 season and 2018/2019 season, which were 44.9, 43.0, 33.2, 10.5 and 5.4%, respectively, in the first season and 53.3, 51.8, 43.5, 24.2 and 20.0%, respectively, in the second season compared to untreated plot in both seasons. The interaction between faba bean Giza 843 cultivar and fenugreek gave the highest values (7.20 ardeb/feddan), followed by garlic for seed yield ardeb/feddan, compared to faba bean Sakha 3 cultivar gave the lowest seed yield (0.60 ardeb/feddan) with untreated plot. Glyphosate in both spraying numbers and hand hoeing greatly exceeded all the other treatments in enhancing the growth and yield of the two faba bean cultivars in both

seasons. The faba bean cultivar Giza 843 treatments than Sakha 3 which showed in showed a higher response to all used both seasons.

Table (8): Effect of interaction trap crops and herbicides treatments on faba bean yield and its components in 2017/2018 and 2018/2019 seasons.

Cultivars	Treatments	Plant height (cm)	Number of branches/plant	Number of pods/plant	Number of seeds/plant	100-seed weight (g)	Seed yield /plant (g)	Seed yield (ardeb/feddan)	Biological yield (ton/feddan)	
										2017/2018 season
Giza 843	Glyphosate once	74.51 c	2.38 c	9.00 c	25.21 c	73.42 d	16.65 c	9.81 b	2.46 b	
	Glyphosate twice	92.35 a	3.46 a	11.09 a	31.06 a	75.25 c	21.79 a	10.92 a	2.74 a	
	Hand pulling	66.11 g	2.35 cd	8.36 d	23.03 d	64.57 b	16.53 c	9.55 c	2.39 bc	
	Flax	72.41 e	1.85 fgh	6.13 i	17.17 i	66.51 ef	10.27 h	5.97 e	1.49 e	
	Parsley	73.46 d	1.73 ghi	5.30 j	14.83 j	57.00 i	7.60 j	4.42 fg	1.11 fg	
	Fenugreek	70.31 f	2.12 de	7.25 f	20.29 f	68.24 e	11.66 e	7.24 d	1.81 d	
	Turnip	59.82 l	1.38 jk	4.46 l	12.49 l	59.59 hi	6.69 k	6.98 d	1.10 fg	
	Garlic	66.11 g	1.92 efg	7.66 e	21.46 e	62.19 gh	11.24 f	6.98 d	1.75 d	
	Untreated control	49.94 o	1.23 kl	3.68 n	10.28 n	45.86 i	5.92 l	2.25 h	1.32 ef	
	Sakha 3	Glyphosate once	65.48 g	2.10 def	8.45 d	22.88 d	72.34 c	14.63 d	6.91 d	1.73 d
Glyphosate twice		81.15 b	3.04 b	9.75 b	27.29 b	76.41 b	19.15 b	8.98 c	2.25 c	
Hand pulling		58.10 m	2.06 ef	7.35 f	20.57 f	81.56 a	14.52 d	6.77 d	1.69 d	
Flax		63.63 j	1.62 hij	5.39 ji	15.09 j	66.20 d	9.03 i	4.03 g	1.01 g	
Parsley		64.55 i	1.52 ij	4.65 k	13.03 k	57.75 fg	6.68 k	3.03 h	0.76 h	
Fenugreek		61.79 k	1.86 fgh	6.37 h	17.83 h	67.73 d	10.95 g	4.87 fg	1.22 fg	
Turnip		52.56 n	1.22 kl	3.92 m	10.97 ml	60.05 ef	5.88 l	2.65 h	0.67 h	
Garlic		58.10 o	1.69 ghi	6.74 g	18.86 g	62.36 e	10.55 h	4.74 fg	1.18 h	
Untreated control		37.29 p	0.93 l	2.09 o	5.84 o	25.72 fg	2.48 m	1.42 i	0.35 i	
F Test		**	**	**	**	**	**	**	**	**
2018/2019 season										
Giza 843	Glyphosate once	76.00 c	2.43 c	9.18 c	25.72 c	67.06 abcd	16.99 c	9.19 b	2.30 b	
	Glyphosate twice	94.19	3.53 a	11.31 a	31.68 a	67.25 abc	22.23 a	9.29 b	2.33 a	
	Hand pulling	67.44	2.39 cd	8.53 d	23.49 d	77.74 b	16.86 c	9.23 b	2.30 b	
	Flax	73.86 c	1.88 efg	6.25 i	17.51 i	78.45 a	10.48 g	7.34 e	1.84 e	
	Parsley	74.93 c	1.77 fgh	5.40 j	15.12 j	76.45 ab	7.76 i	5.44 f	1.36 f	
	Fenugreek	71.72 cd	2.16 cde	7.39 f	20.69 f	73.39 abc	11.90 e	8.91 bc	2.24 bc	
	Turnip	61.01 fg	1.41 ijk	4.55 l	12.74 l	65.13 bcde	6.83 j	5.41 f	1.36 f	
	Garlic	67.44 de	1.96 ef	7.82 e	21.89 e	63.23 bcde	11.47 f	8.58 cd	2.15 cd	
	Untreated control	50.93 i	1.26 jkl	3.74 n	10.48 n	59.48 de	6.71 j	3.95 ij	0.99 h	
	Sakha 3	Glyphosate once	66.79 h	2.14 cde	8.62 d	23.34 d	61.11 cde	14.93 d	8.28 d	2.08 d
Glyphosate twice		82.78 b	3.10 b	9.94 b	27.84 b	63.43 bcde	19.53 b	10.28 a	2.58 a	
Hand pulling		59.26 m	2.10 de	7.49 f	20.98 f	41.58 f	14.81 d	8.12 d	2.04 d	
Flax		64.90 j	1.65 ghi	5.50 j	15.39 j	72.02 abcd	9.21 h	4.83 g	1.21 g	
Parsley		65.84 i	1.55 hij	4.75 j	13.29 j	65.78 hede	6.82 j	3.64 hi	0.91 h	
Fenugreek		63.02 j	1.90 efg	6.49 h	18.19 h	61.07 cde	11.16 f	5.85 f	1.47 f	
Turnip		53.62 m	1.24 kl	4.00 m	11.19 m	58.35 e	6.00 k	3.19 ij	0.80 i	
Garlic		59.26 m	1.72 fgh	6.87 g	19.24 g	57.41 e	10.76 g	5.69 f	1.43 f	
Untreated control		37.95 p	0.95 l	2.13 o	5.96 o	31.48 f	3.45 l	2.91 j	0.73 i	
F Test		**	**	**	**	**	**	**	**	**

Means of each trait designated by the same letter are not significantly different at 5% level using DMR.

Giza 843 that were sprayed twice with glyphosate had the highest plant height (cm), number of branches/ plant, number of pods/plant, number of seeds/plant (g), 100-seed weight (g), seed yield (ardeb/feddan) and biological yield ton/feddan., compared to Sakha 3 that sprayed with glyphosate twice then sprayed Giza 843 with glyphosate once a time in all previously studied traits was detected. The heaviest 100-seeds of faba

bean were obtained under hand pulling on Sakha 3 with averages of 81.56 and 83.19 g, followed by sprayed glyphosate twice at Sakha 3 then sprayed glyphosate twice at Giza 843 (76.30 and 77.83 g) in the two studied seasons, respectively. Therefore, increases in seed yield obtained from the mentioned treatments may be attributed to successful control broomrape parasite which reduced competition and consequently favored growth of faba bean

plants, yield attributes and 100-seed weight and consequently seed yield. This increase in seed yield might be due to increased improved faba bean plant growth and development of yield attributes which in turn resulted in increasing seed yield. Also, this may be due to rapid growth of faba bean plants by controlling in bromrape, which resulted in improving the competitive ability of faba bean to suppress density and growth broomrape parasite weed. These results are in agreement with those reported by Briache et al. (2019) and Eid et al. (2017).

4. Conclusion

Finally, can be concluded that foliar spraying with glyphosate 48% WSC twice on growing tolerant cultivar Giza 843 and some trap crops gave the highest reduction in *Orobanche* injury in faba bean and highest seed yield at Kafr El-Shiek governorate, Egypt.

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