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Evaluation of some insecticides and their combinations with mineral oil against Tuta absoluta and the side-effects on tomato plant and fruits

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ABSTRACT

Tuta absoluta can attack tomato plant at any developmental stage around the year. Thus, the modern integrated pest management recommends effective pesticides that have high efficiency and low side-effects. Therefore, the efficiency of some insecticides and their mixtures with mineral oil was evaluated against tomato leaf miner, T. absoluta under greenhouse conditions. Also, the side-effects of the insecticides on the tomato plant and fruit quality characteristics were evaluated. The results revealed that all the tested treatments decreased the T. absoluta infestation with the following descending order; imidaclopride > (emamectin benzoate + mineral oil) > (pyridalyl + mineral oil) > (abamectin + mineral oil) > (emamectin benzoate + indoxacarb) > (indoxacarb + mineral oil) > (abamectin + lufenuron) > (Bacillus thuringensis, Bt + mineral oil) > (lufenuron + mineral oil) > (diazinon + mineral oil). The inhibitory effect of treatments on the chlorophyll content was lower than that due to the damage of T. absoluta in control. According to the efficacy of insecticides on tomato leafminer and their effects on the tomato quality, the tested insecticides could be divided into four categories as follows: Excellent (imidacloprid, emamectin + mineral oil, abamectin + mineral oil), good (indoxacarb + mineral oil, emamectin + indoxacarb, abamectin + lufenuron), moderate (pyridalyl + mineral oil, B.t + mineral oil) and fail (diazinon + mineral oil, lufenuron + mineral oil).

Key words: Leafminer; Tuta absoluta, insecticides; side-effects, chlorophyll content

INTRODUCTION

Egypt is considered one of the important tomato producers in the world (WPTC, 2011). Tomatoes could be infected by many diseases; fungi, bacteria and virus and attacked by insects particularly tomato leafminer, Tuta absoluta (Meyrick) (Ishaaya et al., 2002; Marja et al., 2011; Gacemi and Guenaoui, 2012). The tomato leafminer is the major limiting factor for tomato production in many countries (Ferrara et al., 2001; Urbaneja et al., 2007; Botto, 201l; Estay, 2000, Torres et al., 2001). Tomatoes are now available year-round (Grierson and Kader, 1986). Also, T. absoluta can be detected all around the year (Vercher et al., 2010). Tomato can be attacked at any developmental stage (Estay, 2000). The larval stage is the most damaging to plants and is completed within 12-15 days under optimal conditions. Up to 100% losses have been reported in tomato crops, and even where chemicals control is implemented, losses can still exceed 5% (Korycinska and Moran, 2009).

The primary *T absoluta* management tactic in most South American countries is chemical control (Lietti et al., 2005). Some insecticides were recommended for the control of larval infestations in deferent countries such as indoxacarb, spinosad, imidacloprid, deltamethrin, chlorpyrifos, abamectin, thiacloprid, lufenuron and *Bacillus thuringensis* var. kurstaki (Mallia 2009; Fera, 2009).

Chlorantraniliprole, chlorfenapyr, indoxacarb, chlofenapyr, spinosad, emamectin benzoate and imidacloprid provide excellent control against *T. absoluta* (Moussa et al., 2013; Reda and Hatem, 2012). Many studies demonstrated that IPM compatible petroleum spray oils are able to provide as effective control of leafminer (Rae et al., 1996; 1997).

Modern integrated pest management recommends effective pesticides that have low mammalian toxicity, low persistence in the environment and high degree of selectivity. Since insecticide control currently remains an indispensable tool, the goal is to minimize the amount and impact of pesticides through the diversification of active ingredients used (Braham and Hajji, 2012). The behaviour of pesticides particularly organophosphate insecticides show that higher concentrations requires more time to degrade and there are reports to show that higher concentrations of pesticides have harmful effects on various growth parameters of plants (Forster et al., 1980; Siddiqui and Ahmed, 1996; Siddiqui et al., 1997 and Siddiqui and Ahmed, 2000). Tomatoes are especially important for the human diet because of their content of phenolic compounds (Davey, 2000), vitamins (Taylor, 1987); minerals and sugars (Gould, 1983); antioxidants (Clinton, 1998) and lycopene (Brandt et al., 2006).

It is well established that certain pesticides influence the chemical composition of the plants after they are applied (Habiba et al., 1992). The photosynthetic pigment chlorophyll is present in most plants. The types of chlorophyll a, b and d can be present in all photosynthetic organisms but vary in concentrations (Milenkovic et al., 2012). Chlorophyll was examined as a parameter that may be a useful indicator of environmental exposure to the pesticides (Mishra et al., 2008). Chlorophyll a, b and total were increased by chlorpyifos (Parween et al., 2011) whereas decreased by dimethoate (Mishra et al., 2008). Total phenols were tested at the vegetative and fruiting phase of the growth in leaf, shoot and fruit to examine by different pesticides (Zamin and Soaliha, 2006). The content of total phenols in untreated potato samples was higher as compared to imidacloprid treated potato samples (Habiba et al., 1992). Also, imidacloprid decreased the phenolic content level by 42.55% of the total phenolics in potato (Radwan et al, 2004). Sugars constitute an important component of tomato fruit contributing to tomato taste (Baldwin et al., 1998; Yilmaz, 2001; Tadesse et al., 2012). The profenofos residue reduced the tomato glucose content compared to the untreated tomato samples (Ismail et al., 1993). The sugar content was increased while, the reducing sugar content was decreased in imidacloprid treated potato samples (Habiba et al., 1992). Carotenoids, such as beta-caroten and lycopene, are important components of antioxidant defense against lipid peroxidation in living cells (Bunghez et al., 2011). At least 85% of our dietary lycopene comes from tomato fruit and tomato-based products (Clinton, 1998). In recent years, lycopene attracted a lot of attention from various researchers because of its nutritional significance and ability to prevent chronic and cancerous diseases for example; prostate, digestive-tract and lung cancer (Marcela et al., 2005).

MATERIAS AND METHODS

Tested insecticides

Diazinon (Durasen EC 60% at 1.5 L/F), abamectin (Gold EC 1.8% at 250 mL/F), lufenuron (Match EC 5% at 80 mL/F), pyridalyl (Pleo EC 50% at 100 mL/F), imidacloprid (Best WP 25% at 500 g/F),indoxacarb (Avaunt EC 15% at 160 mL/F), emamectin benzoate (Pasha EC 1.9% at 250 mL/F), *Bacillus thuringensis*(Dipel-2x WP 6.4% at 200 g/F) and mineral oil (Diver EC 97% at 1 L/F).

Experiments

Two experiments were carried out during the tomato growing season Feb. 2013 under greenhouse conditions at Abo ghalb city, Kaliobia Governorate, Egypt. The cultivation tomato variety was Realiza. All cultural methods were conducted according to good agricultural practice. Plots of 60 m2 each containing 60 plants arranged in complete randomized block design. For each treatment including the check, three replications were tested. The average infestation level in all experimented plots was monitored till that reached three of larvae/tomato plant at zero time of application. The tested insecticides were evaluated as combinations with the mineral oil as a tank mixing. Samples of four leaves were collected at random from each plant (20 leaves/5 plants/replicate). Percentage of infestation by *T. absoluta* was determined by investigation of level samples to detect the externally and internally larvae as well as the infestation symptoms. The percent reduction of *T. absoluta* infestation was calculated according to the equation as reported by Henderson and Tilton (1955). Also the side-effects of some insecticides on the tomato plant and fruit quality; chlorophyll, phenolic compounds, lycopene and sugar content were investigated.

Data were analyzed by analysis of variance (ANOVA) and followed by a least significant difference, LSD test (Anonymous, 1990).

Determination of chlorophyll content

The leaf chlorophyll content (mg/g leaves) was determined according to Grodzinsky (1973). Selected leaf (0.25 g) was cut and homogenized by hand glass homogenizer (using 5 ml of acetone 80%). The resulting homogenate was filtrated through Whatman filter paper No. 1 using Buchner funnel. The filtrate was completed with acetone to satisfy total volume of 25 ml. The absorption of the clear solution was measured spectrophotometrically at 645 nm and 663 nm using Thermo electron corporation evaluation 100 Spectrophotometer.

Determination of total phenolic compounds

The alcoholic extraction was used to determine the phenolic compound in plant fruit (Gergen, 2004). Ten grams of each pre-treated sample was mixed with 10 ml ethanol solution (50%), after 30 min the mixture was filtered. Ethanol extract was diluted by 1/10 with ethanol solution (50%), used the following reagents 2.0 M Folin-Ciocalteu phenol reagent and anhydrous sodium carbonate. The absorption was measured at 750 nm. Total content of polyphenols in tomatoes in tannic acid equivalents was calculated. The calibration curve indicated that K = 0.063 as μg/g.

Determination of lycopene content

Lycopene estimation was done by using AOAC method (AOAC, 1992). Sample (5 g) was repeatedly extracted with acetone until the residue became colorless. The acetone extract was transferred to a separating funnel containing 15 ml petroleum ether and then, 5% sodium sulfate solution was added. The lower acetone phase was repeatedly extracted with petroleum ether similarly, until it became colorless. The upper petroleum ether extract was pooled and its volume was made up to 50 ml with petroleum ether. The color of diluted solution was measured at 503 nm by spectrophotometer. The petroleum ether was used as blank.

Determination of total soluble sugar content

Colorimetric method for the determination of total sugar was based on simple sugars, oligosaccharides, polysaccharides, and their derivative. A sample of 10 g of fresh tomato fruit was mixed with 300 mL distilled water and 3 g of calcium carbonate in conical flask 500 ml, refluxed for 30 min. and kept for cooling. Then 10 mL of saturated lead acetate neutral (49%) was added refluxed and filtered. The access of lead was precipitated by adding dried potassium oxalate and filtered. Clear extract (2 ml) was transferred into test tube, 5 ml sulfuric acid conc. and 1 ml aqueous phenol solution (5%) were added and measured at 580 nm (Michel, 1965). A standard curve for glucose solution in range of 20 to 200 micrograms glucose was carried out. The "K" value for the standard curve is 0.0028 as µg/g.

RESULTS AND DISCUSSION

Effect of certain insecticide treatments against *T. absoluta*

Table (1) presented the infestation reduction percentages of different treatments after 4 and 7 days from treatment. At 4th day, the highest effective treatment was (pyridalyl + mineral oil), caused 84.51% infestation reduction followed by imidaclopride and (emamectin benzoate + mineral oil). Whereas, the lowest effect, 38.96% infestation reduction was obtained by treatment of (B.t + mineral oil). At 7th day, the highest effective treatments included imidaclopride, 91.81% infestation reduction; (emamectin benzoate + mineral oil, 89.63%) and (Abamectin + mineral oil, 88.11%). While, the lowest effective treatments were (lufenuron + mineral oil, 43.81%) and (diazinon + mineral oil, 41.00%). Regarding to the average infestation reduction, the different treatments were classified statistically to three groups. The first group has a considerable effect, including imidoclopride, (emamectin benzoate + mineral oil), (pyridalyl + mineral oil) and (Abamectin + mineral oil) caused 84.78, 83.65, 81.18 and 78.40% infestation reduction, respectively. The second group has acceptable effects as follow; (emamectin benzoate + indxacarb), (indoxacarb + mineral oil) and (abamectin + lufenuron), gave 74.98, 68.47 and 67.75% infestation reduction, respectively. The third group has a moderate efficacy, it included three treatments; (lufenuron + mineral oil, 45.41%), (B.t + mineral oil, 46.15%) and (diazinon + mineral oil, 44.75% infestation reduction).

The result is agreement with the result obtained by Gacemi and Guenaoui (2012) and Lo'pez et al. (2012), their result showed a good activity of emamectin-benzoate against larvae of the tomato leafminer, the mortality reaching 87%. Also, Jansson et al. (1996) demonstrated the efficiency of the same bio-insecticide on other lepidopteran pests on the tomato crops. The product tested indoxacarb (Avaunt) mixed with emamectin benzoate or mineral oil has acceptable efficiency against *T. absoluta* under greenhouse conditions giving 74.98 and 84.78%, respectively. Other studies indicated that the product Avaunt had 72.86% effectiveness (Valchev et al., 2013) over 75% against first- second instars of larvae of tomato leafminer in greenhouses (Yankova and Geneva, 2013). Santos et al. (2011) reported that the tested insecticides including emamectine-benzoate and indoxacarb were effective to control *T. absoluta*. In addition, Hanafy and El-Sayed (2013) stated that pyridalyl was the most effective in reducing infestation of *T. absoluta* then indoxacarb. In some countries, the petroleum spray oils or white oils are recommended for the control of citrus leafminer (Beattie and Smith, 1993). It has generally been accepted that petroleum spray oil is most effective against small, immobile insects which are suffocated or downed when covered with a thin film of oil (Rae et al., 1996). Our results demonstrated that the combination of abamectin or emamectin benzoate with mineral oil (tank mixing, each at half of the recommended rate) caused 78.4% and 83.65 reduction of leafminer infestations, respectively. Furthermore, the use of oils has a number of advantages over conventional pesticides as they are less disruptive to natural enemies, insects do not develop resistance to them, they are non-toxic to vertebrates and they break down easily in the environment (Beattie and Smith, 1993).

In our experiment, the treatment of (B.t + mineral oil) and (lufenuron + mineral oil) caused a moderate effect on *T. absoluta*. This result may be due to the *T. absoluta* parameters. Newly hatched larvae were more susceptible to B.t than 3rd instars (Reda and Hatem, 2012). Also, it was showed that the chemical insecticides such as indoxacarb, abamectin, emamectin benzoate and imidaclopride provide excellent control against *T. absoluta*, while a biopesticide B.t provides moderate control.

Side-effects of tested insecticides on chlorophyll content of tomato leaves

Two controls were used in this experiment, a healthy and infested control by tomato leafminer, T. absoluta. The amount of chlorophyll (a) and total chlorophyll reduced significantly with all treatments compared with healthy control except the treatment of (diazinon + mineral oil). No significant differences were detected in chlorophyll (b) among all tested treatments. The highest inhibitory effect on the total chlorophyll a, b and total content was obtained by (abamectin + lufenuron) treatment, 4.40, 1.89 and 6.28 mg/100g tomato leaves, respectively. It was observed that the inhibitory effect of different treatments on the chlorophyll content was lower than that due to the damage of T. absoluta (Table 2).

Side-effect of tested insecticides on some quality parameters of tomato fruits

Data in Table (3) indicated that all tested insecticides had significant inhibitory effect on soluble sugar formation. Imidacloprid was the most effective one while abamectin and emamectin-benzoate were the least compounds. It is well established that certain pesticides influence the chemical composition of the plants after they are applied. Imidacloprid decreased the reducing sugar content of potatoes (Shailendra et al., 2013), profenofos decreased the glucose content in tomatoes (Habiba et al., 1992 and Ismail et al., 1993), chlorpyrifos, abamectin and lambda-cyhalothrin lowered the quantity of reducing sugars (Asrorov et al., 2014).

Also, the data revealed that the four tested insecticides had high effect on lycopene content in tomato fruits. Abamectin and imidacloprid were more inhibitory effect (5.46 and 5.64 mg/100g tomato fruit) than diazinon and emamectin benzoate (10.98 and 12.60 mg/100g tomato fruit) compared with control (17.77 mg/100g tomato fruit), respectively. In similar, there was significant reduction in lycopene content in cypermethrin treatment (Mohapatra et al., 2003).

About the total phenolic compounds content, no significant differences were detected among different treatments except the insecticide, diazinon which significantly decreased the total phenol content of tomato fruits. In other studies, the total phenol content was depressed by imidacloprid (Shailendra et al., 2013) and by chlorpyrifos and chlorpyrifos-methyl (El-sherief, 1991).

Conclusion

It was interested to state that our study suggested the possibility of grouping the tested insecticides into four categories according to their efficacy on tomato leafminer and their safety on the tomato quality as follows: Excellent (imidacloprid, emamectin benzoate + mineral oil, abamectin + mineral oil), good (indoxacarb + mineral oil, emamectin benzoate + indoxacarb, abamectin + lufenuron), moderate (pyridalyl + mineral oil, B.t + mineral oil) and fail (diazinon + mineral oil, lufenuron + mineral oil).

Table 1: Infestation reduction percentage of Tuta absoluta after different insecticide treatments.

Treatments		Recommended rate / Feddan	% Infestation reduction		General average
Common name	Trade name		After 4 days	After 7 days	
Diazinon + mineral oil	Durasen EC 60% + Diver EC 97%	1.5 L + 1 L	48.50d	41.00f	44.75e
Abamectin + mineral oil	Gold EC 1.8% + Diver EC 97%	250 mL + 1 L	68.70c	88.11ab	78.40bc
Pyridalyl + mineral oil	Pleo EC 50% + Diver EC 97%	100 mL + 1 L	84.51a	77.85c	81.18ab
Imidacloprid	Best WP 25%	500 g	77.75ab	91.81a	84.78a
Indoxacarb + mineral oil	Avaunt EC 15% + Diver EC 97%	160 mL + 1 L	52.08d	84.87b	68.47d
Emamectin benzoate + mineral oil	Pasha EC 1.9% + Diver EC 97%	250 mL + 1 L	77.67ab	89.63ab	83.65ab
B.t + mineral oil	Dipel-2X WP 6.4% + Diver EC 97%	200 g + 1 L	38.96e	53.35e	46.15e
Lufenuron + mineral oil	Match EC 5% + Diver EC 97%	160 mL + 1 L	47.02d	43.81f	45.41e
Abamectin + lufenuron	Gold EC 1.8% + Match EC 5%	250 mL + 80 mL	65.77c	69.74d	67.75d
Emamectin benzoate + indoxacarb	Pasha EC 1.9% + Avaunt EC 15%	250 mL + 80 mL	72.45bc	77.52c	74.98c

Values within the same row having the same letters are not statistically different from each other, $P<0.05$.

Table 2: Side-effect of tested insecticides on the chlorophyll content of tomato leaves.

Treatments		Recommended rate / Feddan	mg chlorophyll/100g leaves		
Common name	Trade name		(a)	(b)	(Total)
Diazinon + mineral oil	Durasen EC 60% + Diver EC 97%	1.5 L + 1 L	8.222a	3.236a	11.458a
Abamectin + mineral oil	Gold EC 1.8% + Diver EC 97%	250 mL + 1 L	6.43 b	2.821a	9.257cd
Pyridalyl + mineral oil	Pleo EC 50% + Diver EC 97%	100 mL + 1 L	6.756b	2.790a	9.546cd
Imidacloprid	Best WP 25%	500 g	7.181b	2.897a	10.078c
Indoxacarb + mineral oil	Avaunt EC 15% + Diver EC 97%	160 mL + 1 L	6.956b	2.848 a	9.804cd
Emamectin benzoate + mineral oil	Pasha EC 1.9% + Diver EC 97%	250 mL + 1 L	6.373b	2.844a	9.217cd
B.t + mineral oil	Dipel-2X WP 6.4% + Diver EC 97%	200 g + 1 L	6.966b	2.867a	9.832cd
Lufenuron + mineral oil	Match EC 5% + Diver EC 97%	160 mL + 1 L	5.978b	2.486a	8.463d
Abamectin + lufenuron	Gold EC 1.8% + Match EC 5%	250 mL + 80 mL	4.396c	1.886a	6.281e
Emamectin benzoate + indoxacarb	Pasha EC 1.9% + Avaunt EC 15%	250 mL + 80 mL	5.566b	3.404a	8.970cd
Control healthy		-	8.540a	2.286a	10.827b
Control infested with T. absoluta		-	0.395d	2.220a	2.616f

Values within the same row having the same letters are not statistically different from each other, P<0.05.

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Table 3: Side-effect of tested insecticides on some quality parameters of tomato fruits.

Insecticides	Recommended rate / Feddan	mg/l00g tomato fruit		
		Total soluble sugar	Lycopene	Total phenols
Diazinon	1.5 L	12.40 c	10.98 b	0.66 b
Abamectin	250 mL	13.20 b	5.46 c	3.97 a
Emactinbenzoat	250 mL	13.00 b	12.60 b	4.62 a
Imidacloprid	500 g	5.32 d	5.64 c	4.67 a
Control	-	15.14a	17.77 a	3.53 a

Values within the same column having the same letter are not statistically different from each other, p<0.05.

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تقييم كفاءة بعض المبيدات ومخاليطها مع زيت معدنى ضد توتا ابسليوتا وتأثيراتها على نبات وثمار الطماطم

تعتبرمصر أحد الدول الهامة فى انتاج الطماطم عالميا. وتصاب الطماطم بحشرة توتا ابسليوتا على مدار العام تقريبا. وتعتبر المبيدات عالية الفعالية ومنخفضة التاثيرات الجانبية أحد عناصر المكافحة الكيماوية الحديثة لهذه الآفة. لذا تم دراسة كفاءة بعض المبيدات ومخاليطها مع الزيت المعدنى ضد توتا ابسليوتا على الطماطم النامية فى الصوبة الزراعية وتم دراسة أيضا التأثيرات الجانبية على النبات وثمار الطماطم وأظهرت النتائج المتحصل عليها أن جميع المركبات المختبرة قللت نسبة الاصابة. ويمكن ترتيب المعاملات تنازليا كما يلى: اميداكلوبريد > (ايمامكتين بنزوات + زيت معدنى) > (بيردليل + زيت معدنى) > (ابامكتين + زيت معدنى) > (ايمامكتين بنزوات + اندكسوكارب) > (اندكسوكارب + زيت معدنى) > (أبامكتين + ليفينيرون) > (باسلس + زيت معدنى) > (ديازينون + زيت معدنى). وبناء على كفاءة المركبات ومستوى الأمان على النبات وخواص الثمار يمكن تقسيم المعاملات المختبرة الى أربعة مجاميع هى: مجموعة ممتازة وتشمل معاملات اميداكلوبريد , (ايمامكتين بنزوات + زيت معدنى) , (أبامكتين + زيت معدنى) ومجموعة جيدة وتشمل معاملات (اندوكسوكارب + زيت معدنى) , (ايمامكتين بنزوات + اندكسوكارب) , (أبامكتين + ليفينيرون) ومجموعة متوسطة وتشمل (بيردليل + زيت معدنى) , (باسلس + زيت معدنى) ومجموعة منخفضة التأثير وتشمل (ديازينون + زيت معدنى) , (ليفينيرون + زيت معدنى).