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Efficiency of some control programs in controlling *Thrips tabaci* (Lindman) infesting garlic plants and resulted yield

Marwa AM Abd-Allah, Maha AM Tantawy, Fatina Baiomy
Plant Protection Research Institute, ARC, Dokki, Giza, Egypt

Abstract
This study was conducted in Al-Zaytoun village - Beni Suef Governorate during two consecutive seasons 2018-2019 and 2019-2020, where five control programs were applied to reduce the population density of *T. tabaci* infesting garlic plants and obtaining the highest yield of heads. The results showed that the application of the five tested programs led to a decrease in the infestation of thrips and an increase the resulted yield when compared to the control, with significant differences between all treatments. The best results obtained after applying the 3rd program (Spinetoram and Emamectin benzoate) where the treated plants were exposed to the significantly lowest infestation of thrips, as the seasonal mean numbers for the two studied seasons were 27.67 and 25.00 individuals/ plant, respectively and produced the highest yield, as the average production of garlic heads for both seasons together was 10886.70 kg/ feddan. Although garlic plants which treated with 1st program were highly exposed to thrips during the two seasons (30.24 and 39.98 individuals/ plant respectively), it occupied second one in production, as it was the average head yield for both seasons is 10221.20 kg/ feddan. Results showed that the garlic plants that were received the 2nd program came in third place for infestation of thrips (34.31 and 44.15 individuals/ plant for the two seasons respectively) and also came in the third place for production, as they produced 10059.50 kg/ feddan for both seasons together. Applying 4th and 5th programs on garlic plants led to plants exposed to the highest significant infestation with thrips during the two seasons and produced the lowest production of garlic heads when compared to the other three control programs. The results confirmed that garlic plants that were not treated with any pesticides (control) were infested with the heaviest infestation of thrips during the two seasons (54.37 and 65.87 fled / plant, respectively, and produced the lowest significant yield of garlic heads, as the average production for both seasons was 5646.85 kg/ feddan. Finally, the results indicated that the application of the 1st program on garlic plants gave the highest net profit of 19382.40 LE / feddan, followed by the 3rd and 4th programs, where they gave the net profit of 18825.40 and 18437.40 LE/ Feddan. As for the applying of the 2nd and 5th programs, they gave the lowest net profit per feddan of 16631.10 and 16038.20 LE/ feddan. On the contrary, the garlic plants in the control (untreated plots) which produced the lowest production of garlic heads gave the lowest net profit when compared to all treatment, as they gave a net profit of 11293.70 LE /feddan.

Keywords: control programs, *Thrips tabaci,* garlic plants, *Alium sativium* L

Introduction

Garlic (*Alium sativium* L.) is one of the most economic important bulb vegetable crops and is next to onion in importance. It is consumed as fresh as well as dried in the spice form and as an ingredient to flavor the various dishes all over the world and it is also medicinally important. In Egypt, garlic is extensively grown for both local consumption and exportation to the foreign countries *viz*., fresh materials, frozen paste, dried powder and extracted oil (Sakr, 1996) [19]. Evidence has been found to show that garlic was grown and consumed in the age of the building of pyramids of Egypt, about 2780-2100 B.C. (Yamaguchi, 1983) [30]. Garlic is grown in most Governorates of Egypt and the cultivated area was increased during the previously two decades, as it was expanded to cultivate it in reclaimed lands. Increasing garlic production in Egypt has become of great increasing meet the ever increased demand of local consumption and exportation. Such increase could be achieved by growing garlic in the reclaimed areas. The garlic crop is infested by many insect pests and diseases at different crop growth stages which cause considerable losses in yield quality and quantity and also poses harmful effects during harvesting, post harvesting, processing and marketing stages, (Mishra *et al* 2014) [15]. The onion thrips, *Thrips tabac*i is the main insect pests infesting garlic. Both nymphs and adults causes a direct damage of garlic include curling of leaves, low yield and poor quality of bulbs. Leaf curling reduces the activity of photosynthesis and thus reduces the crop yield (Singh *et, al* 2014) [15]. It also cause indirect damage to several crops as vector of mainly viral disease including Tomato spotted wilt virus, Tomato yellow ring virus and Iris Yellow Spot Virus which has spread in many importance onion- producing regions of the world and cause yield loss up to 100% (Ahmed and El-mogy 2011; Macharia *et al.* 2015; Berniak 2016 and Woldemelak 2020) [3, 14, 6, 28]. If onion thrips are not controlled, the damage can be reach from 9% to 25% in reducing bulb yield (Ashghar, 2018) [4] In Egypt, *T. tabaci* are active throughout the whole growing season of garlic crop from November to the end of April (Hussein *et., al* 2015) [10]. Control of *T.tabaci* is problematic due to their higher reproductive capacity which producing great number infesting several plants and their cryptic habits, as they feed hidden in crevices of leaf sheets. Some synthetic insecticides (conventional) were used to control *T.tabaci*, these insecticides had negative effects, like environmental pollution, pesticide resistance, and harmful to human health. Several investigations have studied the effect of conventional or non-conventional, bio insecticides and entomopathogens in reducing the population density of *T. tabaci*. Ishaaya *et., al* (2002) [12]; Simon and Victor (2005) [23]; Waiganjo *et., al* (2008); Ullah *et., al* (2010) [27]; Ahmed and El- Mogy (2011) [3]; Awadalla *et., al* (2011); Abou El-Maged *et., al* (2012); Shiberu *et., al* (2013) [21]; Mishra *et., al* (2014) [15]; Shiberu and Mohammed (2014); Ritz (2014); Hussein *et., al* (2015) [10]; Moraiet *et., al* (2015) [16]; Abdul Khaliq *et., al* 2016 [1] and Gahukar and Reddy (2018) [8]. Entomopathogenic such as viruses, bacteria, fungi, and nematodes and biopesticides, have been known as effective pesticide alternatives and involved in integrated pest management programs (Woldemelak 2020) [28]. Therefore the present study was conducted as an attempt to reduce the population densities of *T. tabaci* infesting garlic plants, enhancement plant characteristics and increase garlic head yield by using different control programs.

Material and Methods

Field experiment was conducted in Al-Zaytoun village - Beni Suef Governorate under field conditions during two successive seasons, 2018-2019 and 2019-2020. Five treatments of rotational control programs were conducted to evaluate their efficiency in reducing the population density of *T. tabaci* on garlic plants (Balady variety) and compared with control treatment. The insecticides which used in this study were Emamectin benzoate (Emakty 5% EC with recommended rate 60 cm/ fed), Spinetoram (Radiant 12% SC with recommended rate 120 cm/ fed), Fenitrothion (Sumithion 50% EC with recommended rate 1 Lit / fed., Entomopathogenic fungi (*Metarhizium anisopliae*) Biomagic 1.75% WP 1 gr/ lit and sulfur Nanomite 30% SC with recommended dose 1 lit/ feddan, Table (1). Each program was applied by 8 times with 15 day intervals between them. In both studied seasons, the garlic variety Balady was sown on Oct., 15th. The experimental area of 1440 m^2 was divided into equally six treatments included untreated check. Each treatment was divided into three replicates. Each replicate was about 80 m^2. All replicates were arranged in a randomized complete block design. The experimental area was prepared according to the standard method for garlic cultivation. The first spray of the studied programs was applied at Nov., 15th after one month from sowing in the two studied seasons. Five garlic plants were randomly selected from each replicate and examined directly in the field and kept in a tight closed paper bags and transported to laboratory in where all samples were thoroughly examined by stereomicroscope to count the adult and nymphs number of *T. tabaci* and calculate the mean number / plant.

To study the effect of the five studied control programs on the final garlic yield, fifty garlic plants were collected from each plot during harvesting (April, 21st in the two studied seasons) and then measured of length, whole weight of garlic plant and head weight only.

Table 1: Rotational control programs and spraying dates for controlling *T. tabaci* on garlic plants during 2018-2019 and 2019-2020 seasons.

Dates of spraying	1st Program	2nd Program	3rd Program	4th Program	5th Program	Control
Nov., 15th	Emamectin benzoate	*Metarhizium anisopliae*	Spinetoram	Fenitrothion	Spinetoram	-
29th	*Metarhizium anisopliae*	Spinetoram	Emamectin benzoate	Emamectin benzoate	Sulfur	-
Dec., 13th	Emamectin benzoate	*Metarhizium anisopliae*	Spinetoram	Fenitrothion	Spinetoram	-
27th	*Metarhizium anisopliae*	Spinetoram	Emamectin benzoate	Emamectin benzoate	Sulfur	-
Jan., 10th	Emamectin benzoate	*Metarhizium anisopliae*	Spinetoram	Fenitrothion	Spinetoram	-
24th	*Metarhizium anisopliae*	Spinetoram	Emamectin benzoate	Emamectin benzoate	Sulfur	-
Feb., 7th	Emamectin benzoate	*Metarhizium anisopliae*	Spinetoram	Fenitrothion	Spinetoram	-
21st	*Metarhizium anisopliae*	Spinetoram	Emamectin benzoate	Emamectin benzoate	Sulfur	-

All data concerning counts of the *T. tabaci* in the five studied control programs were statistically analyzed by using a computer software package "SAS" (SAS, Institute, 2008). Comparisons between means of treatments were depended on the F and L.S.D. tests.

Growth return was calculated according to the following equation:

- Cost of treatment LE. = number of spray x cost of each application.
- Garlic heads return= Garlic head weight (kg)/ feddan x price of fresh garlic head.
- *Net returns LE. / feddan = Garlic head return LE/ feddan – cost of treatments LE.

Results and Discussion

Efficiency of five rotational control programs against onion thrips.

Data represented in tables 2 and 3 shows that the *Thrips tabaci* was a principal pest on garlic plants during two studied seasons 2018- 2019 and 2019- 2020, it was appeared from the beginning of the season on all studied treatments.

During the first season, the minimum population of *Thrips tabaci* 24.67 individuals/ plant were recorded on garlic plants which under the 3rd control program (Spinetoram and Emamectin benzoate treatments) throughout the whole growing season till on month before harvesting at the end of April. First control program (Emamectin benzoate and *Metarizium anisoplia*) and second control program (*Metarizium anisoplia* and Spinetoram) occupied the second category, in terms of the effect on reducing the thrips population. Garlic plants which treated with the last mentioned two programs were infested by 30.24 and 34.31 individuals/ plant, respectively. On the contrary, the garlic plants which received 4th control program (Fenitrothion and Emamectin benzoate) and 5th control program (Spinetoram and sulfur) exposed to the highest infestation of *T. tabaci*, being 37.89 and 37.93 individuals/ plant, respectively. On the other hand the significantly heaviest infestation of *T. tabaci* (54.37 individuals/ plant) was recorded on garlic plants in the control plot which did not received any insecticides (Table 2).

According to statistical analysis, the obtained data was classified into four groups based on population density of thrips, as the highest infested group (a) represented by untreated plants, followed significantly by intermediate infested group, (b) which included garlic plants treated by 4th and 5th programs. Lower significantly infested group (c) were recorded by applying 2nd and 1st control programs. The lowest infested group, (d) which infested by the lowest *T. tabaci* population was represented by 3rd control program.

The data illustrated in (Table, 3) proves that the mean numbers of *T. tabaci* population attacking garlic plants during the second season were significantly affected by the application of the five tested control programs. The results of the second season took the same trend of the first season, where the lowest mean number of *T. tabaci* (25.00 individuals/ plant) obtained by applying 3rd control program, while the highest population density was recorded on garlic plants in untreated plots (65.87 individuals/ plant). Generally, all the tested control programs caused significant reduction of thrips compared to the control. According to L.S.D value the obtained data were arranged descending as an untreated check plot (control) > 5th > 4th > 2nd > 1st > 3rd.

Finally, the above mentioned results and their statistical analysis in the two studied seasons clearly showed that the application of 3rd program (Spinetoram and Emamectin benzoate treatments) was the most effective, as it significantly reduced the population density of *T. tabaci* on garlic plants compared to all other four control programs. On the contrary, garlic plants which treated with 5th control programme (Spinetoram and Sulfur) significantly harboured higher population number of *T. tabaci*. On the other hand, garlic plants in control area had significantly highest infested by this pest.

Table 2: Effect of five control programs on the population density of *T. tabaci* on garlic plants during the first season 2018 - 2019, in Beni-Suef Governorate.

Inspection dates	1st program	2nd Program	3rd program	4th program	5th program	Control
Nov., 15th	34	28.4	54	57	22.2	48.8
22nd	57.4	43.6	61.4	25.2	18.4	66.6
29th	22.4	76.6	50	29	25	44.6
Dec., 6th	41	27.4	25.6	62	29.8	80.4
13th	22	26.6	15.6	28.4	34.2	76.8
20th	13.8	32.8	12.8	23	35.2	69.4
27th	18.6	22.4	11	14.8	22.8	62.8
Jan., 3rd	39.6	26	10.8	19.6	29.2	90.4
10th	27.6	25.4	15.4	36.4	41.2	84
17th	15.4	24.6	19.8	53.2	53.2	77.4
24th	38.6	35	45.4	48.2	62.8	72.8
31st	35.4	59.4	41.6	34.6	54.2	52
Feb., 7th	18.2	74	41.4	16.8	27	24.4
14th	24.2	52.4	26.2	12.8	56.2	43.8
21st	34	36.4	19.4	42	58.8	36.6
28th	43.8	20.2	12.4	71	61.2	29.2
Mar., 7th	41.4	12.6	27.6	92.8	35	45
14th	29.6	13.6	20	48.8	29.8	24.4
21st	17.6	14.4	12.4	4.4	24.4	3.6
Mean	30.24c	34.31c	24.67d	37.89b	37.93b	54.37a
F. value	11.56					
L.S.D	3.58					

Table 3: Effect of five control programs on the population density of *T. tabaci* on garlic plants during the second season 2019- 2020, in Beni - Suef Governorate.

Inspection dates	1st Program	2nd Program	3rd Program	4th Program	5th Program	Control
Nov., 15th	49.2	52.6	35.0	46.2	38.4	39.2
22nd	63.1	77.1	44.1	58	51.7	66.4
29th	66.0	73.7	62.3	77.9	69.5	73.5
Dec., 6th	23.2	47.5	14.1	46.8	31.5	84
13th	40.6	62.4	41.6	62.9	56.1	91
20th	26.3	33.1	15.1	33.4	36.0	76
27th	59.2	59.2	34.2	65.2	84.2	82.6
Jan., 3rd	32.6	37.1	11.7	33.7	43.0	59
10th	58.1	64	32.6	59.4	65.1	71
17th	25.4	26.2	13.8	41.5	54.9	43
24th	63.5	44	23.4	57.0	65.2	68
31st	33.1	38	11.1	33.5	34.2	94
Feb., 7th	51.6	79	28.2	52.1	69.1	75.1
14th	32.0	23.7	19.6	35.3	43.7	100
21st	47.5	38	30.4	47.2	69	83
28th	20.4	16.4	10.7	36.4	45.7	64.5
Mar., 7th	29.7	29.8	15.2	44.8	57.2	45.3
14th	15.8	16.7	20.6	21.4	41.6	21.6
21st	22.3	20.3	11.3	18.7	30.2	14.4
Mean	39.98d	44.15c	25.00e	45.86c	51.91b	65.87a
F. value	15.86					
L.S.D	4.11					

In similar work of the effect of different insecticides on reducing the population density of *T. tabaci* had been done in different countries, Ishaaya *et al.,* (2002) [12] mentioned that Emamectin acted as an effective compound for controlling the western flower thrips *Frankliniella occidentalis* (Pergande) under both laboratory and field conditions. Awadalla *et al.,* (2011) [5] in Egypt, stated that Spinetoram (Radiant) had a significant role in reducing the population density of *T. tabaci* infesting onion plants. Kordy and Barakat (2014) [13] in Egypt, mentioned that the best reduction percentage of *T. tabaci* occurred after applied Azadirachtin (94.64%) followed by tracer (Spinosad) (93.65%). Pandey *et al.,* (2014) [17] stated that the lowest population density of *T. tabaci* was recorded by application of profenofos treatment followed by spinosad. Moraiet *et al.,* (2015) [16] who applied some bio-insecticide against thrips on onion crop and they mentioned that most of the tested bio-insecticides caused significant ($P< 0.05$) reduction of thrips compared to the control. Gholan and Sadeghi (2016) [9] stated that Spinosad, Oxymatrine and Azadirachtin play an important role in reducing population density of western flower thrips in vegetable greenhouses. El-Sheikh (2017) [7] in Egypt, and Shiberu *et al.,* (2013) [21] in Ethiopia, they mentioned that *M. anisopliae* caused a considerable rate in reducing the population density of *T. tabaci* infesting onion and garlic plants under field conditions. Sumalathal *et al.,* (2017) [25] showed that Emamectin benzoate and spinosad were the most superior and persistent treatment against *T. tabaci* on onion crop. Ashghar *et al.* (2018) [4] indicated that applying Spinetoram 12% and Spinosad 24% led to decrease the population density of *T. tabaci* infesting onion plant with reduction percentages 88.16% and 88.74%, respectively. Uddin *et al.,* (2019) [26] recorded that the population density of *T. tabaci* were significantly better than untreated check in reducing the population density of *t. tabaci* after application of chemical and bio-insecticide.

Effect of five control programs on the garlic resulted yield.

Three important garlic yield characteristics were studied, *i.e.* plant heights (cm.), full weight of plants that included vegetative and heads (gm.) and weight of garlic heads per each plant (gm.) for each season separately, (2018- 2019) and (2019- 2020).

Data in Table (4) show the differences of garlic plants characteristics under the five investigated control programs and untreated treatment. Significant differences were found between the studied characteristics (heights, full weight and head weights) of the plants treated with 3rd control program (Spinetoram and Emamectin benzoate) and the plants grown under the other five treatments, which could be attributed to the highest efficiency of the third control program in reducing the population density of *T. tabaci* on garlic plants.

Table 4: Effect of five control programs on some characteristics of garlic plants throughout two successive seasons, 2018- 2019 and 2019- 2020 in Beni Suef Governorate.

Treatments	Mean of plant heights (cm)			Mean of plant full weights (gm)			Mean of garlic head weights (gm)		
Seasons	1st	2nd	average	1st	2nd	average	1st	2nd	average
1st program	106.13 b	87.69 b	96.91 b	149.33 b	129.65 b	139.49 b	87.33 b	98.50 ab	92.92 b
2nd program	104.67 b	87.40 b	96.04 b	148.67 b	126.40 c	137.54 b	87.00 b	95.90 b	91.45 b
3rd program	110.33 a	91.50 a	100.92 a	157.67 a	134.85 a	146.26 a	97.33 a	100.60 a	98.97 a
4th program	104.67 b	83.50 c	94.09 b	145.00 c	112.90 d	128.95 c	86.33 b	91.60 c	88.97 c
5th program	103.60 b	80.60 d	92.10 bc	147.67 bc	111.70 d	129.67 c	85.67 b	86.75 d	86.21 c
Control	83.58	67.40	75.49 d	111.33 d	98.70	105.02 d	52.67	50.00	51.34 d
F. value	7.78	10.34	12.5	11.09	14.62	15.09	20.51	26.01	29.50
L.S.D	2.98	2.52	3.01	3.51	2.69	3.85	3.37	2.91	2.40

Regarding the height of plants, the garlic plants treated with 3rd control program were the best one as the mean plant heights were 110.33 cm and 91.50 cm in the two studied seasons, respectively and average of two seasons altogether was 100.92 cm. On the other hand, the difference between the heights of garlic plants which treated with 1st (106.13 & 87.69 cm/ plant) and 2nd (104.67 & 87.40 cm/ plant) control programs was not significant either in the 1st or in the 2nd season, respectively. On the contrary, garlic plants in the control plot that did not received any pesticides and exposed to significantly highest infestation of *T. tabaci* (54.37 and 65.87, respectively for two seasons) were significantly shorter compared to the remaining five studied control programs, as they gave 83.58, 67.40 and 75.49 cm/ plant in the two studied seasons together, respectively. Statistical analysis of the obtained data of the garlic plants height for the two studied seasons altogether indicated that there was a significant differences between the tested treatments (L.S.D value 3.01), as the results were arranged descending as follow 3rd > 1st > 2nd > 4th > 5th > untreated control programs, respectively.

Concerning to the effected of the tested five control programs on the total weight of the resulting garlic plants, the results showed that the total weight of garlic was significantly affected by the tested control programs, as there were large differences in the obtained weight.

During first season, the significantly- highest weight was occurred in garlic plants treated with the 3rd control program (157.67gm/ plant) which occupied as a first group, followed significantly by the second group (b) which produced higher total weight of garlic and represented by applying 1st and 2nd control programs, showing 149.33 and 148.67 gm/ plant, respectively. The third group (bc) obtained from plants received 5th program which produced 147.67 gm/ plant. The fourth group (c) represented by applying 4th program and produced (145.00 gm/ plant). On the other extreme, garlic plants in control plots (untreated) produced the significantly lowest total weight (111.33 gm/ plant). Throughout the second season 2019- 2020, production level of total garlic weight took the same trend as the first season, as the average of plant full weight were 134.85, 129.65, 126.40, 112.90, 111.70 and 98.70 gm/ plant to 3rd, 1st, 2nd, 4th, 5th and control programs, respectively. The average results of the two seasons together confirmed that the 3rd, 1st and 2nd control programs were the best for obtaining a good yield of vegetative and heads of garlic (Table, 4).

With respect to head garlic yield, the obtained results took the same direction in case of plant height and total weight as the results revealed that the significantly highest head yield was obtained from garlic plants treated with 3rd control program which infested by the lightest numbers of *T. tabaci* in the two studied seasons (24.67 and 25.00, respectively), as the average head weight in the two seasons together was (98.97gm/ plant). The application of the 1st and 2nd control programs led to garlic plants infested with a considerable numbers of thrips in the two studied seasons (30.24 and 34.31 & 39.98 and 44.15, respectively), as well as ranked second in production after 3rd control program, as the average head weight in the two seasons together were 92.92 and 91.45gm/ head, respectively. Garlic plants that were collected after applying the 4th and 5th control programs on them and which exposed to a high degree of thrips during two studied seasons (37.89 and 37.93 & 45.86 and 51.91, respectively) produced the least significant heads when compared to the other three control programs, where they were produced 88.97 and 86.21 gm/ head in the two seasons altogether, respectively. On the other hand, garlic plants represented in control plots which were not treated with any pesticides and which were infested with the significantly highest numbers of *T. tabaci* during two studied seasons (54.37 and 65.87, respectively) produced the significantly lowest weight of heads, as the average head weight of the two studied seasons altogether was 51.34 gm/ head.

From the previously mentioned results, we can recommend using 3rd, 1st and 2nd control programs in order to reduce the infestation of *T. tabaci* of the garlic crop and obtain a good crop yield of heads.

Correlation between seasonal mean numbers of *T. tabaci* and characteristics garlic plants under different control programs during two seasons 2018- 2019 and 2019- 2020 together.

With regard to the effect of *T. tabaci* population density infesting garlic plants which obtained after the application of the five studied control programs on the characteristics plant height (cm), full weight contains vegetative and heads (gm) and only garlic heads weight per plant (gm) of the resulted yield during two successive seasons altogether, each of the correlation coefficient values and the explained variance % were calculated and tabulated in Table (5). The obtained results showed a significantly negative correlations between *T. tabaci* population and all the three tested characteristics, as the correlation coefficient values were -0.56, -0.57 and -0.67 respectively, *i.e.,* the three studied characteristics were decreased by increasing the infestation rates of *T. tabaci* on garlic plants. Multiple regression analysis indicated the combined effected (E.V. %) of *T. tabaci* population of the five studied programs on the three above mentioned garlic yield characters were 39.10, 41.30 and 48.60 %, respectively and effected on the three characteristics altogether by 33.40 %.

Table 5: Relationships between mean numbers of *T. tabaci* and characteristics garlic plants under different control programs during two seasons together.

Treatments	Mean no. of *T. tabaci*	Mean of plant heights (cm)	Mean of plant full weight (gm)	Mean of garlic head weight (gm)
1st program	35.11	96.91	139.49	92.92
2nd program	39.23	96.04	137.54	91.45
3rd program	24.84	100.92	146.26	98.97
4th program	41.88	94.09	128.95	88.97
5th program	44.92	92.10	129.67	86.21
Control	60.12	75.49	105.02	51.34
r value	-	-0. 56	-0.57	-0.64
E.V. %	-	39.10	41.30	48.60
E.V. %	-	33.40		

Effect of five control programs on the finally garlic head yield (Kg / feddan) and benefit/ cost analysis ratio in the average two studied seasons.

The obtained results of the effected the five tested control programs which applied to supress the population density of *T. tabaci* on the final garlic head yield were tabulated in Table (6). Results revealed that the yield of garlic heads resulting from the plants treated with the five control programs increased significantly when compared to the control which did not received any pesticides. The highest net profit per feddan (19382.40 L.E.) was obtained from garlic heads resulted from the plants treated with 1st program (Emamectin benzoate and *Metarizium anisoplia*), although it occupied second group for *T. tabaci* infestation during two studied seasons, as 30.24 and 39.98 individuals/ plant, respectively. This is due to the cost of applying this program was inexpensive (1060.00 L.E./ feddan) compared to the other four tested programs. Applying the 3rd program which infested by the lowest number of *T. tabaci* (24.67 and 25.00 individuals/ plant in the two seasons, respectively produced higher yield of garlic heads (10886.70 Kg/ feddan) and gaves higher net profit, 18825.40 L.E./ feddan followed by net return obtained from garlic plants received 4th program (18437.40 L.E./ feddan).

A moderate net profit obtained after applied 2nd and 5th control programs when compared with the three previously mentioned programs, as their net profit were 16631.10 and 16038.20 L.E./ feddan. On the other hand, garlic plants in untreated plots produced the lowest yield of heads (5646.85 Kg/ feddan) and gave the lowest net profit (11293.70 L.E. / feddan) when compared with the all five tested control programs.

Table 6: Yield and economics of different five control programs applied for the control of garlic thrips.

Treatments	Head weight/ plant	Head weight/ feddan	Garlic heads return LE/Feddan	Cost of spraying LE/ Feddan	Net return LE/ Feddan
1st program	92.92	10221.200	20442.40	1060.00	19382.40
2nd program	91.45	10059.50	20119.00	3488.00	16631.10

3rd program	98.97	10886.700	21773.400	2948.00	18825.40
4th program	88.97	9786.70	19573.40	1136.00	18437.40
5th program	86.21	9483.100	18966.200	2928.00	16038.20
Control	51.34	5646.85	11293.70	0.00	11293.70

The above mentioned results of yield and economic evaluation were harmony with different studies in different countries, Ullah *et al.*, (2010) [27] indicated that sprayed of tracer (Spinosad) was significantly effective against *T. tabaci* when compared the control treatment. Shiberu *et al.*, (2013) [21] stated that applied of *Metarhizium anisopliae* led to increase the yield on garlic, as gave (21000 kg/ ha) compared with untreated plants (18430 kg/ ha). Hossain *et al.*, (2014) [11] found the application of Spinosad showed better effectiveness against *T. tabaci* in garlic plants and gave the higher yield and economic return. Pandey *et al*., (2014) [17] recorded that the highest onion marketable yield (271.00 q. /ha) was recorded in profenofos treatment followed by Spinosad (253.00 q. /ha). Furthermore, the ratio of cost: benefit was the highest after application of profenofos followed by *Beauveria bassiana* and spinosad. Hussin *et al.,* (2015) stated that the application of spinetram 12% SC reduced the population density of *T. tabaci* infesting garlic plants and gave the highest yield. Abdul Khaliq *et al.*, (2016) [1] revealed that the reduction of thrips infestation led to increase bulb size as well as the total yield. Sumalathal *et al.*, (2017) [25] the highest bulb yield of onion was recorded after sprayed spinosad.

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