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Efficiency of certain insecticides against the black vine thrips, *Retithrips syriacus* (Mayet) (Thysanoptera: Thripidae) under laboratory and field conditions

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Abstract

The quantity and quality of grapevine fruit is very important to local and export productions. Black vine thrips (BVT), *Retithrips syriacus* (Mayet) (Thripidae: Thysanoptera) injured the leaves from seedling to the blooming fall. Insecticides are the main strategy to grapevine insect control. There is a little information about the susceptibility of BVT to insecticides. This study carried out to test the potency and residual activity of six insecticides with different mode of action under laboratory and field conditions. The LC_{50} values for leaf dip after 24 hours with the insecticides were different. The emamectin benzoate was the most toxic against nymphs, and teflubenzuron was the least one, LC_{50s} value decreased significantly after 48, 72 hours post treatments. For teflubenzuron, the LC_{50} values recorded were 11900, 7.05, 2.58 µg a.i./ ml after 24, 48 and 72 hours from treatment respectively. Based on the laboratory potency ratios, emamectin benzoate , malathion, and mineral oil showed higher effect against nymphs than adults by 3.11, 1.79, 1.18 folds after 24 hours, being 1.63, 12.73 folds for emamectin benzoate and teflubenzuron after 48 hours, and 1.68 for teflubenzuron after 72 hours. King Roby grapevine variety showed the most significant susceptibility to thrips infestation, while the Flaim was the most tolerant one. Emamectin benzoate was the highest in reduction ratios of nymphs thrips, where 92.30, 93.19 and 93.83% reduction at Flaim, Banaty, and King Roby varieties respectively. These results could be used in integrated pest management (IPM) programs for thrips control in grapevine.

Keywords: insecticides toxicity, field residual activity, *Retithrips syriacus*.

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Introduction

Grapevine, *Vitis vinifera* L. is traditionally cultivated as fruit crop all over the world, which it used as vines or food tables. In Egypt, the grape as fruit summer is very essential to most Egyptian people as food table and exportation to some European countries. The quantity and quality properties of fruit are very important for direct feeding or integrated industries of grape food. One of the most important factors that affected grape productions is insect pests. There is numerous insects attack the grape tree parts such as thirps, aphids, jassids, and fruit worm (Reineke & Thiéry, 2016; Walton et al., 2012). Scars are the result of ovipositional and feeding activities of thrips early in the growing season, these cause severe injuries that may become the reason of a saprophytic fungal infection (Lopes et al., 2002; Jensen, 1973) .Three thrips species attack the leaves and vine fruit parts in Assiut, Egypt, the black vine thrips (BVT), *Retithrips syriacus* (Mayet) is commonly infested vine grads in upper Egypt, Assiut (Khalil et al., 2010). Even though, the thrips is not registered as key insect in grape in Egypt, the leaves of grape were heavily attacked by thrips during the summer until falling the leaves, moreover these insect can attack the seedling of nurse production. Some studies referred to the damage of leaves and production by thirps. Because of their high population, low mobility and confined and gregarious feeding, larvae do more than adults (Ananthakrishnan, 1993). Chemical control is still a major method for controlling insect pest in grape vine, also the vine variety level of insect's infestation of should be considered. Therefore, the susceptibility of three cultivated varieties to BVT was investigated. There is little information about any chemical control against it. Therefore, conducting more research related to effective insecticides for chemical control of BVT is highly desired. Hence, the efficacy of 6 selected insecticides belonged to five chemical classes including emamectin benzoate (avermectins), spinosad and spinetoram (spinosyns), teflubenzuron (insect growth regulators), mineral oil (botanical insecticide), and malathion (organophosphate). The insecticidal potency and residual activity are depended by many factors such as type of insecticide, application rate, the insect stages and crop species, and varieties. Therefore, this study was aimed to the screening of the selected insecticides represented from different groups for nymph and adult stages under optimum constant conditions using leaf dip bioassay. Moreover, under open field conditions, the efficiency of the selected insecticides using manufactures labels rate on the three thrips populations obtained from grape varieties was evaluated.

Materials and methods

Insects: The nymphs and adults of the BVT were collected from heavily infested vine grape cultivated in Plant Pathology Experimental Farm, Faculty of Agriculture from August to September 2014 season. All batches plants were cut by scissors and transferred to Plant Protection Laboratory, Faculty of Agriculture, Assiut University. The plants were kept in glass gars until the bioassay initiation.

Chemicals/Insecticides: Six commercial insecticides representing five different insecticide groups were used in this research. Two spinosyns insecticides; Spintor® (spinosad, 24 % SC, Dow AgroSciences Co.); and Radient® (spinetoram SC 12 %, , Dow AgroSciences Co.), one avermectin; Radical® (emamectin benzoate, 0.5 % EC, Agromen Chemicals Co., Ltd.), one insect growth regulator, Nomolt® (teflubenzuron, 15 % EC, Agromen Chemicals Co., Ltd.), one botanical insecticide; KZ oil ® (miniral oil, 95 % EC,) and one organophosphate, Agrothion® (malathion, 57 % EC, AgroChem., Egypt) were obtained from the local market. Surfactant; Triton $_{X-100}$® (purity 100 %, BDH Chem, Ltd. poole England) was bought from Aldrich Chem. Co.

Laboratory Bioassay: Leaf dip-bioassay technique (O'Brien et al., 1992) with little modifications was used in the toxicity tests. Five to six different concentrations of an aqueous solution of each compound plus 0.05% Triton $_{X-100}$ as a surfactant were prepared. In each concentration, separate batches of at least 20 apterous adults and 20 nymphs of thrips with approximately the same size were dipped for 10 seconds in the tested concentration. The treated insects were allowed to dry at room temperature for about half-hour post exposure. Control batches of thrips were similarly dipped in distilled water plus the surfactant, then individually transferred to Petri dishes (7 cm diameter), and held for 24 hours at the optimum conditions (22±2°C, 60±5% RH and photoperiod 12:12 (L:D). Thrips mortality was recorded at 24, 48 and 72 hours from exposure using a binocular microscope. The insect was considered dead if it was incapable of coordinated forward movement. The toxicity experiment of each compound was performed twice with triplicate. Results were corrected by Abbott's formula (Abbott, 1925) and LC_{50} and slope values were determined by a computerized Probit analysis program using SPSS Software Program, 2016.

Field Experiment: The field experiments were carried out on the three commercial vineyard varieties (Flaim, Banaty and King Roby) cultivated in clay loam soil since ten years at Plant Pathology Experimental Farm, Assiut University, Assiut Governorate, Egypt. Vines were planted 1.5 m apart in rows 3 m apart and a double cordon was used as the training system leaving about 80-buds per vine. Sixty three vine trees were used, and divided into 7 groups in randomized complete block design with three replicates. Three vine trees were used to every replicate. On September, 9, 2014, when the thrips infestations reached up to 5 % on trees, in a clear day without wind, the tested insecticide dilutions were applied using nozzle knapsack sprayer covering one liter solution vine tree. The recommendation label concentration of the tested insecticides was applied as follows: Emamectin benzoate (2 ml/liter), Spinetoram (0.6 ml/liter), Spinosad (0.25 ml/liter), Malathion (10.0 ml/liter), Miniral oil (10.0 ml /liter), Teflubenzuron (0.5 ml/liter). Tap water and Triton $_{X100}$ at 0.05 % was used in dilutions and also used as control. Culture practices as irrigation, fertilization and pest control were applied uniformly across the vineyard.

Sampling collection and data analysis: The samples were collected before and after treatment at periods of 3, 10 and 18 days post treatments. Three leaves from each tree were picked up, then put on plastic sac, and then transferred to laboratory for inspection the mortality of nymphs and adults of thrips using a binocular microscope. At all treatments, the average numbers of nymphs and adults per leaf were calculated. Analyses of variance were carried out using SPSS software program. Least significant difference (LSD) was calculated at $P \leq 0.05$. The % reductions were calculated according to the equation of (Henderson & Tilton, 1955).

Results

Laboratory results: The data represented in Table 1 showed that the LC_{50} values of six insecticides after 24 hours. Based on the LC_{50} values, emamectin benzoate revealed the highest toxic insecticide against nymphs (1.37 µg a.i./ml), while teflubenzuron was the react toxic insecticide (11900 µg a.i./ml).. Against adult thrips, spinetoram exhibited the highest toxic insecticide, (1.03 µg a.i./ ml), mineral oil has the lowest effective one (LC_{50} value, with 4560 µg a.i./ ml). On the other hand, teflubenzuron insecticide caused no mortality to thrips. Based on the laboratory potency ratios value emamectin benzoate and malathion were more toxic against nymph than adults by 3.11 and 1.79 folds, while, teflubenzuron showed the same activity against the two stages nymphs and adults. The thrips adults showed more susceptibility toward spinetoram and spinosad than the nymphs. The toxicity lines were sharper with nymphs than that recorded for adults. While the high slope value was recorded for spinetoram against adult (3.46), the least one with teflubenzuron (0.45) (Table 1 and Figure 1).

Table 1: LC_{50} and slope values of six insecticides on the nymph and adult stages of *R. syriacus* after 24 hours post treatment using leaf dip bioassay.

Insecticides	24 Hours post treatment						Potency Ratios(PR)
	Nymphs			Adults			
	$LC_{50\,z}$ (95 % CL) (µg a.i./ ml)	Slope ±SE	χ2	LC_{50} (95 % CL) (µg a.i./ ml)	Slope ±SE	χ2	
Emamectin benzoate	1.37 (0.29-4.94)	1.26 ±0.11	6.28	4.26 (2.71-9.26)	0.97 ±0.17	0.34	3.11
Spinetoram	1.57 (0.07-23.31)	1.48 ±0.15	4.28	1.03 (0.02-64.60)	0.88 ±0.07	42.33*	0.66
Spinosad	24.12 (10.0-49.59)	1.97 ±0.17	18.63*	21.18 (6.84-33.99)	3.46 ±0.35	6.45	0.88
Malathion	1374.57 (1194.00-1578.65)	2.11 ±0.17	3.58	2461.13 (1496.59-5698.35)	1.39 ±0.15	7.23	1.79
Miniral oil	3880.00 (-)	3.03 ±0.48	4.35	4560.00 (-)	2.74 ±0.29	26.21*	1.18
Teflubenzuron	11900.00 (3190.00-140380.00)	0.45 ±0.07	1.40	(-)	(-)	(-)	(-)

[PR] Potency ratios: LC_{50} of adult/ LC_{50} of nymph; [(-)]: the values undetected; * Significant χ2 value.

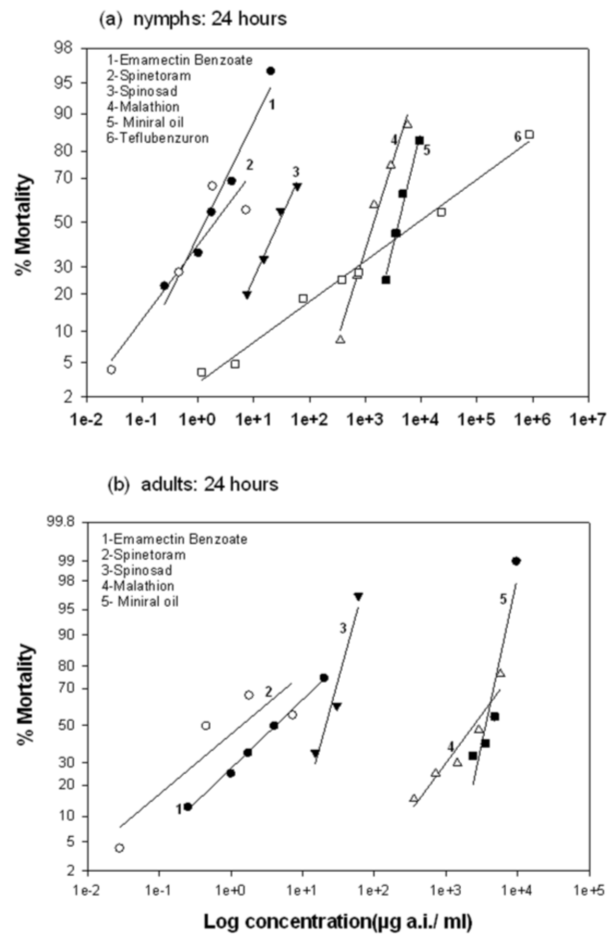

Figure 1: Efficency of emamectin benzoate, spinetoram, spinosad, malathion, miniral oil and teflubenzuron against nymphs **(a)** and adults **(b)** of the black vine thrips, *R. syriacus* after 24 h treatment.

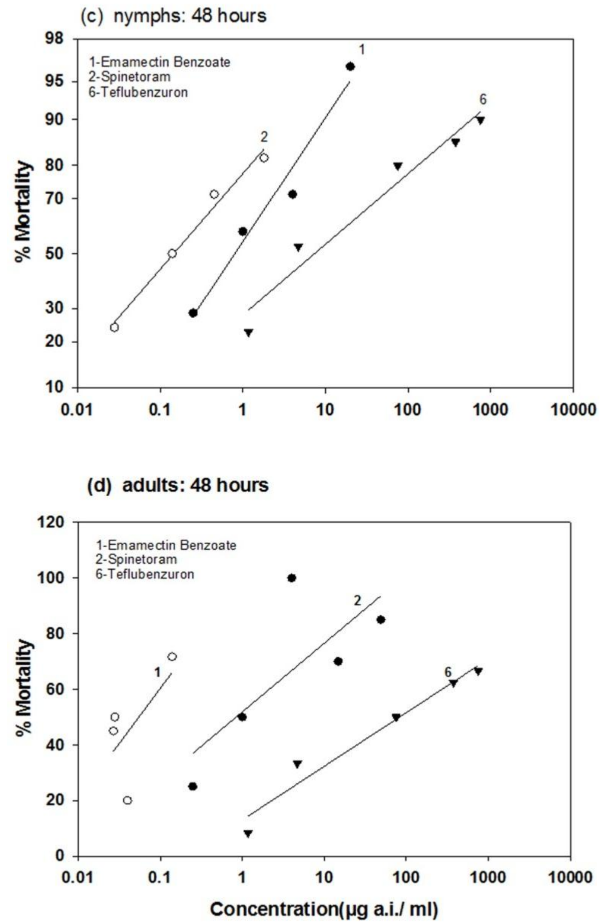

Figure 2: Efficiency of emamectin benzoate, spinetoram and teflubenzuron against nymphs **(c)** and adults **(d)** of the black vine thrips, *R. syriacus* after 48 h treatment.

The LC_{50} values of insecticides decreased after 48 hr post treatment. Spinetoram was the most toxic among tested insecticides against nymph and adults (0.14 and 0.037 µg a.i./ml), while teflubenzuron was the least toxic one (7.05 and 89.77 µg a.i./ ml) . The relative slope values were recorded for emamectin benzoate (1.11, 1.27) while the low values was teflubenzuron (0.68, 0.54) (Figure 2). Emamectin benzoate showed higher toxicity against nymphs than that for adults by 12.73, vice versa; adults were more susceptible four times than nymphs toward spinetoram after 48 hours. Also, teflubenzuron exhibited more potent against nymphs (2.58 µg a.i./ ml) than adults (4.43 µg a.i./ ml) at 72 hours (Table 2 and Figure 3).

Table 2: LC_{50} and slope values of some insecticides on the nymph and adult stages of *R. syriacus* after 48 and 72 hours post treatment.

Insecticides	48 Hours post treatment						Potency Ratios(PR)
	Nymphs			Adults			
	LC 50 (95 % CL) (µg a.i./ ml)	Slope ±SE	χ2	LC50 (95 % CL) (µg a.i./ ml)	Slope ±SE	χ2	
Emamectin benzoate	0.80 (0.14-2.10)	1.11 ±0.01	4.21	1.30 (0.99-1.77)	1.27 ±0.16	1.12	1.63
Spinetoram	0.14 (0.04-6.59)	1.06 ±0.91	7.26	0.04 (-)	0.88 ±0.07	17.54*	0.26
Teflubenzuron	7.05 (1.49-19.59)	0.68 ±0.06	6.52	89.77 (20.36-1726.0)	0.54 ±0.06	8.58	12.73
	72 Hours post treatment						
Teflubenzuron	2.58 (1.43-4.15)	0.74±0.07	3.51	4.43 (0.08-20.50)	0.77±0.24	0.58	1.68

[PR] Potency ratios: LC_{50} of adult/ LC_{50} of nymph; (-): the values undetected; *Significant χ2 value.

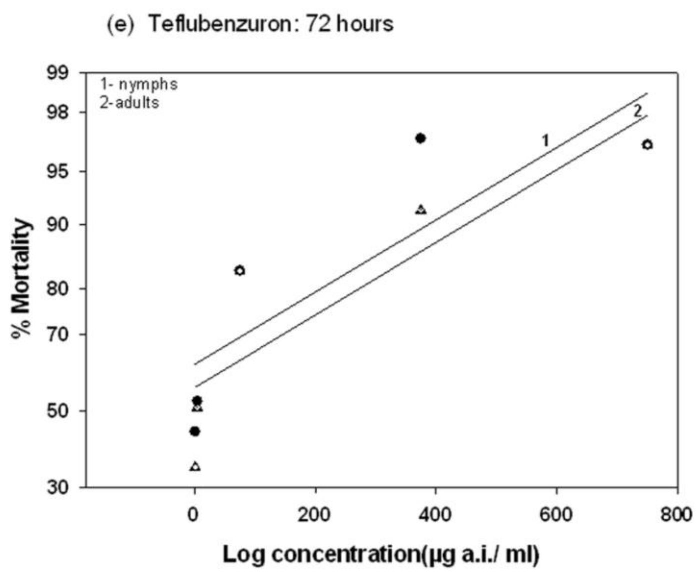

Figure 3: Efficinency of teflubenzuron against nymphs and adults of the black vine thrips, *R. syriacus* after 72 h treatment.

Susceptibility of certain varieties to thrip infestation: The results presented in figure 4 showed that King Roby vine variety was significantly susceptible to thrips infestation, while the Flaim was the most tolerant one during Sept., 10 to Oct., 8. Also, the highest fluctuation peak insect numbers (70.15±5.92 insects/leaf) was recorded at Sept., 22 for King Roby, while the lowest one at Oct., 8 (3.93±1.17 insects/leaf).

Residual activity results: No phytotoxicity symptoms were observed in any of treated plots at manufacture labels. The effect of dose of the five recent insecticides plus malathion was clarified in tables 3, 4 and 5.

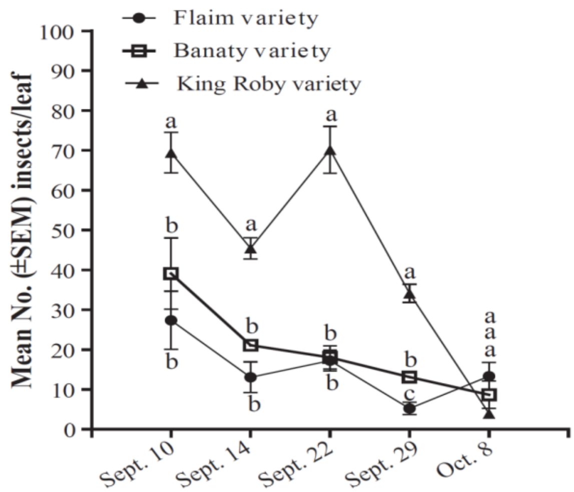

Figure 4: Susceptibility of Flaim, Banaty and King Roby grapevine varieties to the black vine thrips, *R. syriacus* infestation from Sept. 10 to Oct. 8, 2014 under field conditions.

The initial kill, three days post application, recoded 100 reduction percentages in nymph thrips numbers infesting the Flaim and Banaty varieties, where these values were gradually less on nymph thrips of King Roby variety. On the other hand, for adult thrips the reductions were less than 100 % at the tested varieties. In general the reduction in thrips population was varied among the three thrips variety. Generally, the reductions of thrips for all tested insecticides were higher on nymphs than that on adults at 3 days post application, while these values are greatly fluctuated in the rest of test time. Emamectin benzoate and malathion insecticides exhibited the highest reduction percentages among the rest test insecticides on the three vine varieties, where these values recorded 80.3 to 93.19% and 57.02 to 92.30% for emamectin benzoate and malathion, respectively. On the other hand, mineral oil showed the lowest reduction effect, with an average reduction ranged from -42.20 to 71.20%, while, the rest of the tested insecticides spinosad, spinetoram and teflubenzuron were of moderate reduction percentages.

Table 3: Efficiency of six insecticides tested against the black vine thrips, *R. syriacus*, adult and nymph populations on vinegrape Flaim variety under field conditions.

Insecticides	% Reduction of the black vine thrips						Mean reduction%	
	3DAT		10 DAT		18 DAT			
	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs
Emamectin benzoate 0.5%EC	95.73	100	93.64	100	82.74	40.90	90.70	80.30
Spinetoram 12%SC	79.73	100	81.26	83.52	-63.35	35.56	32.55	73.10
Spinosad 24%SC	97.63	100	84.46	62.71	40.80	88.20	90.10	83.64
Malathion 57%EC	95.32	100	100	100	62.31	76.90	85.87	92.30
Miniral oil, 95%EC	88.10	100	-60.09	71.94	-111.1	41.66	-27.96	71.20
Teflubenzuron 15%EC	75.67	100	95.50	63.17	45.42	27.70	72.20	63.60

Table 4: Efficiency of six insecticides tested against the black vine thrips, *R. syriacus*, adult and nymph populations on vinegrape Banaty variety under field conditions.

Insecticides	% Reduction of the black vine thrips						Mean reduction%	
	3DAT		10 DAT		18 DAT			
	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs
Emamectin benzoate 0.5%EC	91.07	100	91.80	91.21	85.48	88.35	89.45	93.19
Spinetoram 12%SC	5.13	100	3.49	72.42	6.03	69.63	4.88	80.68
Spinosad 24%SC	92.66	100	67.71	91.82	69.73	51.61	76.70	81.14
Malathion 57%EC	92.06	100	93.21	80.16	65.33	35.53	83.53	71.90
Miniral oil, 95%EC	52.16	100	-90.77	-37.44	-3.86	51.01	-42.29	37.86
Teflubenzuron 15%EC	75.25	100	59.80	92.91	70.10	85.96	92.96	74.29

Table 5: Efficiency of six insecticides tested against the black vine thrips, *R. syriacus*, adult and nymph populations on vinegrape King Roby variety under field conditions.

Insecticides	% Reduction of the black vine thrips						Mean reduction%	
	3DAT		10 DAT		18 DAT			
	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs
Emamectin benzoate 0.5%EC	74.72	100	89.80	90.02	77.47	91.46	80.66	93.83
Spinetoram 12%SC	69.05	66.74	60.88	77.37	-138.2	21.39	-8.27	55.17
Spinosad 24%SC	66.19	51.09	24.23	-25.59	40.17	-54.45	43.53	-9.65
Malathion 57%EC	84.17	89.15	94.83	90.91	76.82	-8.99	85.27	57.02
Miniral oil, 95%EC	28.84	67.29	42.07	29.32	-70.40	-118.22	0.17	-7.20
Teflubenzuron 15%EC	78.35	76.06	86.82	57.94	56.44	20.67	73.87	51.56

Discussion

The current study evaluated the effectiveness of six insecticides from five chemical classes against nymphs and adults of BVT. The results demonstrated that emamectin benzoate was the highest effective insecticide. Emamectin benzoate and malathion kept the highest efficiency and persistence insecticides against nymphs and adults under laboratory and field conditions. However the two compounds act as nervous neurons poisons, each one have unique mode of action, the former acts on chloride receptor and γ - amino butyric acid (GABA) neuron receptors (Ishaaya et al., 2002), where the later inhibits the neuron acetylcholine esterase (AChEs) (IRAC, 2016). The development of resistance has been a serious problem in the control of thrips (Toda & Morishita, 2009). Insecticide resistance management (IRM) depends on using different insecticide that have unique mode of action. Regular apply of insecticides rise the potential for resistance. An extremely variety of insecticides and modern resistance management tactics need to be expand to reduce existence of resistance in grapevine thrips. The three commercial vineyard varieties influenced the population density of *R. syriacus*, with

Flaim and Banaty being the least suitable host plant and King Roby being the most susceptible host. The low susceptibility of Flaim to the black vine thrips, *R. syriacus* could be attributed to physical and or biochemical characteristics as was found on other vineyard varieties (Khalil et al., 2010), canola cultivars (Fathi et al., 2011), and on different onion host plants (Larentzaki et al., 2007). The susceptibility of grapevine varieties to thrips infestation should be considered to improve the insect management programs. The variations in the reduction of the same insecticides on the difference variety could be explained to factors related to the physio-chemical insecticide properties and host plant characterization e.g. leave form, and leaves thickness, moreover the environmental factors effect on host plant and insecticide interactions. The toxicity and persistence of emamectin benzoate and spinetoram were varied in lablab host plant than cotton (Abdu-Allah, 2011). Our results are supported by other investigations (Yadav et al., 2016) who found that spinosad, emamectin benzoate, fipronil and cyantraniliprole caused mortality from 85.09-98.02 % in laboratory, and 65.36-91.5 % reduction in population in field to *Scirtothrips dorsalis*. In another study, chemical insecticide lambad-cyhalothrin was the higher in reduction onion thrips population than spinetoram, with 84.48 and 81.05% at recommended dose, while pyridayl was the lowest effective, with 74.26% (Temerak et al., 2015). Spinosad and azadirachtin gave the best control and continued to give significant reduction in thrips populations till 21 days of treatment compared to the other insecticides (Mahmoud & Osman, 2007). Although, herein, mineral oil gave low reduction from -7 to 71% comparing with synthetic insecticides, it can be used in thrips control. Insecticides extracted from plants have less negative environmental effects and create comparatively less risk of insecticide resistance than synthetic insecticides; therefore, they can be proposed as a safe tool for management of pests (Murray, 2006). In most cases, the residual efficiency of emamectin benzoate, malathion and teflubenzuron were extended to 18 days post application. In comparison of the tested insecticides to the recommended insecticide (spinetoram), emamectin benzoate, spinetoram analogue (spinosad) and malathion (organophosphate insecticide) were more potent than spinetoram in reduction thrips population. To sum up, the present study recommends that emamaectin benzoate was better than spinetoram in nymphs of BVT in field results, it should use as alternative candidate to spinetoram, also, malathion is still effective in control. Teflubenzuron gave good results especially in extended persistence time, this compound acts as insect growth regulators. So that, emamectin benzoate and teflubenzuron, spinetotram and malathion should be considered in integrated pest management (IPM) programs of thrips.

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