

Effect of Sowing Date of Resistant and Susceptible Faba Bean, *Vicia faba* L. Cultivars on *Orobanche crenata* Forsk Seed Bank and Faba Bean Production

Esmat Mohamed Hussein Hegazi^{1,*}, Wedad Emam Khafagi², Manal Ahmed Attia³,
Abou Zeid Abou Zeid⁴, Mohamed Awad Al-Eryan¹, Nagat Mohamed Aly⁵,
Safaa Moustafa Abd El-Rahman³, Anter Kenawy Mahmoud⁵, Hamdy Kotb Abou Taleb²,
Amany Moustafa Abu-Shall¹, Mervat Abo Elhamed Hasaneen², Sania Fateh Allah Showiel²

¹Entomology Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt

²Plant Protection Research Institute, Agriculture Research Center (ARC), Alexandria, Egypt

³Insecticide Bioassay Department, Central Agricultural Pesticide Laboratory (CAPL), Agricultural Research Center (ARC), Cairo, Egypt

⁴Food Legumes Research Department, Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Cairo, Egypt

⁵Mammalian Toxicology Department, Central Agricultural Pesticide Laboratory (CAPL), Agricultural Research Center (ARC), Alexandria, Egypt

Email address:

eshegazi@gmail.com (Esmat Mohamed Hussein Hegazi), Wedadkhafagi20002000@yahoo.com (Wedad Emam Khafagi),
manal.attia77@gmail.com (Manal Ahmed Attia), Abouzeid23@yahoo.com (Abou Zeid Abou Zeid),
m_a_aleryan@yahoo.com (Mohamed Awad Al-Eryan), nagatmalym@yahoo.com (Nagat Mohamed Aly),
Smoustafa689@gmail.com (Safaa Moustafa Abd El-Rahman), Anterk68@yahoo.com (Anter Kenawy Mahmoud),
aboutalebhk@yahoo.com (Hamdy Kotb Abou Taleb), Amanyabu_shall@yahoo.com (Amany Moustafa Abu-Shall),
boelhamedmervat@gmail.com (Mervat Abo Elhamed Hasaneen), saniashwil@yahoo.com (Sania Fateh Allah Showiel)

*Corresponding author

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Abstract: The broomrape, *Orobanche crenata* Forsk (Orobanchaceae) is a serious annual parasitic weed that causes considerable losses in many major crops including faba bean (*Vicia faba* L.). In Egypt: losses due to *O. crenata* parasitism may reach 40 to 100%. Despite using several methods to control *O. crenata*, success has not been achieved. The impact of different control tactics on *O. crenata* is not well understood. However, Sowing date appears to be one of the potential solutions for controlling *O. crenata*. In this work we investigated the effect of sowing dates on both the level of infection by *O. crenata* and the pod yield of faba bean using resistant (Giza 843) and susceptible (Nubaria 1) faba bean cultivars in naturally *Orobanche* infested soil. Moreover, the *Orobanche* seeds production was determined as an indication of seed bank future adding in soil. Under *Orobanche* free conditions, Nubaria 1 cultivar produces more pod yield than the resistant cultivar. The results demonstrated that, late sowing (3 weeks after normal sowing date) reduced significantly the number of emerged *O. crenata* shoots for both the resistant and the susceptible cultivars. Late sowing similarly contributed to a significant increase in pod yield (dry weight (kg)/plot) especially for Giza 843 (5.15 ± 0.02 Kg /plot), the resistant cultivar, which produced much higher pod yield than the susceptible Nubaria 1 cultivar (2.98 ± 0.06 Kg /plot) during the first season (2019 - 2020). During the second season (2020 - 2021), the pod yield was (3.85 ± 0.10) and (5.49 ± 0.76) Kg/plot for Giza 843 and Nubaria 1 cultivars, respectively, compared with the early sowing date. Furthermore, regarding both seasons, the seeds number per spike decreased significantly with the late sowing date in both the resistant and susceptible cultivars.

Keywords: *Vicia faba*, Sowing Date, Broomrape, *Orobanche crenata*, Seed Bank

1. Introduction

Faba bean is widely consumed pulses in the Mediterranean region and represents the main source of protein for the majority of the population in Egypt. In Egypt, despite the self-sufficiency from this vital crop in the 1970's was estimated to be 115% [1], this figure has severely declined since the 1980's, recording 26.9% in 2020 [2]. Therefore, Egypt has become the major importer of faba bean worldwide, obtaining 480,000-520,000 tons yearly from overseas [3]. This decline in self-sufficiency is principally attributable to the reducing in the cultivated area from 152,000 ha in 1961 to a lower record of 32,500 in 2017, representing 79% decrease [4]. This decline in the cultivated area could be attributed to the spread of the parasitic weed, *Orobanche crenata* Forsk (Orobanchaceae) and the high production costs compared with other winter crops such as wheat or berseem clover. *O. crenata*, a complete root parasite, poses an extreme threat to faba bean [5]. Heavy *O. crenata* infestation level was reported in many faba bean fields. In Egypt; losses of *O. crenata* parasitism may reach 40 to 100% under heavy infestation, [6]. The leguminous losses due to *O. crenata* infestation depend on variation of dominant environmental factors, severity of infection, and sowing date [7]. Broomrapes (*Orobanche* spp.) are parasitic achlorophyllous weeds totally dependent on the host for organic carbon, water and nitrogen [8]. The seeds of these parasitic weed may remain dormant in the soil for many years until germination is stimulated by root exudates from a host plant and the climatic conditions become favorable. A single plant of *Orobanche* can produce over 100,000 seeds which can survive in the field up to 20 years [9].

Several strategies have been applied to control *Orobanche* spp. Physical, cultural, chemical and biological methods have been explored but none has proven to be sufficiently effective, economical and as applicable as desired [10]. The efficacy of these control strategies has, often been affected by environmental conditions.

Planting date is an important on the intensity of *O. crenata* infection. Early plantings of faba bean, lentil, and peas are more severely infected. Unfortunately, delayed planting greatly reduces potential crop yield, but a compromise of a few weeks delay can be found for each particular crop and region, so the decrease in crop biomass is compensated by the reduction in the infection [11]. In this work we studied the effect of sowing dates of faba bean cultivars on *O. crenata* infection and seed production in addition to faba bean production.

2. Materials and Methods

Field trials were conducted during two cropping seasons (2019/2020) and (2020–2021) in the Agriculture

Experimental Unit of Nubaria Research Station. Two faba bean cultivars were used: Giza 843 resistant to *O. crenata* and the susceptible one Nubaria 1. These cultivars were sown in a sandy loam soil field naturally infested with *O. crenata* in 4 rows of 4 m length with 0.5 m row spacing and 50 seeds per row. Two sowing dates at 15 days interval starting from November 10 were evaluated, respectively, during both cropping seasons. No fertilisers or other chemical treatments were applied during both seasons.

A multifactor blocks design with 3 blocks was used. Each treatment was replicate four times with plot area 42m². For the two seasons, the number of emerged *Orobanche* shoots and faba bean dry grain yield (kg/plot) were recorded at crop maturity stage on the two central rows of each plot. As well, the number of fruits and seeds /spike and spike length (cm) were recorded.

Statistical analyses: Means comparison of early and late sowing date for each response variable were performed using independent t-test by SPSS version 20 [12].

3. Results

The number and infestation percent of the emerged *Orobanche* shoots as well the dry pod weight (kg.)/plot, yield, of resistant (Giza 843) and susceptible (Nubaria 1) cultivars at the maturity stage of faba bean are shown in Table 1. The results demonstrated that, late sowing reduced significantly the number of emerged *O. crenata* shoots for both the resistant and the susceptible cultivars. During the first season, the number of parasitic shoots /plot was 112.00 ± 6.31 for the early sowing date vs 79.00 ± 10.10 for the late sowing date of Giza 843 ($t=4.8$, $P < 0.05$) and 202.00 ± 2.60 for the early sowing date vs 100.00 ± 18.65 the late sowing date of Nubaria 1 ($t=9.3$, $P < 0.05$). The same trend was observed in the second season.

During the first season, pod yield increased significantly ($t=99.9$, $P < 0.05$) on late sowing dates for the resistant Giza 843 cultivar (from 2.67 to 5.15 kg/plot, in respect), which produces a much higher pod yield than the susceptible Nubaria 1 cultivar ($t=6.75$, $P < 0.05$) (2.98 kg/plot) during the first season.

As regards the susceptible Nubaria 1 in the second season (2020–2021), the analysis showed significant differences among sowing dates ($t=6.2$, $P < 0.05$) for more dry pod weight per plot of grain yield (Table 1).

Table 2 shows the effect of sowing date of the tested cultivars on the spike length (cm) and capsules number and seed production of the parasitic weed, *O. crenata*. In most cases, late sowing date significantly reduced both of the spike length of Giza ($t=3.4$, $P < 0.05$) and Nubaria ($t=6.6$, $P < 0.05$) during the first season and in the second season for Giza ($t=3.6$, $P < 0.05$) and for Nubaria ($t=6.2$, $P < 0.05$), respectively.

Table 1. Effect of sowing date of two faba bean cultivars on number, infestation rate of *O. crenata* and pod yield (dry weight kg./plot) of faba bean.

Season	Cultivar	Giza 843		Nubaria 1	
	Sowing date	Early	Late	Early	Late
2019-2020	Weed No/plot	112.00±6.31A	79.00±10.10B	56.00±4.12A	40.25±0.31B
	Infestation%	27.80±0.81A	15.60±0.06B	48.33±8.24A	25.00±2.78B
	Pod weight (kg)/plot	2.67±0.04B	5.15±0.020A	1.38±0.03B	3.85±0.10A
2020-2021	Weed No/plot	202.00±2.60a	100.00±18.65b	184.50.940 b	66.25±0.58a
	Infestation%	71.30±8.03a	46.00±2.02b	80.00±6.90a	27.78±3.21B
	Pod weight (kg)/plot	2.35±0.15b	2.98±0.06a	2.46±0.05b	5.49±0.76a

When the letter per each column is the same, the data for separately season is not significantly different ($P < 0.05$).

Table 2. Effect of sowing date of two faba bean cultivars on length (cm), capsules number and seed production of parasitic weed, *O. crenata*.

Season	Cultivar	Sowing date	Spike Length (cm)	Capsules Weight (g)/spike	Seeds Weight (mg)/spike
2019-2020	Giza 843	Early	48.00±3.64A	4.31±0.42A	2.93±0.02B
		Late	39.87±1.80B	2.99±0.06B	2.66±0.07A
	Nubaria 1	Early	45.00±2.71A	3.58±0.42A	2.29±0.01A
		Late	38.72±1.30B	3.16±0.10A	1.69±0.08B
2020-2021	Giza 843	Early	80.13±4.80a	10.02±0.18a	5.89±0.23a
		Late	60.67±1.74b	5.33±0.29b	4.02±0.12b
	Nubaria 1	Early	71.89±4.30a	9.44±0.19a	6.68±0.21a
		Late	50.67±1.16b	4.80±0.29b	3.47±0.06b

When the letter per each column is the same, the data for separately season is not significantly different ($P < 0.05$).

The number of spike fruits reduced in late growing season compared of those found in the first season. The consequences were significant reductions of new additions of seed bank (Figure 1) during late season sowing date. Cultivar of Giza 834 had less emerged *O. crenata* shoots than the susceptible one for both crop seasons.

Regarding *Orobanche* seed production, data in table 2 shows that, *Orobanche* seed production of emerged spikes in the late sowing faba bean significantly decreased compared with that in early sowing plots of both resistant and susceptible cultivars. For example, in the first season, there is a significant difference between seed number produced by the emerged *Orobanche* in late sowing Nubaria 1 cultivar plots ($402,000 \pm 120,00$ seeds/spike) and the seed number that produced by the emerged *Orobanche* in the early sowing plots ($589,000 \pm 230,00$ seeds/spike); [$t = 22.28$, $p < 0.05$]. Like-wise, in the second season, Giza 843 showed the same trend since the seed number The number and infestation percent of the emerged *Orobanche* shoots as well the dry pod weight (kg./plot), yield, of resistant (Giza 843) and susceptible (Nubaria 1) cultivars at the maturity stage of faba bean are shown in Table 1. The results demonstrated that, late sowing reduced significantly the number of emerged *O. crenata* shoots for both the resistant and the susceptible cultivars. During the first season, the number of parasitic shoots /plot was 112.00 ± 6.31 for the early sowing date vs 79.00 ± 10.10 for the late sowing date of Giza 843 ($t = 4.8$, $P < 0.05$) and 202.00 ± 2.60 for the early sowing date vs 100.00 ± 18.65 the late sowing date of Nubaria 1 ($t = 9.3$, $P < 0.05$). The same trend was observed in the second season.

During the first season, pod yield increased significantly ($t = 99.9$ $P < 0.05$) on late sowing dates for the resistant Giza 843 cultivar (from 2.67 to 5.15 kg/plot, in respect), which produces a much higher pod yield than the susceptible

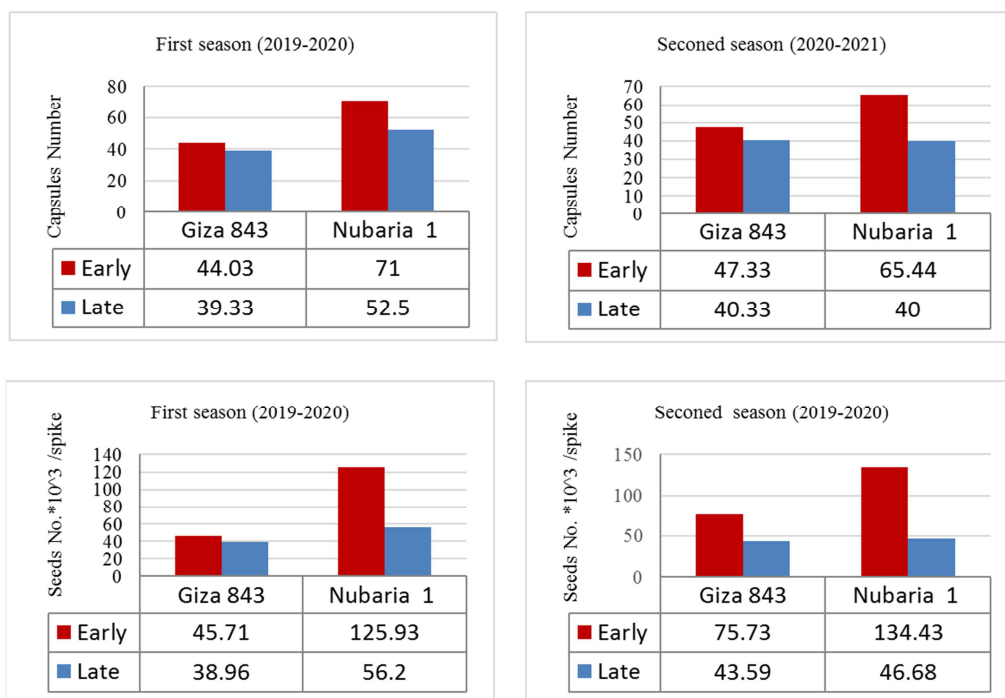
Nubaria 1 cultivar ($t = 6.75$, $P < 0.05$) (2.98 kg/plot) during the first season.

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(note: in the left figure down please correct the season to 2020-2021)

Figure 1. Effect of sowing date on parasite seed bank.

This study investigated the effect of sowing date on *O. crenata* infection level and seed bank employing two faba bean cultivars (resistant and susceptible). The level of infestation by *Orobanche* was higher throughout the first season than that recorded within the second one probably due to a satisfactory environmental condition in particularly milder winter and dry season which ensuring the attribution of the environmental conditions on the parasitism by *Orobanche* as reported by previous studies. [13, 14]. Delayed sowing has been reported to cause reduction in *O. crenata* infection [13, 15]. Another study reported that, early sowing can lead to high crop losses as a consequence of higher infection levels and longer exposure to the parasitic weed [16].

In our study, late sowing dates (November 25) resulted significant reduction in the number fruits of emerged *O. crenata* as well as the dry weight of spike shoots for the resistant faba bean cultivar in the first season but not in the second season. The resistant cultivar demonstrates a better control of *O. crenata* weed infestation with delayed sowing. The reduction of *Orobanche* infection with delayed sowings could be due to the inducing of a secondary dormancy in *Orobanche* seeds, the temperature effects on germination and/or obstructing of *Orobanche* development during underground stages [16, 17, 18]. While delayed sowing could have negatively impact on the yield of certain legumes that have a long-life cycle [19, 20]. Results of our study demonstrated that, according to the measurements of crop yield over two growing seasons, delayed sowing resulted in higher seed yield per plot for both cultivars (especially Giza 843). On the other hand, Pérez-de-Luque [11] reported that, the resistant cultivar usage enables an early sowing and a extended crop cycle, with minute of *O. crenata* development,

and higher crop production. The employing of a resistant cultivar such as Giza 843 represents a respected control solution and could be a beneficial tool for an integrated pest management tactic leading to regain soil with lower level of infestation by *Orobanche*. However, some precautions should be considered to reduce the hazard of developing more virulent ecotypes. Cultivating a susceptible faba bean cultivar in extremely infested field with delayed sowing did not achieve a satisfactory grain yield. Therefore, other control methods, such as chemical treatment should be employed to reduce the infestation levels.

4. Conclusion

Broomrape weed infestation is the principal factor that affecting faba bean production. While integrated weed management is the most known strategy for control the broomrape, the culture practice is the foremost phase for successful control. Sowing timing and suitable cultivar are vital tactics to avoid undesirable conditions and pests. In this work we emphasized the importance of binary effects of different control components. Integrating both delayed sowing and resistant cultivar could be a valuable tool as a component of an integrated weed management strategy to control *O. crenata* in faba bean fields. Moreover, this study highlights the beneficial of both resistant cultivar and delayed sowing for reducing the seed bank of *O. crenata* which might be allow regain the areas where farmers could not cultivate beans as a result of high level of seeds in the soil. However, Further research is required to determine the long-term effects of these measures on *O. crenata* seed bank.

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