Journal of Sohag Agriscience (JSAS) 2022, 7(2):154-170

ISSN 2357-0725
https://jsasj.journals.ekb.eg
JSAS 2022; 7(2): 154-170

Received: 19-10-2022
Accepted: 21-12-2022

Tantawy, A. A.
Agronomy Department
Faculty of Agriculture
Minia University
Minia
Egypt

S. Sh. Abdullah
Y. A. M. Hefny
A. R. M. Ridwan
Agronomy Department
Faculty of Agriculture
Sohag University
Sohag
82524
Egypt

Corresponding author:
A. R. M. Ridwan
ahmed.radwan@agr.sohag.edu.eg

The Integrated Management of Broomrape Weed in Faba bean Under Naturally Infested Soil Conditions

Tantawy, A. A. A., S. Sh. Abdullah, Y. A. M. Hefny and A. R. M. Ridwan

Abstract

A field experiment was conducted at the Agricultural Research Farm at Al-Kawthar site, Faculty of Agriculture, Sohag University, during the 2018/19 and 2019/20 seasons. This study aimed to study the integrated management of *Orobanche* weed in faba bean under naturally infested soil conditions. Randomized complete blocks design (RCBD) in a split split-plot arrangement with three replicates was used. Sowing dates were arranged randomly in the main plots, whereas cultivars were allocated randomly in the sub-plots, and then resistance methods were arranged randomly in the sub-sub-plots. Three sowing dates (20^{th} of October, 10^{th} of November and 1^{st} of December), three cultivars (Sakha 1, Giza 843 and Giza 716) and four resistance methods (Herbicide, Intercropping faba bean with fenugreek, Intercropping faba bean with garlic and Without) were used. The obtained results revealed that sowing faba bean at the third date on the 1^{st} of December significantly decreased broomrape infestation (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) and gave the maximum values of most studied traits in the two seasons, compared with sowing on the 20^{th} of October or 10^{th} of November. Cultivar Giza 843 showed markedly more tolerance to broomrape than other cultivars and gave the lowest values for the number of broomrape (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) under these conditions, as well as superiority in the most studied traits in both seasons, while cultivar Giza 716 was highly susceptible to broomrape infection. Foliar spraying with glyphosate on the leaves of the faba bean plants significantly decreased broomrape infestation (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2), and gave the best values of most studied traits compared with the other resistance methods in both seasons. Finally, under naturally infested soil conditions by broomrape in the study area, it could be strongly recommended for sowing Giza 843 cultivar on the 1^{st} of December with foliar spraying by Glyphosate 48% on the leaves of faba bean plants once at the beginning of flowering at a rate of 75 cm^3/200 liter per feddan to achieve a higher faba bean crop production in ton per feddan under the conditions of this study.

INTRODUCTION

One of Egypt's major winter legume crops for human food is the faba bean (*Vicia faba* L.). The dry seeds are an excellent source of energy because they are 58 percent carbohydrates on average. As seeds contain between 24 and 35 percent protein, they are also a cheap source of protein for a large portion of the population. Faba bean plays a vital role in crop rotations in Egypt because they have potential N_2- fixation via root nodule bacteria, which play an essential role in enhancing soil fertility. Faba bean production saw a considerable decline as a result of susceptibility to foliar diseases such as chocolate spots and rust diseases, insect pests such as aphids, and the effects of parasitic weeds such as broomrape.

Broomrape (*Orobanche crenata Forsk*.) is an annual plant that is obligatory parasitic on the secondary roots of faba bean plants and other susceptible hosts in Egypt and is also extensively dispersed in the Mediterranean region. It causes significant losses to the host and, in severe cases, may result in crop failure. The amount of yield loss changes based on host genotype, parasitism level, sowing date and a variety of other factors. Most crops have few options for broomrape management because of the complexity of mechanical control and a lack of dependable, selective herbicides. There is no one specific method that can provide enough control. The combination of multiple management methods may result in improved broomrape weed control.

Several studies have been conducted on this subject, Ghobashy (1997) revealed that the parasitism by broomrape on the faba bean plants significantly reduced the dry weight/plant, plant height, the number of branches/plant, the number of mature pods/plant and seed yield kg/fed. In addition, the carbohydrates were much lower in the *Orobanche* parasitized faba bean plants compared to values in the free-infested ones. According to El-Metwally *et al.* (2013), the late sowing date resulted in a decrease in broomrape numbers as well as dry weight. The early sowing date (25th of October) decreased the dry weight of broomrape by 27.7% compared to 65.9%, and 87.2% on the 10th of November, 25th of November, and 10th of December, respectively. The highest values of growth characteristics *i.e*, including pigment content (chlorophyll a), the number of branches per plant, and plant height, were recorded on the sowing date of 25th October. (cm). While the sowing date of 25th November produced the highest yield and yield component values, including the number of pods/plant, pod dry weight/plant (g), 100-seed weight (g), and seed yield (ton/ha). The maximum seed yield (ton/ha) was recorded by the interaction between the sowing date on 25th November and the spraying of glyphosate. El-Ghareib *et al.* (2019) recorded that sowing on 30th November gave the lowest value of broomrape infestation percent per plot. Interactions between sowing dates, faba bean cultivars and resistance methods (Spraying with Round up®) were significant for most studied traits. Zeid and Mona (2019) indicated that the resistant cultivars generally had fewer *Orobanche* spikes compared to the susceptible cultivars. The least number of *Orobanche* spikes per plant and dry matter accumulated by the parasite was observed for the resistant cultivar Misr 1 in both seasons, although not significantly different from Giza 843 and Giza 402 in either. The susceptible cultivars Nubaria 1, Nubaria 3, and Giza 3 had the lowest seed yield/plant (g). Intercropping fenugreek with faba beans considerably lowered the broomrape infestation of faba beans, as illustrated by Bakheit *et al.* in (2002). In contrast to sole faba bean, Ghalwash *et al.* (2012) found that intercropping fenugreek with faba bean decreased the amount and dry weight of broomrape spikes/m^2. Additionally, intercropping with fenugreek substantially enhanced 100-seed weight, plant height, pod weight (g/plant), number of pods/plant and seed yield (kg/fed). Abdel-Wahab and Eman (2021) noticed that intercropping 50% faba bean with 100% fenugreek in wide ridges (120 cm) resulted in a fewer number of broomrape spikes/m^2 and a lower dry weight of broomrape spikes/m^2. While, intercropping 100% faba bean and 100% fenugreek in wide ridges (120 cm) resulted in higher seed yields of both crops kg/ha. Kandil *et al.* (2015) stated that spraying Roundup® (glyphosate 48%) resulted in a significant decrease in the number of broomrape spikes/m^2 and their dry weight (g)/m^2, as well as a notable rise in plant height (cm), the number of pods, biological yield (ton/ha), and seed yield (ton/ha). El-Mergawi and El-Dabaa (2021) studied the effects of applying glyphosate on the growth of

faba bean plants and broomrape parasitized on faba bean plants after 90 and 120 days from sowing. An experiment was conducted using infested pots with *Orobanche crenata*. Obtained data indicated that spraying glyphosate on faba bean plants reduced the number and weight of broomrape while increasing the number of branches/plant, plant height (cm), number of leaves/plant, dry weight/plant (g), number of pods/plant and weight of pods (g) when compared to untreated faba bean plants. On the other hand, broomrape infestation caused a great decrease in the growth of untreated faba bean plants. Biomass accumulation by infected and untreated faba bean plants did not reach the 14% of biomass accumulation in healthy plants (Non-infected and untreated faba bean plants).

The goal of this study was to evaluate the ability of some faba bean cultivars to tolerate broomrape infection under naturally infested soil conditions in order to select the best faba bean cultivar for such conditions and to determine the optimal integration of various control methods that could lead to better broomrape control and enhance the productivity of the faba bean crop under these conditions.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Research Farm at Al-Kawthar site, Faculty of Agriculture, Sohag University, during the two seasons of 2018/19 and 2019/20. This study aimed to study the integrated management of *Orobanche* weed in faba bean under naturally infested soil conditions. The experiment included 36 treatments, which were the combinations of three sowing dates, three faba bean cultivars and four resistance methods which were herbicide, intercropping faba bean with fenugreek, intercropping faba bean with garlic and without.

A. Sowing dates

1) 20th of October (S_1).
2) 10th of November (S_2).
3) 1st of December (S_3).

B. Faba bean cultivars

1- Sakha 1 (C_1).
2- Giza 843 (C_2).
3- Giza 716 (C_3).

C. Resistance methods

1) Without (F): Faba bean alone (control).
2) Herbicide (F+H): Spray Roundup[1] (Glyphosate 48% WSC) once at the beginning of flowering a rate of 75 cm^3/200 liter/fed*.
3) Intercropping faba bean with fenugreek (*Trigonella foenum graecum* L.) cultivar Giza 3 (F+T): planting the fenugreek seeds at the empty space on the top of the ridge at a rate of 75 g/Sub-sub-plot was 10.5 m^2.
4) Intercropping faba bean with garlic (*Allium sativum* L.) cultivar Seds 40 (F+A): planting the cloves of garlic at 10 cm in the empty space on the top of the ridge.

[1] **Trade name:** Roundup.
Common name: Glyphosate.
Chemical name: Isopropylamine salt of N (phosphonomethyl) glycine.
***Feddan** = 4200m^2.

Randomized Complete Blocks design in a split split-plot arrangement with three replicates was used. Sowing dates were arranged randomly in the main plots, whereas cultivars were allocated randomly in the sub-plots, then resistance methods: Without, Herbicide, Intercropping with fenugreek and intercropping with garlic were arranged randomly in the sub-sub-plots. The experimental sub-sub-plot area was 10.5 m^2 (4.4 m length and 2.4 m width), consisting of 4 ridges with 60 cm inter-row spacing. Planting faba bean seeds at 20 cm spacing on both sides of the ridge in alternative hills shape, which equivalent 140.000 plants/fed* = 33 plants/m^2. Thinning was done overall plots after 1st hoeing to remain the best two seedlings/hill. During soil preparation before sowing, phosphorus fertilizer in the form of calcium superphosphate (15.5 percent P_2O_5) was added at a rate of 200 kg/fed, while nitrogen fertilizer in the form of ammonium nitrate (33.5 percent N) was given at a rate of 20 kg/fed during sowing irrigation. Other faba bean cultural practices were carried out according to the Egyptian Ministry of Agriculture's recommendations for faba bean production in this area.

Table 1: Soil properties of top-soil (0-30 cm) of the experimental site in 2018/19 and 2019/20 seasons.

Soil properties	2018/19	2019/20
Gravel by weight (%)	11.20	10.91
Sand (%)	42.51	40.93
Silt (%)	29.80	28.42
Clay (%)	27.69	30.65
Soil texture	CL	CL

Data recorded

A. Broomrape parasitic weeds traits

1. Number of broomrape (Spikes/m^2).
2. Dry weight of broomrape spikes (g/m^2).

B. Yield and yield components

1. Plant height (cm). 2. Number of pods/plant. 3. Biological yield (ton/fed). 4. Seed yield (ton/fed).

Statistical analysis

The collected data were statistically analyzed in each season separately according to Gomez and Gomez (1984) using Proc. GLM procedure (SAS version 9.1, SAS Institute 2003). The least significant difference (LSD) test at 5% level of probability was used for comparing among means of the three studied factors and their interaction.

RESULTS AND DISCUSSION

The effect of sowing dates, some faba bean cultivars, resistance methods and their interactions on broomrape parasitic weeds traits, and yield and its components traits will be presented as follows:

A. Broomrape parasitic weeds traits

1. Number of broomrape (Spikes/m^2)

The numbers of broomrape (Spikes/m^2) as affected by sowing dates, some faba bean cultivars, resistance methods and their interaction in the 2018/19 and 2019/20 seasons are presented in Table 2. The results indicated that the mean values of the number of broomrape (Spikes/m^2) were significantly affected by the sowing dates in both seasons. The minimum number of broomrape (Spikes/m^2) of 17.19 and 12.61 spikes/m^2 were obtained from the plots planted at the third date on the 1st of December in the 2018/19 and 2019/20 seasons, respectively. On the other hand, the maximum number of broomrape (Spikes/m^2) of 38.56 and 31.39 spikes/m^2 were obtained from the plots planted at the first date on the 20th of October in the 2018/19 and 2019/20 seasons, respectively. The mean values of the number of broomrape (Spikes/m^2) for the second sowing date on the 10th of November were between the third sowing date on the 1st of December and the first sowing date on the 20th of October. Sowing faba bean at the third date on the 1st of December significantly decreased broomrape infestation (Spikes/m^2) by 55.43% and 59.83% in the first and second seasons, respectively, as compared with sowing at the first date on the 20th of October in both seasons. The data given previously shows that the number of broomrape (Spikes/m^2) decreases with the delay in sowing dates of December. This may be due to the delay in sowing dates that leads to the decrease in the broomrape seed germination due to suboptimal soil temperatures for their germination as the temperatures gradually decline from October to December. Furthermore, low temperatures may also hinder and slow down the development of broomrape tubers during underground stages. The present results are confirmed with those obtained by El-Ghareib *et al.* (2019) and Abdel-Wahab and Eman (2021).

Results in Table 2 show that the three cultivars of faba bean exhibited a significant effect on the number of broomrape (Spikes/m^2) in both seasons. Giza 716 cultivar recorded the highest number of broomrape (Spikes/m^2) of 33.64 and 29.38 spikes/m^2 in the 2018/19 and 2019/20 seasons, respectively, followed by Sakha 1 cultivar, which recorded 25.77 and 20.97 spikes/m^2 in the 2018/19 and 2019/20 seasons, respectively. While, Giza 843 cultivar recorded the lowest number of broomrape (Spikes/m^2) of 17.52 and 12.52 spikes/m^2 in the 2018/19 and 2019/20 seasons, respectively. A tolerant cultivar (Giza 843), significantly reduced broomrape infestation (Spikes/m^2) by 47.91 and 57.38% in the 2018/19 and 2019/20 seasons, respectively, as compared to susceptible cultivar Giza 716 in both seasons. These results can be attributable to the behavior of the tested cultivars, which is governed by genetic constituents and their interaction with the environmental variables present during the growing season. In addition, it could be observed that the tolerance cultivars may provide better protection against broomrape parasitism. Giza 843 cultivar showed markedly more tolerance to

broomrape than other cultivars and gave the lowest values for the number of broomrape (Spikes/m^2) under these conditions. While Giza 716 cultivar was highly susceptible to broomrape infection and gave the highest values of the number of broomrape (Spikes/m^2) under these conditions. Therefore, faba bean plants from Giza 843 cultivar have a low exposure to stress from the broomrape parasitic weeds, allowing them to produce the highest biological yield, seed yield and straw yield under these conditions compared to other susceptible cultivars to broomrape infection. Such findings are in general agreement with those obtained by Megahed (1999), Abbes *et al.* (2006), El-Degwy *et al.* (2010), Bayoumi *et al.* (2014), El-Ghareib *et al.* (2019) and Zeid and Mona (2019).

The resistance methods had a significant effect on the number of broomrape (Spikes/m^2) in both seasons. The highest numbers of broomrape (Spikes/m^2) were recorded from the treatment without (F) in both seasons. The means of the number of broomrape (Spikes/m^2) for this treatment were 38.99 and 30.77 spikes/m^2 in the 1st and 2nd seasons, respectively, followed by intercropping faba bean with garlic (F+A), with no significant differences between them in both seasons. On the contrary, the lowest numbers of broomrape (Spikes/m^2) gave 8.22 and 7.70 spikes/m^2 in the 1st and 2nd seasons, respectively, which were recorded for the faba bean plants treated by foliar spraying with glyphosate (F+H). The mean number of broomrape (Spikes/m^2) of the faba bean plants under intercropping with fenugreek (F+T) was between the treatment without (F) and the faba bean plants treated by foliar spraying with glyphosate (F+H). The number of broomrape (Spikes/m^2) was reduced when faba bean and fenugreek were intercropped. It might be due to allelopathic influence on the parasite, as suggested by the inhibition of broomrape seed germination by allelochemicals (Trigoxazonane was found in fenugreek root exudates) released by fenugreek roots as a mechanism for reducing broomrape infection. Foliar spraying with glyphosate on the leaves of the faba bean plants (F+H) significantly decreased broomrape infestation (Spikes/m^2) by 78.91 and 74.97% in the 1st and 2nd seasons, respectively, as compared with treatment without (F) in both seasons. After the application of glyphosate herbicide to host leaves, glyphosate is thought to fast translocate away from the crop leaves to translocate through the host phloem to broomrape attachments on the host roots (Underground tubercles, immature leaves, and meristems) and exert its toxic effect to kill this parasite. Consequently, it significantly reduces the number of broomrape (Spikes/plant) and the dry weight of broomrape spikes (g). Similar results were also reported by Bakheit *et al.* (2002), Ghalwash *et al.* (2012), El-Ghareib *et al.* (2019) and El-Mergawi and El-Dabaa (2021).

The interaction between sowing dates and cultivars (S × C) exhibited a significant effect on this trait in both seasons. The interaction between sowing dates the resistance methods exhibited (S × D) a significant effect on this trait in both seasons. The interaction between cultivars and the resistance methods (C × D) exhibited a significant effect on this trait in both seasons. The interaction between sowing dates, cultivars and the resistance methods (S × C × D) exhibited a significant effect on this trait in the first season only. The minimum number of broomrape 1.67 spikes/m^2 in the first season was obtained from the plots planted by cultivar Giza 843 at the third date on the 1st of December with glyphosate foliar spraying on the leaves of the faba bean plants (F+H). In contrast, the maximum number of broomrape (Spikes/m^2) of 64.67 spikes/m^2 was obtained from the plots planted by cultivar Giza 716 at the first date on the 20th of October with the treatment without (F).

2. Dry weight of broomrape spikes (g/m^2)

The results in Table 3 indicate the effects of sowing dates, some faba bean cultivars, resistance methods and their interactions on the dry weight of broomrape spikes (g/m^2) in the 2018/19 and 2019/20 seasons. The results showed that the mean values of the dry weight of broomrape spikes (g/m^2) were significantly affected by the sowing dates in both seasons. The lowest values of the dry weight of broomrape spikes (g/m^2) of 28.31 and 23.82 (g/m^2) were obtained from the plots planted at the third date on the 1st of December in the 2018/19 and 2019/20 seasons, respectively. Otherwise, the heaviest dry weight of broomrape spikes (g/m^2) of 109.48 and 81.82 (g/m^2) was obtained from the plots planted at the first date on the 20th of October in the 2018/19 and 2019/20 seasons, respectively. The mean values of the dry

weight of broomrape spikes (g/m^2) for the second sowing date on the 10th of November were between the third sowing date on the 1st of December and the first sowing date on the 20th of October. Sowing faba bean at the third date on the 1st of December significantly decreased the dry weight of broomrape spikes (g/m^2) by 74.14 and 70.88% in the first and second seasons, respectively, as compared with sowing at the first date on the 20th of October in both seasons. The previously given data shows that the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2) decrease with the delay in sowing dates for December. This may be due to the delay in sowing dates that leads to a decrease in the broomrape seed germination due to suboptimal soil temperatures for their germination as the temperatures gradually decline from October to December. Furthermore, low temperatures may also hinder and slow down the development of broomrape tubers during underground stages. The present results are confirmed with those obtained by Grenz *et al*. (2005), Pérez-de-Luque *et al*. (2010) and Abdel-Wahab and Eman (2021).

Data in Table 3 show that the three cultivars of faba bean exhibited a significant effect on the dry weight of broomrape spikes (g/m^2) in both seasons. The highest values of the dry weight of broomrape spikes (g/m^2) of 71.76 and 63.05 (g/m^2) were recorded with the cultivar Giza 716 in the 2018/19 and 2019/20 seasons, respectively, followed by Sakha 1 cultivar, which recorded 63.93 and 51.54 (g/m^2) in the 2018/19 and 2019/20 seasons, respectively. However, Giza 843 cultivar recorded the lowest values of the dry weight of broomrape spikes (g/m^2) of 46.30 and 28.77 (g/m^2) in the 2018/19 and 2019/20 seasons, respectively. Giza 843, a tolerant cultivar, significantly reduced the dry weight of broomrape spikes (g/m^2) by 35.47 and 54.36% in the 2018/19 and 2019/20 seasons, respectively, as compared to susceptible cultivar Giza 716 in both seasons. These results can be attributable to the behavior of the tested cultivars, which is governed by genetic constituents and their interaction with the environmental variables present during the growing season. In addition, it could be observed that the tolerance cultivars may provide better protection against broomrape parasitism. Giza 843 cultivar showed markedly more tolerance to broomrape than other genotypes and gave the lowest values for the number of broomrape (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) under these conditions. While Giza 716 cultivar was highly susceptible to broomrape infection and gave the highest values of the number of broomrape (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) under these conditions. Therefore, faba bean plants from Giza 843 cultivar have a low exposure to stress from the broomrape parasitic weeds, allowing them to produce the highest biological yield, seed yield and straw yield under these conditions compared to other genotypes susceptible to broomrape infection. Such findings are in general agreement with those obtained by Megahed (1999), Abbes *et al.* (2006), El-Degwy *et al.* (2010), Bayoumi *et al.* (2014) and Zeid and Mona (2019).

The resistance methods had a significant effect on the dry weight of broomrape spikes (g/m^2) in both seasons. The highest values of the dry weight of broomrape spikes (g/m^2) were recorded from this treatment without (F) in both seasons. The means of the dry weight of broomrape spikes (g/m^2) for this treatment were 92.12 and 72.12 (g/m^2) in the 1st and 2nd seasons, respectively, followed by intercropping faba bean with garlic (F+A), with no significant differences between them in both seasons. On the other hand, the lowest values of the dry weight of broomrape spikes (g/m^2) were 15.46 and 13.37 (g/m^2) in the 1st and 2nd seasons, respectively, which were recorded for the faba bean plants treated by foliar spraying with glyphosate (F+H). The mean dry weight of broomrape spikes (g/m^2) of the faba bean plants under intercropping with fenugreek (F+T) was between the treatment without (F) and the faba bean plants treated by foliar spraying with glyphosate (F+H). The number of broomrape (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) were reduced when faba bean and fenugreek were intercropped. It might be due to allelopathic influence on the parasite, as suggested by the inhibition of broomrape seed germination by allelochemicals (Trigoxazonane was found in fenugreek root exudates) released by fenugreek roots as a mechanism for reducing broomrape infection. Foliar spraying with glyphosate on the leaves of the faba bean plants (F+H) significantly decreased the dry weight of broomrape spikes (g/m^2) by 83.21 and 81.46% in the 1st and 2nd

seasons, respectively, as compared with treatment without (F) in both seasons. After the application of glyphosate herbicide to host leaves, glyphosate is thought to fast translocate away from the crop leaves to translocate through the host phloem to broomrape attachments on the host roots (Underground tubercles, immature leaves, and meristems) and exert its toxic effect to kill this parasite. Consequently, it significantly reduces the number of broomrape (Spikes/plant) and the dry weight of broomrape spikes (g). Similar results were also reported by Ghalwash *et al.* (2012), El-Metwally *et al.* (2013) and El-Mergawi and El-Dabaa (2021).

The interaction between sowing dates and cultivars (S × C) exhibited a significant effect on this trait in both seasons. The interaction between sowing dates and the resistance methods (S × D) exhibited a significant effect on this trait in both seasons. The interaction between cultivars and the resistance methods (C × D) exhibited a significant effect on this trait in both seasons. The interaction between sowing dates, cultivars and the resistance methods (S × C × D) exhibited a significant effect on this trait in the second season only. The lowest value of the dry weight of broomrape spikes (g/m^2) of 3.87 (g/m^2) in the second season was obtained from the plots planted by Giza 843 cultivar at the third date on the 1st of December with glyphosate foliar spraying on the leaves of the faba bean plants (F+H). In contrast, the highest value of the dry weight of broomrape spikes (g/m^2) of 170.27 (g/m^2) was obtained from the plots planted by Giza 716 cultivar at the first date on the 20th of October with the treatment without (F).

B. Yield and yield components

1. Plant height (cm)

The results in Table 4 cleared that sowing dates, some faba bean cultivars and resistance methods had a significant effect on plant height (cm) at harvest in the 2018/19 and 2019/20 seasons. The interaction between the three factors did not exert a significant effect on this trait in both seasons. Concerning the effect of sowing dates on plant height, it could be concluded that the tallest plants were recorded for the first date on the 20th of October, which recorded plant height values of 100.31 and 101.60 cm at harvest in the 2018/19 and 2019/20 seasons, respectively. On the contrary, the plots planted at the third date on the 1st of December recorded the shortest plants of 88.93 and 91.21 cm at harvest in the 2018/19 and 2019/20 seasons, respectively. In most cases, the tallest plants were recorded from the first sowing date (S_1). This may be due to the length of the vegetative growth period in particular, as well as the life cycle in general until the maturity and harvest for faba bean plants that were planted at this early sowing date. However, a delay in the sowing date has resulted in producing the shortest plants of faba bean. This may be due to the shortening of the vegetative growth period in particular, as well as the life cycle in general until the maturity and harvest for faba bean plants that were planted at the third sowing date (S_3). The results are in agreement with the results found by El-Metwally *et al.* (2013) and El-Ghareib *et al.* (2019).

With regard to the effect of cultivars, it could be noticed that the tallest cultivar was Giza 843, which recorded plant height values of 105.67 and 107.71 cm at harvest in the 2018/19 and 2019/20 seasons, respectively. Whereas, the shortest cultivar was Giza 716 in both seasons. The means of plant height for this cultivar were 85.63 and 87.26 cm at harvest in the 2018/19 and 2019/20 seasons, respectively. These results can be attributable to the behavior of the studied cultivars, which is governed by genetic constituents and their interaction with the environmental variables present during the growing seasons. Similar findings are in agreement with those obtained by Bayoumi *et al.* (2014) and El-Ghareib *et al.* (2019).

As for the effect of the resistance methods, the results showed that the faba bean plants under intercropping with fenugreek (F+T) recorded the tallest plants at harvest in both seasons. The means of plant height for this treatment were 97.45 and 98.76 cm at harvest in the 2018/19 and 2019/20 seasons, respectively. In contrast, the shortest plants at harvest were produced from the treatment without (F), which recorded plant height values of 92.64 and 94.57 cm at harvest in the 2018/19 and 2019/20 seasons, respectively. It could be noticed that there was no significant difference between the two treatments, intercropping faba bean with the garlic (F+A) and without (F) in the mean values of plant height. The tallest plants at

harvesting were recorded from the faba bean plants under intercropping with fenugreek (F+T), followed by foliar spraying with glyphosate on the leaves of the faba bean plants (F+H). This may be due to faba bean plants grown under these two treatments have a low number of broomrape (Spikes/m^2) and the least amount of dry weight of broomrape spikes (g/m^2). Therefore, their exposure to stress from the broomrape parasitic weeds is lower, allowing them to produce a better plant height under these conditions, compared to the other treatments of faba bean plants (F+A) and (F), which were exposed to high stress by the broomrape parasitic weeds, which made them suffer from difficulty in growth, thus the plants became shorter. These results took the same trend as those recorded by Ghalwash *et al.* (2012), and El-Mergawi and El-Dabaa (2021).

2. Number of pods/plant

Results in Table 5 show the effect of sowing dates, some faba bean cultivars, resistance methods and their interaction on the number of pods/plant of faba bean plants in the 2018/19 and 2019/20 seasons. Data in Table 5 showed a significant effect in the number of pods/plant of faba bean plants among the three sowing dates in both seasons. It is clear that the number of pods/plant was significantly increased with a delay in the sowing dates in both seasons under naturally infested soil conditions by broomrape. Sowing at the third date on the 1st of December gave the highest number of pods/plant of 6.52 and 8.34 pods in the 2018/19 and 2019/20 seasons, respectively, followed by sowing at the second date on the 10th of November in the 2018/19 and 2019/20 seasons, respectively. On the contrary, sowing at the first date on the 20th of October gave the lowest number of pods/plant of 3.32 and 4.61 pods in the 2018/19 and 2019/20 seasons, respectively. The increase in the number of pods/plant could be attributed to a significant reduction in the number of broomrape (Spikes/plant) and the dry weight of broomrape spikes (g) with the delay in sowing dates to December. Therefore, faba bean plants sown on the 1st of December have lower exposure to stress from the broomrape parasitic weeds, which reflects on plant vigor, formation of assimilates and its translocation from source to sink, allowing them to produce the highest number of pods/plant under these conditions. Similar results were also reported by Grenz *et al.* (2005), El-Metwally *et al.* (2013) and El-Ghareib *et al.* (2019).

Table 5 clearly shows that faba bean cultivars had a significant influence on the number of pods/plant in both seasons. Giza 843 cultivar produced the highest number of pods/plant of 6.74 and 8.46 pods in the 2018/19 and 2019/20 seasons, respectively followed by Sakha 1 cultivar in both seasons. While, the Giza 716 cultivar gave the lowest number of pods/plant of 3.32 and 4.56 pods in the 2018/19 and 2019/20 seasons, respectively. These results can be attributable to the behavior of the tested genotypes, which is governed by genetic constituents and their interaction with the environmental variables present during the growing season. In addition, it could be observed that the tolerance cultivars may provide better protection against broomrape parasitism. Giza 843 cultivar showed markedly more tolerance to broomrape than other cultivars and gave the lowest values for the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2) under these conditions. While Giza 716 cultivar was highly susceptible to broomrape infection and gave the highest values of the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2) under these conditions. For the previous reasons, faba bean plants from Giza 843 cultivar have a low exposure to stress from the broomrape parasitic weeds, which reflects on plant vigor, formation of assimilates and its translocation from source to sink, allowing them to produce the highest number of pods/plant under these conditions compared to other susceptible cultivars to broomrape infection. Such results agree with those reported by El-Degwy *et al.* (2010) and El-Ghareib *et al.* (2019).

The data in the same table 5 show clearly that the resistance methods exhibited a significant effect on the number of pods/plant in both seasons. Faba bean plants treated by foliar spraying with glyphosate (F+H) recorded the highest number of pods/plant of 7.41 and 9.44 pods in the 1st and 2nd seasons, respectively, followed by intercropping faba bean with fenugreek (F+T) in both seasons. Whereas, the treatment without (F) recorded the lowest number of pods/plant of 3.67 and 5.06 pods in the 1st and 2nd seasons, respectively, with no significant differences between treatment without

(F) and intercropping faba bean with garlic (F+A) in both seasons. Foliar spraying with glyphosate on the leaves of the faba bean plants (F+H) and intercropping faba bean with fenugreek (F+T) recorded the lowest values for the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2). Consequently, faba bean plants grown under these treatments have low exposure to stress from the broomrape parasitic weeds, which reflects on plant vigor, formation of assimilates and its translocation from source to sink, allowing them to produce the highest number of pods/plant under these conditions. These results took the same trend as those recorded by Bakheit *et al.* (2002), Ghalwash *et al.* (2012), El-Mergawi and El-Dabaa (2021), and Abdel-Wahab and Eman (2021).

The interaction between sowing dates and cultivars (S × C) was significant on the number of pods/plant in both seasons. The highest number of pods/plant of 7.96 and 9.93 pods were recorded for planting Giza 843 cultivar on the 1st of December in the 2018/19 and 2019/20 seasons, respectively. While the lowest number of pods/plant of 2.18 and 3.33 pods were recorded for planting Giza 716 cultivar on the 20th of October in the 2018/19 and 2019/20 seasons, respectively.

3. Biological yield (ton/fed)

Data in Table 6 represents the biological yield (ton/fed) of faba bean as affected by sowing dates, some faba bean cultivars, resistance methods and their interaction in the 2018/19 and 2019/20 seasons. Sowing dates had a significant effect on the biological yield (ton/fed) of faba bean plants in the 1st and 2nd seasons. The highest values of the biological yield/fed were produced by sowing at the third date on the 1st of December of 4.05 and 4.23 ton in the 2018/19 and 2019/20 seasons, respectively, followed by sowing at the second date on the 10th of November in both seasons. Whereas, sowing at the first date on the 20th of October gave the lowest values of the biological yield/fed of 2.19 and 2.75 ton in the 2018/19 and 2019/20 seasons, respectively. Under naturally infested soil conditions by broomrape, it could be observed that delaying sowing dates significantly increased the biological yield (ton/fed) in both seasons. These findings were consistent with those obtained by El-Degwy *et al.* (2010), El-Ghareib *et al.* (2019), and Abdel-Wahab and Eman (2021).

Results in Table (6) clarified a significant differences among three faba bean cultivars in the biological yield (ton/fed) in both seasons. Giza 843 cultivar produced highest values of the biological yield/fed of 4.03 and 4.35 ton in the 2018/19 and 2019/20 seasons, respectively, followed by Sakha 1 cultivar in both seasons. In contrast, Giza 716 cultivar gave the lowest values of the biological yield/fed which were 2.28 and 2.82 ton in the 2018/19 and 2019/20 seasons, respectively. These results can be attributable to the behavior of the tested genotypes, which is governed by genetic constituents and their interaction with the environmental variables present during the growing season. In addition, it could be observed that the tolerance cultivars may provide better protection against broomrape parasitism. Giza 843 cultivar showed markedly more tolerance to broomrape than the other cultivars and gave the lowest values for the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2) under these conditions. Similar results were also reported by Bayoumi *et al.* (2014), El-Ghareib *et al.* (2019) and Zeid and Mona (2019).

Data in Table 6 indicated that the mean values of the biological yield (ton/fed) were significantly affected by the resistance methods in both seasons. Under naturally infected soil conditions by broomrape, the biological yield (ton/fed) was clearly increased with the foliar spraying by glyphosate on the leaves of the faba bean plants (F+H) in both seasons. Foliar spraying by glyphosate (F+H) gave the highest values of the biological yield/fed of 4.09 and 4.56 ton in the first and second seasons, respectively, followed by intercropping faba bean with fenugreek (F+T) in both seasons. On the contrary, treatment without (F), gave the lowest values of the biological yield/fed of 2.74 and 3.13 ton in the first and second seasons, respectively, with no significant differences between the treatment without (F) and intercropping faba bean with garlic (F+A) in both seasons. These results took the same trend as those recorded by Ghalwash et *al.* (2012) and Abbes *et al.* (2019).

The interaction between sowing dates and cultivars (S × C) exhibited a significant effect on the

biological yield (ton/fed) in both seasons. The interaction between sowing dates and the resistance methods (S × D) had a significant effect on this trait in the second season only. The interaction between cultivars and the resistance methods (C × D) exhibited a significant effect on the biological yield (ton/fed) in both seasons. The interaction between sowing dates, cultivars and the resistance methods (S × C × D) had a significant effect on the biological yield (ton/fed) in the second season only. The highest value of the biological yield/fed of 5.68 ton in the second season was obtained from the plots planted by Giza 843 cultivar at the third date on the 1st of December with glyphosate foliar spraying on the leaves of the faba bean plants (F+H). In contrast, the lowest value of the biological yield/fed of 1.43 ton was obtained from the plots planted by Giza 716 cultivar at the first date on the 20th of October with the treatment without (F).

4. Seed yield (ton/fed)

Data in Table 7 shows the effect of sowing dates, some faba bean cultivars, resistance methods and their interaction on the seed yield (ton/fed) of faba bean plants in the 2018/19 and 2019/20 seasons. As shown in Table 7 a significant effect on the seed yield (ton/fed) of faba bean plants was found among the three sowing dates in both seasons. Under naturally infected soil conditions by broomrape, the seed yield (ton/fed) was clearly increased with a delay in the sowing dates in both seasons. Sowing at the third date on the 1st of December gave the greatest seed yield/fed of 1.010 and 1.169 ton in the 2018/19 and 2019/20 seasons, respectively, followed by sowing at the second date on the 10th of November of 0.810 and 1.007 ton in the 2018/19 and 2019/20 seasons, respectively. On the contrary, sowing at the first date on the 20th of October ranked the third and last, which gave the lowest values of the seed yield/fed 0.517 and 0.682 ton in the 2018/19 and 2019/20 seasons, respectively. Sowing faba bean at the third date on the 1st of December under naturally infected soil conditions by broomrape, significantly improved seed yield (ton/fed) by 95.35% and 71.40% in the first and second seasons, respectively, as compared with sowing at the first date on the 20th of October in both seasons. According to the previously given data, it is clear that the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2) were reduced with the delay in the sowing dates of December. This may be due to the delay in the sowing dates that leads to a decrease in the broomrape seed germination due to suboptimal soil temperatures for their germination as the temperatures gradually decline from October to December. Furthermore, low temperatures may also hinder and slow down the development of broomrape tubers during underground stages. Therefore, faba bean plants sown on the 1st of December have a less exposure to stress from the broomrape parasitic weeds, which reflects on plant vigor, the formation of assimilates and its translocation from source to sink, which increases the accumulation of dry matter (mass) in seeds and reduces seed abortion rate, resulting in enhanced yield components such as number of pods/plant, number of seeds/pod, 100-seed weight and seed yield/plant, which causes the seed yield (ton/fed) to increase under these conditions. Similar results were also reported by Grenz *et al.* (2005), El-Ghareib *et al.* (2019), and Abdel-Wahab and Eman (2021).

The results recorded in Table 7 indicate clearly that, there was a significant effect on the seed yield (ton/fed) among faba bean cultivars in both seasons. Giza 843 cultivar produced the highest seed yield/fed of 1.114 and 1.227 ton in the 2018/19 and 2019/20 seasons, respectively, followed by Sakha 1 cultivar of 0.778 and 0.943 ton in the 2018/19 and 2019/20 seasons, respectively. Whereas, Giza 716 cultivar ranked the third and last concerning this trait, which gave the lowest seed yield/fed of 0.443 and 0.687 ton in the first and second seasons, respectively. Giza 843, a tolerant cultivar, significantly increased the seed yield (ton/fed) by 151.46 and 78.60% in the 2018/19 and 2019/20 seasons, respectively, as compared to the susceptible cultivar Giza 716 in both seasons. These results can be attributable to the behavior of the tested cultivars, which is governed by genetic constituents and their interaction with the environmental variables present during the growing season. In addition, it could be observed that the tolerance cultivars may provide better protection against broomrape parasitism. Giza 843 cultivar showed markedly more tolerance to broomrape than other genotypes

and gave the lowest values for the number of broomrape (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) under these conditions. While Giza 716 cultivar was highly susceptible to broomrape infection and gave the highest values of the number of broomrape (Spikes/m^2) and dry weight of broomrape spikes (g/m^2) under these conditions. Therefore, faba bean plants from cultivar Giza 843 have a low exposure to stress from the broomrape parasitic weeds, which reflects on plant vigor, the formation of assimilates and its translocation from source to sink, which increases the accumulation of dry matter (mass) in seeds and reduces seed abortion rate, resulting in enhanced yield components, allowing them to produce the highest biological yield, seed yield and straw yield under these conditions compared to other genotypes susceptible to broomrape infection. The same trend was obtained by El-Degwy *et al.* (2010), Bayoumi *et al.* (2014), El-Ghareib *et al.* (2019), and Zeid and Mona (2019).

Results in Table 7 revealed that the resistance methods possessed a significant effect on the seed yield (ton/fed) in both seasons. Under naturally infected soil conditions by broomrape, the seed yield (ton/fed) was clearly increased with the foliar spraying by glyphosate on the leaves of the faba bean plants (F+H) in both seasons. Foliar spraying by glyphosate (F+H) gave the highest seed yield/fed of 1.167 and 1.325 ton in the 2018/19 and 2019/20 seasons, respectively, followed by intercropping faba bean with fenugreek (F+T), which gave 0.704 and 0.903 ton in the 2018/19 and 2019/20 seasons, respectively. On the other hand, treatment without (F), gave the lowest seed yield/fed of 0.610 and 0.784 ton in the 2018/19 and 2019/20 seasons, respectively, with no significant differences between the treatment without (F) and intercropping faba bean with garlic (F+A) in both seasons. Foliar spraying with glyphosate on the leaves of the faba bean plants (F+H) under naturally infected soil conditions by broomrape significantly improved the seed yield (ton/fed) by 91.31% and 69% in the 2018/19 and 2019/20 seasons, respectively, as compared with treatment without (F) in both seasons. It could be observed that foliar spraying with glyphosate (F+H) and intercropping faba bean with fenugreek (F+T) recorded the lowest values for the number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2). The number of broomrape (Spikes/m^2) and the dry weight of broomrape spikes (g/m^2) were reduced when faba bean and fenugreek were intercropped. It might be due to allelopathic influence on the parasite, as suggested by the inhibition of broomrape seed germination by allelochemicals (Trigoxazonane was found in fenugreek root exudates) released by fenugreek roots as a mechanism for reducing broomrape infection. Concerning foliar spraying with glyphosate on the leaves of the faba bean plants (F+H) significantly decreased broomrape infestation in both seasons. After the application of glyphosate herbicide to host leaves, glyphosate is thought to fast translocate away from the crop leaves to translocate through the host phloem to broomrape attachments on the host roots (Underground tubercles, immature leaves, and meristems) and exert its toxic effect to kill this parasite. Consequently, it significantly reduces the number of broomrape (Spikes/plant) and the dry weight of broomrape spikes (g). As a result of this, faba bean plants grown under these treatments have low exposure to stress from the broomrape parasitic weeds, which reflects on plant vigor, the formation of assimilates and its translocation from source to sink, which increases the accumulation of dry matter (mass) in seeds and reduces seed abortion rate, resulting in enhanced yield components such as number of pods/plant, number of seeds/pod and 100-seed weight, allowing them to produce the highest biological yield, seed yield and straw yield under these conditions. The present results are confirmed with those obtained by El-Degwy *et al.* (2010), Ghalwash *et al.* (2012), Abbes *et al.* (2019) and El-Ghareib *et al.* (2019).

The interaction between sowing dates and cultivars (S × C) exhibited a significant effect on the seed yield (ton/fed) in both seasons. The interaction between sowing dates and the resistance methods (S × D) had a significant effect on this trait in the second season only. The interaction between cultivars and the resistance methods (C × D) possessed a significant effect on the seed yield (ton/fed) in both seasons. The interaction between sowing dates, cultivars and the resistance methods (S × C × D) had a significant effect on the seed yield (ton/fed) in both seasons. The highest values of the seed yield/fed of 1.666 and 1.700 ton in the 2018/19 and 2019/20 seasons, respectively, were

obtained from the plots planted by Giza 843 cultivar at the third date on the 1st of December with glyphosate foliar spraying on the leaves of the faba bean plants (F+H). In contrast, the lowest values of the seed yield/fed of 0.104 and 0.285 ton were obtained from the plots planted by Giza 716 cultivar at the first date on the 20th of October with the treatment without (F) in the 2018/19 and 2019/20 seasons, respectively.

Table 4. Mean performance of plant height (cm) at harvest under effects of sowing dates, some faba bean cultivars, resistance methods (Herbicide, intercropping faba bean with fenugreek, intercropping faba bean with garlic and without) and their interactions in the 2018/19 and 2019/20 seasons.

Sowing dates (S)	Trait	Plant height (cm) at harvest									
	Season	Season 2018/19					Season 2019/20				
	Cultivars (C)	Resistance methods (D)					Resistance methods (D)				
		(F + H)	(F + T)	(F + A)	(F)	Mean	(F + H)	(F + T)	(F + A)	(F)	Mean
20th of October	Sakha 1	97.61	98.24	95.53	95.17	**96.64**	99.28	100.37	97.46	96.98	**98.52**
	Giza 843	114.22	117.59	109.47	109.38	**112.66**	116.63	118.46	110.16	110.05	**113.83**
	Giza 716	91.36	93.50	90.92	90.74	**91.63**	92.63	95.13	91.24	90.83	**92.46**
	Mean	**101.07**	**103.11**	**98.64**	**98.43**	**100.31**	**102.85**	**104.65**	**99.62**	**99.29**	**101.60**
10th of November	Sakha 1	94.83	96.18	92.02	91.69	**93.68**	95.76	96.77	94.21	94.16	**95.22**
	Giza 843	107.50	108.16	103.25	103.11	**105.51**	108.54	109.13	105.34	104.96	**106.99**
	Giza 716	86.40	88.09	83.76	83.21	**85.37**	88.82	89.23	85.71	85.18	**87.23**
	Mean	**96.24**	**97.48**	**93.01**	**92.67**	**94.85**	**97.70**	**98.37**	**95.09**	**94.77**	**96.48**
1st of December	Sakha 1	88.10	90.71	86.66	86.42	**87.97**	90.14	91.83	87.48	87.35	**89.20**
	Giza 843	100.48	102.27	96.81	95.90	**98.87**	103.28	103.81	101.19	101.02	**102.33**
	Giza 716	80.72	82.33	78.54	78.19	**79.95**	82.67	84.15	80.93	80.64	**82.10**
	Mean	**89.77**	**91.77**	**87.34**	**86.84**	**88.93**	**92.03**	**93.26**	**89.87**	**89.67**	**91.21**
Cultivars (C) × Resistance methods (D)	Sakha 1	93.51	95.04	91.40	91.09	**92.76**	95.05	96.32	93.05	92.82	**94.31**
	Giza 843	107.39	109.34	103.17	102.79	**105.67**	109.48	110.46	105.56	105.34	**107.71**
	Giza 716	86.16	87.97	84.35	84.04	**85.63**	88.03	89.50	85.95	85.55	**87.26**
Mean		**95.69**	**97.45**	**92.97**	**92.64**	**94.69**	**97.52**	**98.76**	**94.85**	**94.57**	**96.43**
LSD 5% for :	S	2.409					2.567				
	C	1.822					1.610				
	D	2.183					2.128				
	S × C	n.s					n.s				
	S × D	n.s					n.s				
	C × D	n.s					n.s				
	S × C × D	n.s					n.s				

(S): Sowing dates.
(C): Cultivars.
(D): Resistance methods: Herbicide (Glyphosate 48% WSC)
(**F+H**), Intercropping faba bean with Fenugreek
(**F+T**), Intercropping faba bean with Garlic
(**F+A**) and Without (**F**) Faba bean alone

Table 5. Mean performance of the number of pods/plant under effects of sowing dates, some faba bean cultivars and resistance methods (Herbicide, intercropping faba bean with fenugreek, intercropping faba bean with garlic and without) and their interactions in the 2018/19 and 2019/20 seasons.

Sowing dates (S)	Trait	Number of pods/plant									
	Season	Season 2018/19					Season 2019/20				
	Cultivars (C)	Resistance methods (D)					Resistance methods (D)				
		(F + H)	(F + T)	(F + A)	(F)	Mean	(F + H)	(F + T)	(F + A)	(F)	Mean
20th of October	Sakha 1	4.73	2.00	1.60	1.53	**2.47**	5.43	3.27	3.10	2.83	**3.66**
	Giza 843	7.50	5.63	4.67	3.47	**5.32**	9.57	6.80	5.73	5.20	**6.83**
	Giza 716	4.80	1.47	1.23	1.20	**2.18**	6.40	2.53	2.30	2.10	**3.33**
	Mean	**5.68**	**3.03**	**2.50**	**2.07**	**3.32**	**7.13**	**4.20**	**3.71**	**3.38**	**4.61**
10th of November	Sakha 1	8.13	5.10	3.43	3.37	**5.01**	10.77	6.60	4.97	4.83	**6.79**
	Giza 843	9.27	6.37	6.23	5.90	**6.94**	11.63	7.97	7.60	7.33	**8.63**
	Giza 716	5.33	2.90	2.67	2.23	**3.28**	6.73	4.13	3.63	3.40	**4.47**
	Mean	**7.58**	**4.79**	**4.11**	**3.83**	**5.08**	**9.71**	**6.23**	**5.40**	**5.19**	**6.63**
1st of December	Sakha 1	8.20	7.67	6.53	6.00	**7.10**	11.40	9.37	8.63	7.43	**9.21**
	Giza 843	10.93	7.80	6.63	6.47	**7.96**	12.80	9.83	8.77	8.30	**9.93**
	Giza 716	7.83	4.10	3.17	2.93	**4.51**	10.23	4.70	4.47	4.17	**5.89**
	Mean	**8.99**	**6.52**	**5.44**	**5.13**	**6.52**	**11.48**	**7.97**	**7.29**	**6.63**	**8.34**
Cultivars (C) × Resistance methods (D)	Sakha 1	7.02	4.92	3.85	3.63	**4.86**	9.20	6.41	5.56	5.03	**6.55**
	Giza 843	9.23	6.60	5.84	5.27	**6.74**	11.33	8.20	7.36	6.94	**8.46**
	Giza 716	5.98	2.82	2.35	2.12	**3.32**	7.78	3.78	3.46	3.22	**4.56**
Mean		**7.41**	**4.78**	**4.01**	**3.67**	**4.97**	**9.44**	**6.13**	**5.46**	**5.06**	**6.52**
LSD 5% for :	S	0.978					0.737				
	C	0.490					0.435				
	D	0.646					0.521				
	S × C	1.191					0.954				
	S × D	n.s					n.s				
	C × D	n.s					n.s				
	S × C × D	n.s					n.s				

(S): Sowing dates.
(C): Cultivars.
(D): Resistance methods: Herbicide (Glyphosate 48% WSC)
(**F+H**), Intercropping faba bean with Fenugreek
(**F+T**), Intercropping faba bean with Garlic
(**F+A**) and Without (**F**) Faba bean alone

.

Table 6. Mean performance of the biological yield (ton/fed) under effects of sowing dates, some faba bean cultivars and resistance methods (Herbicide, intercropping faba bean with fenugreek, intercropping faba bean with garlic and without) and their interactions in the 2018/19 and 2019/20 seasons.

Sowing dates (S)	Trait	Biological yield (ton/fed)									
	Season	Season 2018/19					Season 2019/20				
	Cultivars (C)	Resistance methods (D)					Resistance methods (D)				
		(F + H)	(F + T)	(F + A)	(F)	Mean	(F + H)	(F + T)	(F + A)	(F)	Mean
20th of October	Sakha 1	3.06	1.69	1.52	1.49	**1.94**	3.31	2.17	2.01	1.97	**2.36**
	Giza 843	3.80	3.32	2.95	2.90	**3.24**	4.51	4.03	3.32	3.29	**3.79**
	Giza 716	3.20	0.88	0.76	0.75	**1.40**	3.74	1.77	1.46	1.43	**2.10**
	Mean	**3.36**	**1.96**	**1.75**	**1.71**	**2.19**	**3.85**	**2.66**	**2.26**	**2.23**	**2.75**
10th of November	Sakha 1	3.81	3.16	2.90	2.88	**3.19**	4.86	3.83	3.22	3.21	**3.78**
	Giza 843	5.08	3.99	3.80	3.76	**4.16**	5.26	4.26	4.24	4.21	**4.49**
	Giza 716	3.41	2.13	1.84	1.79	**2.29**	3.93	2.80	2.60	2.57	**2.98**
	Mean	**4.10**	**3.09**	**2.85**	**2.81**	**3.21**	**4.69**	**3.63**	**3.35**	**3.33**	**3.74**
1st of December	Sakha 1	4.60	4.26	4.11	4.04	**4.25**	5.07	4.48	4.40	4.23	**4.54**
	Giza 843	5.61	4.62	4.38	4.35	**4.74**	5.68	4.65	4.43	4.39	**4.79**
	Giza 716	4.28	2.83	2.76	2.74	**3.15**	4.72	2.97	2.93	2.91	**3.39**
	Mean	**4.83**	**3.90**	**3.75**	**3.71**	**4.05**	**5.16**	**4.03**	**3.92**	**3.85**	**4.23**
Cultivars (C) × Resistance methods (D)	Sakha 1	3.82	3.03	2.84	2.80	**3.12**	4.41	3.49	3.20	3.13	**3.56**
	Giza 843	4.83	3.97	3.70	3.66	**4.03**	5.15	4.31	3.99	3.96	**4.35**
	Giza 716	3.63	1.94	1.78	1.76	**2.28**	4.12	2.51	2.33	2.30	**2.82**
Mean		**4.09**	**2.98**	**2.77**	**2.74**	**3.15**	**4.56**	**3.44**	**3.17**	**3.13**	**3.58**
LSD 5% for :	S	0.328					0.101				
	C	0.203					0.059				
	D	0.243					0.078				
	S × C	0.433					0.131				
	S × D	n.s					0.154				
	C × D	0.418					0.132				
	S × C × D	n.s					0.242				

(S): Sowing dates.
(C): Cultivars.
(D): Resistance methods: Herbicide (Glyphosate 48% WSC)
(**F+H**), Intercropping faba bean with Fenugreek
(**F+T**), Intercropping faba bean with Garlic
(**F+A**) and Without (**F**) Faba bean alone

Table 7. Mean performance of the seed yield (ton/fed) under effects of sowing dates, some faba bean cultivars and resistance methods (Herbicide, intercropping faba bean with fenugreek, intercropping faba bean with garlic and without) and their interactions in the 2018/19 and 2019/20 seasons.

Sowing dates (S)	Trait	Seed yield (ton/fed)									
	Season	Season 2018/19					Season 2019/20				
	Cultivars (C)	Resistance methods (D)					Resistance methods (D)				
		(F + H)	(F + T)	(F + A)	(F)	Mean	(F + H)	(F + T)	(F + A)	(F)	Mean
20th of October	Sakha 1	0.753	0.245	0.214	0.197	**0.352**	0.843	0.459	0.396	0.389	**0.522**
	Giza 843	1.182	0.927	0.776	0.742	**0.907**	1.287	1.128	0.848	0.834	**1.024**
	Giza 716	0.778	0.171	0.111	0.104	**0.291**	1.042	0.373	0.300	0.285	**0.500**
	Mean	**0.904**	**0.448**	**0.367**	**0.348**	**0.517**	**1.057**	**0.653**	**0.515**	**0.503**	**0.682**
10th of November	Sakha 1	1.224	0.839	0.645	0.638	**0.837**	1.432	1.068	0.776	0.773	**1.012**
	Giza 843	1.560	1.068	1.023	1.002	**1.163**	1.630	1.184	1.176	1.158	**1.287**
	Giza 716	0.847	0.325	0.286	0.258	**0.429**	1.100	0.634	0.581	0.570	**0.721**
	Mean	**1.210**	**0.744**	**0.651**	**0.633**	**0.810**	**1.387**	**0.962**	**0.844**	**0.834**	**1.007**
1st of December	Sakha 1	1.308	1.128	1.105	1.046	**1.147**	1.522	1.275	1.222	1.172	**1.298**
	Giza 843	1.666	1.191	1.127	1.105	**1.272**	1.700	1.331	1.233	1.219	**1.371**
	Giza 716	1.189	0.445	0.412	0.400	**0.612**	1.372	0.672	0.661	0.655	**0.840**
	Mean	**1.388**	**0.921**	**0.881**	**0.850**	**1.010**	**1.531**	**1.093**	**1.039**	**1.015**	**1.169**
Cultivars (C) × Resistance methods (D)	Sakha 1	1.094	0.737	0.654	0.627	**0.778**	1.265	0.934	0.798	0.777	**0.943**
	Giza 843	1.469	1.062	0.975	0.949	**1.114**	1.538	1.214	1.085	1.070	**1.227**
	Giza 716	0.938	0.313	0.269	0.253	**0.443**	1.171	0.560	0.513	0.504	**0.687**
Mean		**1.167**	**0.704**	**0.633**	**0.610**	**0.778**	**1.325**	**0.903**	**0.799**	**0.784**	**0.952**
LSD 5% for :	S	0.053					0.026				
	C	0.055					0.017				
	D	0.046					0.021				
	S × C	0.095					0.036				
	S × D	n.s					0.041				
	C × D	0.090					0.036				
	S × C × D	0.154					0.066				

(S): Sowing dates.

(C): Cultivars.

(D): Resistance methods: Herbicide (Glyphosate 48% WSC)

(**F+H**), Intercropping faba bean with Fenugreek

(**F+T**), Intercropping faba bean with Garlic

(**F+A**) and Without (**F**) Faba bean alone.

REFERENCES

Abbes, Z.; I. Trabelsi; M. Kharrat and M. Amri (2019). Intercropping with fenugreek (*Trigonella foenum-graecum* L.) enhanced seed yield and reduced *Orobanche foetida* infestation in faba bean (*Vicia faba* L.). Bio. Agric. and Horti., 35(4): 238-247.

Abbes, Z.; M. Kharrat and W. Chaibi (2006). Study of the interaction between *Orobanche foetida* and faba bean at root level. Tunisian J. of Plant Protection, 1(1): 55-64.

Abdel-Wahab, S. I. and Eman I. A. (2021). Cropping systems of fenugreek with faba bean to reduce broomrape infestation. Legume Research. 44(5): 579-592.

Bakheit, B. R.; A. Y. Allam and A. H. Galal (2002). Intercropping faba bean with some legume crops for control of *Orobanche crenata*. Acta Agronomica Hungarica, 50(1): 1-6.

Bayoumi, T. Y.; S. M. Ammar; M. A. S. El-Bramawy and M. A. Emam (2014). Effect of some broomrape control methods on growth and seed yield attributes of faba bean (*Vicia faba* L.) cultivars. J. Agric. Res.; Suez Canal Univ., (1): 17-24.

El-Degwy, I. S.; Glelah A. A.; A. El-Galaly and Marwa K. M. (2010). Effect of sowing date and broomrape control on yield and yield related traits of some faba bean cultivars. J. Alexandria Sci. Exchange, 31(3): 230-239.

El-Ghareib, A. E.; A. M. Azab; E. A. E. Mesbah and N. E. Etiwa (2019). Influence of sowing dates and broomrape control methods on yield and yield components of some faba bean cultivars. J. Plant Production, Mansoura Univ., 10 (6): 427- 434.

El-Mergawi, R. A. and M. A. T. El-Dabaa (2021). Aromatic amino acids partially alleviated glyphosate induced effects on metabolites and growth in faba bean with a more phytotoxicity in *Orobanche crenata* parasite. Egypt. J. Chem., 64(8): 4641-4652.

El-Metwally, I. M.; T. A. El-Shahawy and M. A. Ahmed (2013). Effect of sowing dates and some broomrape control treatments on faba bean growth and yield. J. Appl. Sci. Res., 9(1):197-204.

Ghalwash, A. M.; H. S. Gharib and Azza E. K. (2012). Integrated broomrape (*Orobanche crenata Forsk.*) control in faba bean (*Vicia faba* L.) with nitrogen fertilizer, intercropping and herbicides. Egypt. J. Agron., 34(2): 301-19.

Ghobashy, A. M. (1997). Physiological studies on *Orobanche crenata* parasitizing faba bean plant. Ph.D. Thesis, Fac. of Agric., Cairo Univ.

Gomez, K. A. and A. A. Gomez (1984). Statistical Procedures for Agricultural Research. John Wiely and Sons.Toronto.

Grenz, J. H.; A. M. Manschadi; F. N. Uygur and J. Sauerborn (2005). Effects of environment and sowing date on the competition between faba bean (*Vicia faba* L.) and the parasitic weed *Orobanche crenata*. Field Crop Res., (93): 300-313.

Kandil, E. E. E.; A. M. Kordy and A. A. Abou Zied (2015). New approach for controlling broomrape plants in faba bean. J. Alexandria Sci. Exchange, 36(3): 282-291.

Megahed, A. H. M. (1999). Influence of *Orobanche* infestation on the productivity and seed quality of some faba bean blends. Ph.D. Thesis, Fac. of Agric., Cairo Univ.

Pérez-de-Luque, A.; H. Eizenberg; J. H. Grenz; J. C. Sillero; C. Ávila; J. Sauerborn and D. Rubiales (2010). Broomrape management in faba bean. Field Crops Res., 115(3): 319-328.

SAS Institute (2003). The SAS system for windows, realease 9.1.SAS Institute, Cary, N. C. USA.

Zeid, M. M. and Mona. M. H. (2019). Effect of glyphosate on performance of faba bean varieties under heavy infestation of *Orobanche crenata*. J. Alexandria Sci. Exchange, 40(1): 169-176.

الملخص العربي

المكافحة المتكاملة لحشيشة الهالوك فى الفول البلدى تحت ظروف العدوى الطبيعية للتربة

أبو بكر عبد الوهاب أحمد طنطاوى[1] ،صفوت شلبى عبد الله[2]، ياسر أحمد محمد حفنى [2] وأحمد رشاد محمود رضوان[2]

[1] قسم المحاصيل ،كلية الزراعة ،جامعة المنيا ـ مصر.
[2] قسم المحاصيل ،كلية الزراعة،جامعة سوهاج ـ مصر.

أجريت تجربة ميدانية في مزرعة البحوث الزراعية بالكوثر، كلية الزراعة، جامعة سوهاج خلال موسمي2018/19و2019/20. هدفت هذه الدراسة إلى دراسة المكافحة المتكاملة لحشائش الهالوك المتطفلة على الفول البلدى تحت ظروف التربة المصابة طبيعياً بالهالوك. تم استخدام تصميم القطاعات كاملة العشوائية فى ترتيب القطع المنشقة مرتين فى ثلاثة مكررات. تم ترتيب مواعيد الزراعة بشكل عشوائي في القطع الرئيسية ، بينما تم تخصيص القطع الفرعية للأصناف كما تم توزيعها عشوائيا ، ثم تم ترتيب طرق المقاومة الأخرى بشكل عشوائي في القطع التحت فرعية. تم إستخدام ثلاثة مواعيد للزراعة (20 أكتوبر ، 10 نوفمبر ، 1 ديسمبر) ، ثلاثة أصناف (سخا 1 ، جيزة 843 وجيزة 716) وأربعة طرق أخرى للمقاومة (مبيدات الأعشاب ، تحميل الفول البلدى مع الحلبة ، تحميل الفول البلدى مع الثوم وبدون). أوضحت النتائج المتحصل عليها أن زراعة الفول البلدى في الميعاد الثالث في 1من ديسمبر قلل معنوياً من عدد الهالوك (الشماريخ/م^2) والوزن الجاف لشماريخ الهالوك (جم/م^2)، كما أعطى القيم القصوى لمعظم الصفات المدروسة في كلا الموسمين، مقارنة بالزراعة في 20 أكتوبر أو 10 نوفمبر. أظهر الصنف جيزة 843 قدرًا أكبر من التحمل بشكل ملحوظ لحشائش الهالوك المتطفلة مقارنة بالأصناف الأخرى وأعطى أقل قيم لعدد الهالوك (الشماريخ/م^2) والوزن الجاف لشماريخ الهالوك (جم/م^2) في ظل هذه الظروف، كما تفوق في أغلب الصفات التى تمت دراستها في كلا الموسمين. بينما كان الصنف جيزة 716 شديد الحساسية للإصابة بالهالوك. أدى الرش الورقي بالجليفوسات على أوراق نباتات الفول البلدى إلى تقليل عدد الهالوك (الشماريخ/م^2) والوزن الجاف لشماريخ الهالوك (جم/م^2)، وأعطى أفضل القيم لمعظم الصفات المدروسة مقارنة مع طرق المقاومة الأخرى في كلا الموسمين. أخيرًا ، تحت ظروف التربة الموبوءة بشكل طبيعي بواسطة حشائش الهالوك في منطقة الدراسة ، يمكن التوصية بشدة بزراعة الصنف جيزة 843 في الأول من ديسمبر مع الرش الورقي بالجليفوسات 48٪ على أوراق نباتات الفول البلدى مرة واحدة في بداية التزهير بمعدل 75 سم^3/200 لتر للفدان لتحقيق أعلى إنتاجية لمحصول الفول البلدى بالطن للفدان تحت ظروف هذه الدراسة.