Effect of Infestation Density with *Phelipanche aegyptiaca* on the Efficiency of Bio-agent, *Phytomyza orobanchia* and Infestation by *Tuta absoluta* on Tomato Crop at El-Beheira Governorate, Egypt

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ABSTRACT

Tomato is the most susceptible hosts to many insect pests and broomrape, which causes significant yield losses. The present study was carried out with the purpose to know which infestation density of Egyptian broomrape (*Phelipanche aegyptiaca* Pomel) was affected on efficiency the bio-agent, *Phytomyza orobanchia* Kaltenbach (Diptera: Agromyzidae) in the area grown with tomato crop, which was affected at the same time by tomato leaf miner, *Tuta absoluta* (Meyrick) (Gelechiidae: Lepidoptera) under natural conditions during two successive years (2019 and 2020) at El-Beheira governorate, Egypt.

Three randomized fields cultivated with tomato crop in summer were selected during 2019 and 2020. Infestation density with *Ph. aegyptiaca* was divided into three levels, Low (1 – 10 shoots / plant), Medium (11 – 25 shoots / plant) and High (≥ 25 shoots / plant). Number of pupae in capsules, number of pupae in stems, total number of pupae in shoots and the percentage of pupae in capsules were determined per *Ph. aegyptiaca* shoot. Highest effectiveness of *P. orobanchia* (36.0%) was recorded in low infestation density with *Ph. aegyptiaca*, while with medium and high infestation density with *Ph. aegyptiaca* only 23.5% and 18.6%, respectively in second year 2020. No significant difference was found between low and medium infestation density with *Ph. aegyptiaca* in the total number of *P. orobanchia* pupae per shoot.

At the beginning of fruiting stage of tomato crop, leaves and fruits were taken from the randomly selected tomato plants according to infestation density with *Ph. aegyptiaca* flourishes, to estimate the infestation percent by leaf miner (*Tuta absoluta*) throughout the two year (2019-2020). In addition to, percentage of parasitism by egg parasitoids of the genus *Trichogramma* on tomato leaf miner was determined. According to infestation density with *Ph. aegyptiaca*, tomato yield was calculated. At the end of this study, under the medium infestation density of Egyptian broomrape the infestation percent by *T. absoluta* was (16.67%) synchronized with high percentage of its parasitoid, *Trichogramma* spp. (63.2%) with high yield of tomato (820 gm/ plant) compared with control (without infestation with *Ph. aegyptiaca*).

Obtained data may provide information for improving effective of *P. orobanchia* in biological control program of *Ph. aegyptiaca* in the frame of integrated pest management (IPM) of *T. absoluta* in tomato fields. However, combining Egyptian broomrape (*Ph. aegyptiaca*) and *T. absoluta* in IPM program will contribute to management efficacy as well as avoid used each control methods separately for each pest. Further research is needed to choose the timing in combining between these pests to use IPM, taking into consideration efficacy, cost and environmental aspects.

Key words: Tomato, *Phelipanche aegyptiaca*, *Phytomyza orobanchia*, *Tuta absoluta*, *Trichogramma* spp.

INTRODUCTION

Tomato (*Solanum lycopersicon* L.) has been suffered from *Orobanche* species, which are obligate root-parasitic weeds widespread in Mediterranean areas, Asia, and Southern and Eastern Europe (Bayram and Çıkman, 2009; Hershenhorn *et al.*, 2009; Salem and Abd El-Sala, 2013). Several broomrape species feed on many plant species by attaching themselves to the root hosts with haustorium to obtain nutrients and water (Lopez-Raez *et al.*, 2008). Tomato is highly weak to three broomrape species, *Phelipanche aegyptiaca* Pomel (syn. *Orobanche aegyptiaca*), *Phelipanche ramosa* Pomel (syn. *O. ramosa*) and *O. cernua* Loefl. (Orobanchaceae) that are exert their greatest damage before emergence the broomrape flowering shoots from soil (Rubiales *et al.*, 2003; Joel *et al.*, 2007; Lopez-Raez *et al.*, 2008; Parker, 2009). The grown tomato varieties are affected by *Ph. aegyptiaca* and caused the economic damage to tomato production (Kacan and Tursun, 2012). These parasitic weeds seriously affect many crops causing significant yield losses, which may occur before emergence above ground (Aksoy *et al*., 2004). Yield losses range was from 5% to 100%, depending on level of infestation with broomrape, host susceptibility and environmental conditions (Joel *et al*., 2007).

Fortunately, bio-control agent, *Phytomyza orobanchia* Kaltenbach (Diptera: Agromyzidae) was found associated with broomrape in tomato growing fields. *P. orobanchia* has four generations annually (Bayram and Çıkman, 2014; Al-Eryan *et al*., 2018). *Phelipanche* is attacked by the monophagous fly, *P. orobanchia*. The larvae feed only on broomrape and can reduce seed production by 30 to 90%. For this reason, this fly is one of the most effective biological control agents of broomrape. But, its effectiveness may be limited by parasitoids and agricultural practices (Klein and Kroschel, 2002).

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In contrast, *Tuta absoluta* (Meyrick) (Gelechiidae: Lepidoptera) was first detected on tomato in 2009 at northwestern Egypt and the pest rapidly spread in different regions of Egypt (Moussa *et al.*, 2013; Salama *et al.*, 2015). It is oligophagous moth feeding on solanaceous crops and one of the major devastating exotic pests attacking tomato crops in many regions of the tomato producing worldwide (Germain *et al*., 2009). Significant damage by larvae of *T. absoluta* can potentially result to its feeding on all aerial parts of tomato plant and affects both yield and fruit quality. If *T. absoluta* is not properly managed, it causes 80–100% crop loss in the field and in protected cultivation (Desneux *et al*., 2010; Khanjani, 2013; Mansour *et al*., 2018). Egg parasitoids of the genus *Trichogramma* among the various natural enemies have received more substantial attention as potential biological control agents to *T. absoluta* (Cagnotti *et al*., 2016; Cherif *et al*., 2018). The parasitoid *Trichogramma achaeae* Nagaraja & Nagarkatti (Hymenoptera: Trichogrammatidae) has been recorded as a successful candidate to help manage *T. absoluta*, which infests tomato crops in Mediterranean countries (Cabello *et al*., 2009 &2012; Wright and Stouthamer 2011; Polaszek *et al*., 2012; Cascone *et al*., 2015; Giorgini *et al*., 2019).

The aim of this study is to determine the effect of infestation density with Egyptian broomrape (*Ph. aegyptiaca*) on efficiency of *P. orobanchia,* as a bio-agent for broomrape and in the same time; the infestation percent by *T. absoluta* and impact of the egg parasitoid, *Trichogramma* spp. during two successive years (2019 and 2020) in tomato crop in order to reduce the damage caused to tomato yield under natural conditions.

MATERIALS AND METHODS

1- Sites of study

In the season of 2019, three randomized fields (about half feddan per field) were selected according to already infestation with Egyptian broomrape, *Phelipanche aegyptiaca* and cultivated with tomato crop, Astrin-B cultivar. Tomato was planted during mid-April in Ad Dilinjat regions "30.8282ºN 30.5329 ºE" at El-Beheira governorate, Egypt. The agricultural practices were performed with avoid insecticidal treatments during the study period. In the season of 2020, the same work was repeated in the same regions.

2- Experimental parameters

At the flourishing time of broomrape in May, the infestation density of *Ph. aegyptiaca* divided into three infestation levels in tomato fields, Low (1 – 10 shoots / plant), Medium (11 – 25 shoots / plant) and High (≥ 25 shoots / plant). From each field, the branched broomrape (*Ph. aegyptiaca*) was picked out according to infestation level (Low, Medium and High) per tomato plant. So, 5 tomato plants were chosen per infestation level and all shoots of *Ph. aegyptiaca* around the plant were picked up. The collected *Ph. aegyptiaca* shoots were put in labeled paper packages then transferred to the laboratory.

2.1-Estimation the efficiency of *Phytomyza orobanchia*

In the laboratory, the branched broomrape inflorescences were left until *P. orobanchia* pupation occurred. To estimate the efficiency of *Phytomyza* population, the capsules from *Ph. aegyptiaca* inflorescence were detached and classified into intact and infested capsules. Infestation percent with *P. orobanchia* / shoot was calculated. Numbers of *Phytomyza* pupae in capsules, stem, and total number of pupae per shoot were counted. The same work was repeated in the same regions during two year of study.

2.2- Estimation the infestation percent by *Tuta absoluta* and its egg parasitoid, *Trichogramma* spp.

At the beginning of fruiting stage throughout the two successive years (2019-2020), infestation leaves by tomato leaf miner, *T. absoluta* were taken from the randomly selected tomato plants according to infestation density with the broomrape, *Ph. aegyptiaca* flourishes. This leaves were put separately in sealed a polyethylene bag and examined in the laboratory under steriomicroscope for count the number of tomato leaf miner (larvae and tunnels). Also, fruits were picked carefully to estimate the leaf miner infestation. The infestation percent by leaf miner, *T. absoluta* in leaves and fruits were counted together per plant. In addition to, percentage of parasitism by egg parasitoid, *Trichogramma* spp. on *T. absoluta* was determined. At the end of season, tomato yield (gm) per plant was recorded in the different infestation levels with *Ph. aegyptiaca*. All studied parameters were compared with control (without infestation with *Ph. aegyptiaca*)..

3- Statistical Analysis

The data were subjected to one-way analysis of variance (ANOVA) after appropriate transformation through an online software OP-STAT (**Sheoran *et al*., 1998**). The significantly different means were separated by LSD.

RESULTS AND DISCUSSION

The present study was carried out to determining the effect of infestation density of Egyptian broomrape (*Phelipanche aegyptiaca* Pomel) on efficiency of *Phytomyza orobanchia*, as a bio-agent for broomrape and on infestation percent by *Tuta absoluta* and its egg parasitoid, *Trichogramma* spp. in the same time. The study was carried under natural conditions in tomato fields during two successive years (2019 and 2020) at

El-Beheira governorate, Egypt. The tomato is among the most susceptible hosts of broomrape, which causes significant yield losses, due to excessive infection in areas used to grow tomato. The broomrape, *Ph. aegyptiaca.* is one of the most economically important flowering parasitic plants, which attacks various crops in the family Solanaceae, especially tomato. At the same time, *T. absoluta* is oligophagous moth feeding on solanaceous crops and one of the major devastating exotic pests attacking tomato crops.

1- Efficiency of *Phytomyza orobanchia*, as a bio-agent on the Egyptian broomrape, *Phelipanche aegyptiaca*

For evaluation of *P. orobanchia* efficiency, total number of pupae (in capsules and stems) and infestation percent were used as the most important parameters. Effect of three infestation densities with *Ph. aegyptiaca* on efficiency of bio-agent, *P. orobanchia* in tomato fields during two years (2019-2020) is given in Table (1). In terms of all examined parameters; number of pupae in capsules, number of pupae in stem, total number of pupae per shoot and infestation percent were determined per shoot. Low infestation density with *Ph. aegyptiaca* was manifested the highest efficiency, while in high infestation density with *Ph. aegyptiaca* was found the least efficiency. Data revealed that the infestation densities, 5-10, 11-25 and ≥25 *Phelipanche*/ tomato plant resulted 36.3, 26.3and 21.1% infestation percent with *P. orobanchia* during the first year (2019), respectively. The same trend was appeared in the second year (2020).

As a consequence of this study, the highest total number of *P. orobanchia* pupae per broomrape shoot was obtained from low infestation density with *Ph. aegyptiaca* (5-10 shoots/plant) and followed by the total number of pupae per shoot from medium infestation density with *Ph. aegyptiaca* (11-25 shoots/plant). Considering the topic in terms of years, it was determined that the high infestation density with *Ph. aegyptiaca* (≥25 shoots/plant), caused decrease in the total number of *P. orobanchia* pupae per shoot in second year, 2020 (11.8) than the first year, 2019 (12.9) (Table. 1).

The efficiency of *P. orobanchia* increased significantly by decreasing the number of Egyptian broomrape shoots (low infestation density with *Ph. aegyptiaca*). While, no significant difference between low and medium infestation density with *Ph. aegyptiaca* in the total number of *P. orobanchia* pupae per broomrape shoot, which important to re- release of *Phytomyza* pupae in biological control of *Ph. aegyptiaca*. during successive seasons.

In line with the findings obtained in the current study, Piwowarczyk *et al*. (2018) reported that the infestation of *Phelipanche ramosa* by *P. orobanchia* in tomato crops was observed in the form of mining in flowers (ovary with seeds), shoots, and tubers. A single broomrape plant could be parasitized by 1 to 10 larvae. Bayram and Çıkman (2014) observed that the density of *P. orobanchia* in each part of broomrape may also change according to broomrape vegetation in lentil and tomato fields. In case of low density of broomrape, more than one larva or pupa (2-4) could be seen in the same capsule. The *P. orobanchia* females prefer fresh and suitable capsules for egg laying and for feeding. When *P. orobanchia* couldn't find suitable capsules, especially when a new broomrape emerge or when plants are getting older and dryer, then *P. orobanchia* lays eggs in fresh shoots and stems. The *P. orobanchia* life cycle depends on fresh broomrape parts, so any part of broomrape has more suitable water and food, females laying their eggs inside it (Bayram and Çıkman, 2016) to sustain its generation (Bayram and Çıkman, 2009). On the contrary, according to a survey study carried out by Aksoy *et al*., (2004), *P. orobanchia* was only found in lentil fields with a very low population, while couldn't find in bean and tomato fields.

When the amount of broomrape in the field is high, the activity of *P. orobanchia* on per broomrape will be lower, but if the amount of broomrape is low or broomrape has fewer capsules, the activity of *P. orobanchia* on per broomrape will be higher. It is completely depend on density of host and parasitoid. Anyway, when infestation level of broomrape is minimal or moderate; it is enough to control broomrape by *P. orobanchia*. (Bayram and Çıkman, 2016 and 2017). Although several potential control measures have been developed in the past decades for tomato crop, any single approach is often only partially effective and sometimes inconsistent and affected by environmental conditions. Therefore, the most feasible way of coping with the weedy root parasites is via the integration of a variety of measures in an integrated management approach to prevent the damage caused by this weedy parasite (Hershenhorn *et al*., 2009).

Future studies should focus on protecting the last generation of *P. orobanchia* in broomrape remains then collecting and releasing them at the beginning of subsequent season. The existence and efficiency of *P. orobanchia* are a source of sight for any subsequent biological control studies. Therefore, protection of *P. orobanchia* population from harmful agriculture practices is necessary. However, releasing of *P. orobanchia* individuals should be made periodically for many years in infested fields. The broomrape fly, *P. orobanchia* is a hopeful agent for controlling broomrape and for integrating with other control methods. The awareness of farmers should be raised about the beneficial role of this biological control agent and about the seriousness of the heavy treatments by pesticides.

2- Infestation percent by *Tuta absoluta* and parasitism by egg parasitoid, *Trichogramma* spp.

In terms of the percentage infestation of *T. absoluta*, the high infestation density of broomrape was correlated with the low infestation percent of *T. absoluta* (11.67 and 10.87%). In contrast, it was correlated with raising in the percentage of parasitism by its parasitoid, *Trichogramma* spp. (68.1 and 68.8%) per plant during two years, respectively. While, the control (without infestation with *Ph. aegyptiaca*) was determined as generating the highest infestation percent by *T. absoluta* (42.67% and 49%) in two years 2019 and 2020, respectively. In contrast, the percentage of its parasitoid, *Trichogramma* spp. was low (50.2% and 51.2%) during two years, respectively. On the other trend, the infestation percent by *T. absoluta* was observed to be moderate in both of the low and medium infestation density with broomrape flourishes, *Ph. aegyptiaca* and the percentage of parasitism by its egg parasitoid, *Trichogramma* spp. was high. No significant differences were found between low and medium infestation density with *Ph. aegyptiaca* in the percentage of parasitism by *Trichogramma* spp. on *T. absoluta* per plant (Table. 2).

The tomato leaf miner, *T. absoluta* is an invasive species threatening tomato crops. Most of *T. absoluta* control strategies are still based on insecticide use (Lietti *et al*., 2005; Guedes and Picanço, 2012), the effectiveness of which is often undermined by insecticide resistance (Silva *et al*., 2011; Roditakis *et al*., 2018; Silva *et al*., 2019) and/or reduced contact with the larvae hidden inside plant stems or fruits (Cocco *et al*., 2013). Since most insecticides have become ineffective to control *T. absoluta*, effective and environmentally friendly alternatives are needed. Biological control by parasitoids, *Trichogramma* spp. is an effective means of reducing this pest (Schäfer and Herz, 2020). As reviewed by previous authors who studied the percentages of parasitism by different *Trichogramma* spp. against different hosts (Chailleux *et al*., 2012; Cabello *et al*., 2012), was close to (65.9–91.74%). Host parasitism by different egg parasitoids (62.56–84.22%) against *T. absoluta*, obtained in the study by (Manohar *et al*., 2019).

In terms of the infestation with *Ph. aegyptiaca* inflorescence in tomato fields and attract natural enemies, Cloyd (2020) noted that the biological control can be also applied by providing flowering plants that will attract natural enemies. However, based on the scientific literature, that providing natural enemies with floral resources will result in an abundance of natural enemies sufficient to management insect pest populations below economically injury levels. Different researches showed that parasitoid, *T. achaeae* was innately attracted to volatiles produced by tomato plants, whether uninfested or infested by *T. absoluta*. However, egg parasitoids (*Trichogramma* spp.) could not distinguish between volatiles from uninfested or *T. absoluta*-infested tomato plants (Gontijo *et al*., 2019). To further increase this parasitoid efficiency, it is important to study the chemical ecology of trophic interactions among tomato plants, *T. absoluta*, and its parasitoid, *T. achaeae*. While it is known that *T. absoluta* eggs and larvae can elicit the production of HIPVs (Herbivore-induced plant volatiles) by tomato plants (Backer *et al*., 2015; Anastasaki *et al*., 2018). The responses of *Trichogramma* spp. to HIPVs remain unexplored. Likewise, it is unknown if *Trichogramma* spp. females could be attracted to *T. absoluta* according to HIPVs from tomato crop only or flourished broomrape also. The pursuit of such knowledge is crucial to improve the effective use of *Trichogramma* spp. in the augmentative biological control of *T. absoluta* in tomato fields. Results and implications are requiring further studies in the context of sustainable *T. absoluta* management.

3- <u>Tomato Yield</u>

Considering the topic in terms of years, it was determined that the high infestation density with *Ph. aegyptiaca* (≥25 shoots/plant), caused significantly losses in tomato yield annually. In the high infestation density with *Ph. aegyptiaca*, a decrease in the tomato yield (gm) per plant was determined from the first year (2019) (450 gm/ plant) to (420 gm/ plant) in the second year (2020) (Table. 2). Tomato yield significantly differ according to infestation density with *Ph. aegyptiaca* (low, medium and high). Also, considerable decreases are observed in the tomato yield due to infestation percent by *T. absoluta*, when compared to control (without infestation with *Ph. aegyptiaca*). Tomato yield was low in control may be according to high infestation percentage by *T. absoluta* and low infestation percentage by *Trichogramma* spp. On the other hand, Tomato yield was low in the high infestation density with broomrape, *Ph. aegyptiaca*, although the infestation percentage by *Tuta absoluta* was low and infestation percentage by *Trichogramma* spp. was very high in the two years 2019 and 2020 (Table. 2).

Table 1. Effect of three infestation densities with *Phelipanche aegyptiaca* on efficiency of bio-agent, *Phytomyza orobanchia* in tomato fields during two years (2019-2020) at El-Beheira governorate, Egypt

Infestation density with *Ph. aegyptiaca* / tomato plant	No. of pupae in *Ph. aegyptiaca* capsules / shoot		No. of pupae inside *Ph. aegyptiaca* stems / shoot		Total number of *P. orobanchia* pupae/shoot		Infestation percent with *P. orobanchia* / *Ph. aegyptiaca* shoot	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Low Infestation (5 – 10 shoots / plant)	9.2 **a**	9.1 **a**	14.7 **a**	14.00 **a**	23.9 **a**	23.1 **a**	36.3 **a**	36.0 **a**
Midium Infestation (11 – 25 shoots / plant)	6.8 **b**	6.6 **b**	11.8 **b**	11.2 **b**	18.6 **a**	17.8 **a**	26.3 **b**	23.5 **b**
High Infestation (≥ 25 shoots / plant)	4.5 **c**	4.1 **c**	8.4 **c**	7.7 **c**	12.9 **b**	11.8 **b**	21.1 **c**	18.6 **c**
LSD 0.01	**2.2**		**2.6**		**5.5**		**4.8**	

Means within a row sharing the same letter are not significantly different at LSD = 0.01

Table 2. Effect of three infestation densities with *Phelipanche aegyptiaca* on infestation percent by *Tuta absoluta* and its egg parasitoid, *Trichogramma* spp. in tomato fields during two years (2019-2020) at El-Behira governorate, Egypt

Infestation density with *Phelipanche aegyptiaca* / tomato plant	Infestation percent by *Tuta absoluta* / plant		Percentage of parasitism by *Trichogramma* spp. on *Tuta absoluta* / plant		Tomato yield / plant (gm/ plant)	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Low Infestation (5 – 10 shoots / plant)	23.67 **b**	22.67 **b**	60.1 **b**	60.4 **b**	650 **a**	690 **a**
Midium Infestation (11 – 25 shoots / plant)	17.33 **c**	16.67 **c**	61.8 **b**	63.2 **b**	800 **a**	820 **a**
High Infestation (≥ 25 shoots / plant)	11.67 **d**	10.87 **d**	68.1 **a**	68.8 **a**	450 **b**	420 **b**
Control (without infestation with *Phelipanche aegyptiaca*)	42.67 **a**	49.0 **a**	50.2 **c**	51.2 **c**	470 **b**	440 **b**
LSD 0.01	**4.25**	**4.84**	**5.2**	**5.4**	**160**	**140**

Means within a row sharing the same letter are not significantly different at LSD = 0.01

CONCLUSION

Although variety studies are available carried out in order to prevent broomrape and *T. absoluta* development in tomato growing, no study has been found concerning the effect of broomrape and *T. absoluta* together as a serious pests in tomato fields. Obtained data may provide valuable information for improving effective of *Phytomyza orobanchia* in biological control program of *Phelipanche aegyptiaca* in the frame of integrated pest management (IPM) of *Tuta absoluta* in tomato fields. However, combining these pests in IPM program will contribute to management efficacy as well as avoid used each control methods separately for each pest. Further research is needed to choose the timing in combining between these pests to use IPM, taking into consideration efficacy, cost and environmental aspects.

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الملخص العربي

تأثير كثافة الإصابة بالهالوك *Phelipanche aegyptiaca* على كفاءة العنصر الحيوي *Phytomyza orobanchia* والإصابة بحشرة *Tuta absoluta* على محصول الطماطم في محافظة البحيرة ، مصر

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محصول الطماطم هو أكثرالعوائل النباتية حساسية للعديد من الآفات الحشرية والهالوك broomrape ، والتي تسبب خسائر كبيرة في المحصول. أجريت هذه الدراسة بهدف معرفة كثافة الإصابة بالهالوك المصري (*Phelipanche aegyptiaca* Pomel) الذى يؤثر على كفاءة العنصر الحيوي *Phytomyza orobanchia* Kaltenbach (Agromyzidae : Diptera) في المنطقة المزروعة بمحصول الطماطم، والتى تأثرت في نفس الوقت بنافقة أوراق الطماطم *Tuta absoluta* (Meyrick) (Gelechiidae: Lepidoptera) في ظل الظروف الطبيعية خلال عامين متتاليين (٢٠١٩ و ٢٠٢٠) في محافظة البحيرة ، مصر.

تم اختيار ثلاثة حقول عشوائية مزروعة بمحصول الطماطم في الصيف خلال عامى ٢٠١٩ و ٢٠٢٠. كثافة الإصابة بالهالوك *Ph. aegyptiaca* قسمت إلى ثلاث مستويات ، منخفض (١ – ١٠ شمراخ / نبات) ، متوسط (١١–٢٥شمراخ / نبات) و عالي (≥ ٢٥ شمراخ / نبات). تم حساب عدد العذارى في الكبسولات ، عدد العذارى في السيقان ، العدد الإجمالي للعذارى في الشمراخ والنسبة المئوية للعذارى في الكبسولات لكل شمراخ *Ph. aegyptiaca*. وسجل أعلى كفاءة من *P. orobanchia* (٣٦٪) في الكثافة المنخفضة من *Ph. aegyptiaca*، بينما كانت فى الكثافة المتوسطة والعالية من *Ph. aegyptiaca* فقط ٢٣,٥٪ و ١٨,٦٪ على التوالي في العام الثاني ٢٠٢٠. لا يوجد فرق معنوي بين كثافة الإصابة المنخفضة والمتوسطة من *Ph. aegyptiaca* في العدد الإجمالي لعذارى *P. orobanchia* لكل شمراخ.

في بداية مرحلة الإثمار لمحصول الطماطم ، تم أخذ الأوراق والثمار من نباتات الطماطم المختارة عشوائيًا وفقًا لكثافة الإصابة بنورات الهالوك *Ph. aegyptiaca* ، لتقدير نسبة الإصابة بنافقة أوراق الطماطم (*Tuta absoluta*) طوال العامين (٢٠١٩– ٢٠٢٠). بالإضافة إلى ذلك ، تم تحديد نسبة التطفل بطفيليات البيض من جنس *Trichogramma* على نافقة أوراق الطماطم. كما تم حساب محصول الطماطم وفقا لكثافة الإصابة للهالوك *Ph. aegyptiaca*. وفي نهاية هذه الدراسة، وجد تحت كثافة الإصابة المتوسطة بالهالوك المصري كانت نسبة الإصابة بنافقة أوراق الطماطم *T. absoluta* (١٦,٦٧٪) متزامنة مع نسبة عالية من طفيل التريكوجراما *Trichogramma* spp. (٦٣,٢٪) مع إنتاجية عالية من الطماطم (٨٢٠ جم / نبات) بالمقارنة مع الكنترول (بدون إصابة بالهالوك *Ph. aegyptiaca*).

قد توفر البيانات التي تم الحصول عليها معلومات لتحسين فعالية العنصر الحيوى *P. orobanchia* في برنامج المكافحة البيولوجية للهالوك *Ph. aegyptiaca* في إطار الإدارة المتكاملة للآفات (IPM) لحشرة *T. absoluta* في حقول الطماطم. ومع ذلك، فإن الجمع بين الهالوك المصري *Ph. aegyptiaca* و *T. absoluta* في برنامج المكافحة المتكاملة للآفات سيساهم في فعالية الإدارة وكذلك تجنب استخدام كل طريقة مكافحة على حدة لكل آفة. وهناك حاجة إلى مزيد من البحث لاختيار توقيت الجمع بين هذه الآفات لاستخدام المكافحة المتكاملة للآفات، مع مراعاة الفعالية والتكلفة والجوانب البيئية.