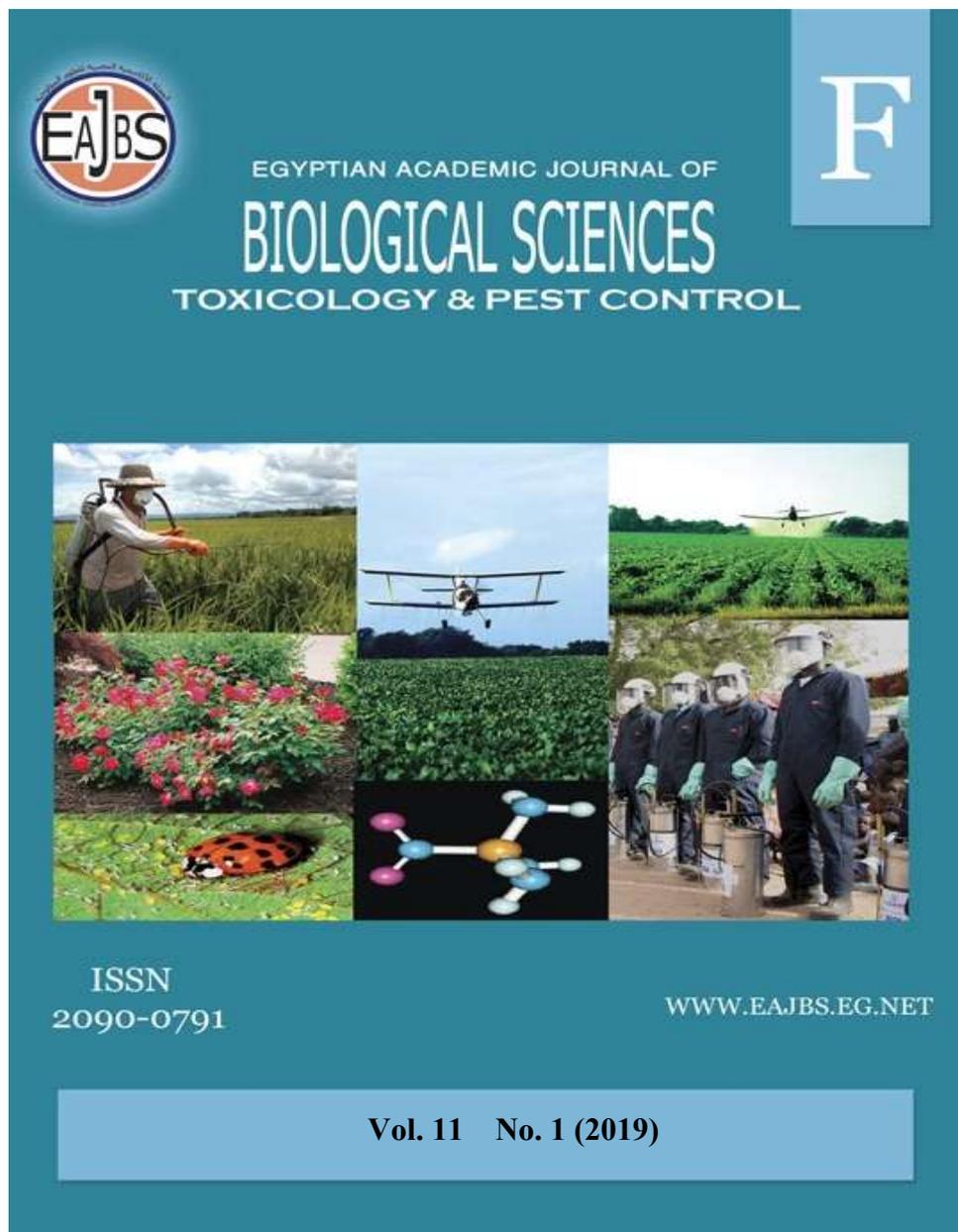


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Management of Pests Attacking Tomato, *Lycopersicon esculentum* (Mill.) Plants and their Relationship with Actual Yield Under the Greenhouse.

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ARTICLE INFO

Article History

Received:28/12/2018

Accepted:18/1/2019

Keywords:

Greenhouse, tomato, *Lycopersicon esculentum*, insecticides, orange oil, mineral oil, binary mixtures, *Bemisia tabaci*, *Tuta absoluta*, *Tetranychus urticae* and product yield.

ABSTRACT

Experiments were conducted in the experimental Horticulture Research Station in Qaha city, Qalubia Governorate under greenhouse conditions during two successive seasons (2016-2017 and 2017-2018). The study aims for managing of pests attacking tomato, *Lycopersicon esculentum* (Mill.) plants and their relationship with product yield, by using insecticides, orange oil and mineral oil alone and in binary mixtures, their relationship with crop yield under the greenhouse. *Bemisia tabaci* (Genn.), *Tuta absoluta* (Meyrick) and *Tetranychus urticae* (Koch) were the most important pests found on a tomato plant. These pests are causing great losses in tomato yield. Results showed that using Actara binary mixtures with mineral oil or orange oil binary mixtures with mineral oil have a highly significant effect on decreasing pests population infesting tomato plants and improving actual yield. The insecticide binary mixtures with mineral oil have an effect on population pests whereas decreased the mean number of pests and were the most efficient method compared to without treatment area.

INTRODUCTION

Tomato, *Lycopersicon esculentum* (Mill.) is a favorite garden plant in many parts of the world, an important source of vitamins and nutrients, and an economically important agricultural commodity (Aneta *et al.* 2015 and Chittaranjan, 2007). In Egypt, it is an important cash crop for small holders and medium scale commercial farmers. The cultivation of tomato and other Solanaceae are main importance for Egyptian agriculture. The revival of the Mediterranean diet is helping to bring back to the tables of European people many Solanaceae, and particularly tomato. The Egyptian and international interest in the processed tomato products has sharply increased in the attention on this culture. Nevertheless, the tomato is a plant already strongly infested by sap-sucking pests, spider mite, aphids, whitefly and thrips are global plant pests that have caused enormous losses in crop production, mainly in Cucurbitaceae, Fabaceae and Solanaceae (Oliveira *et al.* 2001). These insect pests are commonly encountered as a serious pest of various crops both in the open field and greenhouses (Roll, 2004 and Alston, 2007). these pest make direct and indirect damage, direct damage startups by sucking plant sap from the plant foliage, while indirect damage due to the accumulation of honeydew that is considered as a good media for sooty mold growth, and play a vector of plant viruses, a few numbers of these pests is sufficient to cause considerable damage to the importance crops (Francki *et al.* 1979; Berlinger, 1986; Cohen and Berlinger, 1986; Conte, 1998; Devasahyam *et al.*

1998; Stansly *et al.*, 2004 Baiomy, 2008 and Hanafy *et al.* 2014). The state of the art on the spread of Gelechiidae moth, *Tuta absoluta* (Meyrick) in Egypt will be presented. The rapid spread throughout the country, mainly related to the marketing of tomato berries and nursery plants, has allowed the insect to colonize all the areas involved in the production of this Solanaceae plant.

Tomato production in Egypt 2007 was about 8,639,024 tons of fresh fruit with an area of 537,208 feddens with an estimated 16,45 tons/fedden according to the report of Economic Affairs Sector, Department of Agricultural Economics, Ministry of Agriculture (2008). As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily (Abimbola ,2014). So, the aim of this work is management the important pests attacking tomato, *Lycopersicon esculentum* plants under greenhouse and evaluate some insecticides with orange oil and mineral oil against tomato pests for improving product yield.

MATERIALS AND METHODS

Field experiment:

Experiments were conducted in the experimental Horticulture Research Station in Qaha city, Qalubiya Governorate under greenhouse conditions during two successive seasons (2016-2017 and 2017-2018). The tomato, *Lycopersicon esculentum* (Mill.) variety Rosalina was transplanted in October 1st 2016 and October 1st 2017 in the greenhouse. The area of the greenhouse was 40 in length x 9 in width m. Each treatment was replicated three times. Tomato crop was weighted every week during the harvesting period. The insecticides were sprayed as in Table (1) five control agents were used for each application, by a knapsack sprayer was used on three applications in Oct., 10, Oct., 25, and Nov., 10, 2016, respectively and the same dates in the second season 2017. Untreated area for the check; was sprayed only by water. The efficiency of the tested compounds was estimated by counting of the target alive pests *Bemisia tabaci* nymphs, *Tuta absoluta* larvae and *Tetranychus urticae* movable stages on the lower surface of 30 tomato leaflets per each plot for three replicated. The sampling of tomato leaflets was randomly collected from each replicate before spraying as well as 1, 3, 5, 7, 10 and 14 days after spraying. Before calculating the results in tables and figures, the row data which recorded in the first and second season were summed to give one value for both numbers. Reduction percentages were calculated according to Henderson and Tilton equation (1955). The treatments were compared with each other using one way ANOVA with LSD 0.05 (SAS Statistical Software, 1989).

Table 1. Insecticides used

No. of treatment in greenhouse	Trade name and rate of application / 100L water.	Common name and group
1	KZ oil EC 95% 100cm ³	mineral oil
2	KZ oil EC 95% 75 cm ³ + Actara WG 25% 5gm in first spray	mineral oil + thiamethoxam
	KZ oil EC 95% 75 cm ³ + Agri Flex SC18.56% 30cm ³ in second spray	mineral oil + (abamectin + thiamethoxam)
	KZ oil EC 95% 75 cm ³ + Closer SC24% 5cm ³ in the third spray	mineral oil +sulfoxaflor
3	Orange oil 30cm ³	orange oil
4	KZ oil EC 95% 75 cm ³ + orange oil + 7.5 cm ³	mineral oil+ biotech
5	Actara 20 gm	thiamethoxam
6	Check (untreated)	

RESULTS AND DISCUSSION

The efficiency of control agents on tomato pests:

Whitefly, *Bemisia tabaci*

First spray:

Gradual reduction percentages of numbers *B. tabaci* nymphs as a results of treatments, KZ oil , KZ oil + Actara 5 gm, orange oil, KZ oil + orange oil and Actara were recorded in both seasons 2016- 2017 and 2017-2018 (Tables 2). Data indicated significant differences between the five compounds where F. value = 7.11 and L.S.D = 8%. These compounds could be divided three groups. The first group contained on Actara and KZ oil + Actara 5gm, showing high mortality 88.7% and 86.40%, respectively. The second group contained KZ oil + orange oil and KZ oil showing moderate effect 75% and 73.9%, respectively. The third group was orange oil showing low effect 69.3%.

Second spray:

Results of treatments, KZ oil , KZ oil + Agri Flex 30 cm³, orange oil, KZ oil + orange oil and Actara, indicated significant differences between the five compounds where F. value = 5.53 and L.S.D = 7.85%. These compounds could be divided three groups. The first group contained KZ oil + Agri Flex 30 cm³ and Actara showing highly mortality 88.5% and 88.1%, respectively. The second group contained KZ oil + orange oil and KZ oil showing moderate effect 78.2%, 75.4%, respectively. The third group was orange oil showing low effect 71.1%.

Third spray:

Data showed for treatments, KZ oil, KZ oil + Closer 5 cm³, orange oil, KZ oil + orange oil and Actara, significant differences between the five compounds where F. value = 8.77 and L.S.D = 5.22%. These compounds could be divided three groups. The first group contained on Actara and KZ oil + Closer 5cm³ showing highly mortality 93.2%, 91.4%, respectively. The second group was KZ oil + orange oil showing moderate effect 86.3%. The third group contained orange oil and KZ oil showing low effect 80.7% and 78.5%, respectively.

Table 2. Reduction percentage of *B. tabaci* alive nymphs on tomato plants in the greenhouse in Qaha city, Qalubiya Governorate in (2016&2017 and 2017&2018).

Treatments	No. of Nymph Pre-Treatments	Initial Kill After 24 hours	Reduction percentage					Average %	
			3 Days	5 Days	7 Days	10 Days	14 Days		
First spray	1	217	44.11	60	71.5	88.0	91.4	95.0	75.0b
	2	222	52.9	71.3	94.2	100	100	100	86.4a
	3	216	45.2	61.3	69.9	76	80.5	82.9	69.3c
	4	219	48.2	55	66	88.4	91	95	73.9b
	5	250	60.8	81.5	90	100	100	100	88.7a
	Check	234	--	--	--	--	--	--	--
F value	7.11*	L.S.D	8.00						
Second spray	1	145	58.5	62.3	73.2	85.5	93.2	96.2	78.2b
	2	160	60.5	75.2	95.0	100	100	100	88.5a
	3	149	48.2	62.5	70.0	78.5	82.4	85.0	71.1bc
	4	143	52.2	61.5	69.5	80.0	93.3	95.6	75.4b
	5	122	63.3	71.6	93.8	100	100	100	88.1a
	Check	297	--	--	--	--	--	--	--
F value	5.53 *	L.S.D	7.85						
Third spray	1	75	59.2	62.5	72.5	87.3	94	95.5	78.5c
	2	55	65.9	83.4	99	100	100	100	91.4a
	3	88	55.8	69	77.2	90.6	95.6	96.2	80.7c
	4	70	62	75	87.9	95	98	100	86.3b
	5	65	70	88.9	100	100	100	100	93.2a
	Check	301	--	--	--	--	--	--	--
F	8.77*	L.S.D	5.22						

Means followed by the same letters are not significantly different according to the LSD_{0.05}

Tomato leafminer, *Tuta absoluta*:**First spray:**

Gradual reduction percentages of numbers *T. absoluta* larvae as a result of KZ oil , KZ oil + Actara 5 gm , orange oil, KZ oil + orange oil and Actara treatments were recorded in both seasons (Tables 3). Data indicated significant differences between the five compounds where F. value = 10.01 and L.S.D = 7.5%. These compounds could be divided three groups. The first group contained on KZ oil+ Actara and Actara showing highly mortality 87.9% and 84.6%, respectively. The second group contained KZ oil + orange oil and KZ oil showing moderate effect 78.1% and 74.4%, respectively. The third group was orange oil showing low effect 65.5%.

Second spray:

Results of treatments, KZ oil , KZ oil + Agri Flex 30 cm³, orange oil, KZ oil + orange oil and Actara, indicated significant differences between the five compounds where F. value = 9.98 and L.S.D = 10.23%. These compounds could be divided three groups. The first group contained on KZ oil + Agri Flex and Actara showing highly mortality 89.2% and 87.1%, respectively. The second group contained KZ oil + orange oil and KZ oil showing moderate effect 77.1% and 75.5%, respectively. The third group was orange oil showing low effect 71.5%.

Third spray:

Data showed that significant differences between the five compounds where F. value = 6.12 and L.S.D = 8.43%. These compounds could be divided three groups. The first group contained on KZ oil + Closer and Actara showing highly mortality 91.3%, 87.1%, respectively. The second group was KZ oil + orange oil showing moderate effect 85.7%. The third group contained orange oil and KZ oil showing low effect of 79.6% and 78.9%, respectively.

Table 3. Reduction percentage of *T. absoluta* alive larvae on tomato plants in the greenhouse in Qaha city, Qalubiya Governorate in (2016&2017 and 2017&2018).

Treatments	No. of Larvae Pre-Treatments	Initial Kill After 24 hours	Reduction percentage					Average %	
			3 Days	5 Days	7 Days	10 Days	14 Days		
First spray	1	111	42.5	58.2	73.4	88	92	92	74.4b
	2	102	60.9	74.5	92	100	100	100	87.9a
	3	108	41.2	56.9	70.1	73	77.4	74.3	65.5c
	4	99	48.2	62	79	88.4	92.8	98	78.1b
	5	104	62.2	65.2	88	92	100	100	84.6a
	Check	109	--	--	--	--	--	--	--
	F value	10.01*	L.S.D.	7.5					
Second spray	1	87	55.2	57.4	66.2	88.5	91.5	94.3	75.5b
	2	70	67.2	77.7	90.2	100	100	100	89.2a
	3	77	50.6	65.4	72.4	77	80	83.6	71.5bc
	4	75	53.2	60	67.4	93.8	94.9	93.1	77.1b
	5	69	61.3	69	92	100	100	100	87.1a
	Check	143	--	--	--	--	--	--	--
	F value	9.98 *	L.S.D.	10.23					
Third spray	1	55	60.2	66.4	70.3	89.5	92.2	94.5	78.9b
	2	42	68.4	81.2	98.2	100	100	100	91.3a
	3	60	53.1	67.5	76.4	91.2	94.4	95	79.6b
	4	56	60.2	73.3	88.3	94.4	98.2	100	85.7ab
	5	50	63	68.9	90.4	100	100	100	87.1a
	Check	152	--	--	--	--	--	--	--
	F value	6.12*	L.S.D.	8.43					

Means followed by the same letters are not significantly different according to the LSD_{0.05}.

Red mite, *Tetranychus urticae*:

First spray:

Mean reduction percentages of numbers *T. urticae* movable stage as a result of KZ oil, KZ oil + Actara 5 gm, orange oil, KZ oil + orange oil and Actara treatments were recorded in both seasons 2016- 2017 and 2017-2018 (Tables 4). Data indicated significant differences between the five compounds where F. value = 5.20 and L.S.D = 4.90%. These compounds could be divided three groups. The first group contained on KZ oil + Actara and Actara showing highly mortality 91.9% and 89.0%, respectively. The second group contained KZ oil + orange oil and KZ oil showing moderate effect 83.7% and 80.0%, respectively. The third group was orange oil showing low effect 77.7%.

Second spray:

Results of treatments, KZ oil, KZ oil + Agri Flex 30 cm³, orange oil, KZ oil + orange oil and Actara, indicated that significant differences between the five compounds where F. value = 8.0 and L.S.D = 6.66%. These compounds could be divided three groups. The first group contained KZ oil + Agri Flex and Actara showing highly mortality 92.2% and 89.1, respectively. The second group contained KZ oil + orange, KZ oil showing moderate effect 83.9% and 80.8%, respectively. The third group was oil orange showing low effect 79.0% (Table 4).

Third spray:

Data showed for treatments, KZ oil, KZ oil + Closer 5 cm³, orange oil, KZ oil + orange oil and Actara, significant differences between the five compounds where F. value = 6.70 and L.S.D = 5.77%. These compounds could be divided three groups. The first group contained on KZ oil + Closer and Actara showing highly mortality 92.6% and 89.2%, respectively. The second group contained KZ oil + orange, KZ oil showing moderate effect 83.9% and 81.2, respectively. The third group was oil orange showing low effect 78.7% (Table 4).

Table 4. Reduction percentage of *T. urticae* alive movable stage on tomato plants in the greenhouse in Qaha city, Qalubiya Governorate in (2016&2017 and 2017&2018).

Treatments	No. Nymph Pre-Treatments	Initial Kill After 24	Reduction percentage					Average %	
			3 Days	5 Day	7 Days	10 Days	14 Days		
First pray	1	132	55.0	69.8	79.8	85.5	90.0	100	80.0c
	2	112	72.8	85.9	92.5	100	100	100	91.9a
	3	143	50.8	65.6	77.8	85.6	90.5	95.8	77.7d
	4	122	65.0	75.5	84.4	88.2	92.8	96	83.7b
	5	134	66.8	73.5	93.8	100	100	100	89.0a
	6	120	--	--	--	--	--	--	--
F value	5.20*	L.S.D	4.90						
Second spray	1	98	53.8	70.8	80.2	88.2	92.0	100	80.8b
	2	88	75.8	84.2	93	100	100	100	92.2a
	3	87	51.8	67.8	78.8	88.0	91.5	96	79.0c
	4	79	64.8	74.5	85	87.8	93.2	98	83.9b
	5	60	64.0	75.5	95	100	100	100	89.1a
	check	112	--	--	--	--	--	--	--
F value	8.00 *	L.S.D	6.66						
Third spray	1	44	50.6	72.5	81.2	87.8	93.0	100	81.2b
	2	40	77.0	83.8	94.6	100	100	100	92.6a
	3	55	52.0	66.8	78.8	85.8	92.5	96.4	78.7c
	4	45	65.8	73.8	84.8	86.8	94.2	98	83.9b
	5	30	63.0	77.5	94.5	100	100	100	89.2a
	check	99	--	--	--	--	--	--	--
F value	6.70*	L.S.D	5.77						

Means followed by the same letters are not significantly different according to the LSD₀.

The Relationship Between Applying Treatments of Insecticides and Its Product Yield of Tomato:

The relationship between the population density of three pests and mean average weight of product yield was studied through the correlation coefficient value (r), regression coefficient value (b), F value and explained variance (E.V. %) on tomato yield during two seasons (Table, 5 and Fig., 1). The highest product yield was obtained, 1120 and 1085 Kg/160 plants, in case of insecticide (Actara, Agri Flex and Closer) and orange oil treatments binary mixtures, KZ oil, respectively. Product yield on the treatments by (KZ oil, orange oil and low rate of Actara) were 960, 930 and 924 Kg visa vis 775 Kg /160 plants in check treatment. These relationships were significantly positive with the mean weight of product yield with r value was 0.981 and 0.750 while "b" values were 7.45 Kg and 1.91 Kg for two successive seasons, respectively. The explained variances (E.V. %) were 99% and 95% during two seasons, respectively. ("F" values were 449.9 & 7.99).

Data revealed that the relationship between the population density of three pests and mean average weight of product yield in insecticide treatments of Actara, KZ oil and orange oil for each treatment alone. The relationship was significantly positive with a mean weight of product yield with r value was 0.711, 0.850 and 0.66 while "b" values were 2.57 Kg, 4.20 Kg and 2.40 Kg for two successive seasons, respectively. The explained variances (E.V. %) were 89%, 72% and 71% during two seasons, respectively. ("F" values were 5.91, 7.03 & 3.85) compared with the check

Table 5. Correlation and partial regression of pests and weight of product yield tomato plant under the effect of treatments and corresponding percentages of explained variance in Qaha city, Qalubiyah Governorate in (2016&2017 and 2017&2018) seasons.

Treatments	Mean number of pests/30 leaves			Mean Yield (kg)/ 160 plants	Correlation between insect pests and weight yield (r)	b value	F Value	E.V%
	<i>B. tabaci</i>	<i>T. absoluta</i>	<i>T. urticae</i>					
1	252	136	152	960	0.850*	4.20	7.03*	72%
2	257	127	137	1120	0.981*	7.45	449.9*	99%
3	246	133	163	930	0.66*	2.40	3.85*	71%
4	249	119	142	1085	0.750*	1.91	7.99*	95%
5	280	124	154	924	0.711*	2.57	5.91*	89%
Check	535	181	219	775	0.401 insig.	0.312 insig.	0.42	7%

r = correlation coefficient * = probity of correlation, b= regression coefficient, * = probity of regression, E.V= Explained Variance

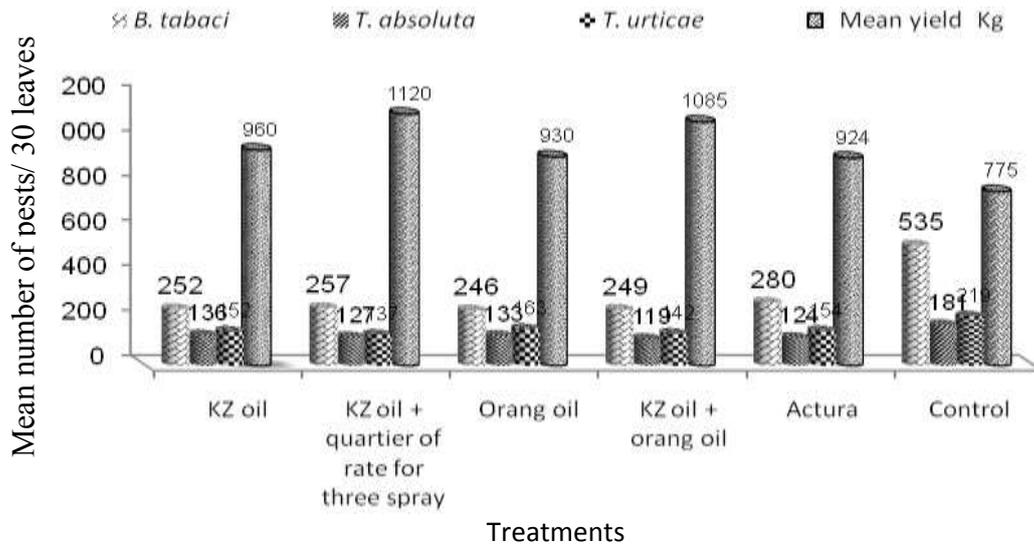


Fig.(1): Mean number of pests infesting tomato plant with different treatments and their relationship with product yield under the greenhouse.

These results were in line with those obtained by (Horowitz *et al.*, 1998, Aslam *et al.*, 2004, Abdel-Rahman and Abou-Taleb. 2008, Yadav, and Kumawat. 2013 and Hamdy and Barrania 2014).

Conclusion

Use insecticides binary mixtures with mineral oil or orange oil binary mixtures with mineral oil have a highly significant effect on pests infesting tomato growth and product yield. It's very important to notice that, the product yield of untreated (check) was more affected by the general conditions of different insecticides applications in greenhouse experiment, which improves the yield crop due to the low level of infestation in check plants.

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ARABIC SUMMARY

إدارة الآفات التي تصيب نباتات الطماطم وعلاقتها بالمحصول الناتج تحت ظروف الصوب

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تم زراعة الطماطم في الصوب في موقع الزراعات المحمية بمحطة بحوث البساتين في مدينة قها محافظة القليوبية خلال موسمي الدراسة (٢٠١٦ و ٢٠١٧) ، (٢٠١٧ و ٢٠١٨) . تهدف الدراسة إلى كيفية إدارة الآفات التي تصيب نباتات الطماطم باستخدام بعض المبيدات الحشرية وزيت البرتقال والزيت المعدني KZ بمفردها أو مخلوطة وأثر ذلك على إنتاجية المحصول تحت ظروف الصوب. أظهرت النتائج أن أكثر الحشرات أصابه هي الذبابة البيضاء *Bemisia tabaci* وحافرة أوراق الطماطم *Tuta absoluta* والعنكبوت الأحمر *Tetranychus urticae*. وأظهرت النتائج وجود علاقة معنوية قوية بين المعاملات المختلفة و الإصابة بالآفات . وبإجراء تحليل احصائي للربط بين تأثير الثلاثة آفات على المحصول الناتج تحت تأثير المعاملات المختلفة وجدت علاقة معنوية موجبة للمعاملات وتأثيرها في خفض التعداد مما ينعكس بالزيادة في المحصول الناتج.