Evaluation of TheEffectiveness and Synergistic Activity of Two Insecticides from Neem and Jojoba Oils Combined with Sulfoxaflor and Buprofezin Against Whitefly on Tomato Plants

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DOI:10.21608/JALEXU.2023.222386.1144

Article Information

Received:July11th2023

Revised:July20th2023

Accepted:July22nd2023

Published:September30th2023

ABSTRACT:*Bemisiatabaci*management demands the employment of different control strategies in addition to developing alternative or additional strategies that would allow for the sensible use of pesticides to limit their dangers while not hurting natural enemies and providing enough crop protection. This research was intended to evaluate the effects of Romer® insecticide (Sulfoxaflor), Applaud® insect growth regulator (Buprofezin), Achook® (Neem oil), and Top Healthy® (Jojoba oil) alone and in combination on adults and nymphs of whiteflies, as well as the residual effect on tomato plants during two seasons. under field conditions. The results indicated that the tested insecticides, Sulfoxaflor followed by Buprofezin, were effective against both adults and nymphs of *B. tabaci* after one day for two sprays. In addition, the Qveral mean persistence residues for Sulfoxaflor were more effective than Buprofezin against adults. While that Buprofezin was more effective than Sulfoxaflor against nymphs of *B. tabaci*. Among oils alone, jojoba oil (Top Healthy®) was more effective against both nymphs (77.80%) and adults (65.93%) reduction in population. On the other hand, When the half-recommended dose of neem oil (Achook® 0.15% EC) or jojoba oil (Top Healthy® 60% EC) combined with a half-recommended dosage of sulfoxaflor (Romer®) decreased the adult whitefly abundance significantly compared to all other treatments. Also, the highest synergism was recorded with a combination of jojoba oil (Top Healthy® 60% EC) with buprofezin (Applaud®) was most effective in decreasing the nymphs of whitefly abundance significantly compared to all other treatments and having the longest persistence residues under field conditions. In general, neem oil (Achook® 0.15% EC) or jojoba oil (Top Healthy® 60% EC) were promising as synergists with the sulfoxaflor (Romer®) insecticide against adults and jojoba oil (Top Healthy® 60% EC) with buprofezin (Applaud®) insecticide against nymphs of whitefly and having the longest persistence residues on tomato plants under field conditions.

***Keywords**:Bemisiatabaci, White fly, Synergism, Sulfoxaflor. Buprofezin, Neem oil, Jojoba oil,insecticides combinations, persistence residue*

INTRODUCTION

Tomato (*Lycopersiconesculentum*Mill) is an important Solanaceae vegetable crop and Egypt's first horticultural crop (**Radwan and Taha, 2012**). Egypt, Nigeria, Tunisia, and Morocco are the top four producers in Africa, accounting for 37.8 million tonnes of the annual of total output (**FAOSTAT, 2020**). Tomato plants are cultivated in open fields as well as under plastic-covered greenhouses. Wherever they are cultivated, tomato plants are attractive hosts for a variety of insect pests, including whiteflies, leaf miners, aphids, cutworms, cabbage loppers, pinworms, fruit worms, mealy bugs, and flea beetles (**Abd El-Ghany, 2011; Ibrahim et al., 2015**).

Bemisiatabaci(Hemiptera: Aleyrodidae) is a a group of secretive species comprising more than 40 distinct types. Among them, the invasive MEAM1 (Middle East-Asia Minor 1 or B biotype or Bemisiaargentifolii) and MED species (Mediterranean or Q biotype) are the most prevalent and economically significant. These species are responsible for crop damage in over 600 different plant species, leading to economic losses in the production of food, fiber, and ornamental crops (**Rossitto De Marchi *et al*., 2023),** causing crop losses in more than 600

distinct plant species and causing economic losses in food, fiber, and ornamental crops (**Lapidot *et al.*, 2014; Sani, 2020**). This species' feeding injury have had severe negative effects on plant growth its adults directly harm plants by injecting them with saliva, which in turn spreads several Gemini viruses such as the tomato leaf curl virus, the bean yellow mosaic virus, and the tobacco leaf curl virus (**Markham *et al.*, 1994**). The honeydew released by its many larvae points to the significance of crystalline rot on the leaves (**Navas-Castillo *et al.*, 2011**). *B. tabaci*has evolved significant levels of pesticide resistance to both traditional and novel insecticides (**Yao *et al.*, 2017; Guedes *et al.*, 2019; Horowitz *et al.*, 2020**).In recent years, there have been several reports of pesticide resistance in *B. tabaci* MED/Q, reducing the possibilities for successful control using conventional approaches (**Yao *et al.*, 2017; Zheng *et al.*, 2017**). MED is known to rapidly develop resistance to several common insecticides, including acetamiprid (**Horowitz *et al.*, 2005; Horowitz and Ishaaya, 2014**), thiamethoxam (**Horowitz *et al.*, 2005**), imidacloprid (**Karunker*et al.*, 2008),** and the growth regulator pyriproxyfen (**Horowitz *et al.*, 2005).**These problems highlight the importance of developing alternative or additional strategies that would allow for the sensible use of pesticides to limit their dangers while not hurting natural enemies and providing enough crop protection (**Bernard and Philogène, 1993**). Using synergists along with insecticides is one of the alternate solutions for the efficient management of insect pests that are known to be insecticide-resistant. Whitefly infestations have been observed to decrease with the use of plant oils (**Sastry, 1989; Butler *et al.*, 1991; Csizinsky*et al.*, 1997**), which could be used in mixtures with synthetic insecticides.

Early uses of synergism indicated that combining chemicals with diverse modes of action might result in a more effective product that can theoretically inhibit or delay the formation of resistant strains to a wide range of insect pests (**Bernard and Philogène, 1993**). In the same context, it has been discovered that certain essential oils have a synergistic impact on insects when used with synthetic pesticides (**Ismail, 2020; Celestino *et al.*, 2016**). In the present study, the efficacy of Romer® (sulfoxaflor), Applaud® (buprofezin), were Achook® (neem oil), and Top Healthy® (jojoba oil) alone and their mixtures with insecticide (sulfoxaflor) or insect growth regulator (buprofezin) were evaluated against adults and nymphs of the whitefly insect on tomato plants under field condition. were evaluated also determined the residual effect.

MATERIALS AND METHODS

The experiments were carried out to evaluate the efficacy and synergistic rate of four compounds and their mixture against whiteflies at rates as shown in **Table 1** under field conditions.

Table 1. Pesticide treatments were used.

Trade name	Common name	Formulation	calssification	Rate/L
Romer®	sulfoxaflor	12% SC	Insecticide	1ml/L
Applaud®	buprofezin	25% SC	Insect Growth Regulator	1ml/L
Achook®	azadirachtin	0.15% EC	Botanical nematicide/insecticide extracted from the Neem tree	2ml/ L
Top Healthy®	jojoba oil	EC %60	Insecticide	4ml/L

Experimental design and treatments:

The field experiments were conducted during the two seasons of , 2021 and 2022, in El-Beheira Governorate, Egypt. The experimental area was divided into 27 plots: (each plot100 m^2) per treatment, eight plots for insecticide treatments, and one for the control treatment. Each plot (treatment area) was split into three replicates. It was transplanted with the tomato variety Beto 86. All the standard agricultural practices were followed as recommended for the growth of tomato plants. Treatments were tested in this area under a randomized complete block design. The treatments were imposed using motor- operated knapsack sprayer to spray the tested pesticides with the recommended dose and spray the half-recommended dose when mixing pesticides with bio-pesticides, as shown in **Table 1**. The plots were treated with two sprays of sulfoxaflor alone, buprofezin, neem oil, or jojoba oil, and a mixture of sulfoxaflor / neem oil or sulfoximines /jojoba oil, and buprofezin / neem oil or buprofezin /jojoba oil. There were two foliar sprays for all treatments, the observations were recorded on the population of white flies (nymphs and adults) were recorded from randomly selected 5 plants per plot at 10 days' interval after each spray. The leaves with nymphs of whitefly were collected and brought to the laboratory. Their numbers were recorded per leaf under a binocular microscope. The observations recorded were analyzed statistically to work out the relative efficacy of different biopesticide treatments. Percent reduction in the population of

whiteflies (nymphs and adults) over control was calculated using Henderson and Tilton's (**Henderson and Tilton, 1955**) formula as following.

Statistical analysis:

Data were analyzed using one-way analysis of variance (ANOVA), followed by LSD test for comparison between treatments, and expressed as mean ±S.E. Statistical significance was set at $p \leq 0.05$. The percent reduction of infestation was statistically calculated according to the equation of.

$$\%\ \textbf{Reduction} = 1 - (\mathrm{Ta} \times \mathrm{Cb}/\mathrm{Tb} \times \mathrm{Ca}) \times 100$$

Where: Ta = Post treatment snails counts, Cb = Untreated snails count before treatment, Tb = Pretreatment counts, Ca = Untreated snails count after treatment.

RESULTS AND DISCUSSION

1. Efficacy of the tested insecticides against adult of *B. tabaci* .

The efficacy ratings presented here are based on the results of field studies. In 2021, The experimental data tabulated in **Table 2** showed a significant reduction in *B. tabaci*population in all treatments. The percentages of adults' mortalities in the sulfoxaflor and buprofezin treatments were examined after one day (Initial kill). The highest mortality was seen in adults treated with sulfoxaflor after the 1st and 2nd sprays, which were 80.94 and 96.25 %, respectively, whereas the lowest percent reduction was recorded in the case of buprofezin treatments after the 1st and 2nd sprays, which produced 44.09 and 62.00 %, respectively. In terms of reduction percentages of the residual efficacy after seven days, sulfoxaflor remained the superior insecticide, producing 26.95 and 64.59% after the 1st and 2nd sprays, respectively, compared to buprofezin treatments of 25.98 and 47.62% after the 1st and 2nd sprays. After ten days, buprofezin was the most effective treatment in terms of residual reduction against adults of *B. tabaci* by 28.45% after the 1st spray, while in the 2nd spray; sulfoxaflor remained the superior insecticide, giving a reduction of 67.60% more than buprofezin generated the lowest decrease percentage of 58.86%. The table shows the overall mean residual kill for the 1st and 2nd sprays, which was computed as the average of cumulative mortalities from day 7 to day 10 after treatment. The maximum mortality effect (45.64%) was found in sulfoxaflor treatments, whereas the least mortality effect (40.23%) was found in buprofezin treatments.

In 2022, the observations obtained after the first and second sprays among the different treatments as showed in **Table 3** Sulfoxaflor had the highest population decrease of adults of *B. tabaci* following the first and second sprays, 82.14 and 94.25%, respectively. The lowest percent decrease was obtained in the case of buprofezin treatments after the first and second sprays, which provided 46.00 and 64.00%, respectively. In terms of reduced percentages of residual efficacy after seven days, sulfoxaflor remained the superior insecticide, generating 46.25 and 69.35% after the first and second sprays, respectively, compared to buprofezin treatments, which produced 30.11and 46.32% after the first and second sprays, respectively. Following ten days, sulfoxaflor was still the best pesticide in terms of residual reduction against adults of *B. tabaci* by 33.50 and 66.68%, respectively, after the first and second treatments. The table displays the overall mean residual kill for the first and second sprays, calculated as the average of cumulative mortalities from day 7 to day 10 following treatment. Sulfoxaflor treatments had the highest mortality impact (53.94%), whereas buprofezin treatments had the lowest mortality effect (39.59%).

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2. Efficacy of the tested insecticides against nymphs of *B. tabaci*.

Data in **Table 2** summarize the efficacy of sulfoxaflor and buprofezin treatments against *B. tabaci* on tomato plants in season 2021. sulfoxaflor had the highest mortality 90.09 and 71.93%, respectively, after one day of the 1st and 2nd sprays, compared to buprofezin treatments of 72.38 and 53.22%, respectively. Seven days later, buprofezin reduced *B. tabaci*nymphs by 91.67%, compared to 88.0% for Sulfoxaflor insecticide after the firstspray. In the second spray, sulafoxaflor remained the superior insecticide, giving a reduction of 58.46% more than buprofezin, which generated the lowest decrease percentage of 34.23%. Furthermore, after ten days, buprofezin remained the most effective component, with 88.89 and 94.23% after the 1st and 2nd sprays, respectively, while sulfoxaflor was the least effective compound, with 76.29 and 55.77% after the 1st and 2nd sprays, respectively. The overall mean of percent residual kill among 7–10 days indicates that buprofezin is the most effective, with 77.26%, whereas sulafoxaflor is the least effective, with 69.63%.

The findings in **Table 3** illustrate the effectiveness of sulfoxaflor and buprofezin treatments against *B. tabaci*on tomato plants throughout the 2022 growing season. After one day of the first and second sprays, sulfoxaflor had the highest mortality of 91.00 and 73.21%, respectively, compared to buprofezin treatments of 75.32 and 55.02%, respectively. Buprofezin decreased *B. tabaci*nymphs by 93.63% seven days later, compared to 87.08% using Sulfoxaflor pesticide after the first treatment. In the second spray, sulfoxaflor was still the better insecticide,

producing a reduction of 61.70% greater than buprofezin, which produced the lowest reduction percentage of 31.28%.Buprofezin continued to be the most effective ingredient after ten days, with 86.00 and 96.47% after the first and second sprays, respectively, whereas sulfoxaflor was the least effective ingredient, with 74.27 and 59.11% after the first and second sprays. Buprofezin is the most effective insecticide, with an overall mean percent residual kill between 7 and 10 days of 76.84%, while sulfoxaflor is the least effective, with an overall mean of 70.54%.

In this study, the insecticide sulfoxaflor was the most effective insecticide among the tested insecticides, followed by buprofezin. This is in line with (**Jahel *et al.*, 2017; Essam *et al.*, 2022**) discovered that sulfoxaflor was the most effective pesticide. Furthermore, sulfoxaflor provided the greatest decrease in *B. tabaci* one day after treatment (initial kill). In another study, **Darwish *et al.* (2021)** discovered that sulfoxaflor was the most effective insecticide against *B. tabaci* nymphs, followed by thiamethoxam, acetamiprid, pyriproxphene, and buprofezin**.** Also, the current results demonstrate that the chitin synthesis inhibitor buprofezin was effective against *B. tabaci* nymphs, which is consistent with previous findings (**Lee et al., 2002; Cutler et al., 2005),** who found that the insect growth regulator was effective against immature stages of *B. tabaci* but only moderately effective against adults. This study also confirms that the studied IGRs were efficient against *B. tabaci*, greatly reducing its population for up to a week. These results also agree with (**Saleem and Akbar, 2018; Gogi *et al.*, 2021**). The deadly effects of IGRs only on the ecdysis of *B. tabaci* immatures may explain why pest populations are reduced more throughout the longer post-exposure interval (**Gogi et al., 2021**).

3. Efficacy of the tested biopesticides against adult of *B. tabaci*.

Data tabulated in **Table 4** show the initial and residual action of neem oil (Achook® 0.15% EC) and jojoba oil (Top Healthy® 60% EC) against adult of *B. tabaci*in season 2021. The results showed that after three days, jojoba oil was the most effective, with a reduction in mortality rates of 64.76 and 76.14% after the 1st and 2nd sprays, respectively. Neem oil showed a smaller decrease percentage in adult of *B. tabaci* than jojoba oil, with values of 36.19 and 67.69%, respectively, after the 1st and 2nd sprays. After one week, Jojoba oil was clearly the most efficacious, with a reduction in mortality percentages of 61.58% after the 1st spray, while in the 2nd spray, neem oil recorded a slight increase in reduction mortality percentages of 69.65% compared to jojoba oil 68.69%. After ten days, neem oil was the most effective treatment, producing 53.94% after the first spray. In the second spray, jojoba oil recorded the maximum efficiency with a reduction in mortality percentage of 74.21%. As shown in **Table (4),** the overall mean of the residual effect is estimated as the mean of cumulative mortalities from day 3 to day 10 after spraying. Jojoba oil had the greatest mortality percentage of 65.93%, whereas neem oil had the lowest mortality rate of 53.51%.

In 2022, the findings in **Table 5** indicated that jojoba oil was the most effective after three days, with a reduction in mortality rates of 66.77 and 79.10% after the first and second sprays, respectively. After the first and second sprays, neem oil exhibited a lower percentage decrease in adults of *B. tabaci* than jojoba oil, with values of 39.13 and 70.89%, respectively. After one week, jojoba oil was definitely the most effective, with mortality percentages reduced by 64.34 and 71.85% after the first and second sprays, respectively. After ten days, the most successful treatment was neem oil, which produced 58.22% after the first spray. Jojoba oil demonstrated the greatest effectiveness in the second spray, with a 72.01% reduction in mortality. As indicated in **Table (5),** the overall mean of the residual effect is evaluated as the mean of cumulative mortalities from day 3 to day 10 following spraying. Jojoba oil had the highest mortality percentage of 68.60%, while neem oil had the lowest mortality rate of 55.37%.

4 Efficacy of the tested biopesticides against nymphs of *B. tabaci*.

Data in **Table 4** presents the comparison effect of tested biopesticides against nymphs of *B. tabaci*in season 2021. After 72 hours of exposure, as well as the long-acting effect after 7 and 10 days of treatment. The maximum percentage of nymph mortalities after three days of jojoba oil treatment was 78.47% after the first spray, while in the second spray, neem oil was the most effective treatment, producing a reduction of 80.69%. In terms of the reduction percentages of the efficacy after seven days, jojoba oil proceeded to be the better compound, providing 94.91% compared to neem oil, which produced reduction percentages of 83.27% after the first spray, while in the second spray, neem oil was the most effective treatment, producing a reduction of 85.71%. Furthermore, reduction percentages after ten days following treatment showed variations in efficacy among the jojoba oil, which was the most effective, producing a residual reduction of 74.88% after the 1st spray, in comparison, the 2nd spray of neem oil was the most effective treatment, producing a reduction of 76.19% compared to the jojoba oil produced reduction of 69.20%. The overall mean of cumulative mortalities in **Table 4** from day 3 to day 10 after spraying was computed as the general mean of

residual effect, the greatest mortality result 77.80% was found in jojoba oil, whereas the lowest mortality effect was observed in neem oil 75.52%.

In 2022, as illustrated in **Table 5**. After 72 hours of exposure, as well as the long-acting impact after 7 and 10 days of treatment. The highest rates of nymph mortalities following three days of jojoba oil treatment were 80.36 and 81.22%, respectively, after the first and second sprays. After one week, the jojoba oil treatment was still the most effective, providing a reduction of 93.41% after the first spray, while neem oil was the most effective treatment, producing a reduction of 82.70% in the second spray. Additionally, ten days after treatment, reduction percentages showed differences in efficacy among the different treatments. Jojoba oil was the most effective, producing a residual reduction of 83.18% after the first spray. In contrast, neem oil was the most effective treatment, producing a reduction of 78.10% compared to the reduction produced by jojoba oil of 67.54%. The highest mortality result of 79.78% was obtained in jojoba oil, while the lowest mortality effect was seen in neem oil 76.55%. The overall mean of cumulative mortalities in **Table 5** from day 3 to day 10 after spraying was computed as the general mean of residual effect.

Results of our research observed the mortality of neem oil formulation against adults ranged from 53.51% to 75.52% against nymphs during the first and second sprays, which was quite similar to **Jat and Jeyakumar** (**2006**) found that the population of *B. tabaci* was reduced between 50% and 60% at all concentrations of neem derivatives. In another study, Neem Azal-T/S decreased the population of *B. tabaci* by 61% in three comparable field trials in eggplant (**EL Shafie and Basedow, (2003**). In addition, the adult and nymphal populations of *B. tabaci* were significantly reduced by NSKE at 5% and neem oil at 2%, according to **Nimbalkar *et al*. (1993).** Furthermore, **Kumar *et al*. (2005)** examined the effectiveness of two commercial products of neem oil, NeemAzal T/S 1% and NeemAzalU 17%, on tomato plants against the whitefly, *B. tabaci*, and found that the reduction varied from 74 to 82%. In addition, **AbdElhady *et al*. (2014)** discovered that the efficacy of jojoba oil and azadirachtin against *B. tabaci* Biotype "Q" was moderate effect. Also, **Salem *et al*. (2003)** revealed that the formulation of jojoba oil was the most effective against both white fly and leafhopper species, with a lethal concentration 50 (LC_{50}) of 5.4% for *B.tabaci*.

Table 2. Efficacy of different insecticides against nymphs and adults of *Bemisiatabaci* on tomato plants under filed conditions during cropping season (2021)

Treatments	Adults						Qveral mean	Nymphs						Qveral mean
	Spray I			Spray II				Spray I			Spray II			
	Initial kill	Residual kill		Initial kill	Residual kill			Initial kill	Residual kill		Initial kill	Residual kill		
	1st day	7th days	10th days	1st day	7th days	10th days		1st day	7th days	10th days	1st day	7th days	10th days	
Sulfoxaflor (Romer® 12% SC)	80.94±2.3	26.95±0.6	23.42±0.7	96.25±2.4	64.59±2.7	67.60±2.1	45.64	90.09±2.9	88.00±2.8	76.29±5.59	71.93±2.9	58.46±2.0	55.77±0.8	69.63
Buprofezin (Applaud® 25% SC)	44.09±1.9	25.98±1.9	28.45±0.9	62.00±0.7	47.62±1.3	58.86±2.7	40.23	72.38±2.4	91.67±2.6	88.89±1.9	53.22±3.4	34.23±1.4	94.23±0.9	77.26
L.S.D$_{0.05}$	7.96							12.03						

Table 3. Efficacy of different insecticides against nymphs and adult of *Bemisiatabaci* on tomato plants under filed conditions during cropping season (2022)

Treatments	Adults						Qveral mean	Nymphs						Qveral mean
	Spray I			Spray II				Spray I			Spray II			
	Initial kill	Residual kill		Initial kill	Residual kill			Initial kill	Residual kill		Initial kill	Residual kill		
	1st day	7th days	10th days	1st day	7th days	10th days		1st day	7th days	10th days	1st day	7th days	10th days	
Sulfoxaflor (Romer® 12% SC)	82.14±1.60	46.25±1.60	33.50±1.85	94.25±3.60	69.35±5.90	66.68±3.29	53.94	91.00±3.60	87.08±5.90	74.27±4.84	73.21±1.60	61.70±1.45	59.11±1.30	70.54
Buprofezin (Applaud® 25% SC)	46.00±4.35	30.11±3.66	22.39±2.52	64.00±3.65	46.32±4.84	59.56±1.85	39.59	75.32±3.65	93.63±4.79	86.00±3.35	55.02±1.66	31.28±1.45	96.47±3.56	76.84
L.S.D$_{0.05}$	6.38							5.53						

Table 4. Efficacy of different bio pesticides against nymphs and adults of *Bemisiatabaci* on tomato plants under filed conditions during cropping season (2021)

Treatments	Adults						Qveral mean	Nymphs						Qveral mean
	Spray I			Spray II				Spray I			Spray II			
	Residual kill			Residual kill				Residual kill			Residual kill			
	3th day	7thdays	10th days	3th days	7th days	10th days		3th days	7th days	10th days	3st days	7th days	10 th days	
Neem oil (Achook® 0.15% EC)	36.19±1.8	54.84±1.3	53.94±1.2	67.69±2.1	69.65±1.1	38.76±0.6	53.51	66.98±1.6	83.27±1.32	60.26±3.59	80.69±3.0	85.71±2.0	76.19±3.8	75.52
Jojoba oil (Top Healthy® 60%EC)	64.76±2.7	61.58±1.5	50.19±0.5	76.14±5.5	68.69±1.7	74.21±1.6	65.93	78.47±1.7	94.91±0.8	74.88±2.91	78.28±2.4	71.07±3.7	69.20±5.4	77.80
L.S.D$_{0.05}$	10.82						-	9.94						-

Table 5. Efficacy of different bio pesticides against nymphs and adult of *Bemisiatabaci* on tomato plants under filed conditions during cropping season (2022)

Treatments	Adults						Qveral mean	Nymphs						Qveral mean
	Spray I			Spray II				Spray I			Spray II			
	Residual kill			Residual kill				Residual kill			Residual kill			
	3th day	7thdays	10th days	3th days	7th days	10th days		3th days	7th days	10th days	3st days	7th days	10 th days	
Neem oil (Achook® 0.15% EC)	39.13±2.05	56.08±2.70	58.22±1.4	70.89±5.37	67.14±3.34	40.77±4.59	55.37	65.90±3.05	85.07±1.65	68.20±3.7	79.36±3.45	82.70±6.45	78.10±2.95	76.55
Jojoba oil (Top Healthy® 60% EC)	66.77±2.75	64.34±2.45	57.55±2.2	79.10±3.65	71.85±4.05	72.01±2.00	68.60	80.36±2.20	93.41±1.80	83.08±4.3	81.22 ±2.95	73.07±2.65	67.54±3.49	79.78
L.S.D$_{0.05}$	4.11						-	3.01						-

5. Efficacy of some plant oil combinations with insecticides against adults of whiteflies on tomato plants.

The effectiveness of combinations of neem oil (Achook® 0.15% EC) and jojoba oil (Top Healthy® 60% EC) with sulfoxaflor or buprofezin against adults of *B. tabaci* was tested. In growing season 2021 the findings revealed that different combinations induced varying levels of adult mortality, as shown in **Table 6** the initial kill of adult mortalities examined after one day, the highest mortality 94.42% was seen in adults treated with a combination of sulfoxaflor at 0.5 ml with jojoba oil at 2 ml in the 2nd spray, followed by a combination of buprofezin with neem oil, by recording a reduction of 87.33% in the 2nd spray, respectively. In terms of the mean reduction for the residual kill of *B. tabaci* over two sprays (Qveral mean) revealed, sulfoxaflor was most effective in combination with neem oil with a percent reduction of 76.28%, followed by sulfoxaflor in combination with jojoba oil with 72.68%.

In the growing season of 2022, the results showed that various combinations caused diverse degrees of adult mortality, as indicated in **Table 7**. The highest mortality in the initial kill of adult mortalities examined after one day was observed in adults treated with a combination of sulfoxaflor at 0.5 ml and jojoba oil at 2 ml in the second spray, followed by a combination of buprofezin and neem oil, which recorded a reduction of 88.34% in the second spray, respectively. In terms of the mean reduction for the residual kill of *B. tabaci* after two sprays (Qveral mean), sulfoxaflor was most effective when mixed with jojoba oil with a percent reduction of 81.25%, followed by sulfoxaflor when combined with neem oil with 80.31%.

6. Efficacy of some plant oil combinations with insecticides against nymphs of whiteflies on tomato plants.

In the growing season of 2021, as shown in **Table 6**, the average reduction in the white fly nymphs revealed that the combination of jojoba oil with buprofezin was proven to be effective, with the highest reduction of the nymph population at 87.67% after one day in the first spray. In the second spray, jojoba oil with sulfoxaflor and buprofezin was most effective in combination, with reductions of 71.93 and 70.37%, respectively. In terms of the overall mean reduction for the residual kill of *B. tabaci* nymphs for the two sprays revealed, jojoba oil with buprofezin was most effective in combination with a reduction of 85.86%, followed by buprofezin in combination with neem oil at 57.45%.

Data for the growing season 2022 in **Table 7** revealed that among the various treatments imposed, the average reduction in the white fly nymphs revealed that the combination of jojoba oil with buprofezin was proven to be effective, with the highest reduction of the nymph population at 90.07 and 75.87% after one day in the first and second sprays, respectively. In terms of the overall mean reduction for the residual kill of *B. tabaci* nymphs for the two sprays revealed, jojoba oil with buprofezin was most effective in combination with a reduction of 78.74%, followed by Sulfoxaflor in combination with jojoba oil at 60.73%.

The compiled results thus show that the biopesticide and pesticide combinations have shown synergism in the overall mean reduction percentage of whitefly adults and nymphs as compared to the pesticide taken alone. The combination of a commercial product of neem oil and jojoba oil with sulfoxaflor insecticide treatment decreased the adult of whitefly abundance significantly compared to all other treatments. Also, the combination of jojoba oil with buprofezin was most effective in decreasing the nymphs of whiteflies significantly compared to all other treatments and had the longest persistence residues in the field. As a result, combining pesticides with these oils might change their characteristics, enhancing the efficiency of the insecticides (**Nicetic*et al*., 2011).** These results are consistent with those of **Ismail (2021)** whoassessed the effectiveness of imidacloprid when combined with jojoba oil or KZ oil increase its synergistic effectiveness against whiteflies. Synergistic action was seen in the whiteflies by a combination of imidacloprid with jojoba oil or KZ oil, approximately 12 and 40 times more, respectively, than imidacloprid alone**.** In another study, **Sridhar *et al*. (2017)** studied the combination efficacy of neem oil with spinosad, imidacloprid, and fipronil and found that oils showed synergism with different insecticides tried against whitefly, and the highest synergism was recorded with neem oil in combination with spinosad, which gave additional mortality of up to 16% against *B. tabaci*when oil was used along with the insecticideon tomato. Results also, are in the same direction as that recorded by **Guleria (2013)** whodetermined that imidacloprid with NeemAzal T5 and acetamiprid with NeemAzal T5 were more effective at reducing the population of whiteflies than either pesticide used alone when tested against them in poly house conditions.

Table 6. Effect of pesticides and bio pesticides and their combinations against nymphs and adult of *Bemisiatabaci* on tomato plants under filed conditions during cropping season (2021).

Treatments	Adults						Qveral mean	Nymphs						Qveral mean
	Spray I			Spray II				Spray I			Spray II			
	Initial kill	Residual kill		Initial kill	Residual kill			Initial kill	Residual kill		Initial kill	Residual kill		
	1st day	7thdays	10th days	1st day	7th days	10th days		1st day	7th days	10th days	1st day	7th days	10th days	
Sulfoxaflor 0.5 ml + **Neem oil** 1 ml/L	73.45±5.6	75.03±2.9	77.60±4.8	85.34±4.4	80.17±3.7	77.30±3.1	77.52	27.03±1.2	24.37±1.1	68.41±4.2	33.33±1.2	40.26±0.9	70.39±2.6	50.86
Sulfoxaflor 0.5 ml + **Jojoba oil** 2 ml/L	70.94±1.1	80.01±4.9	76.55±5.6	94.42±3.9	71.50±2.9	62.64±2.9	72.67	67.81±2.1	55.91±0.79	44.96±2.9	71.93±4.2	48.79±1.3	60.53±2.2	52.55
Buprofezin 0.5 ml + **Neem oil** 1 ml/L	13.17±1.0	49.05±2.7	55.83±0.8	87.33±2.9	87.75±5.4	34.55±1.5	56.79	33.11±1.2	51.16±0.56	68.41±2.24	53.22±1.6	43.10±2.56	67.11±2.6	57.45
Buprofezin 0.5 ml + **Jojoba oil** 2 ml/L	39.03±0.6	45.60±3.3	51.11±1.8	63.29±1.2	84.89±3.7	64.78±0.9	61.59	87.67±2.8	76.67±2.0	51.23±0.6	70.37±5.0	84.98±3.9	65.28±2.8	85.86
L.S.D$_{0.05}$	10.79							6.86						

Table 7. Effect of pesticides and bio pesticides and their combinations against nymphs and adult of *Bemisiatabaci* on tomato plants under filed conditions during cropping season (2022).

Treatments	Adults						Qveral mean	Nymphs						Qveral mean
	Spray I			Spray II				Spray I			Spray II			
	Initial kill	Residual kill		Initial kill	Residual kill			Initial kill	Residual kill		Initial kill	Residual kill		
	1st day	7thdays	10th days	1st day	7th days	10th days		1st day	7th days	10th days	1st day	7th days	10th days	
Sulfoxaflor 0.5 ml + **Neem oil** 1 ml/L	74.22±2.24	76.23±5.41	79.30±3.55	88.34±1.55	83.17±2.3	80.60±2.15	80.31	30.23±2.1	23.03±1.7	70.01±0.65	32.30±3.25	48.52±4.17	80.09±5.92	47.36
Sulfoxaflor 0.5 ml + **Jojoba oil** 2 ml/L	73.04±1.59	85.31±2.15	80.15±2.3	96.42±2.86	81.90±5.7	70.69±3.55	81.25	66.91±4.3	53.70±2.1	50.25±2.25	73.53±4.51	50.89±1.04	69.11±3.97	60.73
Buprofezin 0.5 ml + **Neem oil** 1 ml/L	20.58±3.14	48.20 ±1.07	59.88±2.04	87.33±2.89	89.75±4.1	45.81±4.27	58.59	39.50±4.15	55.47±2.49	70.20±3.6	55.72±3.44	49.15±2.4	70.81±6.40	56.80
Buprofezin 0.5 ml + **Jojoba oil** 2 ml/L	44.25±2.25	50.45±1.2	55.70±1.45	73.29±1.55	83.09±5.7	69.28±0.9	62.67	90.07±3.98	86.17±3.7	64.80 ±7.4	75.87±4.30	88.08±1.64	67.48±2.51	78.74
L.S.D$_{0.05}$			3.79							3.78				-

CONCLUSION

It is concluded from the present study that the application of pesticide combinations has shown synergism in the overall mean reduction percentage of whitefly adults and nymphs as compared to the pesticide taken alone during two seasons. The combination of neem oil (Achook® 0.15% EC) and jojoba oil (Top Healthy® 60% EC) biopesticides with sulfoxaflor (Romer®) insecticide treatment decreased the adult whitefly abundance significantly compared to all other treatments. Also, a combination of jojoba oil (Top Healthy® 60% EC) with buprofezin (Applaud®) was most effective in combination decreased the nymphs of whitefly abundance significantly compared to all other treatments and had the longest persistence residues under field conditions, and kept whitefly numbers much below levels that would cause economic damage. Also, combining a half recommended dosage of insecticide with a half recommended dose of botanicals lowers the amount of pesticides used to the crop and lowers the expense of the treatment, both of which protect the crop's natural enemies. Combinations can minimize production costs for farmers, increase the natural enemy of the whitefly, and decrease pest resistance to synthetic pesticides. As a result, the mixture of the new compounds with insecticides and botanical oils may be incorporated into the IPM program.

REFERENCES

Abd El-Ghany N.M. (2011). Molecular evaluation of *Bacillus thuringiensis* isolates from the soil and production of transgenic tomato plants harboring Btgene for controlling lepidopterous insects in Egypt. Ph.D. thesis, Faculty of Science, Ain Shams University, Egypt, 270 pp.

AbdElhady, A., F. Shaheen, , S. Negm, , I. Heikal, and E. Asharm, (2014). Efficacy of natural compound on the whitefly *bemisiatabaci* biotype "b"(hemiptera: aleyrodidae) and its natural enemies of cucumber crop. J. Plant Prot. and Path., Mansoura Univ. 5(12), 1161-1176.

Bernard, C. and B. J. Philogène (1993) Insecticide synergists: role, importance, and perspectives. Journal of Toxicology and Environmental Health, 38 199-223.

Butler, G. D. J. and T. J. Henneberry (1991). Sweet potato whitefly control: Effect of tomato cultivars and plant derived oils. South Western Entomologist, 16: 37-43.

Celestino, F. N., D. Pratissoli, , L. C. Machado, , H. J. G. D. Santos Junior, V. T. D. Queiroz, and L. Mardgan (2016) Control of coffee berry borer, *Hypothenemushampei* (Ferrari) (Coleoptera: Curculionidae:Scolytinae) with botanical insecticides andmineral oils. Acta Sci., Agron. 38 (1): 1-8.

Csizinsky, A. A., D. J. Schuster and J. B. Kring (1997). Evaluation of colour mulches and oil spray for yield and for the control of silver leaf whitefly, *Bemisiaargentifolii* (Bellows and Perring) on tomatoes. Crop Protection, 16: 475-481.

Cutler, G.C., C.D. Scott-Dupree, J.H. Tolman and C.R. Harris. (2005). Acute and sub lethal toxicity of Novaluron, a novel chitin synthesis inhibitor, *to Leptinotarsa decemlineata*(Coleoptera: Chrysomelidae). J. of Pest Management Sci.61: 1060-1068.

Darwish, A., M. M. Attia and A. M. Khozimy (2021). Effect of some integrated pest management elements on the population density of *Bemisiatabaci* (Gennadius)(Hemiptera: Aleyrodidae) on tomato plants (*Solanumlycopersicum* L.). Alexandria, Sci. Exchange, J., (1): 57-68.

EL Shafie, H.A.F. and T. Basedow (2003). The efficacy of different neem preparation for the control of insect damaging potatoes and eggplants in the Sudan. Crop Protection, 22: 1015-1021.

Essam, E., I. Eldosooky, H. Walid, J. Ammar, I. Wahba, and I. Abdallah (2022). The efficacy of certain insecticides against whitefly, *Bemisiatabaci* (Genn.) on tomato and their effects on fruit quality. Polish, J. Entomo., 91(3), 137-148.

FAOSTAT (**2020**). FAO Statistical Database (FAOSTAT). Available at: http://www.fao.org/faostat/en/#data/QC (Accessed Oct 2020).

Gogi, M.D., A.H. Syed, B. Atta, M. Sufyan, M.J. Arif, M. Arshad, A. Nawaz, M.A. Khan, A. Mukhtar and O.E. Liburd (2021) Efficacy of biorational insecticides against *Bemisiatabaci* (Genn.) and their selectivity for its parasitoid *Encarsiaformosa* Gahan on Bt cotton. Sci. Rep., 11(1):2101.

Guedes, R.N.C., E. Roditakis, M.R. Campos, K. Haddi, P. Bielza, H.A.A. Siqueira, A. Tsagkarakou, J. Vontas and R. Nauen (2019) Insecticide resistance in the tomato pinworm *Tuta absoluta*: patterns, spread, mechanisms, managementand outlook. J. Pest. Sci., 92:1329–1342.

Guleria, S. J. (2013). Field efficacy of biopesticides and pesticide combinations against whitefly infesting gerbera. Munis Entomo. Zoo., 8(2): 895-899.

Henderson, C.F, E.W. Tilton (1955). Tests with acaricides against the brown wheat mite. J. Econ. Entomol., 48: 157-161.

Horowitz, A.R., S. Kontsedalov, V. Khasdan and I. Ishaaya(**2005**). Biotypes B and Q of *Bemisiatabaci* and their rele-vance to neonicotinoid and pyriproxyfen resistance. Archives of Insect Biochemistry and Physiology.Arch Insect Biochem Physiol., 216–225 .

Horowitz, A.R. and I. Ishaaya (2014). Dynamics of biotypes B and Q of the whitefly *Bemisiatabaci* and its impact on insecticide resistance. Pest. Manag. Sci., 70: 1568–1572.

Horowitz, A.R., M. Ghanim, E. Roditakis, R. Nauen, and I. Ishaaya, (2020). Insecticide resistance and its management in *Bemisiatabaci* species. J. Pest. Sci.,93:893–910.

Ibrahim, S.S., F.A. Moharum and N. M. Abd El-Ghany (2015). The cotton mealybug *Phenacoccussolenopsis* Tinsley (Hemiptera: Pseudococcidae) as a new insect pest on tomato plants in Egypt. J. Plant Protec. Res., 55 (1): 48–51.

Ismail, S. (2021). Synergistic efficacy of plant essential oils with cypermethrin and chlorpyrifos against *Spodoptera littoralis*, field populations in Egypt. Int. J. Adv. Biol. Biomed. Res., 9, 128-137.

Ismail., S. (2021). Botanical insecticides & mineral oils synergize toxicity of imidacloprid against *Bemisiatabaci* (Hemiptera: Aleyrodidae). .Prog. Chem. Biochem. Res., 4(3), 295-304.

Jahel, M.K., M. H. Safaa, A.A. Hafez, T.R. Abd El-Zahar andK. Kh. Elgizawy. (2017). Comparative efficacy of different insecticides against whitefly, *Bemisiatabaci* (Gennadius)(Homoptera: Aleyrodidae) on Tomato Plants. Middle East. J. Appl. Sci., 07 (04): 786-793.

Jat, M.C. and P. Jeyakumar (2006),Bioefficacy of botanicals and bioagents on sucking pests of cotton. Ann. Plant Protec. Sci., 14 (1): 8-10.

Karunker, I., J. Benting, B. Lueke, T. Ponge, R. Nauen, E. Roditakis, J. Vontas, K. Gorman, I. Denholm, and S. Morin (2008). Over-expression of cytochromeP450 CYP6CM1 is associated with high resistance to imidacloprid in the B and Q biotypes of *Bemisiatabaci* (Hemiptera: Aleyrodidae). Insect Biochem. Mol. Biol., 38(6): 634-644.

Kumar, P., H. M. Poehling and C. Borgemeister (2005). Effects of different application methods of Neem against Sweet potato Whitefly *Bemisiatabaci* Gennadius (Homoptera: Aleyrodidae) on Tomato plants. J. Appl. Entomol., 129:889-497.

Lapidot, M., J.P. Legg, W. M. Wintermantel and J. E. Polston, (2014). Management of whitefly-transmitted viruses in open-field production systems. In: Advanc. Virus. Res.. Elsevier, 147–206.

Lee, Y. S., S. Y. Lee, E. C. Park, J. H. Kim and G. H. Kim. (2002). Comparative toxicities of pyriproxyfen and thiamethoxam against the sweet potato whitefly, *Bemisiatabaci* (Homoptera: Aleyrodidae). J. Asia-Pacific. Entomol.,.5: 117-122.

Markham, P. G., , I. D. Bedford, S. Liu, and M. S. Pinner (1994).The transmission of Gemini viruses by *Bemisiatabaci*..Pest. Sci., 42: 123-128.

Navas-Castillo, J., E. Fiallo-Olivé, and S. Sánchez-Campos (2011) Emerging virus diseases transmitted by whiteflies. Annual. Rev. Phytopatho., 49: 219-228.

Nicetic, O., Y.R.,Cho, Rae, D.J. (2011) Impact of physical characteristics of some mineral and plant oils on efficacy against selected pests. Journal of Applied Entomology, 153 204-213.

Nimbalkar, S.A., S. M. Khodke, Y.M. Taley and K.J. Patil, (1993). Bioefficacy of some new insecticides including neem seed extract and neem oil for control of whitefly, *Bemisiatabaci* in cotton. Botanical Pesticides in Integrated Pest Manag.t. 256-260.

Radwan, E.M.M. and H. S. Taha (2012). Toxic and biochemical effects of different insecticides on the tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Egypt. Acad. J. Biol. Sci., 4 (1): 1- 10.

Rossitto De Marchi, B., A. B. Gama, and H. A. Smith, (2023). Evidence of the association between the Q2 mitochondrial group of *Bemisiatabaci* MED species (Hemiptera: Aleyrodidae) and low competitive displacement capability. Plos one, 18(1), 280002.

Saleem MS, M. F. Akbar (2018). Bio-efficacy of neonicotinoids and insect growth regulators against *Bemiciatabaci* Genn. on *Solanum melongena* L. Pak. J. Zool. **51**:1615–1620.

Salem, H. E. M., R. E. M. Omar, A. G. El-Sisi and A. M. Mokhtar (2003): Field and laboratory use of environmentally safe chemicals against white-fly *Bemisiatabaci* (Gennandius) and leafhopper *Empoascadiscipiens* (Paoli): Annals. Agric. Sci., Moshtohor, 4l(4): 1737-1741.

Sani, I., S. I., Ismail, S. Abdullah, J. Jalinas, S. Jamian and N. Saad, (2020). A review of the biology and control of whitefly, *Bemisiatabaci* (Hemiptera: Aleyrodidae), with special reference to biological control using entomopathogenic fungi. Insects 11(9):619.

Sastry, S. K. (1989). Tomato leaf curls virus management by Carbofuran plus oils combination. J. Turkish Phytopatho., 18: 11-16.

Sridhar, V., S. O. Naik, K. A. Paripurna, V. K. Rao, K. G. Pillai and D. C .Reddy (2017). Efficacy of neem, pongamia and fish oils alone and as synergists with insecticides for the management of whitefly, *Bemisiatabaci* (Gennadius) on tomato. Pest Manag. Horticul.Ecosystems, 23(2): 119-123.

Yao, F.L., Y. Zheng, X.Y. Huang, X. L. Ding, J. W. Zhao, N., Desneux, Y.X. He, and Q.Y. Weng, (2017) Dynamics of *Bemisiatabaci* biotypes and insecticide resistance in Fujian province in China during 2005–2014. Sci Rep. 7(1):40803.

Zheng, H., W. Xie, S. Wang, Q. Wu, X. Zhou and Y. Zhang (2017). Dynamic monitoring (B versus Q) and further resistance status of Q-type *Bemisiatabaci* in China. Crop. Prot., 94:115–122.

الملخص العربى

تقييم الفعالية والنشاط الابادى لاثنين من المبيدات الحشرية زيت النيم و زيت الجوجوبا وفى خليط مع مبيد السلفوكسافلو و الببروفيزين ضد الذبابة البيضاء على نباتات الطماطم

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تتطلب ادارة الذبابة البيضاء توضيف استراتيجيات مكافحة مختلفة بالاضافة الى تطوير استراتيجيات بديلة او اضافية من شأنها ان تسمح بالاستخدام المعقول لمبيدات الافات للحد من مخاطرها مع الحاق الضرر بالاعداء الطبيعين و توفير الجماية الكافية للمحاصيل يهدف هذا البحث الى تقييم تأثيرات Romer® الحشرى (Sulfoxaflore) ومنظم نمو الحشرات (Apploud® (Buprofezin و((Achook زيت النيم و (Top Healthy) زيت الجوجوبا بمفرده وفى مخاليط على البالغين وحوريات الذباب الالبيض و كذلك التأثر المتبقى على نباتات الطماطم خلال موسمين. تحت ظروف الحقل .اشارت النتائج الى ان المبيدات الحشرية المختبرة سلفوكسافلو متبوعة بمبيد ببروفيزين كانت فعالة ضد كل من الحشرات البالغة والحوريات من الذباب الابيض بعد يوم واحد من الرش خلال الرشتين, بالاضافة الى ذلك, كانت متبقى المبيدات للسلفوكسافلور اكثر فاعلية من الببروفيزين ضد البالغين بينما كان مبيد الببروفيزين من سلفوكسافلور ضد حوريات الذبابة البيضاء. كان زيت الجوجوبا (Top Healthy)اكثر فاعلية ضد كل من الحوريات (77.8%) و بالبالغين بنسبة (65.93%) انخفاض فى تعداد الذبابة البيضاء. من ناحية اخرى, عندما تقلل الجرعة الى نصف التركيز الموصى به من زيت النيم (Achook 0.15% EC) او زيت الجوجوبا (Top Healthy 60%)مع نصف الجرعة الموصى بها من السلفوكسافلور(Romer) انخفض تعداد الحشرة الكاملة للذبابة البيضاء بشكل ملحوظ مقارنة بالمعاملات الاخرى. ايضا, تم تسجيل اعلى نشاط مع مخلوط من زيت الجوجوبا مع الببروفيزين كان الاكثر فاعلية فى تقليل تعداد حوريات الذبابة البيضاء و كان لها اطول تأثير باقى تحت ظروف الحقل. بشكل عام, كان زيت النيم (Achook 0.15% او زيت الجوجوبا (Top Healthy® 60% EC) مع مبيد السلفوكسافلور لها تأثير قوى ضد الحشرات الكاملة للذبابة البيضاء, بينما كان زيت الجوجوبا مع مبيد الببروفيزين كان له تأثير قوى ضد حوريات الذبابة البيضاء و له اطول اثر باقى على نباتات الطماطم تحت الظروف الحقلية.