Middle East Journal of Applied Sciences
ISSN 2077-4613
Volume : 06 | Issue :04 |Oct.-Dec.| 2016
Pages: 1169-1179

Survey and Controlling of whitefly, *Bemisia tabaci* and cassava mealy bug, *Phenacoccus manihoti* on Cassava

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Received: 20 Oct. 2016/ Accepted: 19 Dec. 2016/ Publication date: 31 Dec. 2016

ABSTRACT

Cassava is an important source of food to more than one fifth of the world's population spread over Africa, Asia, and South America. Nowadays, in Egypt, cassava was grown because it has economic importance and cassava provides a main source of calories for poor families. The aim of study was to survey the insect pests and to evaluate different oils in controlling whitefly, *Bemisia tabaci* and two photosensitizers in controlling cassava mealybug, *Phenacoccus manihoti*. There are three commercial liquid formulations, Neem (nimbecidine), Ginger oil and Dill oil. Two concentrations 5 and 10 ml /liter water for each formulation were sprayed on cassava plants infested by *B. tabaci* and a recommended rate of imidacloprid (insecticidal reference)were sprayed two times for each season while the control was sprayed with distilled water. Two types of photosynthetizers (Copper chlorophylline (Cu-Chl) and Magnesium chlorophylline (Mg-Chl))were evaluated in controlling of *P. manihoti*. Two concentrations of the photosensitizes compound of Cu-Chl and Mg-Chl were used and a recommended rate of Lex 25% WG (insecticidal reference). The results showed that cassava attacked by different insects species in the field. The identified species are as follows: 2 species belong to Odonata, 1 species belongs to Thysanoptera, 1 species belongs to Hemiptera, 4 species belong to Homoptera. 1 species belongs to Neuroptera, 2 species belong to Lepidoptera, 2 species belong to Coleoptera, 1 species belongs to Diptera, 2 species belong to Hymenoptera. This study demonstrated that Dill oil was the highest effective against *B. tabaci* followed by nimbecidinein during two seasons. The photosensitizer compounds (Cu-Chl (10^{-2}) and Mg-Chl (10^{-2})) were more effective on the cassava mealybug *P.manihoti*in during two seasons.

Keywords: Cassava, *Bemisia tabaci, Phenacoccus manihoti*, Formulations

Introduction

Cassava (*Manihot esculenta*) is one of the leading foods and feed plants of the world and grown mainly for food to millions of people worldwide, and is especially important in Africa. Furthermore, people eat the leaves of the cassava as a green vegetable, which provide a cheap and rich source of protein and vitamins A and B (Nweke, 2005). It is an important source of food to more than one fifth of the world's population spread over Africa, Asia, and South America (Cossa, 2011). Cassava is a robust and reliable crop which tolerates a wide range of climatic conditions and is able to grow under marginal soil fertility. Cassava is a primary main or co-staple food source in much of Africa, with just under 39% of the continent's consumed food energy deriving from cassava (Gleadow *et al.,* 2016).Moreover, cassava can be grown on poor soils, is easily propagated and relatively cheap to produce (Okigbo, 1980). Cassava production in Africa is increasing in response to famine, hunger and drought, and because of its general resistance to pests and diseases (Spencer, 2005). In Southeast Asia and Latin America, it has also taken on an economic role. Various industries use it as a binding agent, because it is an inexpensive source of starch. Cassava flour is used to make cookies, quick breads, loaf breads, pancakes, doughnuts, dumplings, muffins, bagels. The roots can be prepared in various ways, much like potato and sweet potato. The young shoots are used as vegetables. It is also grown as animal feeds and for industrial uses such as bio-fuel, bio-ethanol, alcohol (Wyatt and Brown. 1996, International Institute of Tropical Agriculture 2003). Thresh *et al.* (1997) estimated that the losses in Africa to be 15–24%. FAO projections are that the global area devoted to cassava by 2005 will be 18.6

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million ha, with Africa accounting for 11.9 million ha (FAO, 1997). Furthermore, it is estimated that the introduction of high-yielding varieties, improved pest and disease control and better processing methods could increase cassava production in Africa by 150% by the year 2015 (FAO, 2000).
Cassava pests reduce the yield and cause food and income losses. Pest control measures should be undertaken only when the pests are becoming very abundant and pose a high risk of yield loss and/or the crop looks unhealthy.

The whitefly, *Bemisia tabaci* is an important cassava pest inject the plant mosaic disease viruses (Colvin, *et al.,* 2004 and Legg, *et al.,* 2014).The adults and nymphs occur on the under-surfaces of young leaves. The nymphs appear as pale yellow oval specks to the naked eye. Leaves become smaller, wrinkled and chlorotic. In severe cases, leaves are reduced in size, twisted and distorted. It affects the growth of the plant, resulting in a significant reduction in plant height, stem girth, petiole length and leaf size.

The cassava mealybug, *Phenacoccus manihoti* has resulted in serious losses in cassava production in South America as neither of these pests faced the competition and parasitoids of their native range. Although *P. manihoti* originated in South America and is endemic to the Paraguay River basin, it is patchily distributed, generally occurs in low numbers, and is of no economic importance in this region (Iheagwam and Eluwa 1983). This insect is disaster in African commonly found at cassava shoot tips, on the under surfaces of leaves and on stems. The insects are covered with large amounts of white waxy materials. They are wingless, pink in color, oval in shape, and have very short body filaments Herren (1994). The cassava mealy bug is a clear and present threat to food security and livelihoods of some of the world's most impoverished citizens. Populations of *P. manihoti* were monitored in Paraguay (Herren and Neuenschwander 1991 and Bellotti, 1999).Although a lot of conventional insecticides have been successfully used, they often show undesirable side-effects. For instance, significant toxicity was observed to non-target organisms, such as natural enemies (Gonzalez-Zamora *et al*., 2004). Human health is also related to wide application of conventional insecticides; because their residues are found in water, different kinds of food and might induce various illnesses. Chemical application has resulted in development of resistance against these chemicals, with subsequent population outbreak (Palumbo *et al*., 2001).There are increasing restrictions on the different of pesticides registered for pest control and on the maximum residue levels (MRLs) allowed in the final food products. Therefore, it is needed to implement alternative strategies for the control of insect pests. Only limited attention has been given to other possible control measures such as the use of intercrops, crop disposition or the manipulation of planting date to decrease the risk of infestation (Thresh and Otim-Nape,1994, Dung, *et al*., 2005). Such measures merit consideration in the current search for integrated pest managements (IITA. 2000 and Youdeowei, 2002) that seek to make the most effective use of Photosensitizes and resistant varieties (Hillocks, 1997). There is a need to interest at present in the application of environmentally friendly tools to control insect pests. These essential oils have been traditionally used as medicines in many countries, and as odorants in fragrances and flavor enhancers in many food products. In addition, essential oils could be used in field crops in rotation with other insecticides, lessening the total quantities of more persistent products applied over a growing season. Nowadays, in Egypt, cassava was grown because it economic importance and Cassava provides a main source of calories for poor families. Therefore, the aim of the present study was to survey of insect pests and to evaluate the various oils in controlling whitefly, *B. tabaci* and two photosensitizers prepared by copper and magnesium in controlling the cassava mealybug, *P.manihoti*as major cassava insects.

Materials and Methods

The host plant

Experiment was conducted at Giza Research Station, Agriculture Research Center during 2014/2015 and 2015/2016 seasons. The experiment was carried out in randomized complete block experimental design with four replications. Cassava stem cuttings of Brazilian (Aramaris) variety cultivar obtained from Giza Research Station, ARC, were planted in 1stApril during two seasons. Cuttings were of similar thickness 25-30 cm in length and inserted vertically in the soil with two thirds into the soil keeping one third over ground, then irrigated after planting directly. The randomized complete block experimental design was used. Each experimental plot size was 7x 4m (28m^2). Cassava stakes were spaced at1.0m x 1.0m. Phosphorus fertilizer was added during land preparation at a rate of

50kg P205/fed. in the form of calcium superphosphate (15% P205). Nitrogen fertilizer in the form of ammonium nitrate (33.5%N) at a rate of 50kg N/fed was divided into 3 equal doses. Potassium in the form of potassium sulphate (48% K20) divided into 3 equal doses. Fertilization program started from the third week after planting. Cassava roots were harvested 11 months after planting.

Survey insect pests on cassava:

Field investigation

Plants were investigated after the appearance of the leaves. The leave samples were randomly collected from each plot to record the insect species. The survey was performed weekly when the plant height reached 4 m till 5 months before harvest. Forty plants were weekly taken to monitor the insect species, during two seasons.

The formulation used in controlling of B. tabaci

Three commercial liquid formulations, Neem (nimbecidine) contains0.03% azadirachtin as active ingredient, Ginger oil (*Zingiber officinale*) and Dill oil (*Anethum graveolens*).Two concentrations 5 and 10ml /liter water for each product were sprayed on cassava plants infested by *B. tabaci* in the early morning. The rates were prepared by diluting the compounds in distilled water. A recommended rate of Imidacloprid 35% Sc(30cm/100liter water) was used as insecticidal reference. The control treatment was sprayed with distilled water.

Experimental design of controlling of B. tabaci

The experimental area of about 160 m^2 was divided into 8 equal blocks each involving of5 equal plants, separated by 25-30 cm. distance. Eight treatments, with 3 replicates each, were distributed in the experimental area as follows: blocks 1 and 2 were sprayed with two rates of Nimbecidine, blocks 3 and 4 were sprayed with two rates of Ginger oil, blocks 5 and 6 were sprayed with two rates of Dill oil, block 7was sprayed with imidacloprid using recommended rate by the manufacturer and block 8 was sprayed with ditilled water as a control. The spraying was carried out twotimes for each season. The second spraying was done two weeks interval . The samples were taken on 1st, 3rd, 7th and 10th days after each spraying. The sample includs ten leaves/plant (30leaves/three plants)which were randomly selected from each plot and investigated for alive adults of *B. tabaci*. Whitefly specimens on the leaves plants were indvidually counted in the field. The reduction in the number of *B. tabaci* individual was calculated by using Henderson and Tillton equation (Henderson and Tilton, 1955).

The formulation used in controlling, *P. manihoti*

There are two types of photosynthetizers (Copper chlorophylline (Cu-Chl) and Magnesium chlorophylline (Mg-Chl))which were evaluated in controlling of cassava plants infested by *P. manihoti*in the early morning. The photosensitizescompound of Copper chlorophylline (Cu-Chl)was used two concentration Cu10^{-2} (3.2g/l) and Cu10^{-3} (0.32g/l), also the photosensitizes compound of Magnesium chlorophylline (Mg-Chl) was used two concentration Mg10^{-2} (2.8g/l) and Mg10^{-3}(0.28g/l). A recommended rate ofLex 25% WG(20g/100liter water) was used as insecticidal reference. The control treatment was sprayed with distilled water.

Experimental design of controlling, P. manihoti

The experimental area of about 160m.^{2} was divided into 6equal blocks each involving of 5 equal plants, separated by 25-30 cm. distance. Six treatments, with 3 replicates each, were distributed in the experimental area as follows: blocks 1 and 2 were sprayed with two concentrations of the Cu-Chl, blocks 3 and 4 were sprayed and two concentrations of the Mg-Chl, block 5 was sprayed with Lex 25% WGusing recommended rate by the manufacturer and block 6 was was sprayed with ditilled water as a control. The spraying was carried out twotimes for each season. The samples were taken on 1st, 3rd, 7th and 10th day after each spraying. The sample included ten leaves/ plant (30 leaves/three plants) which were randomly selected from each plot and investigated for alive adults of *P. manihoti*. The cassava mealybug specimens on the plants were indvidually counted in the field during growing phase. The reduction in the number of the cassava mealybug individual was calculated by using Henderson and Tillton equation (Henderson and Tilton, 1955).

Statistical analysis

Data was statistically analyzed by one way ANOVA using F tests used by Duncan test to detect of significantly between concentrations(SPSS computing program), as described by Snedecor and Cochran (1956).

Results

Survey of insect pests on the cassava

Table (1) shows the insect species attack cassava in the field, the destructive stage of each, the feeding habits of these stages and its occurrence, site on the plant. The identified species are as follows: 2 species belong to Odonata, 1 species belongs to Thysanoptera, 1 species belongs to Hemiptera, 4 species belong to Homoptera. 1 species belongs to Neuroptera, 2 species belong to Lepidoptera, 2 species belong to Coleoptera, 1 species belongs to Diptera, 2 species belong to Hymenoptera.

Effect of treatments against whitefly, *B. tabaci*

Field treatments of the infested cassava plants by *B. tabaci* revealed that all the tested compounds reduced significantly the alive number of whitefly in comparison to the control one during all investigated days (1, 3, 7 and 10 days) in both the first and second seasons. The highest rate (10ml/L) was more effective than the lower (5ml/L) for all tested compounds in the first and second spray. The number of whitefly alive increased in the control through the successive days for each spray in both the two seasons, while it decreased with the most tested compounds.

In Table 2, Fig 1, the monitoring of whitefly population on the1st , 3rd, 7th, and 10th days after the first field application and reduction percentages revealed that imidacloprid 35%Scwas the highest effective followed by Dill oil and nimbecidine, Ginger oil at first spray 2014/2015 season. However, Dill oil was the highest effective followed by nimbecidine and Ginger oil at the same season (2ndspray). According to the reduction percentages corresponding to the high rates, the effective of the tested compounds in the second season could be arranged as follows nimbecidine and imidacloprid then Dill oil then Ginger oil at 2015/2016 season. While, Dill oil was the highest effective followed by imidacloprid and nimbecidine in 2nd spray the same season (Table 3, Fig 2).

Effect of treatments against the cassava mealybug, *P. manihoti*

The treatments of the infested cassava plants by *P. manihoti* revealed that all the tested compounds reduced significantly the alive number of the cassava mealy bug in comparison to the control one during all investigated days (1, 3, 7 and 10 days) in both the first and second seasons. The first rate (10ml/L) is more effective than the second (5ml/L) for all tested compounds in the first and second spray. The number of a live cassava mealy bug increased in the control through the successive days for each spray in both the two seasons, while it decreased with the most tested compounds. In Table 4, Fig 3, the population of *P. manihoti* during the1st, 3rd, 7th, and 10th days after the first field application and reduction percentages revealed that Mg-chl10^{-2} and Cu-chl10^{-2} is the highest effective followed by Lex at first spray first season that are 83.8, 81.0 and 66.0%, respectively. However, the 2nd spray, the effective of treatments wasn't significant at the same season. According to the reduction percentages corresponding to the high rates, the effective of the tested compounds in the second season could be arranged as follows Cu-chl10^{-2} and Mg-chl10^{-2} then Lex that is 88.3, 87.5 and 77.3% respectively at first spray second season. AlsoCu-chl10^{-2} and Mg-chl10^{-2}was the highest effective followed by Lex 2nd spray the same season (Table 5, Fig 4).

Table 1: Survey of insect pests associated with cassava during 2014/2015 and 2015/2016 seasons in field.

Order	Family	Scientific name	stages	Feeding habits	Site
Odonata	Agrionidae	*Ischnura senegalensis* Rand	Adults	Predator	-
Odonata	Aschnidae	*Hemianax ephippiger* Selys	Adults	Predator	-
Neuroptera	Chrysopidae	*Chrysoperla carnea* (Steph)	Larvae	Predator	-
Thysanoptera	Thripidae	*Thrips tabaci* Lind	Nymphs, Adult	Sap sucker	Leaves
Hemiptera	Pentatomidae	*Nezara viridula* L	Nymphs Adults	Sap sucker	Leaves,
Homoptera	Aleyrodidae	*Bemisia tabaci*	Nymphs, Adult	Sap sucker	Leaves
Homoptera	Aphididae	*Aphis gossypii* Glover	Nymphs Adults	Sap sucker	Leaves
Homoptera	Pseudococcidae	*Phenacoccus manihoti*	Nymphs Adults	Sap sucker	Leaves
Homoptera	Cicadallidae	*Emposca decipiens* Paodi	Nymphs Adults	Sap sucker	Leaves
Lepidoptera	Pieridae	*Pieris rapae* L.	Larvae	Chewing	Leaves
Lepidoptera	Noctuidae	*Spodoptera littoralis* Boisd	Larvae	Chewing	Leaves
Coleoptera	Coccinellidae	*Coccinella undicempunctata* L.	Larvae, adult	Predator	-
Coleoptera	Coccinellidae	Coccinella septempunctata	Adults	Predator	-
Diptera	Syrphidae	*Syrphus corollae* F.	adult	Predator	-
Hymenoptera	Vespidae	*Polistes gallica* L.	Adults	Predator	-
Hymenoptera	Vespidae	*Vespa orientalis* F.	Adults	Predator	-

Table 2: Effect of some biological formulations against *Bemisia tabaci* on cassava at 2014/2015 season.

Formulation	Rate ml/l	(Mean of live insects ±SE)					Grand mean	Reduction%
		Before spray	After spray(days)					
			1	3	7	10		
1st spray								
Dill oil	**5**	19.7±2.0b	11.3±0.8cd	7.7±1.8de	13.7±5.4b	8.0±2.5c	10.2±2.5bcd	25.2±1.8d
	10	23.0±2.1b	7.7±1.8d	7.3±2.2de	10.3±3.5bc	9.7±3.3bc	8.7±2.6cd	55.8±5.0ab
Ginger oil	**5**	33.3±4.6a	19.3±2.8ab	9.3±1.7cd	13.7±3.3b	14.7±2.7ab	14.2±2.4b	34.4±7.5cd
	10	23.3±2.4b	12.0±1.7bcd	4.7±0.7e	9.0±0.6bc	7.7±1.4c	8.3±0.9cd	45.1±3.3bc
Neem	**5**	21.0±1.5b	17.0±4.5abc	13.0±2.9ab	8.3±0.7bc	4.0±1.5cd	11.3±1.3bc	33.4±5.4cd
	10	23.7±3.3b	13.0±1.0bcd	12.0±2.6bc	3.7±1.7c	6.7±2.7cd	8.8±1.8cd	51.8±11.3ab
Imidaclo-prid 35% Sc	**0.3cm/L**	22.0±4.2b	10.0±1.2cd	7.3±2.2de	4.3±1.2c	1.0±0.5d	5.7±0.6d	65.1±2.6a
control		24.0±0.8b	22.0±3.5a	15.7±0.3a	33.0±4.5a	16.7±1.7a	21.8±0.4a	
F		3.083	3.775	9.636	10.382	6.053	8.876	7.169
P		0.035	0.016	<0.001	<0.001	0.002	<0.001	0.002
2nd spray								
Dill oil	**5**	16.0±0.0c	10.6±0.3bc	7.0±0.0bcd	3.8±0.8ef	5.0±0.0cde	6.3±0.3cd	50.2±3.3ab
	10	24.0±0.6ab	5.7±1.6c	5.0±1.3cd	5.0±0.0de	4.3±0.6de	5.0±0.7d	64.3±9.2a
Ginger oil	**5**	25.0±0.0a	22.0±3.0a	11.0±0.0ab	11.3±0.3b	11.3±0.3b	13.9±0.6b	34.3±5.6bc
	10	20.0±2.0abc	11.0±1.0bc	5.3±0.7cd	9.3±0.7bc	8.3±1.6bc	8.5±1.0c	51.4±7.7ab
Neem	**5**	19.7±1.6bc	21.3±0.3a	15.3±1.3a	7.6±0.6cd	3.3±1.3ef	11.9±0.9b	25.5±0.5c
	10	20.3±3.3abc	12.0±1.0bc	9.3±3.3bc	3.8±1.7ef	7.3±2.3bcd	8.25±2.0c	53.8±1.1a
Imidacloprid 35% Sc	**0.3cm/L**	17.3±1.3c	11.3±0.7bc	4.7±1.7d	3.3±1.3f	0.6±0.3f	5.0±0.5d	64.6±0.7a
control		23.0±0.8ab	15.0±3.5b	16.3±0.3a	29.0±0.0a	17.5±1.7a	18.0±0.4a	-
F		3.260	12.447	8.473	76.66	14.763	20.207	9.621
P		0.028	<0.001	<0.001	<0.001	<0.001	<0.001	0.002

Means followed by the different letters are significantly different from each other at $P<0.05$ (Duncan test).

Table 3: Effect of some biological formulations against *Bemisia tabaci* on cassava at 2015/2016 season

formulation	Rate ml/l	(Mean of live insects ±SE)					Grand mean	Reduction%
		Before spray	After spray(days)					
			1	3	7	10		
1st spray								
Dill oil	**5**	24.3±0.7c	15.0±0.0c	12.0±0.5bc	10.0±5.0b	10.0±0.0b	12.1±1.0b	46.3±1.8c
	10	27.3±2.7bc	4.5±0.3f	9.0±2.0cd	8.3±1.7bc	2.3±0.7d	5.9±0.8de	71.5±3.2ab
Ginger oil	**5**	35.7±5.3ab	14.3±1.7cd	8.3±2.6cde	11.0±1.0b	10.7±1.3b	11.0±1.6bc	58.8±8.4bc
	10	35.0±5.0b	18.7±0.7b	14.0±0.0b	8.6±1.3bc	5.0±0.0c	11.7±0.0b	61.7±7.6ab
Neem	**5**	29.0±2.0bc	11.3±1.7de	12.0±0.0bc	8.7±1.7bc	4.0±0.0cd	8.6±0.8cd	61.2±6.3ab
	10	32.3±2.6bc	14.0±0.0cd	4.0±0.0e	2.0±0.0d	2.3±0.3d	5.5±0.2e	76.5±3.4a
Imidacloprid 35% Sc	**0.3cm/L**	33.7±4.3bc	9.3±0.7e	5.3±1.3de	5.3±0.7cd	3.0±00cd	6.25±0.0de	75.2±3.8a
Control		45.0±6.3a	39.0±3.8a	26.3±3.4a	23.0±2.0a	20.7±2.3a	27.0±3.5a	
F		3.777	78.555	20.697	16.944	66.174	50.397	4.646
P		0.016	<0.001	<0.001	<0.001	<0.001	<0.001	0.012
2nd spray								
Dill oil	**5**	22.0±2.1	9.3±0.3cd	9.0±0.0b	11.3±2.6b	10.0±2.1ab	10.0±0.7b	39.1±6.0d
	10	24.0±2.8	5.0±0.6d	7.0±2.0b	6.0±2.1cd	2.3±0.7c	5.1±0.8e	72.3±3.8a
Ginger oil	**5**	28.0±6.8	13.3±1.4bc	5.7±2.7b	9.0±1.7bc	7.0±3.2bc	8.6±2.1bcd	58.6±8.2bc
	10	29.7±5.2	15.7±3.4b	5.0±0.6b	8.0±1.0bcd	8.3±2.8bc	9.2±1.6bc	56.8±6.2bc
Neem	**5**	24.7±3.7	11.3±1.7bc	10.7±1.3b	8.7±1.7bc	3.3±0.7c	8.5±0.8bcd	55.4±0.9c
	10	27.7±4.1	13.0±1.0bc	7.0±3.0b	3.0±1.0d	2.3±0.3c	6.3±0.8cde	69.5±2.4ab
Imidacloprid 35% Sc	**0.3cm/L**	26.3±6.3	11.3±0.7bc	4.7±1.7b	4.3±0.8cd	2.3±0.7c	5.7±0.6de	71.1±1.4a
Control		36.3±6.3	32.0±3.8a	19.3±3.4a	25.0±2.0a	15.7±2.3a	23.0±1.2a	-
F		0.865	14.587	4.487	15.565	5.668	23.744	9.531
P		0.556	<0.001	0.008	<0.001	0.003	<0.001	0.001

Means followed by the different letters are significantly different from each other at *P<0.05* (Duncan test).

Table 4: Effect of two photosensitizes compounds against *Phenacoccus manihoti* on cassava at 2014/2015 season.

Formulation	Rate g/l	(Mean of live insects ±SE)					Grand mean	Reduction%
		Before spray	After spray					
			1	3	7	10		
1st spray								
Cu-chl10^{-3}	0.32	37.0±1.5	24.0±6.2abc	17.0±4.6ab	7.3±1.7b	6.3±1.3b	13.7±3.2bc	63.1±5.1b
Cu-chl 10^{-2}	3.2	45.0±2.9	12.0±1.2bc	8.7±3.2b	7.3±1.4b	4.0±1.2b	8.2±1.4bc	81.0±7.2a
Mg-chl 10^{-3}	0.28	35.0±2.9	12.3±0.3bc	8.0±1.0b	3.0±0.6b	2.0±1.0b	6.3±0.7c	76.7±6.3ab
Mg-chl 10^{-2}	2.8	35.0±5.8	9.3±2.3c	6.3±1.2b	2.7±0.3b	2.0±0.0b	5.1±0.3c	83.8±0.4a
Lex 25% WG	0.2	50.0±5.0	26.0±7.2ab	24.3±5.8a	11.7±1.2b	6.3±2.0b	16.3±4.0b	66.0±2.7b
Control		38.0±4.0	38.0±4.0a	27.3±8.2a	29.3±8.7a	29.3±5.8a	31.2±4.9a	
F		3.102	5.521	4.308	8.548	16.467	13.015	5.537
P		0.06	0.011	0.024	0.002	<0.001	<0.001	0.021
2nd spray								
Cu-chl10^{-3}	0.32	35.3±0.3bc	18.6±3.6b	15.0±0.0b	9.0±0.0b	6.3±1.3b	12.0±1.0b	65.0±2.0
Cu-chl 10^{-2}	3.2	40.0±0.0ab	11.3±0.6cd	13.3±1.6bc	9.3±0.6b	3.3±0.7bc	8.5±0.7cd	76.6±2.2
Mg-chl 10^{-3}	0.28	28.3±3.3c	6.6±1.6d	7.6±0.3d	2.6±0.3c	2.0±0.0c	4.7±0.3e	68.7±1.6
Mg-chl 10^{-2}	2.8	31.7±1.7c	12.3±0.3bcd	8.6±1.3cd	2.3±0.3c	1.6±0.8c	6.3±0.7de	77.7±3.7
Lex 25% WG	0.2	45.0±5.0a	17.3±1.3bc	14.7±2.7b	10.3±0.3b	4.0±1.0bc	11.7±1.5bc	71.5±3.7
Control		42.0±5.0ab	42.0±5.0a	24.0±3.2a	28.0±3.7a	28.0±1.8a	30.5±2.0a	-
F		7.208	34.847	11.324	70.620	51.905	106.980	0.099
P		0.004	<0.001	<0.001	<0.001	<0.001	<0.001	2.815

Table 5: Effect of two photosensitizes compounds against *Phenacoccus manihoti* on cassava at 2015/ 2016 season.

Formulation	Rate g/l	(Mean of live insects ±SE)					Grand mean	Reduction%
		Before spray	After spray 1	3	7	10		
1st spray								
Cu-chl10^{-3}	0.32	45.0±0.0c	15.0±3.0c	13.3±1.6c	6.7±1.3b	4.3±0.3c	9.7±0.3c	78.7±2.6b
Cu-chl 10^{-2}	3.2	43.3±1.6c	10.0±1.0cd	6.6±0.6e	4.6±0.6b	2.3±0.3cd	5.9±0.3d	88.3±1.2a
Mg-chl 10^{-3}	0.28	43.3±1.6c	12.6±0.6c	10.0±0.0d	6.0±1.0b	5.0±0.0c	8.3±0.3c	79.6±2.7b
Mg-chl 10^{-2}	2.8	36.6±3.3c	7.0±2.0d	8.0±0.0de	3.6±0.6b	0.0±0.0d	4.8±0.3d	87.5±0.3a
Lex 25% WG	0.2	61.6±3.3b	37.0±3.0b	21.6±0.6b	11.0±1.0b	9.3±1.6b	19.0±1.0b	77.3±0.7b
control		87±5.0a	95.0±5.0a	65.0±3.0a	70.0±10.0a	60.0±3.0a	72.5±8.0a	
F		42.208	406.355	662.32	277.21	636.09	1675.0	17.642
P		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00
2nd spray								
Cu-chl10^{-3}	0.32	36.6±6.0bc	10.3±2.8b	10.3±2.6b	5.7±1.2b	3.7±0.8b	8.7±1.1b	76.1±2.6c
Cu-chl 10^{-2}	3.2	36.6±6.0bc	9.3±0.7b	6.0±1.2b	3.0±1.5b	1.7±0.9b	5.0±1.0b	88.8±1.3a
Mg-chl 10^{-3}	0.28	33.3±3.3c	11.3±2.2b	11.3±2.4b	5.3±2.3b	3.3±0.9b	7.8±4.8b	76.9±4.6c
Mg-chl 10^{-2}	2.8	33.3±6.0c	10.0±2.5b	5.7±1.2b	3.7±0.7b	1.3±0.7b	5.1±0.3b	85.2±1.4ab
Lex 25% WG	0.2	55.0±5.8b	27.0±5.0b	17.7±3.4b	8.3±3.2b	5.7±3.2b	14.7±3.4b	76.3±4.0bc
control		76.0±6.3a	82.0±11.9a	75.0±15.0a	78.3±13.6a	81.7±12.0a	79.2±12.9a	
F		7.968	24.118	15.523	24.171	34.892	24.464	5.862
P		0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.017

Means followed by the different letters are significantly different from each other at *P<0.05*(Duncan test) .

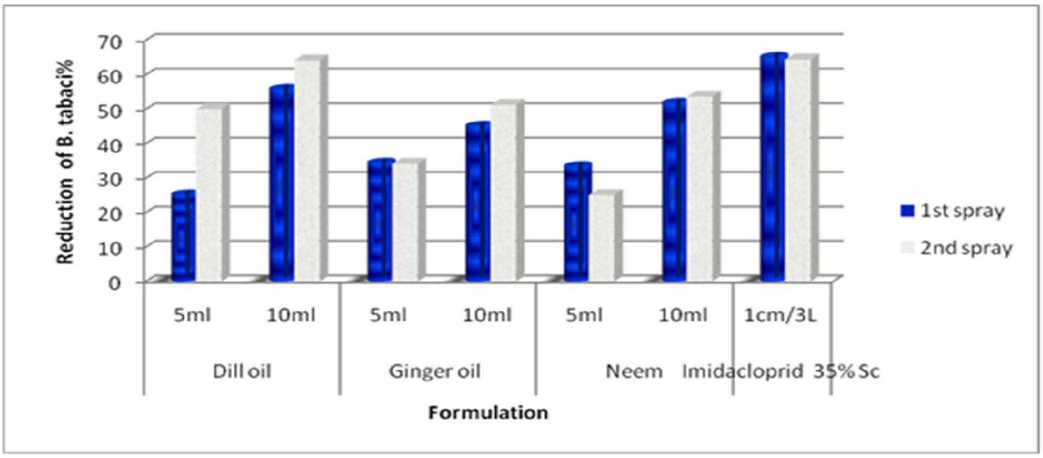

Fig 1: Reduction in population of *Bemisia tabaci* on cassava sprayed with dill oil, ginger oil, Neem and Imidacloprid at 2014/2015 season

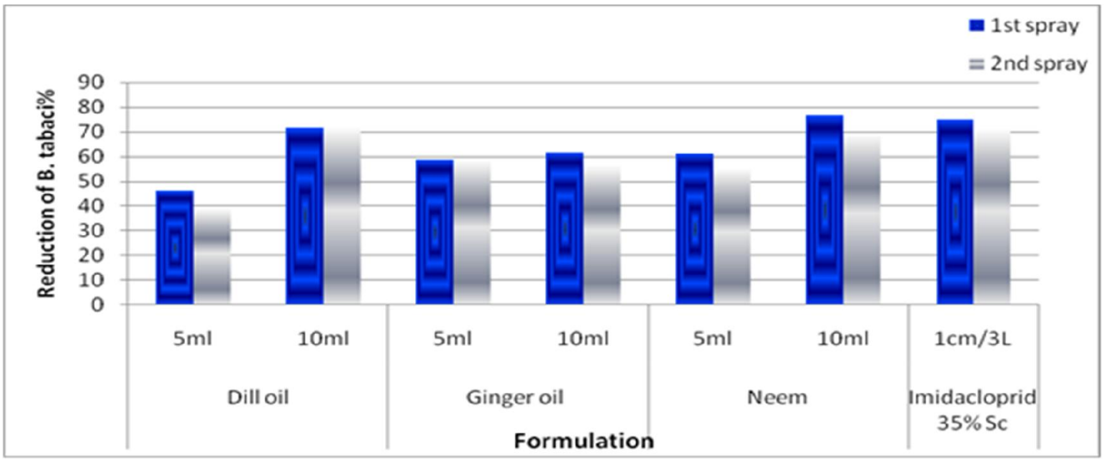

Fig 2: Reduction in population of *Bemisia tabaci* on cassava sprayed with dill oil, ginger oil, Neem and Imidacloprid at 2015/2016 season.

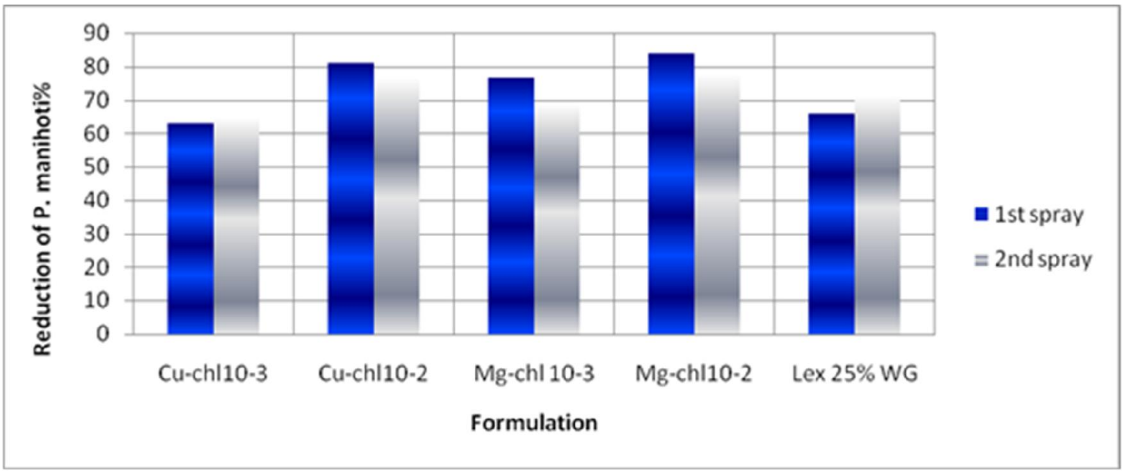

Fig 3. Reduction in population of *Phenacoccus manihoti* on cassava sprayed with two photosensitizes compounds at 2014/2015 season.

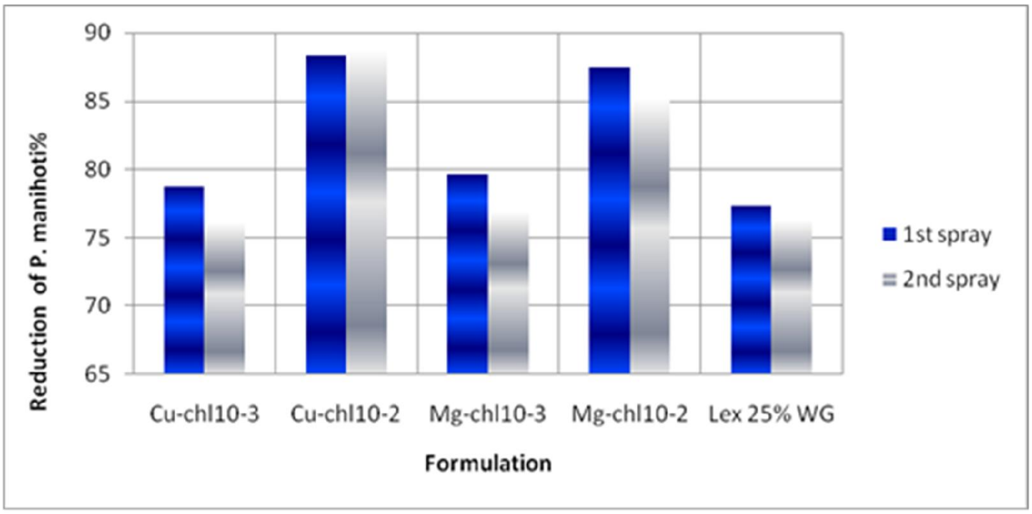

Fig 4: Reduction in population of *Phenacoccus manihoti* on cassava sprayed with two photosensitizes compounds at 2015/2016 season

Discussion

Cassava became a major source of calories for poor families; because of it was high starch content. In Africa, people also eat the leaves of the cassava as a green vegetable, which provide a cheap and rich source of protein and vitamins. In Southeast Asia and Latin America, cassava has also taken on an economic role. Various industries use it as a binding agent, because it is an inexpensive source of starch (Welzen *et al.,* 1997). Recently, it remained largely free from pests, possibly because it is an introduced species, and possibly because it possesses high quantities of cyanogenicglucosides and latex (Herren and Neuenschwander, 1991). Cassava infested with several pest insects. These results are in agreement with those surveyed the insects associated with cassava the most dominant insect pests on these plants were aphids, whiteflies, leafhoppers, mealy bugs, bugs and thrip (Ellis and Bradle, 1996), Garden (1999), Bissdorf (2009) and Bellotti *et al.,* (2011).

There are chemical application resulted in development of resistance against these insects, with subsequent population outbreak (Palumbo *et al*., 2001). Essential oils were valuable secondary metabolites obtained through steam distillation of herbs and medicinal plants (Yatagai, 1997). These data demonstrated that Dill oil was the highest effective on *B. tabaci* followed by nimbecidine in two seasons. These results are in agreement with those Aslan *et al*., 2004; Çalmasur *et al*., 2006 where showed essential oil caused more than 90% mortality of *B. tabaci* adults, while ginger oil had faint repellent activity to *B. Tabaci*a dults (Zhang *et al.,* 2004). However, these oils were only effective against adults of *B. tabaci*, which is inadequate to suppress reproducing populations of this pest. Series of studies have revealed that many pest insects have shown repellent and toxic effects in different essential oils (Isman 2000; Zhang, *et al.,* 2004 and Nerio *et al*. 2010). In earlier studies carried out essential oils of lemon oil was demonstrated a reaction significant increase in the pest (Górski, 2001).

Barkman (2013) showed that efficiency of essential oils was the repellent and toxic effects on *B. tabaci*. The addition of lemon oil increased the number of whitefly trapped on yellow sticky traps by 94.51% in comparison with the control combination without aromatic substances. The application of this compound increased the number of insects caught on yellow sticky traps by 25.32% in comparison with the control (Górski 2004). Yang *et al*., (2010) showed that essential oil derived from *Thymus vulgaris* possessed the greatest contact toxicity, while *Pogostemoncablin* oil exerted the strongest repellency to *B. tabaci*. Hence, these two oils could be used as effective and environmentally sustainable bio-insecticides for the control of *B. tabaci*.

Photosensitizers compounds were efficient alternatives of control many insects (Ben Amor and Jori 2000). Sunlight-activated compounds are usually characterized by a low environmental impact and negligible toxicological risk for humans, mammals, plants or animals. Of special interest would be those photosensitizers, which are already registered as food additives or phototherapeutic agents. Consequently, some studies could open the way for the definition of photo treatment protocols tailored to specific insects and environmental conditions.Luksiene.*et al.*(2007) described that plant pest *Liriomyza bryoniae* (Diptera, Agromyzidae) is sensitive to photosensitizater compounds; the point is that the treatment efficiency strongly depends on used photosensitizer. The combination of sunlight plus photosensitizers was low environmental impact and nontoxic in respect to the WHO classifications (WHO 1975). These observations must be coupled to previous results (Ben Amor and Jori 2000, Moreno *et al*. 2001) showing that adult pests can be effectively killed by photoinsecticides. The preliminary field studies suggest that it is possible to develop field conditions where modest volumes of water, contained in plastic bowls and reasonably transmitting sunlight can be used for killing mosquitoes and pupae, both at the same time. In this regard, recent reports point to the role of simple molecules as specific attractants of adult pests such as mosquitoes (Hallem*et al*. 2004). Field assays combining suitable baits for several vectors and one or possibly several photosensitizers might be valuable, similar to those used in this study where the results showed that the reduction percentages of mealybug, *P.manihoti* were the high rates; the effective of the tested compounds could be Cu-chl10^{-2} and Mg-chl10^{-2}in two seasons.

Conclusion

The cassava attacked by different insect species in the field, the destructive stage of each, belongs to different insect orders. These results demonstrated that Dill oil was the highest effective on *B. tabaci* followed by nimbecidine during two seasons. The photosensitize compounds (Cu-chl10^{-2} and Mg-chl10^{-2}) were more effective on the cassava mealybug, *P. manihoti* in two seasons.

Acknowledgment

The authors would be like to thank Dr. Sayeda S. Ahmed, Department of Economic Entomology and Pesticides, Faculty of Agriculture, Cairo University, Giza, Egypt, for providing the photosensitizer materials to carry out this research work.

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