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Efficacy of different natural compounds on cotton and tomato whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) and its parasitoid *Eretmocerus mundus* (Hymenoptera: Aphelinidae) on vegetable crops

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Abstract:

The cotton and tomato whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is a widely distributed and highly harmful plant pest species. In this study, we evaluated the insecticidal effects of insecticides and botanical oils against the cotton and tomato whitefly *B. tabaci* infested squash and cucumber and its parasitoid *E. mundus* in Garbiya and Minufiya Governorates, respectively, throughout the experiment period 2020 and 2021. The results indicated that the confidor was the most effective treatment against *B. tabaci* and its parasitoid *Eretmocerus mundus* (Mercet) (Hymenoptera: Aphelinidae). Lemon oil compound caused the lowest reduction against *B. tabaci* and its parasitoid *E. mundus*. It is concluded that essential oil and plant extract are promising compounds to control *B. tabaci* and are safe to survive the parasitoid *E.mundus*.

Introduction

The cotton and tomato whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), a pest with piercing-sucking mouthparts, is the most significant pest of agriculture and horticulture worldwide and is widely distributed throughout tropical and subtropical regions (Brown and Bird, 1992 and Abd-Rabou and Simmons, 2010)).

B. tabaci is not a single species but a complex of 46 cryptic species, which are potential vectors of approximately 320 begomovirus species, most of which are significant plant viruses (De Barro *et al*., 2011). High populations of *B. tabaci* induce losses in plant productivity by direct feeding, fungal growth associated with honeydew contamination, and plant physiological disorders. Losses also occur from *B. tabaci* due to the efficient transmission of *Begomovirus*, a genus of the taxonomic family Geminiviridae that causes leaf yellow mosaic and mottling, leaf distortion, and stunting (Oliveira *et al*., 2001 and Morales, 2007).

Synthetic chemical pesticides have served as a main tool in crop protection over the past 50 years (Chandler *et al*., 2011). However, excessive and injudicious use of these synthetic pesticides has resulted in management failure and damage to human health and the environment (Palumbo *et al*., 2001 and Isman, 2006). The use of pesticide products based on "old" chemistry is becoming more

difficult and being withdrawn because of the development of heritable resistance and new health and safety legislation (Chandler *et al*., 2011). Despite the urgent need for alternative tactics, the rate at which new and more environment-friendly chemicals such as biopesticides are being developed is very low (Thacker, 2002). To date, pyrethrum and neem are well established in the marketplace, and plant essential oil products have been recently added to the arsenal (Pimentel, 2005).

The management of *B. tabaci* has been typically carried out by chemical pesticides. In the last decade, however, there has been an increasing interest in natural products, particularly those of plant origin, to control this pest species. In a recent review article by Chandler *et al.* (2011) only four biopesticides including *Bacillus thuringiensis var kurstaki (Bacterium), Beauveria bassiana* (Fungus), *Cydia pomonella* GV (Virus), and azadirachtin (Biochemical) were listed as active ingredients in the representative examples of commercially available biopesticides. For *B. tabaci*, previous studies indicate that pyrethrum, neem-based formulation, and essential oils have promising potentials to control whiteflies (Golmohammadi *et al*., 2014). Simmonds *et al.* (2002) stated that for the whitefly *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae), applications of pyrethrum resulted in fast and high mortality to the adults but also showed high toxicity on a whitefly parasitoid *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae). In the same study, the authors concluded that a commercial neem-based formulation had the most potential for use in an IPM program because the neem product caused 50% mortality of adult whiteflies in 6 h with very low toxicity to the parasitoid.

Limonene is an active insecticidal compound in several pesticides used as insecticides, insect repellents, and dog and cat repellents (Hebeish *et al*., 2008). The potential adverse effects of insecticides on plants have been studied with various synthetic and natural compounds (Liu *et al*., 2006). A recent study showed the deterrence and toxicity effects of citronellol and geraniol on *B. tabaci* (Baldin *et al*., 2014). In many studies, the activity of essential oil against insects is explained by the major compounds (Ipek *et al*., 2005). Cruz-Estrada *et al.* (2013) stated that the most promising compounds of four essential oils (Cumin, cinnamon, citronella, and lemongrass) for pest control applications and the most promising compounds for net treatments were cinnamaldehyde, limonene, citronellol, citronellal, citral, and geraniol because their associated whitefly net-crossing rates were low. The identified volatile candidates may be emitted by companion plants or by diffusers, e.g., Chemically impregnated nets, to repel whiteflies. Essential oils could be used alone or in mixtures to establish an olfactory barrier as a supplement to the visual and physical barrier of an insect-proof net in order to protect vegetables (Deletre *et al*., 2016).

In this study, we evaluated the insecticidal effects of insecticides and botanical oils against the cotton and tomato whitefly *B. tabaci* infested squash and cucumber and its parasitoid *E. mundus* in Garbiya and Minufiya, Governorates, respectively.

Materials and methods

1. Efficacy of insecticides and botanical oils against the cotton and tomato whitefly *Bemisia tabaci* and its parasitoid:

The current study was carried out to evaluate the field performance of

eight insecticides in their respective commercial formulations available on the market. The insecticide generic and chemical information is given in Table (1). The concentrations used were based on the recommendations of the Egyptian Ministry of Agriculture for each insecticide to control the pest insects under field conditions.

A field trial was conducted on squash and cucumber plants grown on a farm located in Garbiya and Minufiya Governorates, respectively, during two consecutive summer seasons of 2020 and 2021. The infested plants with cotton and tomato whitefly were identified, selected, and labeled before the application of insecticides. This area did not receive any insecticidal treatments before the start of the experiment. The trial of nine treatments (Eight insecticides + control) was laid out in a randomized complete block design with three replicates. A spray was applied with a CP3 knapsack sprayer (Cooper Pegler Co. Ltd., Northumberland, England). The insecticides were used in the commercial formulation and the concentrations were prepared using water as a diluent. Insecticides were sprayed in the early morning when the insects were active, and the environmental conditions minimize the potential risk of spray drift and evaporation. Control plots were sprayed with water only. Thirty plants with a heavy infestation of whitefly and associated the parasitoid were randomly selected in the field. Plant to plant distance was 30 cm. Each plant acted as a replicate. The spray application was done on 20th and 30th October during 2020 and 2021, respectively. Data were recorded on the selected plants before spraying and 7, 14 and 21 days after application. The mean numbers cotton whitefly per plants and associated parasitoid were recorded.

2. Statistical Analysis:

The data were subjected to analysis of variance (ANOVA) and the means were compared with LSD test at 0.05 level, using the SAS. The percent reduction of the whitefly population and associated parasitoid in all treatments compared to the control were calculated according to the Henderson and Tilton formula (1955).

Table (1): Insecticides and botanical oils with their trade name, the active ingredient, and rate of application.

Trade Name	Common Name	Rate/ L Water
KZ oil	Mineral oil	1 Litre oil/ 100 Liter water
Biovar	*Beauveria bassiana*	200 gm / 100 L.
Bioranza	*Metarhizium anisopliae*	200 ml/100 L.
Azadirachtin	*Azadirachtin indica*	5 ml/Lw
Lemon oil	Lemon oil	5 cm/1L
Applaud	Buprofezin	600 cm3 /fed.
Garlic oil extraction	Garlic oil extraction	5 cm/1L
Confidor 20 SL	Imidacloprid	30 cm /100L

Results and discussion

1. Efficacy of insecticides and botanical oils against the cotton and tomato whitefly *Bemisia tabaci* and its parasitoid in Garbiya on squash during 2020-2021:

The obtained data shown in (Tables 2-5) revealed that the confidor was the most effective treatments against *B. tabaci* throughout the experiment period 2020 and 2021. Whereas the reduction percentage for confidor was 91.97 and 93.35, respectively. In addition, Kz oil gave (89. 17 and 90.22%) reduction followed by garlic oil (85.62 and 86.56%), applaud (85.01 and 84.01), bioranza (83.63 and 85.71), azadirachtin (82.88 and 93.42), biovar (80.53 and 81.17) and lemon oil (80.0 and 78.68),

respectively. Considering the probable occurring side effects of the tested compounds on the non-targeted parasitoid *E. mundus* during 2020 and 2021, the data shown in (Tables 2 to 5) illustrate that lemon oil compound caused a lowest reduction effect (58.86 and 57.5%) followed by ascending by azadirachtin (62.91 and 64.26%), then bioranza (63.71 and 64.26 %), and garlic oil (63.87 and 69.34%) with no significant differences between them. Then confidor, KZ oil, biovar and applaud where they caused highest parasite reduction percentage reached (73.18 and 74.54%), (69.32 and 70.79%), (69.32 and 66.95 %) and (69.95 and 68.88%) in respect without no significant differences between them. Results of statistical analysis (F value and L.S.D.) (Tables, 3-5) showed that seven treatments had significant effect on populations.

2.Efficacy of insecticides and botanical oils against the cotton and tomato whitefly *Bemisia tabaci* **and its parasitoid in** Minufiya **on cucumber 2020-2021:**

The obtained data shown in (Tables, 6 - 9) revealed that the confidor was the most effective treatments against *B. tabaci* throughout the experiment period 2020 and 2021. Whereas the reduction percentage for confidor was 92.02, respectively. In addition, KZ oil (91.58 and 90.85) reduction followed by garlic oil (85.97 and 84.85%), applaud (85.97 and 83.84%), bioranza (84.71 and 85.07), biovar (83.33 and 82.62), azadirachtin (82.67 and 80.40), and lemon oil (79.9 and 81.91), respectively. Considering the probable occurring side effects of the tested compounds on the non-targeted parasitoid *E. mundus* during 2020 and 2021, the data shown in (Table 6 and 9) illustrate that lemon oil compound caused a lowest reduction effect (62.77 and 53.98 %) followed by ascending by garlic oil (65.76 and 60.87 %), azadirachtin (66.54and60.72 %) and applaud (66.72-62.48) (With no significant differences between them. Then KZ oil, confidor, bioranza, biovar. Where they caused the highest parasite reduction percentage reached (75.58 and 78.45%), (72.78 and 68.42%), (70.61 and 68.4 %) , (68.72and 64.76%) in respect without no significant differences between them.

Results of statistical analysis (F value and L.S.D.) (Tables, 7 and 9) showed that seven treatments had a significant effect on populations.

The results of the present work indicated that Kz oil gave (89. 17 and 90.22%) reduction followed by garlic oil (85.62 and 86.56%), and lemon oil (80.0 and 78.68%), respectively, during the two years under consideration in Garbiya on squash. While KZ oil (91.58 and 90.85%) was reduced followed by garlic oil (85.97 and 84.85%), and lemon oil (79.9 and 81.91%), respectively. during the two years under consideration in Minufiya on cucumber.

Essential oils of *Cymbopogon citratus*, *Cymbopogon winterianus*, *Cuminum cyminum* and *Cinnamomumzey lanicum* showed toxic effects at 1%, i.e. 96.3% mortality for cinnamon oil, 64.7% forcitronella oil, 61.0% for lemongrass oil and 30.0% for cumin oil (Deletre *et al*., 2016). The present work results indicated that the effect of azadirachtin on *B. tabaci* were (82.88 and 93.42%) in Garbiya on squash and (82.67and 80.40 %) in Minufiya on cucumber 2020-2021, respectively. Plant extracts are currently being studied as an ecologically friendly alternative to manage plant pests. Studies on botanical insecticides against *B. tabaci* have focused particularly on essential oils of different plants, such as *Thymus vulgaris, Allium cepa, Allium sativum, Satureja hortensis*, *Achillea biebersteinii, Cinnamomum verum, Syzygium aromaticum, Alkanna strigosa, Ballota undulate, Galium longifolium, Lepidium sativum, Peganum harmala,*

Pimpinella anisum, Ruta chalepensis, Retama raetam and *Urtica pilulifera*, where 60-100% mortality has been reported (Ateyyat *et al*., 2009). Other authors have also documented the insecticidal effects of seed oil from *Azadirachta indica*, and their principle active ingredient azadirachtin on *B. tabaci* (Aslan *et al*., 2004; Pinheiro *et al*., 2009 and Lynn *et al*., 2010). In general, the insecticidal properties of most of the native and adapted plants in Yucatan have been scarcely studied. In this work, all aqueous and ethanolic extracts of tested plants caused high mortality on *B. tabaci* eggs, however, on *B. tabaci* nymphs only ethanolic extracts were active (Cruz-Estrada *et al*., 2013).

Studies on the insecticidal properties of *A. squamosa* have been focused mainly on the activity of its seed extracts, where activity has been attributed to the metabolites squamocin, annotemoyin and neoannonin, which target Diptera, Coleoptera and Lepidoptera, (Castillo-Sánchez *et al*., 2010). This is worth noting that among all plant species tested, only in *Petiveria alliaceae* both types of extracts (Aqueous and ethanolic) were active on immature *B. tabaci*. The insecticidal activity of extracts of leaves and other organs of *P. alliaceae* has been previously reported. For example, García-Mateos *et al*. (2007) reported that aqueous, methanolic and dicloromethane extracts of leaves caused 100% mortality on the whitefly *Trialeurodes vaporariorum* (Westwood). The plant extracts *Trichilia arborea* showed high insecticidal activity. To the best of our knowledge, no reports of insecticidal activity or chemical constituents of this endemic species was previously available. Nevertheless, *Trichilia* genus belongs to the Meliacea family, as *Azadirachta indica*, for instance we might expect *T. arborea* to have insecticidal properties. Other species of *Trichilia*, like *T. pallida*, has shown insecticidal effects. For example, Baldin *et al*. (2007) documented those aqueous extracts of branches and leaves of *T. pallida* caused high mortality on *B. tabaci* nymphs in tomato plants under greenhouse conditions.

The plant extracts tested in this study, particularly those of *T. arborea* and *P. alliaceae* showed the potential to be developed into compounds for the management of immature whitefly. Further research will focus on evaluating these extracts through a bioassay-guided process, to determine the metabolites responsible for the insecticidal effect on immatures of *B. tabaci*. In the long term, our goal is to develop safer alternatives to manage *B. tabaci*. These natural products might be considered an important component of the integrated pest management system.

The family Aphelinidae contains many *B. tabaci* parasitic wasps including the most important genus *E. mundus* is indigenous to the Mediterranean region and is used commercially for *B. tabaci* management in many parts of the world (Urbaneja *et al*., 2007). The three most promising plant extracts (*Alkanna strigosa , Peganum harmal* and *Ruta chalepensis*) were tested to determine if they adversely affect *E. mundus*. The results showed that the extracts *P. harmala* and *R. chalepensis* were not detrimental to the parasitoid; however, *A. strigosa* adversely affected the emergence of *E. mundus* from *B. tabaci* parasitized pupa. The identification of selective chemicals with little or no harmful effects on the *B. tabaci* parasitoid is a desirable goal for the development of sound and effective management strategies.

It is concluded that essential oil and plant extract are promising control methods for *B. tabaci* and are safe to survive the parasitoid *E.mundus*. Also, it plays a good role in the integrated management of this pest.

Table (2): Average numbers of the cotton whitefly, *Bemisia tabaci* and its associated parasitoid on squash plants in Garbiya during summer season 2020.

Treatment	Rate of Applic. /L.W.	Pre spraying count			Post spraying count after:									Average number			
					7			15			21						
		A	N	P	A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	78.8	314	81.1	14.1	38.9	28.2	11.7	28	27	9.9	17.5	26.1	11.9	28.1	20	27.1
Biovar	200 gm / 100 L.	84.9	362	83.7	24.9	81.0	34.3	22.3	61.3	32.9	19.1	43.1	31.8	22.1	61.8	41.95	33.0
Bioranza	200 ml/100 L.	87.7	408	86.2	20.1	79.7	36.2	18.3	64.3	34.7	15.3	56.0	32.8	17.9	66.66	42.28	34.56
Azadirachtin	5 ml/Lw	81.3	325.9	78.2	18.1	69.3	32.9	17.9	54.0	31.2	15.1	43.1	30.7	17.03	55.46	36.24	31.6
Lemon oil	5 cm/1L	92.3	433.8	99.8	29.3	99.5	48.1	23.3	78.7	44.3	18.1	65.0	42.2	23.56	81.06	52.31	44.86
Applaud	600 cm3 /fed.	82.8	330	79.3	21.6	46.3	27.4	19.0	36.7	26.1	14.8	22.5	25.2	18.46	35.16	26.81	26.26
Garlic oil extraction	5 cm/1L	90.9	429.7	85.5	18.7	72.2	35.0	16.3	58.3	33.9	13.9	49.0	32.3	16.3	59.83	38.06	33.73
Confidor 20 SL	30 cm /100L	88.7	389.4	83.0	12.0	26.7	26.3	9.3	28.7	24.0	6.8	18.0	22.3	9.36	27.8	18.58	24.2
Control		91.6	421.7	94.6	96.3	45.7	77.1	101.1	47.2	103.3	108.2	489.3	110.0	101.83	472.16	287.01	103.46

A. Adult N.Nymph P. Parasitoid T. Total

Table (3): Reduction percentage of different compounds on the cotton whitefly, *Bemisia tabaci* and its parasitoid on squash plants in Garbiya during summer season 2020.

Treatment	Rate of Applic. /L.W.	%Reduction after:									Average %reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	82.98	89.4	66.13	86.55	92.13	69.52	89.37	95.28	72.33	86.3	92.05 Ab	89.17 ab	69.32 ab
Biovar	200 gm / 100 L.	72.11	79.36	60.08	76.21	84.82	64.01	80.96	89.74	67.33	76.42	84.64	80.53 c	63.80 bc
Bioranza	200 ml/100 L.	78.69	84.98	59.09	81.52	85.87	63.14	85.56	88.18	67.28	81.92	85.34	84.13 bc	63.17 bc
Azadirachtin	5 ml/Lw	78.83	80.38	59.02	80.06	85.14	63.47	84.28	88.61	66.24	81.05	84.71	82.88 c	62.91 c
Lemon oil	5 cm/1L	69.81	78.84	53.05	77.13	83.73	59.35	83.4	87.09	63.64	76.78	83.22	80.0 c	58.68 c
Applaud	600 cm3 /fed.	75.04	87.06	66.34	79.09	90.03	69.86	84.78	94.13	72.57	79.63	90.40	85.01 bc	69.59 ab
Garlic oil extraction	5 cm/1L	80.44	84.5	60.12	83.76	87.84	63.7	87.06	90.18	67.52	83.75	87.50	85.62 ab	63.78 bc
Confidor 20 SL	30 cm /100L	87.14	91.31	69.13	90.51	93.39	73.52	93.51	96.02	76.9	90.38	93.57	91.97 a	73.18 a
F value													3.49	4.43
L.S.D.													6.58	6.70

A. Adult N.Nymph P. Parasitoid T. Total
A b c d letters indicating significantly differences between treatments

Table (4): Average numbers of the cotton whitefly, *Bemisia tabaci* and its associated parasitoid on squash plants in Garbiya during summer season 2021.

Treatment	Rate of Applic. /L.W.	Pre spraying count			Post spraying count after:									Average number			
					7			15			21						
		A	N	P	A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	82.1	328.3	78.8	14.8	41.1	28.2	9.7	29.7	25.1	6.1	18.1	22.9	10.2	29.63	19.91	25.4
Biovar	200 gm / 100 L.	79.6	301.3	72.7	22.3	77.3	27.7	17.7	55.9	26.9	14.1	38.1	25.5	18.03	57.1	37.56	26.7
Bioranza	200 ml/100 L.	84.2	345.2	83.7	19.1	69.1	32.1	13.9	43.2	29.3	9.9	38.1	27.9	14.3	50.13	32.21	29.76
Azadirachtin	5 ml/Lw	80.9	316.4	76.6	19.6	600.7	31.8	17.9	45.5	30.7	14.8	37.7	28.4	17.43	47.96	32.69	30.3
Lemon oil	5 cm/1L	75.9	289.9	68.4	24.2	75.7	33.9	20.7	53.1	32.8	17.8	41.9	29.7	20.9	56.9	38.9	32.1
Applaud	600 cm3 /fed.	86.3	361.2	85.5	23.9	48.9	31.0	21.4	35.1	29.0	19.7	25.7	28.4	21.66	36.56	29.11	29.46
Garlic oil extraction	5 cm/1L	77.9	293.2	74.7	17.8	44.3	26.2	31.1	36.6	25.3	9.4	28.3	24.4	13.43	36.4	24.91	25.3
Confidor 20 SL	30 cm /100L	87.1	377.0	88.2	10.9	34.1	27.9	8.3	19.0	24.4	4.8	6.9	22.0	8.0	20.0	14.0	24.76
Control		81.9	320.2	79.9	84.1	34.33	82.1	89.7	371.1	89.2	94.2	404.0	95.8	89.33	372.8	231.06	689.03

A. Adult N.Nymph P. Parasitoid T. Total

Table (5): Reduction percentage of different compounds on the cotton whitefly, *Bemisia tabaci* and its parasitoid on squash plants in Garbiya during summer season 2020.

Treatment	Rate of Applic. /L.W.	%Reduction after:									Average %reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N		P
KZ oil	1 Litre oil/ 100 Liter water	82.45	88.33	65.13	89.22	92.2	71.47	93.55	95.64	75.77	88.40	92.05	90.22 ab	70.79 ab
Biovar	200 gm / 100 L.	72.72	76.08	62.92	79.7	84.0	66.86	84.6	89.98	70.75	79.0	83.35	81.17 c	66.84 ab
Bioranza	200 ml/100 L.	77.91	81.33	62.68	84.93	89.14	68.65	89.78	91.21	72.2	84.20	87.22	85.71 ab	67.84 ab
Azadirachtin	5 ml/Lw	76.41	82.11	59.6	79.8	87.6	64.11	84.1	90.56	69.08	80.10	86.75	83.42 bc	64.26 bc
Lemon oil	5 cm/1L	68.96	75.65	51.7	75.1	84.2	57.05	79.62	88.55	63.79	74.56	82.8	78.68 c	57.51 c
Applaud	600 cm3 /fed.	73.04	87.38	64.72	77.36	91.62	69.62	80.3	94.37	72.3	76.9	91.12	84.01 bc	68.88 ab
Garlic oil extraction	5 cm/1L	77.75	85.91	65.87	84.65	89.23	69.67	89.51	92.35	72.76	83.97	89.16	86.56 abc	69.43 ab
Confidor 20 SL	30 cm /100L	87.82	91.57	69.22	91.3	95.66	75.22	95.2	98.55	77.2	91.44	95.26	93.35 a	73.88 a
F value													2.79	3.38
L.S.D.													8.48	7.98

A. Adult N.Nymph P. Parasitoid T. Total

A b c d letters indicating significantly differences between treatments

Table (6): Average numbers of the cotton whitefly, *Bemisia tabaci* and its associated parasitoid on cucumber plants in Minufiya during summer season 2020.

Treatment	Rate of Applic. /L.W.	Pre spraying count			Post spraying count after:									Average number			
					15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	91.2	414.1	93.7	13.9	40.0	27.3	11.0	30.9	26.0	7.3	19.3	24.9	10.73	30.06	20.39	26.06
Biovar	200 gm / 100 L.	87.7	387.2	86.3	21.1	75.0	32.1	19.0	63.2	31.0	16.8	51.2	30.0	18.96	63.13	41.04	31.03
Bioranza	200 ml/100 L.	93.7	431.3	98.2	22.0	76.6	34.0	18.1	64.3	33.1	16.3	49.0	32.5	18.8	63.3	41.05	33.2
Azadirachtin	5 ml/Lw	97.8	482.0	102.1	23.9	101.0	41.1	21.3	83.9	38.8	18.9	69.0	37.9	21.36	84.63	52.99	39.26
Lemon oil	5 cm/1L	89.9	406.4	91.1	26.1	93.3	39.8	23.0	81.0	38.9	20.2	69.9	38.4	23.1	81.4	52.25	39.03
Applaud	600 cm3 /fed.	94.7	449.1	96.3	22.1	67.9	37.7	20.7	55.6	37.0	17.0	38.3	35.9	19.93	53.93	36.93	36.86
Garlic oil extraction	5 cm/1L	88.9	382.0	90.0	18.9	61.5	36.0	16.8	52.0	35.5	15.6	36.7	34.9	17.1	50.06	33.58	35.46
Confidor 20 SL	30 cm /100L	85.9	351.2	83.8	12.0	33.1	28.0	9.1	24.0	26.2	7.3	17.1	24.3	9.46	24.73	17.09	26.1
Control		95.7	4221.0	91.2	103.2	449.3	76.7	111.3	468.1	104.3	122.1	499.7	115.9	112.2	472.3	292.25	105.6

A. Adult N.Nymph P. Parasitoid T. Total

Table (7): Reduction percentage of different compounds on the cotton whitefly, *Bemisia tabaci* and its parasitoid on cucumber plants in Minufiya during summer season 2020.

Treatment	Rate of Applic. /L.W.	%Reduction after:									Average %reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	85.87	90.93	72.53	89.63	93.28	75.74	93.73	96.07	79.09	89.74	93.42	91.58 ab	75.78 a
Biovar	200 gm / 100 L.	77.69	81.81	64.92	81.38	85.29	68.6	84.99	88.84	72.65	81.35	85.31	83.33 C	68.72 bc
Bioranza	200 ml/100 L.	78.23	83.32	67.35	83.4	86.56	71.24	86.37	90.41	73.96	82.66	86.76	84.71 C	70.61 ab
Azadirachtin	5 ml/Lw	77.34	80.32	62.04	81.28	84.31	66.78	84.86	87.91	70.8	81.16	84.18	82.67 C	66.54 bc
Lemon oil	5 cm/1L	73.08	78.44	58.8	78.01	82.03	62.67	82.39	85.48	66.84	77.82	81.98	79.9 C	62.77 c
Applaud	600 cm3 /fed.	78.36	85.8	63.08	81.21	88.84	66.41	85.93	92.8	70.67	81.83	89.14	85.48 Bc	66.72 bc
Garlic oil extraction	5 cm/1L	80.29	84.88	62.28	83.76	88.32	65.51	86.25	92.33	69.49	83.43	88.51	85.97 Ab	65.76 c
Confidor 20 SL	30 cm /100L	87.05	91.15	68.49	90.9	93.84	72.67	93.34	95.89	77.19	90.43	93.62	92.02 A	72.78 ab
F value													4.20	3.58
L.S.D.													6.16	6.66

A. Adult N.Nymph P. Parasitoid T. Total

A b c d letters indicating significantly differences between treatments

Table (8): Average numbers of the cotton whitefly, *Bemisia tabaci* and its associated parasitoid on cucumber plants in Minufiya during summer season 2021.

Treatment	Rate of Applic. /L.W.	Pre spraying count			Post spraying count after:									Average number			
					15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	89.3	395.8	91.3	13.8	42.4	30.0	10.4	37	28.8	7.4	23.7	27.4	10.53	34.36	22.44	28.73
Biovar	200 gm / 100 L.	96.6	465.9	111.0	25.3	88.9	46.0	21.5	76.6	45.7	19.1	66.0	44.8	21.96	77.16	49.56	45.5
Bioranza	200 ml/100 L.	85.6	361.4	83.9	18.9	65.7	32.0	16.1	53.0	31.3	14.9	35.2	29.0	16.63	51.3	33.96	30.76
Azadirachtin	5 ml/Lw	92.9	427.8	107.2	25.0	91.2	51.1	22.9	86.0	48.7	21.1	73.9	46.9	23.0	83.7	53.35	48.9
Lemon oil	5 cm/1L	98.1	481.0	118.3	24.6	88.7	64.0	22.8	83.3	63.5	21.9	80.2	62.5	23.1	84.06	53.58	63.33
Applaud	600 cm3 /fed.	87.8	392.7	89.8	25.9	58.8	40.8	22.8	41.0	38.7	18.7	28.8	37.9	22.46	42.86	32.66	39.13
Garlic oil extraction	5 cm/1L	90.3	398.9	96.1	21.7	65	45.0	19.0	49.3	43.9	16.8	41.3	42.2	19.16	51.86	35.51	43.7
Confidor 20 SL	30 cm /100L	93.1	433.4	98.2	14.0	41.8	31.1	11.1	28.3	30.8	7.1	15.9	29.0	10.7	28.6	19.65	30.3
Control		91.8	409.2	96.2	97.1	425.3	103	106.5	454	113.3	117	489.6	121.3	106.8	456.3	281.55	112.46

A. Adult N.Nymph P. Parasitoid T. Total

Table (9): Reduction percentage of different compounds on the cotton whitefly, *Bemisia tabaci* and its parasitoid on cucumber plants in Minufiya during summer season 2021.

Treatment	Rate of Applic. /L.W.	%Reduction after:									Average %reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
KZ oil	1 Litre oil/ 100 Liter water	85.39	89.7	69.31	89.97	91.58	73.22	93.5	95.0	76.16	89.62	92.09	90.85 ab	72.89 a
Biovar	200 gm / 100 L.	75.32	81.65	61.3	80.88	85.19	65.05	84.54	88.17	67.94	80.24	85.0	82.62 c	64.76 bc
Bioranza	200 ml/100 L.	79.13	82.51	64.38	83.79	86.79	68.33	86.35	91.86	72.55	83.09	87.05	85.07 bc	68.42 ab
Azadirachtin	5 ml/Lw	74.56	79.49	55.48	78.76	81.89	61.43	82.18	85.56	65.25	78.5	82.31	80.40 c	60.72 cd
Lemon oil	5 cm/1L	76.3	82.62	49.48	79.97	84.4	54.43	82.49	86.07	58.04	79.58	84.24	81.91 c	53.98 d
Applaud	600 cm3 /fed.	72.12	85.6	57.57	77.62	90.59	63.41	77.62	93.88	66.48	77.67	90.02	82.91 c	62.48 bc
Garlic oil extraction	5 cm/1L	77.29	84.33	56.27	81.87	88.87	61.22	85.41	91.35	65.12	81.52	88.18	84.85 bc	60.87 cd
Confidor 20 SL	30 cm /100L	85.79	90.73	70.43	89.73	94.12	73.37	94.02	96.74	76.55	89.84	93.93	91.88 a	73.45 a
F value													4.09	8.01
L.S.D.													6.17	7.02

A. Adult N.Nymph P. Parasitoid T. Total

A b c d letters indicating significantly differences between treatments

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