Journal of

Entomology

ISSN 1812-5670

Academic
Journals Inc.

www.academicjournals.com

Journal of Entomology 11 (1): 42-48, 2014
ISSN 1812-5670 / DOI: 10.3923/je.2014.42.48

Population Status of Broomrape Fly, *Phytomyza orobanchia* (Diptera: Agromyzidae) with some Agricultural Practices under Semi-field Conditions

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ABSTRACT

The use of some agricultural practices such as tillage and irrigation affected the natural population of *Phytomyza orobanchia* Kalt., the main active bioagent against broomrape in Egypt. During March of 2010/2011 season, fleshy plants of *Orobanche crenata* shoots were collected from faba bean fields. Under semi-field conditions, whole plants of *Orobanche crenata* shoots were buried at different depths (5, 10, 15, 20 and 25 cm) in sandy, sandy-loam and clay soil in pots and treated with three treatments of water (moistened, flooded and dry). At the beginning of the new activity season 2011/2012, emergence percentages of the broomrape fly, *P. orobanchia* from *Orobanche* shoots contained diapaused pupae were estimated, which were buried under the effects of different agricultural practices. Results revealed that the emergence percentage of *Phytomyza* adults had significantly reduced with increasing the depth of buried *O. crenata* shoots. Highest mean emergence percentage was (52.31%) occurred from puparia in *Orobanche* shoots buried in moist soil. On the other hand, sandy-loam soil was enough for emergence of 42.40%. It could be recommended to bury *Orobanche* shoots containing diapaused *Phytomyza* pupae at 5 cm depth after collected during March. After that it is recommended to cover the shoots with moistened and sandy-loam soil in order to increase the rate of initial *Phytomyza* population working in faba bean field against *Orobanche crenata* at the start of new season's activity.

Key words: *Phytomyza orobanchia*, *Orobanche crenata*, biological control

INTRODUCTION

The broomrape fly, *Phytomyza orobanchia* Kalt. has three generations annually (Shalaby, 1974; Al-Eryan, 1996). At the end of *Orobanche* season, larvae of last generation migrate from *Orobanche* capsules towards the aerial and underground parts for pupation to stay in diapause till the subsequent season (Tawfik *et al*., 1976; Al-Eryan and Zaitoun, 1998). The greatest numbers of diapaused pupae occur in the underground parts of the plant (Mihajlovic, 1986). The third generation faces some of environmental resistance factors such as agricultural practices and natural enemies (insect parasitoids) causing significant reduction in *Phytomyza* population size (Kroschel and Klein, 1999). In this respect, the fleshy *Orobanche* shoots collected in early March were completely free from the parasitoid (*Tetrastichus phytomyzae*), on one hand and since *P. orobanchia* pupate and enter diapause in the underground parts of *Orobanche*, it faces different death factors such as, some agricultural practices until the new activity season, on the other hand. Factors limiting the natural population of *P. orobanchia* such as pupal parasitoids, destruction of pupae by tillage and flooding can be avoided by means of controlled rearing (Abu-Shall, 2001).

The present study was carried out during 2010/2011 faba bean season to estimate the population status of *P. orobanchia* with some agricultural practice (tillage and irrigation), aiming to reach high rates of the initial *P. orobanchia* population during the new activity season 2011/2012 against *O. crenata* spikes to guarantee a quick build-up of their population.

MATERIALS AND METHODS

Sampling and estimation natural infestation rates by diapaused *Phytomyza* pupae: During March of 2010/2011 season, fleshy plants of *Orobanche crenata* shoots (Hess *et al.*, 1997) infested with *P. orobanchia* were collected from faba bean fields in the Agricultural Research Station (ARS), Faculty of Agriculture, Alexandria University, Egypt.

In the laboratory, a random sample of 20 *Orobanche* shoots were picked up and dissected when the pupation took place. The *Orobanche* shoots were examined, to detach and count the diapaused pupae of *Phytomyza* per stem. After that, the mean number of diapaused pupae per stem was determined as follows:

$$\text{Mean No. of diapaused pupae per stem} = \frac{\text{Total No. of diapaused pupae in stems}}{\text{No. of } \textit{Orobanche crenata} \text{ shoots dissected}}$$

Effect of some agricultural practices on *P. orobanchia* under semi-field conditions: At the end of 2010/2011 season, whole plants of *O. crenata* shoots infested with diapaused pupae of *Phytomyza* were buried at different depths 5, 10, 15, 20 and 25 cm in sandy, sandy-loam and clay soil in plastic pots (60 cm length and 20 cm width) to be similar to tillage under filed conditions. Each type of soil was treated with three treatments of water (moistened, flooded and dry) to be similar to irrigation under field conditions. Each treatment consisted of 3 replicates and each replicate of 5 *Orobanche* shoots.

Natural activity of initial *Phytomyza* population during the new season: At the beginning of the subsequent season 2011/2012, the glass tube was hung up at 10 to 15 cm height above the soil surface on wooden stake in each pot. Piece of cotton saturated with honey solution was put in the glass tube (replaced weekly) for feeding the emerged *Phytomyza* adults, (Abu-Shall, 2001). A plastic funnel was upset on the glass tube opening (Fig. 1). The glass tube was connected to the narrow opening of the plastic funnel, through which, only the *Phytomyza* adults could pass into the funnel to glass tube. Pot contents were covered with metal-screen cloth cage (Fig. 2). For bringing the glass tube out, a small window of 8×10 cm was cut into the cloth cage to collect and count the emerged adults of *Phytomyza* weekly.

To calculate the percentage of emerged *Phytomyza* adults at the end of season as follows:

$$\text{Emergence percentage of } \textit{Phytomyza} \text{ adults} = \frac{\text{No. of emerged } \textit{P. orobanchia} \text{ adults}}{\text{No. of buried } \textit{Orobanche} \text{ shoots} \times \text{Mean No. of diapaused pupae per stem}} \times 100$$

Statistical analysis: Data were subjected to the analysis of variance test (ANOVA), with mean separation at 5% levels of significance, Computer program IRRISTAT and Duncan's Multiple Rang Test was used to compare the averages according to the method of Snedecor and Cochran (1967).

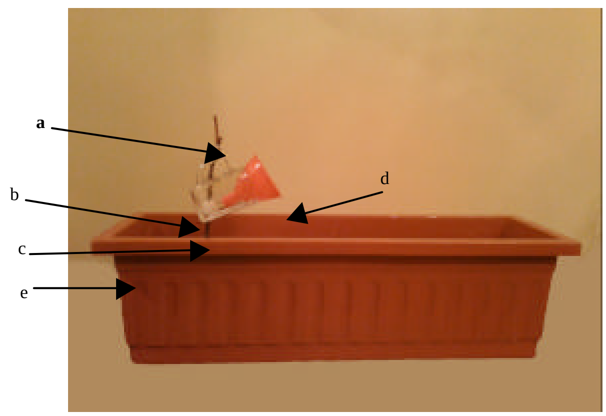

Fig. 1(a-e): Glass tube was hung up on wooden stake and provided with piece of cotton saturated with honey solution, which connected to the narrow opening of the plastic funnel, (a) Wooden stake, (b) Glass tube, (c) Piece of cotton saturated with honey solution, (d) Plastic funnel and (e) Plastic pot contain on whole plants of *O. crenata* shoots infested with diapaused *Phytomyza* pupae, which buried in different depths and soils with three treatments of water

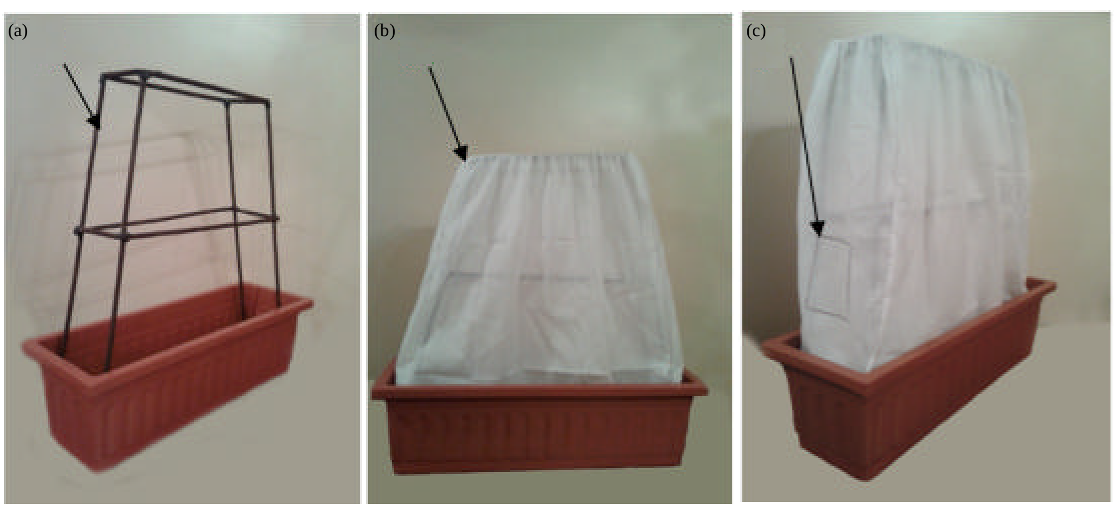

Fig. 2(a-c): Metal-screen cloth cage with a small window was covered pot contents, (a) Metal-screen, (b) Metal-screen with cloth cage cover the previous plastic pot contents in Fig. 1 and (c) Metal-screen cloth cage provided with a small window (8×10 cm)

RESULTS

The natural capacity of *P. orobanchia* to reduce the *Orobanche* population is limited by several factors such as low temperature, cultural practices (soil preparation, crop rotations, irrigation and the use of insecticides against crop pests) and natural enemies (microorganisms and parasitoids) (Kroschel and Klein, 1999). Also, the use of intensive agrotechnical measures includes the following factors affecting the mass reproduction of *Phytomyza* populations: soil cultivation, crop rotation and pesticide application. In autumn and spring, during the preparation of soil for sowing, the

Table 1: Emergence percentages of *Phytomyza* adults from *Orobanche* shoots buried at different depths and soil with three water treatments

Type of soil	Buried depth of *Orobanche* shoots (cm)	Treatments of water: Moistened	Dry	Flooded	Mean
Sandy soil	5	74.52	54.04	44.45	57.67
	10	67.83	46.05	38.56	50.81
	15	57.72	30.52	27.51	38.58
	20	33.37	17.38	14.04	21.60
	25	25.41	10.22	9.17	14.93
	Mean	51.77[a]	31.64[b]	26.75[c]	36.72[b]
Sandy-loam soil	5	81.62	64.44	49.10	65.05
	10	74.99	56.75	43.06	58.27
	15	60.57	40.97	30.91	44.15
	20	38.01	20.44	16.16	24.87
	25	29.40	18.74	10.79	19.64
	Mean	56.92[a]	40.27[b]	30.00[c]	42.40[a]
Clay soil	5	72.33	48.21	41.32	53.95
	10	65.47	40.51	34.86	46.95
	15	53.67	28.43	22.38	34.83
	20	30.03	15.48	11.46	18.99
	25	19.69	8.90	8.09	12.23
	Mean	48.24[a]	28.31[b]	23.62[c]	33.39[c]
Buried depth of *Orobanche* shoots (cm) and treatments of water mean effect	5	76.16	55.56	44.96	58.89[a]
	10	69.43	47.77	38.83	52.01[b]
	15	57.32	33.31	26.93	39.19[c]
	20	33.80	17.77	13.89	21.82[d]
	25	24.83	12.62	9.35	15.60[e]
	Mean	52.31[a]	33.40[b]	26.79[c]	37.50

Values are means of 3 replicates each of 5 *Orobanche* shoots per treatment. Means followed by the different letter are significantly different at the 5% level by DMRT, $L.S.D_{0.05}$ (Type of soil) = 0.85, $L.S.D_{0.05}$ (Buried depth of *Orobanche* shoots) = 1.26, $L.S.D_{0.05}$ (Treatments of water) = 0.68

broomrapes were ploughed in together with the pupae of *Phytomyza* overwintering generation. In spring, the flies did not manage to go out through the deeper layers of soil, so they die in high percentages, thus decreasing the initial *Phytomyza* population during the sprouting and the beginning of flowering of broomrapes (Mihajlovic, 1986).

Emergence percentages of *Phytomyza* adults in the new season from diapaused pupae in *Orobanche* shoots buried in different depths and soil with three treatments of water are presented in Table 1. Results revealed that emergence percentages were 58.89, 52.01, 39.19, 21.82 and 15.60% from different depths 5, 10, 15, 20 and 25 cm, respectively. At the level of treatments of water, these were 52.31, 33.40 and 26.79% from moistened, dry and flooded soil, respectively. Irrespective of treatments of water and bury depths of *Orobanche* shoots, it was 36.72, 42.40 and 33.39% emergence in sandy, sandy-loam and clay soil, respectively.

Statistical analysis revealed that emergence percentages of *Phytomyza* adults, significantly, decreased with increasing the depth at which *Orobanche* shoots containing diapaused pupae were buried. This finding indicated that 5 cm depth to bury *Orobanche* shoots, significantly, led to emergence of highest percentage of *Phytomyza* adults in the new season compared with other depths. On the other hand, moist and sandy-loam soils were significantly rich with emergence percent of *Phytomyza* adults in the new season.

DISCUSSION

In this regard, Abu-Shall (2001) indicated that the dry (both clay and sandy) soil is the optimum type of soil for preservation and storage the collected pupae of *P. orobanchia* till the next season. Also, the suitable depth to bury *P. orobanchia* pupae (5-10 cm) should be undertaken in release programs to improve emergence of *Phytomyza* adults. While, Trenchev (1981) found that the pupae of *P. orobanchia* which have been buried at a depth of 20-25 cm resulted to an emergence rate of only 21% and the beneficial role of the fly was diminished by autumn ploughing. Moreover, the deep tillage and the incorporation of *Orobanche* shoots by ploughing may have caused a mechanical destruction of pupae and adults were only able to emerge after hatching from a soil depth of maximum 20 cm. For the same target, Cubero (1983) pointed out that pupae could be destroyed by irrigation.

At the level of the effect on *O. crenata*, Zahran (1982) noted that subsoil ploughing did not differ significantly from conventional tillage in its effect on *O. crenata* in faba bean. Consequently, deep plowing will be a solution only in limited cases. Zero or minimum tillage so far provided hardly significant differences when compared to conventional tillage (Kukula and Masri, 1984). This finding is conflicting with the effect of tillage on emergence *Phytomyza* adults from diapaused pupae. While, several observations document the less severe *Orobanche* infestation under high moisture levels or after periods of flooding (Cubero, 1983). Zahran (1982) reported a decrease of *O. crenata* infestation in faba bean after two weeks of flooding prior to the sowing of the crop in Egypt. Also, he reported about 65% reduction in *O. crenata* infestation in faba beans following a flooded rice crop when compared with fallow. On the other hand, the respective values of reduction in *Orobanche* spikes were found to be 0 and 25% with 10 and 30 day irrigation interval without pre-sowing flood, compared with 4 and 36% with pre-sowing flood (Hassanein and Salim, 1999). Also, it was found that irrigation during summer reduced the infestation with *O. crenata* in Spain (Mesa-Garcia *et al*., 1984). This finding is conflicting with the effect of flood on emergence *Phytomyza* adults from diapaused pupae. According to Van Hezewijk *et al*. (1993), it was found that a prolonged period of moistening induced secondary dormancy in *O. crenata* seeds. There are some reports that indicated a reduction of *Orobanche* infestation after a period of flooding, as for rice, but the mechanism is not yet fully understood. The decline of the *Orobanche* population may be a result of an enhanced microbial activity and decay of the seeds or shoots. Anaerobic conditions in the soil, which favor the formation of toxins that lead to a decrease in the viability of the seed population, may also contribute to the detrimental effect on broomrape infestation (Sauerborn and Saxena, 1986; Mohamed-Ahmed and Drennan, 1994).

Another approach to increase the initial population of *Phytomyza* was reported by Bronstejn and Kabulov (1961) who stated that the simplest method to enhance the survival rate of pupae in the field is to store collected *Orobanche* shoots at field borders. A mechanical destruction caused by tillage there can be avoided. In the former USSR, (Tsybul'skaya and Skoklyuk, 1978) calculated the number of infested *Orobanche* stems required for release of the fly over one hectare. Therefore, the best method is the stems containing puparia should be released in the field as soon as flowers appear on the weed and bury them in special trenches cut between the crop rows, which are then filled up with a 20 cm layer of soil to pass and to purify the population.

CONCLUSION

From semi-field experiment, fleshy *Orobanche* shoots collected during March and buried on depth 5 cm in moist and sandy-loam soil caused the highest emergence percent of *Phytomyza orobanchia*, being required to increase the rate of initial *Phytomyza* population in faba bean fields against *Orobanche crenata* in the new activity season. These findings may be helpful in the future field studies which related to the damage effects of some agricultural practices such as tillage and irrigation. This study should be undertaken in release programs for increasing the population of *P. orobanchia* first generation which play an important role in biological control of the emerging *O. crenata*. Consequently, the number of infested *Orobanche* shoots contained diapaused *Phytomyza* pupae, which are required for early release of the fly adults in field should be calculated per feddan. After that, *Orobanche* shoots could be buried at 5 cm depth at field borders and covered with moistened and sandy-loam soil.

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