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Field trials to control *Thrips tabaci* (Thysanoptera: Thripidae) infesting onion crop

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Abstract:

Thrips tabaci Lindeman (Thysanoptera: Thripidae) attack many vegetable crops specially onion causing grate economic damage on onion crops. Individuals of thrips are protected between the inner leaves of the plant where the pupal stage is spent in the soil. Field trial were conducted during two seasons 2017 and 2018 at Moshtohor, Toukh district, Qalubiya Governorate, to evaluat the efficacy of entomogenous fungus bioranza (*Metarhizium anisopliae*), two insecticide tracer 24% Sc (Spinosad) and marshall 25% EC (Carbosulfan), agriculture soap (potassium salts os fatty acids 49% Liquid) and two releasing rates (i.e. 3000 and 1000 pred./20m^2) of phytoseiid predatory mites, *Neoseiulus californicus* (McGregor) and *Neoseiulus arundonaxi* Metwally and Sanad (Acari: Phytoseiidae) for controlling *T. tabaci* infesting onion crop. Two applications were carried out during March and April during the two seasons. The results showed that all treatments reduced thrips populations compared to control. The maximum reduction in thrips population 73.42% for the predatory mite *N. californicus* at rate 3000 pred./ 20m^2 followed by *N. arundonaxi* at rate 3000 pred./ 20m^2. However, the minimum reduction in thrips population 57.27% for soap at rate 500ml/ 100 liter of water. Reduction percentage of thrips was highly in the second season 69.11% and 65.42% in the first year. The results indicate the potential of using *N. californicus*, *N. arundonaxi*, *M. anisopliae* and soap for the control of *T. tabaci*, there are safe enough to be used in an integrated pest management programs (IPM).

Introduction

Onion, *Allium cepa* L. (Alliaceae), is an important cash crop in Egypt for local consumption and exportation. Onion plants are infested with different insect pests during their growing season. *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), attack many vegetable crops specially onion causing grate economic damage on onion crops, which feeds on onion plants during their vegetative growth and fruit filling (Mahmoud, 2008). Both nymphs and adults cause severe damage to the crop, which can reach 40-60% in foliage damage and can lead to 10-20% yield losses annually (Waiganjo *et al.*, 2008).

Management of *T. tabaci* has proved to be difficult, due to its minute size and its thigmotactic behavior (Lewis, 1997). Usually, controlling thrips is conducted via the usage of chemical applications, which may explain the widespread chemical-resistance development in onion thrips (Jensen, 2000). Chemical control methods and alternative methods including biocontrol have been assayed against thrips (Cloyd and Sadof, 2000; Shelton *et al*., 2008; Shan *et al*., 2012 and Asghar *et al.*, 2018).

In previous studies, the applications of the biopesticide bioranza which is dependent upon the entomopathogenic fungi *Metarhizium anisopliae* was the most efficacious fungal formulation tested because it caused the highest reduction in mite counts in the hives. Mites are susceptible to entomopathogenic fungi (Chandler *et al.,* 2000). Some predators recorded here are known to readily accept *T. tabaci* as prey and may play an important role the integrated pest management of onion thrips (Lewis, 1973). The predacious mites of family Phytoseiidae are used as a biological control agent of thrips, which is a major pest of greenhouse crops (Gillespie, 1989). *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) is a potential biological control agent of spider mites and tarsonemid mites, and is commercially mass-produced for sale in various countries of the world (Cooping, 2001). Generally, control the thrips with phytoseiid predatory mites has established to be very success. The potential of *Neoseiulus arundonaxi* Metwally and Sanad (Acari*:* Phytoseiidae) in control western flower thrips Frankliniella occidentalis (Pergande) were assessed (Sanad and Hassan, 2019).

The present study was carried out during two successive seasons 2017 and 2018 at Moshtohor, Toukh district, Qalubyia Governorate, to evaluate the entomogenous fungus *M. anisopliae*, two insecticides tracer and marshall, soap and two predacious mite, *N. californicus* and *N. arundonaxi* as an ecofriendly tools in an IPM strategy to control infestation of thrips of onion production in Egypt.

Material and methods

1. Study sites:

Field trials to control were conducted at Moshtohor, Toukh district, Qalubiya Governorate, during 2017 and 2018 seasons. The site has an annual rainfall during December to February. The minimum and maximum temperatures during study are between 15.84˚C and 17.2˚C and between 25.8˚C and 28.46˚C, respectively.

2.Endomophagous fungi:

Commercial formulations of entomogenous fungus *M. anisopliae* is bioranza was used in this investigation; this was manufactured and produced by Plant Protection Research Institute, Agricultural Research Center. The active ingredient of bioranza is *M. anisopliae* (10% WP) and the recommended application concentration is 200g/100 liter of water.

3.Predacious mites:

3.1.Mass rearing of the predatory mite *Neoseiulus californicus*:

The predatory mite *N. californicus* was collected from different plants especially strawberry and cucumber plants. The colonies were maintained at room temperature under laboratory conditions in large plastic boxes (70x30x40 cm). Water was added when needed. Excised bean leaves highly infested with *T. urticae* were provided every day as prey source for the predatory mite.

3.2.Mass rearing of the predatory mite *Neoseiulus arundonaxi*:

N. arundonaxi was extracted from giant reed plants, using modified Tullgren funnel and was reared constantly on a mixture of all stages of the acarid mite, Tyrophagous putriscentiae (Schrank) (*Acari*: *Acaridae*) under controlled conditions of 25 ± 2°C in top vented plastic containers (6 cm diameter and 10 cm depth). All units were kept in large boxes provided with NaCl saturated solution for keep up RH inside the boxes as 75% (Winston and Bates, 1960). The acarid mite Tyrophagous putriscentiae (Schrank) (*Acari*: *Acaridae*) was reared on mixture of wheat bran and bakery dry yeast at 25°C in top vented plastic containers (6 cm diameter and 3 cm depth) (Sanad et al., 2007).

3.3.Release of the predacious mite:

Releases were carried out before sunset. It was released at the rate of 1000 and 3000 predator per treatment. The two predators were released twice per season on early March and April during 2017 - 2018 seasons. Releasing of phytoseiid mite was conducted by using main rearing medium mixed with means of a carrier, consisted of a mixture of wheat bran and vermiculate material by 1:1 ratio.

4.Field plots and treatments:

Onion cultivar, 'Red Creole' was transplanted in a complete randomized block design (1/2 feddan) with four replicates; each replicate consisted of four rows (10-m-long). Plants were spaced 10 cm within rows and 30 cm between rows, and a 1-m-long distance was used to separate each block. The seedlings of onion were sown in the early of December 2017 and 2018, using the recommended agriculture practices.

The experimental area was divided into nine treatments including control. Two pesticides were evaluated Tracer 24% Sc as 30 ml/100 liter and marshall 25% EC as 100 ml/100 liter of water), an entomogenous fungus bioranza (5x10^6 conidia/ml of water), soap as 500ml/ 100 liter of water two predacious mite, *N. californicus* and *N. arundonaxi* at rate of 1000 and 3000 predators/20-m^2 (Table, 1).

Table (1) : Treatments and their application rates.

Trade name	Active ingredient	Rate of application
Bioranza	*Metarhizium anisopliae*	200 g/100 liter
Tracer 24% Sc	Spinosad	30 ml/100 liter
Marshall 25% EC	Carbosulfan	100 ml/100 liter
Soap	(Potassium salts of fatty acids 49%Liquid)	500 ml/100 liter
Neoseiulus californicus	-	1000 predators/20-m^2
Neoseiulus californicus	-	3000 predators/20-m^2
Neoseiulus arundonaxi	-	1000 predators/20-m^2
Neoseiulus arundonaxi	-	3000 predators/20-m^2

Two applications were conducted, the first in early March and the second in early April during two seasons. Samples of 5 plants/ replicate were collected randomly at early morning. Insect pests and their predators were sampled weekly. The thrips number on plants was counted immediately before treatment and 1st week, 2nd week, 3rd week and 4th week and shaking them over a white sheet and motile stages were counted.

Materials were sprayed using a highly volume motor sprayer of 20 liters capacity. Pre-count was conducted before spraying. Percentage reduction in population was estimated using Henderson and Tilton (1955) equation.

% population reduction= 100 * (1 - (Ta * Cb)/(Tb * Ca), where:

Ta= number of mite after spray; Tb= number of mite before spray;

Ca =number of mite in the control after spray; Cb = number of mite in the control before spray.

5.Statistical analysis:

Reduction percentage of thrips was analyzed by one-way ANOVA and means were compared by using student's least significant difference. Significance level was P< 0.05. Analysis was conducted using SAS statistical software (SAS Institute, 2003).

Results and discussion

1.In the first season 2017:

The first application in early March 2017, the number of nymphs were counted in a sample of 20 plants collected from different treatments randomize. From the data demonstrated in (Table, 2), it was found that the highest reduction percentage were 62.68, 62.62, 59.77 and 56.50 for entomogenous fungus bioranza (*M. anisopliae*), release of *N. californicus* at rate 3000/20m^2, *N. californicus* at rate 1000/20m^2 and *N. arundonaxi* at rate 1000/20m^2 after four weeks of first application, respectively. Efficiency of insecticide treatments decreased with increase in data collecting interval. While, the efficacy of bioranza, soap and the two predacious mites increased with increase the time after application (Figure, 1 and Table, 2).

After second application in season 2017, data in Table, 2 and Figure,1 illustrated that, significant differences between reduction percentages of treatments, it can be divided into three categories. The highest reduction percentages ≥75% of *T. tabaci* were recorded at treatments; *N. arundonaxi* at rate 3000/20m^2, *N. arundonaxi* at rate 1000/20m^2, *N. californicus* at rate 1000/20m^2 and *N. californicus* at rate 3000/20m^2, they averaged 78.66, 76.04, 76.56 and 76.04% after four weeks, respectively. The moderate reduction percentages (≤75 to 70>) were recorded at treatments of bioranza and marshall 25% EC averaged 71.29 and 71.16%, respectively. The lowest reduction percentages (< 70%) of *T. tabaci* were recorded at treatments of tracer 24% Sc and soap with averaged 69.5 and 66.44%, respectively.

2.In the second season 2018:

The population of thrips nymphs per plant a day before application of treatments in different treatments was uniform which ranged from 22.2 to 26.2 nymphs/ plant in the second season 2018 (Figure,2).

Data presented in Table (3) showed that the reduction percentage of *T. tabaci* population as a result of spraying four products of fungi, marshall, tracer and soap and releasing the two predators at two rates in season 2018 after two application. Highest reduction percentage of *T. tabaci* nymphs were recorded at end of experiment at treatments; *N. californicus* at rate 3000/20m^2 (84.86%), *N. arundonaxi* at rate 3000/20m^2 (84.77%), marshall (84.77%), *N. californicus* at rate 1000/20m^2(82.04%), bioranza (79.74%) and *N. arundonaxi* at rate 1000/20m^2 (79.22%) without nonsignificant differences. The lowest reduction percentage was recorded at tracer (69.99%) and soap (65.96%).

Table (2): Reduction percentage of individuals Thrips tabaci infesting onion as a result after first and second application of different treatments under field conditions first application season 2017.

Treatments	Rate of	Reduction percentage of individuals/ 20 plants after First application				Reduction percentage of individuals/ 20 plants after Second application			
		First week	Second week	Third week	Fourth week	First week	Second week	Third week	Fourth week
Neoseiulus californicus 1000	$1000/20m^2$	52.99 b	61.22 ab	65.78 abc	59.77 a	72.93 b	71.39 bc	79.46 a	76.56 ab
Metarhizium anisopliae	$5 x10^6$ spores/1ml	47.78 b	66.20 a	67.94 ab	62.68 a	74.53 ab	75.85 ab	78.33 a	71.29 bc
Neoseiulus californicus 3000	$3000/20m^2$	61.68 ab	73.28 a	73.56 a	62.62 a	76.46 ab	76.55 ab	74.17 a	76.04 ab
Tracer 24% Sc	30 ml/100 liter	71.37 a	59.11 abc	60.78 bcd	44.39 c	81.03 a	77.81 a	71.91 a	69.50 c
Neoseiulus arundonaxi 1000	$1000/20m^2$	29.39 c	49.18 bcd	54.09 cde	56.50 ab	71.31 bc	72.76 ab	73.01 a	76.76 ab
Marshall 25% EC	100 ml/100 liter	72.55 a	44.54 cd	46.87 e	39.79 c	81.31 a	77.39 ab	75.36 a	71.16 bc
Neoseiulus arundonaxi 3000	$3000/20m^2$	45.52 bc	63.21 ab	68.94 ab	52.28 b	74.16 ab	73.26 ab	75.43 a	78.66 a
Soap	500 ml/100 liter	60.63 ab	42.69 d	49.00 dc	52.07 b	65.56 c	65.69 c	63.16 b	66.44c
F value		5.94	4.05	5.8	12.32	4.25	3.73	3.58	4.75
Probability		0.0007	0.00059	0.0008	0.0001	0.0046	0.0089	0.0108	0.0025
LSD at level 5%		17.36	15.86	5.8	6.99	7.33	6.15	7.77	5.79

Different letters in same column denote significant difference (P < 0.05).

Table (3): Reduction percentage uction of individuals *Thrips tabaci* infesting onion as a result after first and second application of different treatments under field conditions first application season 2018.

Treatments	Rate of	Reduction percentage of individuals/ 20 plants after First application				Reduction percentage of individuals/ 20 plants after Second application			
		First week	Second week	Third week	Fourth week	First week	Second week	Third week	Fourth week
***Neoseiulus californicus* 1000**	$1000/20m^2$	48.30 bc	62.01 bcd	71.63 abc	62.57 ab	71.71 bc	75.58 b	79.60 a	82.04 a
Metarhizium anisopliae	$5 x10^6$spores/1ml	54.73 b	65.09 cd	75.78ab	60.67 ab	67.60 c	73.48 cd	77.64 ab	79.43 a
***Neoseiulus californicus* 3000**	$3000/20m^2$	60.66 b	70.27 abc	80.94 a	67.15 ab	77.61 ab	76.33 a	82.27 a	84.86 a
Tracer 24% Sc	30 ml/100 liter	78.76 a	73.27 ab	72.47 abc	58.20 bc	81.03 a	71.38 bc	71.96 b	69.99 b
***Neoseiulus arundonaxi* 1000**	$1000/20m^2$	41.69 c	58.22 cd	65.80 c	49.12 cd	57.09 d	68.48 a	76.43 ab	79.22 a
Marshall 25% EC	100 ml/100 liter	77.67 a	76.30 a	70.60bc	64.50 ab	82.90 a	73.35 bc	71.86 b	84.77 a
***Neoseiulus arundonaxi* 3000**	$3000/20m^2$	58.97 b	66.47abcd	78.76 ab	70.17 a	79.91 ab	84.25 a	81.40 a	84.77 a
Soap	500 ml/100 liter	39.50 c	57.99 d	65.90 c	42.16 d	57.75 d	56.83 d	64.57 c	65.96 b
F value		12.42	2.61	2.86	6.21	11.25	10.8	6.16	9
Probability		0.0001	0.0416	0.0293	0.0005	0.0001	0.0001	0.0001	0.0001
LSD at level 5%		12.36	12.27	9.6	11.09	9.01	6.98	7.07	7.22

Different letters in same column denote significant difference ($P < 0.05$).

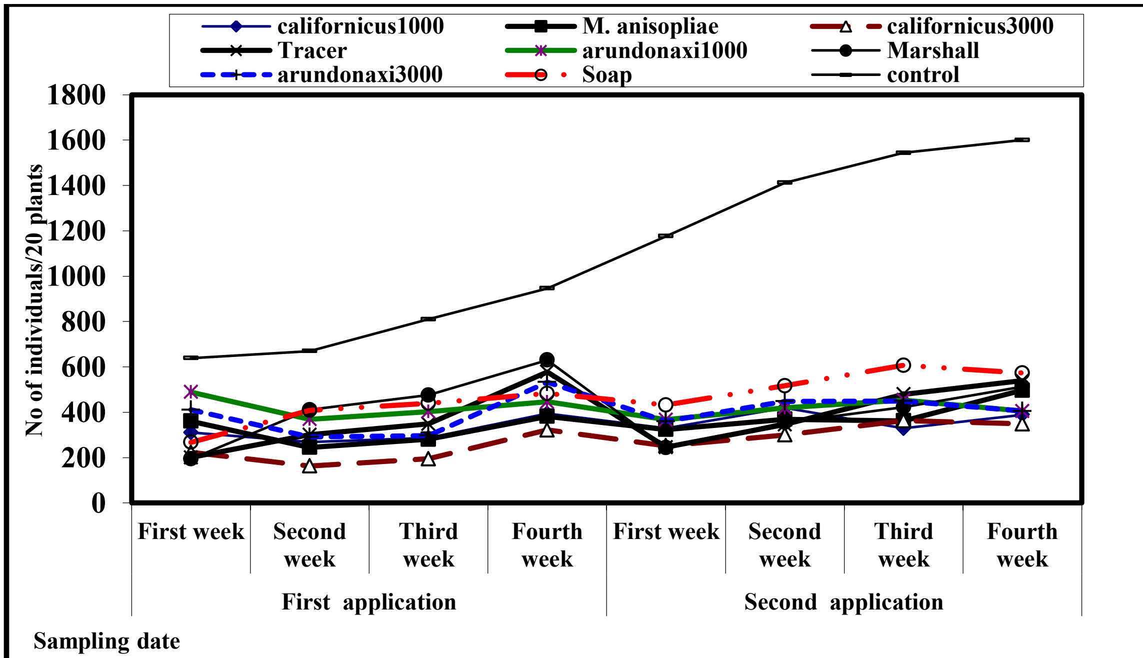

Figure (1):Populations of motile stages of *Thrips tabaci* infesting onion as a result after first and second application of different treatments under field conditions first application season 2017.

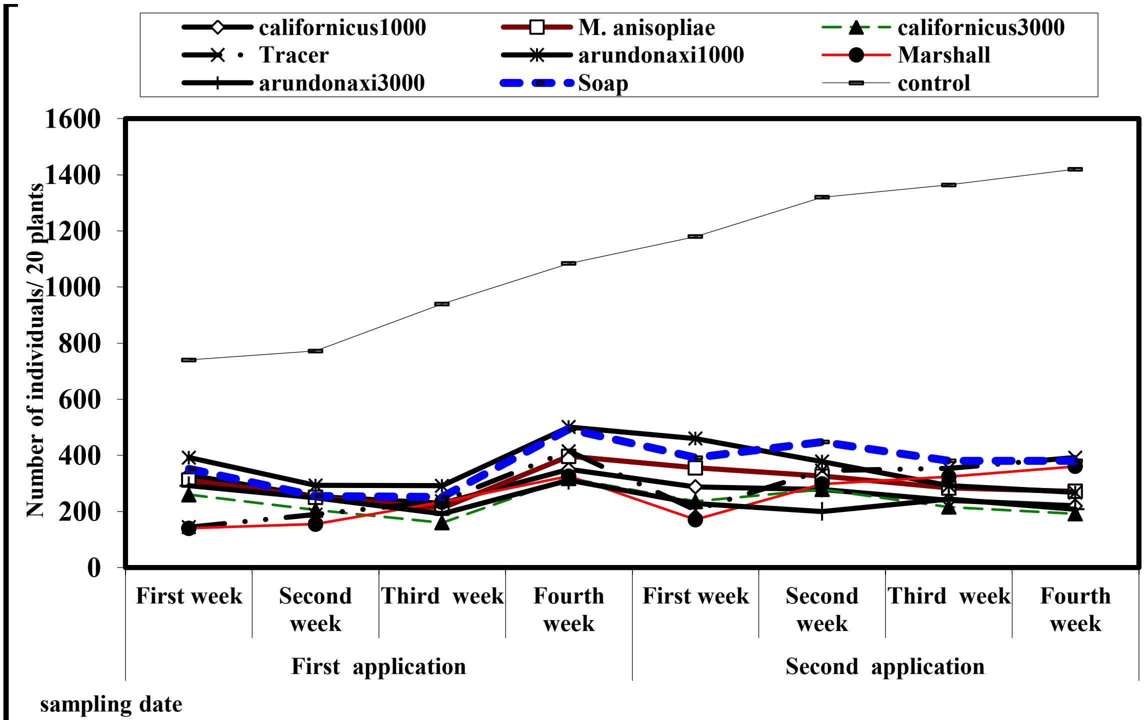

Figure (2):Populations of motile stages of *Thrips tabaci* infesting onion as a result after first and second application of different treatments under field conditions first application season 2018.

Generally, the results showed that all treatments reduced thrips populations compared to control. The maximum reduction in thrips population 73.42% for the predatory mite *N. californicus* at rate 3000 pred./ 20m^2 followed by *N. arundonaxi* at rate 3000 pred./ 20m^2. However, the minimum reduction in thrips population 57.27% for soap at rate 500ml/ 100 liter of water. Significant differences between two seasons, the percent reduction of thrips was highly in the second season 69.11% and 65.42% in the first year (Table, 4 and 5).

The results indicate the potential of using *N. californicus*, *N. arundonaxi* , *M. anisopliae* and soap for the control of *T. tabaci*, there are safe enough to be used in an integrated pest management programs (IPM).

Table (4): Reduction percentage of *Thrips tabaci* during two years 2017-2018 .

Treatments	Reduction percentage of two years 2017-2018
***Neoseiulus californicus* 1000**	68.37 b
Metarhizium anisopliae	68.71 b
***Neoseiulus californicus* 3000**	73.42 a
Tracer 24% Sc	69.56 ab
***Neoseiulus arundonaxi* 1000**	61.22 c
Marshall 25% EC	68.54 b
***Neoseiulus arundonaxi* 3000**	71.03 ab
Soap	57.27 c
F value	12.60
Probability	0.0001
LSD at level 5%	4.14

Different letters in same column denote significant difference ($P < 0.05$).

Table (5): Comparison between two seasons reduction percentage.

Season	%R	F value	Prob.	LSD
2017	65.42 b	12.10	0.0005	2.08
2018	69.11 a			

Different letters in same column denote significant difference (P < 0.05).

Entomopathogenic fungi are widely distributed with both restricted and wide host ranges which have different biocontrol potentials against arthropods insects and plant pathogenic fungi. These fungi have a lower risk on the environment and humans. These findings are in a close agreement with that presented by Goettel *et al*. (1990) showed that some commercial formulations of the entomopathogenic fungi can control aphids and thrips with low impact on non-target insects. Cloyd and Sadof (2000) indicated that both spinosad and acephate are efficacious against thrips in a commercial situation. Greenhouse managers should consider the presence of natural enemies out-doors when implementing pest management strategies because natural enemies may provide supplemental control of western flower thrips. Maniania *et al.* (2003) indicate that the potential of using *M. anisopliae* for the control of *T. Tabaci* while protecting biodiversity in the onion agroecosystem. Shelton *et al.* (2008) showed that acetamiprid, dimethioate, spinosad and imidacloprid performed better than lambda -cyhalothrin against thrips on cabbage. Arthurs *et al.* (2009) evaluated two species of phytoseiid mites as predators of chilli thrips, *Scirtothrips dorsalis* Hood. Gravid females of *Neoseiulus cucumeris* and *Amblyseius swirskii* both fed on *S. dorsalis* at statistically similar rates. Larvae were the preferred prey for both species, consuming on average 2.7/day, compared with 1.1–1.7 adults/day in no choice tests. Rahmani *et al.* (2009) reared the predatory mite, *N. californicus* on *T.tabaci*. The development, survivorship and life-history parameters of the boku strain of *N. californicus* feeding on first instar larvae of *T. tabaci*. Total prey consumption by protonymphs, deutonymphs and adult were 3.85 and 3.50 and 65.1, respectively. Arthurs *et al.* (2013) applied the commercial strains of entomopathogenic fungi were evaluated for control of chilli thrips, *S. dorsalis* Hood on pepper plants Spinosad reduced populations by 94–99%, *M. brunneum* F52 by 84–93%. Jafari *et al.* (2013) indicated that *Neoseiulus barkeri* Hughes is an indigenous biological control agent in west of Iran on cucumber and maize that preys on spider mites and *T. tabaci* and can prevent the outbreak of them. Asghar *et al.* (2018) indicated that the insecticides reduced thrips populations compared to controls. The maximum reduction in population of thrips and highest onion bulb yield was obtained with dimethoate 40EC followed by bifenthrin 10EC and the minimum onion bulb yield was obtained in the control.

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