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Ahmed A.A. Sallam
Ibrahim M. Refaie

Plant protection Department
Faculty of Agriculture
Sohag University
Sohag
Egypt

Ibrahim S. Abdallah

Economic Entomology and pesticides Department
Faculty of Agriculture
Cairo University
Cairo
Egypt

Corresponding author:
Ibrahim M. Refaie
ibrahim_m_17@agr.sohag.edu.eg

Effect of intercropping and fluazifop herbicide on broomrape (*Orobanche* sp.) in tomato fields

Ahmed A.A. Sallam, Ibrahim S. Abdallah and Ibrahim M. Refaie

Abstract

This study investigated the effect of intercropping and fluazifop herbicide on controlling broomrape (*Orobanche* sp.) in tomato fields. Two consecutive field experiments were conducted in fall-winter seasons (2022-2023 and 2023-2024) in Sohag governorate, Egypt. Treatments included intercropping of fenugreek (*Trigonella foenum-graecum*) and garlic (*Allium sativum*) with tomato, application of fluazifop, and the untreated control. The study evaluated control efficiency, broomrape emergence, spike number, dry weight, as well as tomato yield. Results showed that intercropping with fenugreek was most effective in delaying broomrape emergence, reducing spike numbers and dry weight, and increasing control efficiency. Fenugreek intercropping exhibited the highest broomrape control efficiency (66.67% and 73.62% in both seasons, respectively), with an increase in yield reached 31.85% and 27.68% compared to the untreated control in both seasons, respectively. While intercropping garlic with tomato exhibited lower levels of broomrape control efficiency (52.74 and 41.78% in both seasons, respectively). Fluazifop treatment showed limited efficacy in controlling broomrape (21.89 and 28.84% in both seasons, respectively). The study concluded that intercropping fenugreek with tomato could be an effective, environmentally friendly alternative to herbicides for broomrape control in tomato that may be included in the integrated weed management programs.

Keywords: Fluazifop, Intercropping, Broomrape, Tomato, Chlorophyll content

INTRODUCTION

Tomato (*Lycopersicum esculentum* L.) is a globally significant vegetable crop, with an annual production value exceeding $90 billion and ranking second only to potato in production (FAOSTAT, 2019; Prajapati *et al*., 2014). It is rich in minerals, carbohydrates, and vitamins. However, tomato is highly susceptible to broomrape (*Orobanche*) infestation, particularly species like *Orobanche aegyptiaca*, *O. ramosa* (Mariam and Suwanketnikom, 2004). This parasitic weed causes substantial yield losses estimated at $1.3 to 2.6 billion annually, infesting about 2.6 million ha of solanaceous crops globally (Joel *et al*., 2007; Fernandez-Aparicio *et al*., 2009; Abbes *et al*., 2007). The problem is severe in Asia, the Mediterranean, and North Africa, including Egypt, where *Phelipanche* significantly reduces tomato yields. In newly reclaimed Egyptian lands, infestation is high due to soil and manure transfer, grazing animals, and contaminated irrigation water. Broomrapes alone account for about 30% of total losses caused by all crop management constraints. *Phelipanche ramosa* is particularly devastating to vegetables in both irrigated and rain-fed agriculture, especially to tomatoes in Egypt (Hershenhorn *et al*., 2009). Despite extensive global research efforts in recent years to mitigate broomrape damage in tomato fields, the effectiveness of control methods has been variable due to factors such as application technique, tomato variety, study location, broomrape species, and infestation density. To develop more accurate and effective management practices for this parasitic plant, it is crucial to compare various control methods and evaluate their impact on tomato yield and broomrape-related characteristics under different treatments. A key consideration in broomrape control is timing, as by the time the parasite emerges aboveground, significant damage to the tomato plant has already occurred, rendering control measures largely ineffective at this stage. The present work was designed to compare and identify the most appropriate control methods for Egyptian broomrape in tomato fields, with the ultimate goal of developing more effective strategies to protect tomato crops from this destructive parasite. Although herbicides are generally the most often used method for weed management, there are no recommendations in Egypt for controlling broomrape in tomatoes. Fluazifop butyl is a post emergence herbicide recommended in Egypt for controlling annual and perennial grassy weeds in tomatoes. To the best of our knowledge, there are no previous studies investigating broomrape response to fluazifop. Fluazifop is selective and rapidly absorbed by leaves and green stems translocated throughout the phloem. It was acting by inhibiting lipid biosynthesis. On the other hand, the intercropping system in which two crops or more are grown concurrently to ensure simultaneous crop production and soil fertility building (Liebman and Dyck, 1993) can also help to manage weeds, diseases and pests in an ecological manner (Maitra *et al*., 2021). Intercropping practices are already used in regions of Africa as, a means of controlling the broomrapes (Oswald *et al*., 2002). Recently, studies demonstrated that intercrops with cereals, fenugreek, or clover can reduce *O. crenata* infection in faba beans and peas (Fernandez-Aparicio *et al*., 2010a). Intercropping fenugreek, Egyptian clover, or flax with faba beans was also found to be trap crops reducing the *O. crenata* infestation and attaining high seed yield (Al-Menoufi, 1991). Fenugreek intercropping treatment resulted in the highest pod yield in two cultivars of faba beans (Bakheit *et al*., 2002; Safina, 2017). Abu Shall and Ragheb (2014) stated that trap / catch crops such as fenugreek and garlic, flax and turnip can be used to reduce *O. crenata* infestation. Intercropping with flax, radish and fenugreek on faba beans showed that fenugreek treatment resulted in the highest pod yield for both two cultivars tested (Hegazy, 2024). Likewise, El-Sherbeni *et al.*, (2021) found that intercropping with garlic and fenugreek showed the highest reduction in broomrape in faba bean. The main objective of this work was to evaluate the effect of the fluazifop related to intercropping with fenugreek and garlic in controlling *Orobanche sp.* infesting tomato fields.

MATERIALS AND METHODS

Site description and procedure

The experiment was conducted successively during the fall-winter seasons from September to February of 2022/2023 as the first season (SI) and 2023/2024 as the second season (SII) at the new village of Beit Khallaf, Gerga city, Sohag governorate (26°17'23.65"N latitude and 31°45'52.20"E longitude with an altitude of 96.012 meters above mean sea level), Egypt. Soil samples collected from the different field sites were analyzed for their physical and chemical properties by adopting standard procedures and depicted in Table (1).

Table (1): physical and chemical analysis of soil.

Soil property	Soil texture	Sand (%)	Silt (%)	Clay (%)	pH	EC (dS cm-1)	nitrogen (ppm)	phosphorus (ppm)	potassium (ppm)
Used soil	Sandy loam	62	30.66	7.34	7.76	3.63	70	14	66.69

Tomato seedlings variety 010 were planted in September during the fall-winter seasons of 2022/2023 and 2023/2024. Tomato seedlings were planted on ridges 140 cm wide with a spacing of 40 cm between plants.

Field preparation, experimental design, and treatments

Fluazifop butyl under the trade name fusilade was sprayed as a foliar application, 40 days after tomato transplanting when flowering and before broomrape emergence, with a CP3 knapsack sprayer equipped with one nozzle using a spray volume of 200 L feddan^{-1}. The experiment was set in a randomized block design with three replicates. All agricultural practices were carried out as recommended.

Common name: Fluazifop P-butyl.
Trade name: Fusilade max 12.5% EC.
Chemical name: butyl (R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy] 10 phenoxy] propanoate.
Used rate: 1500 cm^3 fed^{-1}

Intercropping assay

Seeds of fenugreek were planted in hills at the rate of 7.5 kg/ feddan and cloves of garlic was planted in hills at a rate of 30 kg/feddan . Both fenugreek and garlic were planted in the empty space between tomato seedlings on the same date of transplanting at a spacing of 20 cm apart from the seedlings .The control check was just transplanted tomatoes without trap crops.

Data collection

Broomrape Measurements

The parameters related to broomrape in two seasons included

1-Number of d ays taken for the emergence of broomrape spike above-ground Days taken for emergence of the broomrape spike after transplanting of tomato was observed periodically and recorded as a number of days.

2-Number of broomrape spikes m^{-2}

The number of broomrape spikes per square meter area at 75, 90 days after transplanting (DAT), and at harvest was recorded and the average was calculated.

3-Dry weight of broomrape spikes (g m^{-2})

Broomrape spikes from the square meter area at the time of harvest were removed and air dried first for a few days then kept in the oven at 65°C for three days to dry it to a constant weight and the dry weight was recorded.

4-Weed Control Efficacy

The weed control efficiency (WCE) of broomrape was calculated by using the formula given by Patel *et al.* (1987) and expressed as a percentage.

$$WCE\ (\%) = \frac{DMC - DMT}{DMC} x 100$$

Where
WCE =Weed control efficiency (%)
DMC =Dry matter of broomrape in the untreated check
DMT =Dry matter of broomrape in treatment

Crop Measurements

The parameters related to tomatoes in two seasons included

1- The chlorophyll content in tomato leaves (one, two, and four weeks after herbicide application)

The total chlorophyll content (Ch a and Ch b) was determined at one week, two weeks, and four weeks after herbicide treatment according to the procedures described by Lichtenthaler and Buschmann (2001), Faraj (2017), and Brix (2009). About 0.25g of fresh leaf sample was grounded in 2 ml of 80% acetone in a combination of sand 0.1% or 0.1 $CaCO_3$ to avoid chlorophyllase activities, then samples were filtered through filter papers and the final volume was completed to 25 ml, and then were measured using a spectrophotometer at three wavelengths of absorbance (A 663, A 646, and A470). calculation was done according to Equations 1, 2, and 3

Cha = $12.25(A_{663}) – 2.79\ (A_{646})$ ……(1)

Chb = $21.5\ (A_{646}) – 5.1\ (A_{663})$………(2)

Total chlorophyll = $\frac{5.24*(A663)+22.24*(A646)}{FW}$ ...(3)

Where Fw: Fresh Weight

2- The yield of tomato fruit (kg fed^{-1})

The total fruit yield from all plants of the net plot area was weighted and calculated as kilogram fruit yield per feddan. The mean of five harvests of tomato fruits was taken to represent the productivity of this plot.

Statistical Analysis

Data were analyzed by one-way analysis of variance (ANOVA) using the SPSS version 26 software program package followed by Duncan's Multiple Range Test to determine the significant differences at $p<0.05$ between the mean values of treatments according to (Gomez and Gomez, 1984).

RESULTS

1- Effect of different treatments on the chlorophyll content of tomato leaves

This study investigated the effects of fluazifop herbicide and intercropping with fenugreek and garlic on the chlorophyll content in tomato leaves. The chlorophyll a (Chl a), chlorophyll b (Chl b), and total chlorophyll (T Chl) levels were assessed one week, two weeks, and four weeks after herbicide application for all treatments during two consecutive seasons.

Intercropping with fenugreek treatment consistently showed the highest chlorophyll content during the three periods in both seasons and was statistically similar to the other treatments and the weedy check .Fenugreek as a legume plant is able to fix nitrogen and thus increase nutrients in soil providing tomato plants to grow better which is reflecting on chlorophyll content. These results are shown in Table 2-4.

Table (2): Effect of treatments on the chlorophyll content in tomato leaves after one week of treatment.

Treatments	One week after treatment					
	The first season 2022-2023			The second season 2023-2024		
	Chl a (mg/g)	Chl b (mg/g)	T Chl	Chl a (mg/g)	Chl b (mg/g)	T Chl
Fluazifop	$1.20^{a}\pm0.03$	$0.38^{a}\pm0.04$	$1.59^{a}\pm0.07$	$1.22^{a}\pm0.04$	$0.34^{ab}\pm0.03$	$1.56^{a}\pm0.07$
Fenugreek	$1.32^{a}\pm0.04$	$0.40^{a}\pm0.02$	$1.72^{a}\pm0.05$	$1.31^{a}\pm0.02$	$0.38^{a}\pm0.02$	$1.69^{a}\pm0.04$
Garlic	$1.24^{a}\pm0.07$	$0.32^{a}\pm0.03$	$1.57^{a}\pm0.09$	$1.24^{a}\pm0.03$	$0.28^{b}\pm0.03$	$1.52^{a}\pm0.05$
Weedy check	$1.29^{a}\pm0.09$	$0.41^{a}\pm0.02$	$1.70^{a}\pm0.11$	$1.26^{a}\pm0.07$	$0.36^{ab}\pm0.02$	$1.62^{a}\pm0.08$
Mean	1.26±0.03	0.38±0.01	1.64±0.04	1.26±0.02	0.34±0.02	1.60±0.03
P 0.05	0.581	0.222	0.531	0.534	0.111	0.331

Table (3): Effect of treatments on the chlorophyll content in tomato leaves after two weeks of treatment.

Treatments	Two weeks after treatment					
	The first season 2022-2023			The second season 2023-2024		
	Chl a (mg/g)	Chl b (mg/g)	T Chl	Chl a (mg/g)	Chl b (mg/g)	T Chl
Fluazifop	1.23[a]±0.02	0.41[a]±0.05	1.64[a]±0.05	1.24[a]±0.03	0.36[a]±0.02	1.60[a]±0.05
Fenugreek	1.35[a]±0.07	0.43[a]±0.03	1.77[a]±0.11	1.32[a]±0.03	0.39[a]±0.01	1.72[a]±0.04
Garlic	1.27[a]±0.01	0.38[a]±0.01	1.64[a]±0.003	1.29[a]±0.02	0.34[a]±0.01	1.62[a]±0.03
Weedy check	1.30[a]±0.03	0.40[a]±0.04	1.70[a]±0.07	1.28[a]±0.07	0.37[a]±0.03	1.65[a]±0.10
Mean	1.29±0.02	0.41±0.02	1.69±0.03	1.28±0.02	0.36±0.01	1.65±0.03
P 0.05	0.343	0.775	0.527	0.651	0.373	0.621

Table (4): Effect of treatments on the chlorophyll content in tomato leaves after four weeks of treatment.

Treatments	Four weeks after treatment					
	The first season 2022-2023			The second season 2023-2024		
	Chl a (mg/g)	Chl b (mg/g)	T Chl	Chl a (mg/g)	Chl b (mg/g)	T Chl
Fluazifop	1.23[a]±0.04	0.36[ab]±0.01	1.59[a]±0.06	1.20[a]±0.06	0.33[ab]±0.03	1.53[a]±0.09
Fenugreek	1.32[a]±0.06	0.46[a]±0.05	1.78[a]±0.11	1.35[a]±0.05	0.42[a]±0.04	1.77[a]±0.09
Garlic	1.28[a]±0.04	0.38[ab]±0.02	1.67[a]±0.02	1.26[a]±0.04	0.33[ab]±0.02	1.59[a]±0.03
Weedy check	1.27[a]±0.03	0.34[b]±0.03	1.6[a]±0.07	1.25[a]±0.04	0.30[b]±0.02	1.55[a]±0.06
Mean	1.27±0.02	0.39±0.02	1.66±0.04	1.26±0.03	0.34±0.02	1.61±0.04
P 0.05	0.610	0.136	0.330	0.230	0.110	0.152

2-Number of days taken for the emergence of broomrape spike above-ground

Data in Table (5) show the number of days taken for the emergence of broomrape spikes above-ground after transplanting the tomato. It was found that there were significant differences among the treatments in both seasons. The fenugreek intercropping treatment was the best in delaying the emergence of broomrape above the soil surface for a period of 82.33 and 85 in both seasons, respectively, while the shortest period for broomrape to emerge above the soil surface was in the weedy check treatment (68 and 65.67) in both seasons, respectively, which is statistically similar to the garlic intercropping treatment and the fluazifop treatment.

3- Number of broomrape spikes m^{-2}

The study examined the effects of various treatments on broomrape spike numbers in tomato fields over two growing seasons (2022-2023 and 2023-2024). The number of broomrape per square meter was calculated over three periods, which were 75 days after transplanting (DAT), 90 DAT, and at harvest. Our results are presented in Table (6). In both seasons, the weedy check treatment showed the highest number of broomrape spikes per square meter in the three periods (11.33, 34.33, and 67 spikes m^{-2}) in the first season, respectively, and (17, 33.33, and 61.67 spikes m^{-2}) in the second season, respectively. In contrast, the fenugreek intercropping treatment was the best in reducing the number of broomrape spikes per square meter (1.33, 10.33, and 22.33 spikes m^{-2}) in the first season, respectively, and (0.00, 3, and 17.67 spikes m^{-2}) in the second season, respectively. The garlic intercropping treatment also affected the number of broomrape spikes per square meter in the three periods (2.67, 18.67, and 31.67 spikes m^{-2}) in the first season, respectively, and (4.33, 16.33, and 39 spikes m^{-2}) in the second season, respectively. As for the fluazifop treatment, its effect was slight on the number of broomrape spikes per square meter, which was close to the number of spikes in the weedy check treatment (11, 23.33, and 52.33 spikes m^{-2}) in the first season, respectively, and (2, 15.67, and 47.67 spikes m^{-2}) in the second season, respectively.

4- Broomrape dry weight

Data in Table (7) show the dry weight of broomrape (g m^{-2}) at the harvest. The intercropping fenugreek treatment demonstrated the highest efficacy, significantly reducing broomrape dry weight to 15.09 and 10.25 g m^{-2} in both seasons, respectively. This was followed by intercropping garlic treatment, which resulted in a broomrape dry weight of 21.40 and 22.62 g m^{-2} in both seasons, respectively. The highest dry weight of broomrape was recorded in the weedy check treatment (45.28 and 38.85 g m^{-2}) in both seasons, respectively. Fluazifop treatment was the most similar treatment to the weedy check treatment, recording 35.37 and 27.65 g m^{-2} in both seasons, respectively.

5- Efficiency of broomrape control

Data in Table (7) showed the broomrape control efficiency (%) in the two successive seasons. The intercropping fenugreek treatment exhibited the highest control efficiency at 66.67 and 73.62% in both seasons, respectively. Significantly outperforming other treatments. Followed by the intercropping Garlic treatment, which exhibited lower levels of broomrape control efficiency (52.74 and 41.78%) in both seasons, respectively. Fluazifop treatment performed the lowest efficiency of 21.89 and 28.84% in both seasons, respectively.

6- Effect of fusillade and intercrops on the fruit yield of tomato

The results in Table (8) showed that intercropping fenugreek treatment achieved the highest tomato yield, with 25.5 and 26 tons $feddan^{-1}$ in both seasons, respectively, an increase of 31.85% and 27.68% compared to the untreated control, which recorded the lowest yield with 19.4 and 20.4 tons $feddan^{-1}$ in both seasons, respectively. In contrast, the intercropping garlic treatment recorded yield of 22.5 and 22.2 tons $feddan^{-1}$ in both seasons, respectively, an increase of 16.37% and 8.99%. Fluazifop treatment recorded yield with 21.07 and 21.01tons $feddan^{-1}$ in both seasons, respectively, an increase of 8.52% and 3.11%.

Table (5): Days taken for emergence of broomrape spike above-ground (Days after transplanting of tomato).

Treatments	The first season 2022-2023	The second season 2023-2024
	Days taken for emergence of spike above-ground	Days taken for emergence of spike above-ground
Fluazifop	71.67^{b}±1.45	72.00^{b}±2.08
Fenugreek	82.33^{a}±4.41	85.00^{a}±3.60
Garlic	73.00^{b}±1.00	73.67^{ab}±2.96
Weedy check	68.00^{b}±2.08	65.67^{b}±4.81
Mean	73.75±1.94	74.08±2.58
P 0.05	0.024	0.027

Table (6): Effect of fluazifop and intercropping on broomrape spikes number m^{-2} at different growth stages of tomato.

Treatments	Broomrape spike number m^{-2}					
	The first season 2022-2023			The second season 2023-2024		
	75 DAT	90 DAT	At harvest	75 DAT	90 DAT	At harvest
Fluazifop	11.00^{a}± 2.52	23.33^{ab}±2.33	52.33^{ab}±12.91	2.00^{b} ±0.58	15.67^{b}±3.76	47.67^{ab}±7.88
Fenugreek	1.33^{b}±1.33	10.33^{b}±3.67	22.33^{c}±5.36	0.00^{b} ±0.00	3.00^{b}±1.15	17.67^{b}±2.40
Garlic	2.67^{b}±0.88	18.67^{b}±4.63	31.67^{bc}±4.10	4.33^{b}±2.60	16.33^{b}±8.33	39.00^{ab}±9.81
Weedy check	11.33^{a}±1.45	34.33^{a}±4.33	67.00^{a}±3.60	17.00^{a}±1.53	33.33^{a}±2.91	61.67^{a} ±13.97
Mean	6.58±1.56	21.67±3.09	43.33±6.16	5.83±2.10	17.08±3.85	41.50±6.28
P 0.05	0.004	0.014	0.012	<.001	0.015	0.059

Table (7): Effect of fluazifop and intercropping on broomrape dry weight and control efficiency.

Treatments	The first season 2022-2023		The second season 2023-2024	
	dry weight (g m^{-2})	Weed (broomrape) control efficiency (%)	dry weight (g m^{-2})	Weed (broomrape) control efficiency (%)
Fluazifop	35.37^{ab}±8.73	21.89^{b}±14.17	27.65^{ab}±4.57	28.84^{b}±6.88
Fenugreek	15.09^{c}±3.62	66.67 ^{a}±8.01	10.25^{b}±1.39	73.62^{a}±3.59
Garlic	21.40^{bc}±2.77	52.74^{ab}±6.11	22.62^{ab}±5.69	41.78^{ab}±14.65
Weedy check	45.28^{a}±2.44	--------------	38.85^{a}±8.80	--------------
Mean	29.28±4.16	47.10 ±8.30	24.84±3.95	48.10 ±8.20
P 0.05	0.012	0.049	0.045	0.040

Table (8): Effect of fluazifop and intercropping on the fruit yield of tomato.

Treatments	The first season 2022-2023	The second season 2023-2024
	Fruit yield kg fed^{-1}	Fruit yield kg fed^{-1}
Fluazifop	21068^{b}±1494.39	21013^{b}±1064.52
Fenugreek	25597^{a}±987.50	26021^{a}±632
Garlic	22592^{ab}±571.29	22212^{ab}±1446.98
Weedy check	19413^{b}±1509.27	20380^{b}±1678.46
Mean	22167.39±857.60	22406.5±1046.52
P 0.05	0.035	0.053

DISCUSSION

Intercropping; a method facilitating both simultaneous crop production and soil fertility building. Intercropping is already used in regions of Africa as a low-cost technology for controlling broomrapes (Oswald *et al*., 2002). Intercropping is regarded as an ecological method to manage pests, diseases and weeds via natural competitive principles that allow for more efficient resource utilization (Liebman and Dyck, 1993). Many African farmers traditionally intercrop corn with legumes to increase crop production, achieving better returns on fertilizers, pesticides, energy and manpower resources (Carson, 1989; Carsky *et al.*, 1994; Oswald *et al.*, 2002). Very little research is available on the potential of intercropping in tomatoes as a weed control means. Our results showed that fenugreek can lessen the number of *Orobanche* spikes infesting tomato plants more than garlic treatments which agree with Fernandez-Aparicio *et al.*, (2010b) who demonstrated that intercrops with fenugreek can decrease *O. crenata* infection on faba bean and pea due to allelopathic interactions on the parasitic life cycle at the level of germination. Moreover, Abbes *et al* . (2019) revealed a significant reduction in *O. foetida* infestation in two faba bean cultivars was happened when intercropped with fenugreek in field, pot and petri dish experiments. This reduction appeared to be a result of allelochemicals released by fenugreek roots. Intercropping fenugreek among two faba bean cultivars caused a significant reduction in the infestation levels of *O. crenata* and the highest pod yield for both two cultivars (Hegazi *et al*., 2024). Intercropping with fenugreek and/or application of glyphosate significantly reduced the number/weight of broomrapes spikes/plot (El-Mehy *et al*., 2022). Several authors have described fenugreek as a suitable crop for intercropping with legumes, reducing the infection level of *O. crenata*. A subsequent study indicated that trigoxazonane as an allelochemical was identified in the root exudates of fenugreek which might be responsible for the inhibition of *O. crenata* seed germination (Evidente *et al.*, 2007). In contrast, El-Sherbeni *et al.* (2021) found that not only fenugreek but also garlic caused a higher reduction in the number and dry weight of *O. crenata* spikes. In Tunisia, the results suggested that the use of fenugreek in the crop rotation may reduce the *Orobanche* seed bank in fields infested with *O. foetida* (Fernández-Aparicio *et al*., 2011). Trap crops like fenugreek, were shown to decrease *Orobanche* seed density (Acharya, 2012). However, other trap crops like garlic were classified as non-potential trap crops against *Orobanche* based on the degree of effects on the *Orobanche* seed bank which is in harmony with our results. Razavifar *et al* .(2017) revealed that intercropping canola with wheat could significantly reduce growth of *P. aegyptiaca*. Fluazifop-P-butyl is a post-emergence phenoxy herbicide, non-residual, systemic, used to control a long list of perennial and annual grass weeds (Syngenta, 2006). It acts as an inhibitor of acetyl-CoA carboxylase (ACCase) that catalyzes the formation of malonyl-CoA during metabolism of lipids and/or of some secondary compounds (Walker *et al*., 1988). Fluazifop butyl is a post emergence herbicide recommended in Egypt for controlling annual and perennial grassy weeds in tomatoes. To the best of our knowledge, there are no previous studies investigating broomrape response to fluazifop. In our results, fluazifop was the least effective treatment on broomrape in tomato, as the control efficiency was 21.89 and 28.84% in both seasons, respectively, without any apparent effect on tomato plants. Fluazifop-p-butyl is utilized for the post-emergence control of various grassy weeds, including volunteer cereals and wild oats, across a wide range of crops such as oilseed rape, potatoes, fodder beet, sugar beet, vegetables, pome fruit, cotton, soybeans, stone fruit, bush fruit, citrus fruit, pineapples, strawberries, vines, bananas, alfalfa, sunflowers, and ornamentals. This herbicide is particularly noted for its non-phytotoxic nature to broad-leaved crops (FAO, 2000). In a study conducted by El-Mahy (2005), the application of fluazifop-p-butyl (12.5% EC) at a rate of 1.5 liters per feddan in tomato crops demonstrated significant effectiveness in controlling both annual and perennial grassy weeds. The herbicide achieved control rates of 86.9%, 86.1%, and 80.3% at three, six, and twelve-weeks post-application, respectively. The lower effect of the fluazifop herbicide on the broomrape can be explained, as it may be due to the low concentration of the herbicide in the roots and thus the insufficient amount of the herbicide to eliminate broomrape.

CONCLUSION

Our results indicated that intercropping with fenugreek in tomato fields can be a feasible, effective and safe alternative to herbicides for broomrape control, which may be included in the integrated weed management programs to suppress broomrape infestation.

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