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Occurrence and efficacy of natural compounds of the pomegranate whitefly, *Siphoninus phillyreae* (Hemiptera: Aleyrodidae) and its parasitoid, *Eretmocerus parasiphonini* (Hymenoptera: Aphelinidae) in Egypt

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Abstract:

The pomegranate whitefly, Siphoninus *phillyreae* (Haliday) (Hemiptera: Aleyrodidae) is a dangerous pest of pomegranate in different locations in Egypt. The aim of this research was to evaluate the effect of botanical extracts on *S. phillyreae* and its parasitoid, *Eretmocerus parasiphonini* Evans and Abd-Rabou (Hymenoptera: Aphelinidae) on pomegranate (*Punica granatum* L.) as well as the distribution of this pest in Egypt. During the present work, S. *phillyreae* was recorded distributed and occurred in four governorates. These are Assuit, Daqahylia, Giza, Kafr El-Shikh and Qalyubiya. The results also indicated that, in the first season, the average reduction of the three compounds (Jojoba oil, *Peacilomyces fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae*, percent reduction ranged between (39-45%) and while its parasitoid, *E. parasiphonini*, percent reduction ranged between (72-81%). Azadirachtin compound gave 56% and 72% for *S. phillyreae* and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, malathion gave high efficacy against *S. phillyreae* (75%) and E. *parasiphonini* (93 %). In the second season, the average reduction of the three compounds (Jojoba oil, *Peacilomyces fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae*, percent reduction ranged between (41-53%) and while its parasitiod *E. parasiphonini*, percent reduction ranged between (72-76%). Azadirachtin compound gave 63% and 63% for *S. phillyreae* and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, malathion gave high efficacy against *S. phillyreae* (85%) and *E. parasiphonini* (95 %).

Introduction

The pomegranate whitefly, *Siphoninus phillyreae* (Haliday) (Hemiptera: Aleyrodidae) is one of the most economic pest infested pomegranate in Egypt. Heavy infestation caused leaf wilt, early leaf drops and smaller fruit (Abd-Rabou, 1998). It is distributed in 28 countries specially in Palaearctic region (Bellows *et al.,* 1990) and distributed in three governorates in Egypt (Abd-Rabou, 2001b). Recently, *Eretmocerus parasiphonini* Evans and Abd-Rabou (Hymenoptera: Aphelinidae) recorded associated with *S. phillyreae* in Egypt (Evans and Abd-Rabou, 2005). Abd-Rabou and Ahmed (2007) studied the distribution of this pest in Egypt.

In recent years whiteflies have developed resistance to many conventional insecticides throughout the world, especially organophosphates and pyrethroids (Horowitz *et al*., 2004 and Fernandez *et al*., 2009).

So, in modern agriculture and an increasingly regulated world, natural plant-based insecticides can be a feasible plant pest management method and an attractive alternative to synthetic chemical insecticides because botanicals reputedly pose little threat to the environment, non-target organisms or to human health (Isman, 2006). A number of plant substances have been considered for use as insecticides, antifeedants or repellents, which include terpenes, flavonoids, alkaloids, phenols, and other related compounds (Adeyemi, 2010). Several factors, however, appear to limit the success of botanicals, most notably regulatory barriers. In this context, plant-derived products are best suited for use in organic food production and in the production and postharvest protection of food in developing countries (Isman, 2006 and Dayan *et al*. , 2009).

Some of botanical extracts potential allows up to 90% success in pest control within agroecological management, having the advantage of preserving natural enemies (Abreu Júnior, 1998). Several studies have shown that neem products are safe for beneficial insects (Schmutterer, 1990).

The aim of this work is to study the efficacy of botanical extracts on the pomegranate whitefly, *S. phillyreae* and its parasitoid, *E. parasiphonini* with emphasis on distributions status in Egypt.

Materials and methods

1. Distribution of *Siphoninus phyllireae* in Egypt:

Infested leaves of pomegranate were examined in the field using a pocket magnification lens. Infested leaves were collected from pomegranate trees from different locations in Egypt during 2017-2018. The leaves collected and placed separately in paper bags for further examination in the laboratory. Identification of *S. phyllireae* was done by examining fourth larval instar in Canada Balsam (according Abd-Rabou, 2001b).

2. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate:

The experiments were carried out to evaluate of the five compounds Jojoba oil, *Peacilomyces fumosoroseus,* Sulfur, Azadirachtin and Malathion) on *S. phillyrea* and associated parasitoid, *E. parasiphonini* on pomegranate at Giza Governorate. When the numbers of *S. phillyreae* and its parasitoid were high during July.

2.1. The experiments comprised five compounds:

2.1.1. Jojoba oil: Al kanz 2000 70% WE The application rate 10 ml /LW.

2.1.2. Sulfur WP S8 the application rate 2.5 mg/Lw.

2.1.3. *Paecilomyces fumosoroeus* (Priority)**:** An entomopathogenic fungi: 1 $\times 10^8$ unite/cm^3 (100 million), containing the fungus *P. fumosoroeus*, used at a rate of 5ml/Lw

2.1.4. Azadirachtin Azadirachtin *(Azadirachtin indica)* The application rate 5ml/Lw

2.1.5. Malathion 57% EC, a chemical insecticide of the common name Malathion and the chemical name, O, O-dimethyl-S- (1,2-dicarbethoxyethyl) dithio-phosphate. It was applied at a rate of 1.5 ml/ Lw

Each treatment conducted in 1/4 Fadden. One quarter of Fadden was also used as an untreated check (control). Spraying was applied at the rate of per plant which was accomplished by the use of a Knapsack sprayer Cp-20 of 20-liter capacity. Pre-spraying counts were made just before spraying.

The post spraying counts were made after 3, 7 and 15 days from application. Random samples of 120 leaves were picked up from each replicate. A total number of 40 infested leaves for each treatment thus examined. By means of a stereoscopic microscope insect whitefly and its parasitoid were inspected.

2.2. Statistical analysis:

The percent reduction of infestation was statistically calculated according to the equation of (Henderson and Tilton, 1955).

$$\% \text{ mortality} = 100 \left[1- \frac{Ta \times Cb}{Tb \times Ca}\right]$$

Where:

Ta = Post treatment insect counts

Cb = Untreated insect count before treatment

Tb = Pretreatment counts

Ca = Untreated insect count after treatment.

Results and discussion

1.Distribution of *Siphoninus phyllireae* in Egypt:

During the present work this species was recorded distributed and occurred in four governorates. These are Assuit, Daqahylia, Giza, Kafr El-Shikh and Qalyubiya. Tables (1-2) indicated that the numbers of population were reached maximum in Assuit governorate with 6421 and 6544 individuals / 80 leaves during October, 2017 and 2018. Followed by Giza governorate with 2100 and1998 individuals / 80 leaves during October, 2017 and 2018. The lowest numbers recorded in Qalyubiya with 1004 and 988 individuals / 80 leaves during October, 2017 and 2018.

These results observed the five areas of Egypt surveyed were distinctive in their locations as well as their weather. Assuit and Giza were highly abundant with *S. phyllireae*, both of these areas are nile river valley. South of nile Delta with Assuit about 300 Km south of Giza. Higher temperature in Assuit may correlate to higher whitefly. Abd-Rabou (2001b) recoreded this species distributed in three Governorates, these are, Assuit, Behira and Sinai.

Table (1): Distribution and occurrence **of *Siphoninus phyllireae* in Egypt during 2017**

Inception date	Kafr El-Shikh	Giza	Daqahylia	Qalyubiya	Assuit
June	750	1200	985	587	2059
July	841	1425	1345	698	3210
Aug.	956	1687	1541	842	4522
Sep.	1451	1894	1652	945	5500
Oct.	1654	2100	1756	1004	6421
Total	5653	8306	7279	4076	16212
Mean	1130.4	1661.2	1455.8	815.3	3242.4
%	11.3	16.61	14.55	8.15	32.42

Table (2): Distribution and occurrence **of *Siphoninus phyllireae* in Egypt during 2018**

Inception date	Kafr El-Shikh	Giza	Daqahylia	Qalyubiya	Assuit
June	633	1125	1001	455	2145
July	754	1500	1124	610	3321
Aug.	832	1612	1235	695	4462
Sep.	1241	1795	1478	758	5461
Oct.	1455	1998	1650	988	6544
Total	4915	8030	6488	3506	21933
Mean	983	1606	1297.6	701.2	4386.6
%	9.83	16.06	12.97	7.2	43.86

2. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate:

2.1. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate during the first season (2017):

In the first season, the average pre-spraying counts of larval stages of *S. phillyreae* and the average number of the parasitoid, *E. parasiphonini* are o.3-4.5 ⁄ leaf (Table,3). Results in Table (4) indicated that in the first season (2017), the average reduction of the three compounds (Jojoba oil, *P. fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae,* percent reduction ranged between (39-45%) and while its parasitoid, *E. parasiphonini*, percent reduction ranged between (72-81%). Azadirachtin compound gave 56% and 72% for *S. phillyreae* and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, ***Malathion*** gave high efficacy against *S. phillyreae* (75%) and *E. parasiphonini* (93 %). (Table, 4).

2.2. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate during the second season (2018):

In the second season, the average pre-spraying counts of larval stages of *S. phillyreae* and the average number of the parasitoid, *E. parasiphonini* are o.3-4.6 ⁄ leaf (Table, 5). Results in Table (6) indicated that in second year (2018), the average reduction of the three compounds (Jojoba oil, *P. fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae,* percent reduction ranged between (41-53%) and while its parasitiod, *E. parasiphonini,* percent reduction ranged between (72-76%).

Azadirachtin compound gave 63% and 63% for *S. phillyreae* and and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, malathion gave high efficacy against *S. phillyreae* (85%) and *E. parasiphonini* (95 %) (Table, 6). In the present work the traditional compound, malathion gave high efficacy against *S. phillyreae* ranged between (75-85%) and *E. parasiphonini* (93-95 %) during the two years under consideration. Abdel-Salam *et al.* (1971), Abdel-Salam *et al.* (1972), Shaheen *et al.* (1973), Darwish and Farghal (1990), Radwan *et al.* (1990), Mohamed *et al.* (1992), Hegab and Moawad (1994) and Hassan (1996) evaluated the efficiency of some traditional compounds as spray for the control of the whitefly. The results gave effective control and the mortality ranged from 87.95 to 96.75%. Kumar *et al.* (2005) tested the efficacy of two different commercial neem products (NeemAzal T/S 1% azadirachtin and NeemAzalU 17% azadirachtin) against the whitefly. Results indicated that reduction ranged from 74 to 82%. Results here research observed the mortality of Azadirachtin compound gave 56 -63% and 63-72% for *S. phillyreae* and its parasitoid, *E. parasiphonini* during the two years of the investigation, respectively. Azadirachtin-A (Aza-A) also recorded as an effective control measure of the whitefly by Badary (1997) and Swaran et al. (2008).

Also, during the present work Azadirachtin gave moderate mortality ranged between 56 -63% during the first and second years of the investigation, respectively. Abd-Rabou (2001a) tested Neemazal 3ml/L on the parasitoids of the whitefly on different host plants and in different locations in Egypt. Results observed the present parasitism reduced from 37.1 to 24.5% for the *parasitoid.* Here the mortalities ranged from 64.17% to 61.30%. Successful parasitism was the lowest when adult parasitoids were introduced after dipping second instars in the *Melia azedarach* L. fruit extract and when whitefly nymphs were dipped in extract 2 d after parasitism. However, the level of parasitism in parasitized nymphs dipped in extracts 4 and 8 d after parasitism was comparable with that of the control. The number of dead whitefly nymphs in combined treatments declined as the age of whitefly nymphs at application increased, with a concomitant increase in successful parasitism (Abou-Fakhr and McAuslane, 2006).

Simmons and Abd-Rabou (2005) stated that the compounds when were sprayed on the crops at the rates of 5 ml/liter for jojoba oil, 1.5 to 2.5 ml/liter for M-Pede®; and 2 to 3 ml/liter for NeemAzal®. Regardless of concentration, parasitism by either *Encarsia sophia* (Hymenoptera: Aphelinidae) or *E. mundus* was low (< than 5% by each of 2 species). Parasitism was relatively high (~25-40% by each of two species) for crops treated with either NeemAzal® or M-Pede® at the lowest concentrations. In this investigation, results in indicated that in the first and second seasons (2013-2014), the average reduction of the three compounds (Jojoba oil, *Peacilomyces fumosoroseus,* Sulfur) gave moderate toxic effect against *S. phillyreae,* percent reduction ranged between (39-53%) and while its parasitiod *E. parasiphonini*, percent reduction ranged between (72-81%). Azadirachtin compound gave 56% and 72% for *S. phillyreae* and and its parasitoid, *E. parasiphonini* mortality, respectively.

Table (3): Average number of the *Siphoninus phyllireae* and parasitoid on pomegranate trees pre and after application of various control agents during season, 2017.

Treatment	Rate of Applic. /L.W	Pre spraying count					Average number after:														
							One week					Two weeks					Three weeks				
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.
Malathion	1.5 ml/L.	3.8	3.6	3.5	3.2	0.3	0.4	0.5	0.6	0.9	0.1	0.4	0.5	0.5	0.7	0.1	0.1	0.3	0.3	0.3	0.1
Azadirachtin	5 ml/L.	4.5	3.7	3.6	3.4	0.4	1. 7	1.9	1.9	2.09	0.2	1.1	1.6	1. 8	1.9	0.1	1.1	1.4	1.6	1.6	0.1
Jojoba oil	10 ml/L.	3.9	3.8	3.6	3.4	0.3	1.7	2.2	2.3	2.39	0.1	1.9	1.9	2.1	2.2	0.1	1.2	1.6	1.9	1. 9	0.1
Sulfur	2.5mg/Lw.	3.7	3.5	3.4	3.3	0.4	1.9	2.2	2.4	2.5	0.1	1.9	2.0	2.0	2.3	0.1	1.4	1.8	1.9	2.0	0.1
Paecilomyces fumosoroeus	5 ml/L.	3.9	3.8	3.5	3.4	0.4	2.3	2.4	2.4	2.5	0.1	2.2	2.3	2.2	2.4	0.1	1.6	1.9	2.0	2.2	0.1
Control	-	4.7	3.8	3.6	3.4	0.4	4.5	3.7	3.5	3.4	0.4	4.5	3.8	3.3	3.4	0.4	3.9	3.5	3.4	3.3	0.3

Table (4): Reduction percent induced by application various control agents for management the *Siphoninus phyllireae* and parasitoid on pomegranate trees during season 2017.

Treatment	Rate of Applic. /L.W	Reduction percent after:																
		One week					Two weeks					Three weeks					Mean Total %	
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	W.	P.
Malathion	1.5	88.5	85.3	81.3	73.2	89.1	90.	86.5	83.9	79.1	93.1	95.9	94.3	90.4	90.2	96.0	75	93
Azadirachtin	5 ml/L.	68.1	48.7	43.1	40.4	57.3	68.9	55.8	45.7	43.9	76.6	70.3	58.8	52.5	51.2	80.7	56	72
Jojoba oil	10 ml/L.	54.4	41.4	35.3	29.6	69.2	50.4	46.4	36.5	34.2	79.2	62.8	52.4	42.2	42.6	80.7	45	77
Sulfur	2.5	45.6	36. 6	28.0	25.6	75.0	45.1	41.8	35.6	31.8	84.2	54.7	43.2	41.2	36.9	86.5	40	81
Paecilom-yces fumosoroeus	5 ml/L.	38.0	36.1	29.8	25.3	62.2	40.8	38.8	33.1	28.8	74.0	49. 8	42.5	39.9	34.3	78.6	39	72

Table (5): Average number of the *Siphoninus phyllireae* and parasitoid on pomegranate trees pre and after application of various control agents during season, 2018 .

Treatment	Rate of Applic. /L.W	Pre spraying count					Average number after:														
							One week					Two weeks					Three weeks				
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.
Malathion	1.5 ml/L.	4.4	3.9	3.7	3.5	0.4	0.5	0.6	0.8	0.8	0.1	0.2	0.3	0.4	0.3	0.1	2.0	1.9	1.8	1.8	0.1
Azadirach-tin	5 ml/L.	4. 6	3.9	3.8	3.7	0.3	1.7	1.4	1.5	1.9	0.1	1.4	1.1	1.3	1.5	0.1	0.2	0.3	0.3	0.3	0.1
Jojoba oil	10 ml/L.	4.3	4.1	3.9	3.7	0.3	2.1	2.1	2.1	2.1	0.1	2.0	1. 8	1.9	2.0	0.1	1.2	1.1	1.3	1.3	0.1
Sulfur	2.5 mg/Lw.	4.0	3.8	3.7	3. 6	0.3	2.3	2.0	2.0	2.2	0.1	2.0	1.9	2.9	2.1	0.1	1.9	1.8	1. 9	1.8	0.1
Paecilom-yces fumosoroeus	5 ml/L.	4.3	4.0	3.8	3. 7	0.4	2.5	2.9	2.1	2.4	0.1	2.2	2.1	2.2	2.2	0.1	1.9	1.8	2.0	2.0	0.1
Control	-	4. 5	4.2	3.9	3.8	0.4	4.5	3.7	3.5	3.6	0.4	4.5	4.0	3.8	3.7	0.4	2.1	2.2	2.1	2.1	0.4

Table (6): Reduction percent induced by application various control agents for management the *Siphoninus phyllireae* and parasitoid on pomegranate trees during season 2018.

Treatment	Rate of Applic. /L.W	Reduction percent after:																
		One week					Two weeks					Three weeks					Mean Total %	
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	W.	P.
Malathion	1.5	88.4	82.6	76.8	75.5	9	95.3	91.2	90.3	90.3	95	95.4	93.4	90.6	90.0	97	88.3	95
Azadirach-tin	5 ml/L.	63.1	61. 9	55.7	46.2	5	69.3	68.6	64.7	57.1	64	73.0	71.1	66.7	64.1	74	63	63
Jojoba oil	10	51.7	42. 5	40.2	38. 5	69	54.8	51.2	49.2	43.8	78	55.0	52.2	50.9	49.2	82	53	76
Sulfur	2.5	44.5	41.3	37.7	35.8	68	50.8	45.1	44.3	38.8	75	51.5	50.2	45.9	42.3	79	44	74
Paecilomyces fumosoroeus	5 ml/L.	43.4	39.9	33.6	32.3	67	49.3	41.0	40.8	38.3	74	49.8	43.7	42.9	39.8	77	41	72

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