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Impacts of Different Insecticides on *Tuta Absoluta* (Meyrick) Larvae with Their Effects on Physiological Characteristics and Fruits Yield of Stressed Tomato Plants

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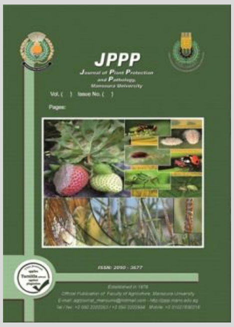

ABSTRACT

Recently tomato leaf miner, *Tuta absoluta*, has become one of the major pests and causes genuine damages to tomato production. Consequently, the present investigation was carried out during 2016/2017 and 2017/2018 winter seasons to determine the efficacy of different insecticides (Chlorantraniliprole, Fipronil and Indoxacarb) and their mixture against *T. absoluta* larvae and study physiological characters and fruits yield of stressed tomato plants. The results showed that, the Chlorantraniliprole insecticide alone and their mixture (Chlorantraniliprole + Fipronil and Chlorantraniliprole + Indoxacarb) were highly effective in relation to tomato leafminer larva reduction than other treatments and untreated control. Chlorantraniliprole + Fipronil treatment proved to be the superior achieving mean reduction level of 79.2% and 76.5% in during the two seasons respectively. The maximum average reduction percentages for the above-mentioned insecticides treatments against leaf miner were 90.1%, 93.4% and 91.1%, respectively in the first season and were 83.5%, 89.8% and 87 % respectively in the second season after seven days of spray. Indoxacarb was less effective on larvae population (49.5% and 49.9%) in both seasons. Chlorophyll a and b, vitamin C, lycopene and relative water content were increased with application of Chlorantraniliprole alone and their mixture. In conclusion Chlorantraniliprole alone and/or in combination with Fipronil or Indoxacarb may recommend for achieving effective control against *T. absoluta* and use in IPM programs in the tomato fields.

Keywords: Tomato (*Solanum lycopersicum* L.), Chlorantraniliprole insecticide, chlorophyll content, proline, fruits yield

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) crop has a particular economic importance in Egypt. It is widely grown both for fresh market and processing (Wachira *et al*., 2014). Tomato fruits are rich source of many vitamins, minerals and organic acids (Meena *et al*., 2014). The economic plants expose to several stresses which effect on their growth and yield production such as drought (Abdelaal 2015, Abdelaal *et al*., 2017 Abdelaal *et al*.,–2018), salinity (EL Sabagh *et al*., 2017, Helaly *et al*., 2017, El-Banna and Abdelaal 2018 and Abdelaal *et al*., 2020) and insects (Ali and Zedan, 2018). However, most of the countries don't produce their needs of tomatoes due to many obstacles: the most important is insect pests which reduce quantity, quality and profitability (Ali and Zedan, 2018). Under biotic stress, the morphological and physiological characters of stressed plants are seriously affected. For example, fungal disease stress led to decrease morphological characters, chlorophyll concentration and relative water content in wheat and barley plants (Abdelaal *et al*., 2014, Hafez *et al*., 2014 and Hafez *et al*., 2020). Also, insect pests stress led to harmful effects on plant growth and yield to many economic plants (Abou-Attia and Abd El-Aziz, 2007). Tomato leafminer, *Tuta absoluta*, (Meyrick) (Lepidoptera: Gelechiidae), has assumed to be the most wrecking verminous and caused serious damages to tomato production in Egypt (Medeiros *et al*., 2005). *T. absoluta* Larvae affects any part of a tomato plant leaves, flower, stem of fresh tomatoes and yield losses up to 100% (Viggiani *et al*., 2009).

Control of tomato leafminer invasion is troublesome and relied on repeated insecticides treatment, since larvae are secured in the leaf mesophyll or inside fruits (Picanço *et al*., 1995), such excessive use of insecticides leads to the appearance of a pest resistance in addition to environmental damage (Ali *et al*., 2019).

Hence, it is very essential to find new insecticides which are compelling in *T. absoluta* control while, having less harmful impact on beneficial insects and the environment. So, the objective of our study was to evaluate the efficiency of variety insecticide and their mixture in controlling the tomato leaf miner, *T. absoluta* with low side effects on physiological characteristics of tomato plants under open field conditions.

MATERIALS AND METHODS

A-Experimental design and plant materials

A field experiments was implemented at the Agricultural Research Farm of the Faculty of Agriculture, New Valley University, New Valley Governorate, Egypt during the two successive winter seasons of 2016/2017 and 2017/2018. Tomato (*Solanum lycopersicum* L.) cv. Basha 1077 F1 was used in this study. The experimental unit area (plot) was 5 m x 3 m in size and contained 5 ridges 3 m long and 1m wide, each ridge includes 30 plants. Each plot was separated from the adjacent one by half-meter plastic belt. Foliar spray was applied 56 days after transplanted using a knapsack sprayer. The plants of untreated check (control) were sprayed with water only. Randomized complete block design was used with three replications for each treatment.

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B-Insecticides

Chlorantraniliprole (Coragen® 20% SC, DuPont), Fipronil (Coach® 20 % SC, Shoura chemical) and Indoxacarb (Avant® 15% EC, DuPont). They had been sprayed at the rates recommended by the Egyptian Ministry of Agriculture (60, 25 and 25ml/feddan respectively). Meanwhile, mixtures of Chlorantraniliprole plus Fipronil, Chlorantraniliprole plus Indoxacarb and Fipronil plus Indoxacarb were applied at half dose of each insecticide.

C-Sampling technique and monitoring of *Tuta absoluta*

The infestation rate of larvae was recorded before spraying as well as 1, 7, 14 and 21 days after each treatment. The actual presence of *T. absoluta* was recorded according to (Willcocks and Bahgat, 1937). Samples of 25 leaflets taken from 5 randomly taken plants (5 leaflets/plant). All alive larvae/5plants were counted under a binocular microscope for each treatment. The percentages of infestation reduction were calculated using the equation of Flemming and Rentnakaran (1985) as follow:

Percentages reduction (% R) = $[1- (T_a/T_b \times C_b/C_a)] \times 100$

C_a & C_b are the means of larvae population in post-treatment and pre-treatment, respectively in the control area. T_a & T_b are the means of larvae population in post-treatment and pre-treatment, respectively in the treatment area.

D-The physical and chemical properties of the soil in the experiment site.

Randomized samples at 30 cm depth were collected from the experimental site soil before plantation to determine its physical and chemical properties according to Page *et al*., (1982), the data are presented in Table (1).

E- Cultural practices

The cultural practices and fertilization in all the experimental units were done according to the recommendations of the Ministry of Agriculture in Egypt. After soil ploughing, 30 m^3 organic manure, 350 kg of calcium superphosphate (15% P_2O_5) and 50 Kg sulpher per Fadden were added. Tomato were transplanted (50 cm apart on one side of ridge) 45 days after sowing, later, 300 kg of ammonium nitrate (33.5% N), 200 kg of potassium sulphate (48% K_2O), and 10 Kg magnesium sulphate/Fad were added on four doses. The harvesting was done during April in both seasons of study.

Table 1. Physical and chemical characters of the experimental site soil.

Soil properties	Value
Particle size distribution (%)	
Coarse sand	4.71
Fine sand	72.65
Silt	14.55
Clay	8.09
Texture class	Sandy
Chemical properties	
E.C. (dsm^{-1} at 25°C)*	1.09
pH (1:2.5 w/v)**	8.11
Organic matter (%)	0.55
$CaCO_3$ (%)	5.42
Water soluble ions meq/100g soil	
Ca^{+2}	1.13
Mg^{+2}	0.79
Na^+	3.37
K^+	0.29
CO_3^{-2}	0.00
HCO_3^-	1.29
Cl^-	3.15
SO_4^{-2}	1.14
Available nutrients (mg kg^{-1})	
N	51.3
P	5.48
K	141.3

***E.C: Electrical conductivity (in 1:5 soil water extract).**
****In the 1:2.5 soil/water suspension.**
The values are the average of the two growing seasons.

F- Physiological characteristics

The following data were recorded during the plant growth period and at harvesting date. Representative samples, five plants were randomly taken from each experimental unit at 65 days after transplanting to estimate the physiological characteristics.

For chlorophyll determination, one gram of leaves was finely cut and gently mixed in a clean pestle and mortar. To this homogenized leaf material, 20ml of 80% acetone and 0.5gm $MgCO_3$ powder were added. The materials were further grind gently. The sample was then put into a refrigerator at 40°C for 4 hours. Then after, the sample was centrifuged at 500 rpm for 5 minutes. The supernatant was transferred to 100 ml volumetric flak. The final volume was made up to 100 ml with addition of 80% acetone. The color absorbance of the solution was estimated by a spectrophotometer at 645 and 663nm wavelength. Acetone (80%) was used as a blank (APHA, 1989). Chlorophyll a and b was calculated as follow:

$$\textbf{Chl a} = 11.75\times A662.6 - 2.35\times A645.6$$

$$\textbf{Chl b} = 18.61\times A645.6 - 3.96\times A662.6$$

At breaker stage, ten ripe tomato fruits per experimental unit were picked and used for determination of the following data: (CAT) catalase (3mol H_2O_2/min/g FW), proline (mg/g) and relative water content (RWC %).

Extraction and estimation of the activity of catalase enzymes (CAT), it was used homogenized leaves (0,3g) in disodium phosphate buffer (pH-7). Each homogenate was transferred to centrifuge tubes and was centrifuged at 4 º C for 20 min. at 3000xg. The supernatant was used for enzymes activity assay. (Ivan *et al*., 2012), CAT activity was determined by the decomposition of H_2O_2 which, in turn, was measured by the decrease in absorbance at 240 nm**.** For proline content determination, the fifth fully expanded leaves were detached from the plants after tested treatment. Free proline content in the leaves was determined in accordance with the method described by Bates *et al*. (1973).

Determination of vitamin C (mg/100 g F.W) and lycopene (mg/100 g F.W) were recorded as follow: Vitamin C (mg/100g F.W) was measured according to A.O.A.C. (1975), while, lycopene (mg/100g F.W) was determined according to Lichenthaler and Wellburn (1983).

Relative water content (RWC %) was determined as follow: fresh weigh was calculated, then the samples were floated in distilled water within a closed petri dish and kept in darkness at 4.0 °C for 24 h to obtain the turgid weight (TW). Finally, plant samples were placed in a preheated oven at 80 °C until constant weight to obtain the dry weight [Sánchez et al. 2004]. RWC was calculated using the following equation:

$$\textbf{RWC (\%)} = \frac{FW-DW}{TW-DW} \times 100.$$

G- Yield characteristics

At harvesting date (April in both seasons), all fruits of each plot were harvested weighed and the records of average yield per plant (kg), marketable yield (Tons/fed.) and unmarketable (Tons/fed.) were determined.

H- Statistical analysis

The data were analyzed using two-way a nova (ANOVA) to determine differences between numbers of *T. absoluta* larvae after using insecticides under field conditions. Means were separated using Duncan Multiple Rang Test (DMRT) at $P \leq 0.05$ (Steel and Torrie, 1981). All statistical analyses were carried out using Proc Mixed of SAS package version 9.2 (SAS 2008). Because of zero values for some reduction percentages, they were subjected to transformation before the analysis as described by

Wadley (1967) where each value (x) was transformed to $\sqrt{x + 0.5}$.

RESULTS AND DISCUSSION

Efficacy of different applied treatments against *Tuta absoluta* in tomato under field conditions

The tested insecticides (Chlorantraniliprole, Fipronil and Indoxacarb) and their mixture (Chlorantraniliprole + Fipronil, Chlorantraniliprole + Indoxacarb and Fipronil + Indoxacarb) were tested for controlling leaf miner, *Tuta absoluta* under field condition during two seasons 2016/2017 and 2017/2018 (Table 2). All treatments recorded significantly lower population of *T. absoluta* than untreated control that had the highest larvae counts. Individually, Chlorantraniliprole insecticide achieved the highest decrease in the percentage of *T. absoluta* larvae (73 % and 71.5 %) during the two seasons respectively of cultivation of tomato crop compared to Fipronil and Indoxacarb insecticides. These results are concordant with Larraín *et al*., (2014) and Sapkal *et al*., (2018) who found that Chlorantraniliprole was most effectively controlled larvae and reduced damage caused by *T. absoluta* to foliage and fruit. While, Indoxacarb was the least one, with respect to reduction of larvae and mine blotch counts in treated plants. Similarly, Moussa *et al*., (2013) demonstrated that, Indoxacarb was less effective than Chlorantraniliprole against *T. absoluta* larvae.

Table 2. Field efficiency of various insecticides and their mixture against tomato borer, *T. absoluta* at different time intervals for two seasons 2016/2017 and 2017/2018.

Treatment	Pre-treatment	Post – treatment								Mean
		1 day		7 days		14 days		21 days		
		No.*	% R**	No.	% R	No.	% R	No.	% R	
Season (2016/2017)										
Chlorantraniliprole	09.7^{a}	02.3	78.5^{ab}	01.3	90.1^{a}	06.7	61.8^{b}	07.7	62.1^{a}	73.0
Fipronil	11.3^{a}	03.3	73.3^{b}	05.7	64.0^{c}	09.0	56.1^{c}	10.7	55.2^{b}	62.1
Indoxacarb	10.0^{a}	05.0	54.8^{c}	06.3	54.3^{d}	10.3	42.9^{d}	11.3	46.0^{c}	49.5
Chlorantraniliprole+ Fipronil	11.0^{a}	02.0	83.3^{a}	01.0	93.4^{a}	04.7	76.5^{a}	08.3	63.7^{a}	79.2
Chlorantraniliprole+ Indoxacarb	10.7^{a}	02.3	81.1^{a}	01.3	91.1^{a}	07.0	63.6^{b}	08.3	62.7^{a}	74.6
Fipronil + Indoxacarb	10.0^{a}	04.7	57.4^{c}	04.0	75.4^{c}	08.3	53.7^{c}	10.0	52.2^{b}	58.7
Control	10.3^{a}	11.3	00.0^{d}	14.3	00.0^{e}	18.7	00.0^{f}	21.7	00.0^{d}	00.0
Season (2017/2018)										
Chlorantraniliprole	05.7^{a}	01.7	76.3^{ab}	01.3	83.5^{a}	03.7	67.0^{b}	05.3	59.2^{ab}	71.5
Fipronil	06.0^{a}	02.3	69.5^{b}	03.0	67.1^{b}	05.4	54.8^{c}	06.7	52.3^{c}	60.9
Indoxacarb	06.3^{a}	04.0	49.9^{c}	05.0	45.4^{c}	06.3	48.9^{d}	06.3	55.8^{bc}	49.9
Chlorantraniliprole+ Fipronil	07.0^{a}	01.7	81.6^{a}	01.0	89.8^{a}	03.7	72.8^{a}	06.0	61.9^{a}	76.5
Chlorantraniliprole+ Indoxacarb	07.0^{a}	02.3	73.2^{ab}	01.3	87.0^{a}	04.7	65.9^{b}	05.7	64.8^{a}	72.7
Fipronil + Indoxacarb	05.7^{a}	03.7	48.9^{c}	03.3	60.4^{b}	05.3	51.9^{cd}	06.0	54.3^{bc}	53.8
Control	07.7^{a}	09.7	00.0^{d}	14.3	00.0^{d}	15.0	00.0^{e}	17.7	00.0^{d}	00.0

***No. of larvae/5plant**

**** Percentages reduction**

Means with in columns having the same superscript letter are not significantly different at $P \leq 0.05$.

The combined toxicity effectiveness of the different insecticide mixtures, continually component synergizes or counteracts the other (Corbel *et al.*, 2006 and Diab, 2012). In the same way, Chlorantraniliprole and their mixtures with other insecticides showed the highest decrease of *T. absoluta* larvae compared to the untreated control during the two seasons, where the highest decrease were 79.2% and 76.5%, respectively, for the mixture of Chlorantraniliprole + Fipronil, followed by Chlorantraniliprole + Indoxacarb (74.6% and 72.7%, respectively) without differences from Chlorantraniliprole alone.

These results are in agreement with the finding of Shiberu and Geeta (2017) who reported that, Chlorantraniliprole (Coragen 200) and their mixture of Emamectin benzoate and Prosuler oxymatrine showed good efficacy for controlling *T. absoluta* larvae. Therefore, they can be used in conjunction with chemical products and applied within a programs of integrated pest control. Contrary to, the mixing of fipronil with Indoxacarb was reduced the effectiveness of using fipronil alone, the reduction percentages were 62.1 %, and 60.9 % for Fipronil in two seasons, respectively, opposite to 58.7% and 53.8% for (Fipronil + Indoxacarb) in the two seasons respectively. In additional to all treatments of Chlorantraniliprole insecticide didn't show significant differences from their mixture of other insecticides (Chlorantraniliprole + Fipronil) and (Chlorantraniliprole + Indoxacarb) during the time periods of the experiment, which continued to outweigh in reducing the number of *T. absoluta* larvae until a week of treatment. The reduction percentages were increased to 90.1%, 93.4% and 91.1%, respectively, in the first season (2016/2017) and to 83.5%, 89.8% and 87%, respectively, in the second season (2017/2018).

The efficacy of insecticides and their mixtures were decreased on the 14th day of the treatments. Nevertheless, Chlorantraniliprole, Chlorantraniliprole + Fipronil and Chlorantraniliprole + Indoxacarb treatments continued to affect the moral decrease in the infestation of *T. absoluta* larvae until the 21st day of the treatment without any significant differences between them compared to the untreated control. The decline percentages were 62.1%, 63.7% and 62.7% respectively, in first season and it were 59.2%, 61.9% and 64.8%, respectively, for the second season. Eventually, Chlorantraniliprole and this mixture may recommend for achieving efficient control and use for management of *T. absoluta* under field condition (Ahmed, 2009). Conversely, Indoxacarb has achieved maximum larvae reduction only 49.9 %. Berxolli and Shahini, (2018) reached to similar findings as, they reported that, Avaunt 15 EC (Indoxacarb) does not give high technical effect but must be combined with other control measures.

Efficacy of various insecticides treatments on physiological and fruits yield characters of tomato plants infested with *Tuta absoluta*

It is evident from the results in Table 3 that chlorophyll a and b content were increased with various treatments, moreover, the significant increase was recorded for Chlorantraniliprole+ Fipronil followed by Chlorantraniliprole then other treatments. The lowest levels of chlorophyll a and b were recorded for control treatment in both seasons. Also, vitamin C and lycopene were significantly increased with insecticide treatments mainly Chlorantraniliprole+ Indoxacarb and Chlorantraniliprole+

Fipronil in comparison to other treatments. Intriguingly, application of these treatments on tomato stressed plants (infested with *Tuta absoluta*) resulted in decreased proline concentration and catalase under all insecticide treatments compared with control treatment (Table 3). On the other hand, relative water content (RWC) was increased with various treatments; the highest level of relative water content was obtained with Chlorantraniliprole+ Fipronil in both seasons. The negative effects of insect stress (*Tuta absoluta*) on tomato plants may be due to *T. absoluta* prefers tomato plants in feeding more than other plants (Adil *et al*., 2015) which, may led to decrease in most of physiological characters such as chlorophyll content. The same results were recorded with the various stresses such as insects, plant diseases, salinity and drought stress on many plants (Abdelaal *et al*., 2014, Abdelaal *et al.,* 2017, Abdelaal *et al*., 2018). Hasan *et al.,* 2017, El-Banna and Abdelaal 2018 and Omara *et al.,* 2019) under tomato plant infection with *Tuta absoluta* showed high concentration of proline and catalase enzyme as a defense factors against stress infection to scavenge the oxidative stress factors (reactive oxygen species) and protect plant cells against oxidative stress.

Table 3. Effect of various insecticides and their mixture on physiological characters of tomato plants against T. absoluta in the two seasons 2016/2017 and 2017/2018.

Treatments	Physiological characters						
	Season 2016/2017						
	Chl. a (mg/g F.W)	**Chl. b (mg/g F.W)**	**Vitamin C (mg/100 g F.W)**	**Lycopene (mg/100 g F.W)**	**Proline (mg/g)**	**Catalase**	**Relative water content (%)**
Chlorantraniliprole	1.7^{a}	0.49^{bc}	31.54^{c}	9.51^{bc}	10.59^{b}	70.15^{d}	69.36^{b}
Fipronil	1.48^{bc}	0.50^{b}	31.54^{c}	9.38^{bc}	10.59^{b}	80.49^{c}	68.03^{b}
Indoxacarb	1.40^{c}	0.38^{de}	31.17^{d}	8.99^{bc}	9.14^{b}	93.97^{b}	61.96^{c}
Chlorantraniliprole+ Fipronil	1.79^{a}	0.66^{a}	31.98^{b}	10.43^{a}	10.45^{b}	71.57^{d}	74.86^{a}
Chlorantraniliprole+ Indoxacarb	1.64^{ab}	0.47^{bc}	32.43^{a}	9.64^{ab}	10.76^{b}	71.79^{d}	69.83^{b}
Fipronil+Indoxacarb	1.31^{cd}	0.43^{cd}	31.98^{b}	9.03^{bc}	9.45^{b}	84.90^{c}	63.86^{c}
Control	1.20^{d}	0.34^{e}	31.17^{d}	8.65^{c}	13.81^{a}	108.64^{a}	59.93^{c}
	Season 2017/2018						
Chlorantraniliprole	1.72^{a}	0.51^{b}	31.51^{c}	9.20^{bc}	10.60^{b}	68.16^{d}	69.7^{b}
Fipronil	1.49^{bc}	0.49^{bc}	31.54^{c}	9.42^{b}	10.57^{b}	76.82^{c}	68.97^{b}
Indoxacarb	1.38^{c}	0.40^{e}	31.15^{d}	9.12^{bc}	9.45^{b}	92.30^{b}	61.84^{cd}
Chlorantraniliprole+ Fipronil	1.79^{a}	0.64^{a}	31.98^{b}	10.69^{a}	10.51^{b}	73.23^{cd}	77.99^{a}
Chlorantraniliprole+ Indoxacarb	1.64^{ab}	0.46^{cd}	32.40^{a}	9.66^{b}	9.8^{b}	70.77^{d}	69.37^{b}
Fipronil +Indoxacarb	1.33^{c}	0.43^{ed}	32.00^{b}	9.27^{b}	10.48^{b}	87.57^{b}	63.93^{c}
Control	1.29^{c}	0.34^{f}	31.13^{d}	8.60^{c}	13.44^{a}	103.30^{a}	60.04^{d}

Means with in columns having the same superscript letter are not significantly different at P ≤ 0.05.

According to our results in Table 4, the data revealed that fruit yield characters particularly, marketable yield and fruits yield/plant were increased with application of insecticide treatments. The highest values of these characters were obtained with Chlorantraniliprole+ Fipronil and Chlorantraniliprole+ Indoxacarb, however, these treatments led to decreased unmarketable yield compared with control treatment. The highest value of unmarketable yield was increased with control untreated treatment. The negative effect of infection of fruits yield characters could be attributed the destructive role of *Tuta absoluta* on plant growth status and physiological characters, consequently, decreased yield production. Contrariwise, the positive effect of the studied insecticide treatments may be due to the role of these treatments in elevation of phenols, lycopene and antioxidant enzymes which play an essential role and acts as a barrier to insect feeding (Mohamed and Abd-El Hameed 2014) and finally positively affected fruits yield. These results are in harmony with those obtained by Esmail *et al.,* (2019), Omara and Abdelaal (2019) and Abdelaal *et al.,* (2020) under various stresses.

Table 4. Effect of various insecticides and their mixture on yield characters of tomato plants against *T. absoluta* in the two seasons 2016/2017 and 2017/2018.

Treatments	Season 2016/2017		
	Yield characters		
	Marketable (Ton/Fed.)	**Unmarketable (Ton/Fed.)**	**Yield/plant (Kg)**
Chlorantraniliprole	14.53^{b}	2.88^{b}	2.14^{cd}
Fipronil	14.50^{b}	2.51^{bc}	2.16^{bc}
Indoxacarb	13.24^{c}	3.75^{a}	1.99^{de}
Chlorantraniliprole+ Fipronil	16.12^{a}	2.08^{c}	2.34^{a}
Chlorantraniliprole+ Indoxacarb	16.10^{a}	1.53^{d}	2.28^{ab}
Fipronil+ Indoxacarb	15.75^{ab}	2.34^{c}	2.13^{cd}
Control	12.14^{c}	3.71^{a}	1.91^{e}
	Season 2017/2018		
Chlorantraniliprole	16.07^{a}	2.53^{bc}	2.31^{a}
Fipronil	13.81^{b}	2.94^{b}	2.16^{b}
Indoxacarb	12.63^{bc}	1.94^{c}	1.94^{c}
Chlorantraniliprole+ Fipronil	15.49^{a}	2.37^{a}	2.37^{a}
Chlorantraniliprole+ Indoxacarb	16.14^{a}	2.29^{a}	2.29^{a}
Fipronil+ Indoxacarb	15.73^{a}	2.15^{b}	2.15^{b}
Control	11.43^{c}	1.87^{c}	1.87^{c}

Means with in columns having the same superscript letter are not significantly different at P ≤ 0.05.

CONCLUSION

Under infection with *T. absoluta*, the growth characters of tomato plants without insecticides treatments were significantly decreased. Furthermore, chlorophyll a and b content, vitamin C, lycopene content and relative water content as well as fruits yield were markedly reduced. However spraying tomato plants with

Chlorantraniliprole, Fipronil and Indoxacarb insecticides and their mixture substantially improved the growth of stressed tomato plants and increased the physiological characters such as chlorophyll contents, vitamin C and relative water content as well as fruits yield. The best treatment was Chlorantraniliprole+ Fipronil that improved the stressed tomato plants by alleviation the adverse effects of *T. absoluta* consequently, improved fruits yield of tomato.

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تأثير بعض المبيدات الحشرية على يرقات حشرة التوتا أبسليوتا وعلى الخصائص الفسيولوجية ومحصول الثمار في نباتات الطماطم المجهدة

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فى الفترة الأخيرة أصبحت صانعة أنفاق الطماطم التوتا أبسليوتا أحد الآفات الرئيسية التي تسبب أضرار حقيقية في إنتاج الطماطم، لذلك أجريت تجربة حقلية في موسمي 2016-2107 و2017-2018 لتقدير فاعلية المبيدات الحشرية المختلفة (كلورانترانيليبرول، فيبرونيل، أندوكساكارب) وخلائطها ضد حشرة صانعة أنفاق الطماطم وكذلك دراسة الصفات الفسيولوجية وإنتاجية ثمار الطماطم المجهدة. أوضحت النتائج لمبيد كلورانترانيليبرول بمفرده وخلائطه (كلورانترانيليبرول + فيبرونيل، كلورانترانيليبرول + أندوكساكارب) أنها كانت الأكثر فاعلية في خفض الإصابة بيرقات صانعة أنفاق الطماطم عن المعاملات الأخرى والكنترول. وحققت معاملة كلورانترانيليبرول + فيبرونيل أعلى مستوى لمتوسط خفض الأصابة بقيمة 79.2% و76.5% على التوالي خلال موسمي الزراعة، وكانت أعلى المتوسطات لنسب الانخفاض للمعاملات المذكورة ضد صانعة الأنفاق في الموسم الأول 90.1 %، 93.4 % و91.1 % على التوالي و83.5 %، 89.8 % و87 % على التوالي للموسم الثاني وذلك بعد 7 أيام من المعاملة، بينما كان أندوكساكارب أقل فاعلية في خفض تعداد اليرقات (49.5 % و49.9 %) في كلا الموسمين. وأدت المعاملات أيضا إلى زيادة محتوى كلوروفيل أ وب، فيتامين سي، الليكوبين ومحتوى الماء النسبي بتطبيق معاملة مبيد كلورانترانيليبرول منفردا وخلائطه. وفى النهاية يمكن التوصية باستخدام مبيد كلورانترانيليبرول بمفرده أو خلطه مع فيبرونيل أو أندوكساكارب للمكافحة الفعالة ضد التوتا أبسليوتا وتطبيقها في برامج المكافحة المتكاملة (IPM) في حقول محصول الطماطم.