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The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) as a new menace to cotton in Egypt and its chemical control

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Abstract: The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is a polyphagous sap sucking insect with a wide geographical and host range causing severe losses in economically important crops. This study represents the first record of *P. solenopsis* as a new insect attacking cotton plants (*Gossypium barbadense* var. Giza 86) in Kafr El-Sheikh governorate, Egypt. The insect was noticed on cotton plants for the first time during its growing season of 2014. The mealybug specimens were collected from infested cotton plants and identified as *P. solenopsis*. In an attempt to control this pest, eight toxic materials *viz*., imidacloprid, thiamethoxam, flonicamid, emamectin-benzoate, chlorpyrifos, methomyl, deltamethrin and mineral oil (KZ-oil), belonging to different chemical groups, were tested for their influence against *P. solenopsis* on cotton under field conditions. Methomyl, imidacloprid, thiamethoxam and chlorpyrifos showed the highest efficacy against *P. solenopsis* recording 92.3 to 80.4% reduction of the insect population. Flonicamid, emamectin-benzoate and KZ-oil failed to exhibit sufficient *P. solenopsis* control.

Key words: cotton, Egypt, mealybug, *Phenacoccus solenopsis*, toxicants

Introduction

The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is a polyphagous insect pest. It attacks more than 154 plant species including field crops, vegetables, ornamentals, weeds, bushes and trees (Arif *et al*. 2009; Saini *et al*. 2009) belonging to the families: Malvaceae, Solanaceae, Asteraceae, Fabaceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae. It causes economic damage mainly to cotton, brinjal, okra, tomato, sesame, sunflower and China rose (Arif *et al*. 2009). *Phenacoccus solenopsis* has a wide range of variations in morphological traits, biological adaptation and ecological adjustability (Hodgson *et al*. 2008). It has been found in 35 various ecological zones of the world (Ben-Dov *et al*. 2009). However, it was originally reported as a pest of cotton in Texas, USA in 1989 (Fuchs *et al*. 1991), and later spread to several countries such as Ecuador (Ben-Dov 1994), Chile (Larrain 2002), Argentina (Granara 2003), Brazil (Culik and Gullan 2005), Pakistan (Hodgson *et al*. 2008), Nigeria (Akintola and Ande 2008), India (Nagrare *et al*. 2009) and China (Wang *et al*. 2009). In Egypt, *P. solenopsis* was first recorded on weeds (Abd-Rabou *et al*. 2010) and subsequently as a new insect pest on tomato plants (Ibrahim *et al*. 2015). Unfortunately, this solenopsis mealybug has the propensity to spread through many natural carriers such as raw cotton seeds, wind, rain water, birds, human beings and farm animals. The infested cotton plants become stunted, weak and produce only a few small bolls. The leaves appear distorted, turn yellow and eventually drop off (Dhawan *et al*. 1980; Culik and Gullan 2005). Moreover, this insect excretes honey dew resulting in sooty mold growth, which hinders photosynthesis and reduces the marketability of the product (Saeed *et al*. 2007). Generally, late season infestations of cotton plants, during the reproductive crop stage, cause severe economic damage to the yield. Vennila *et al*. (2010) recorded a cotton yield loss of 34.9% in the Indian Central Zone, and about 3.1 million bales of cotton in 2006–2007 were lost in Punjab, Pakistan (Mahmood *et al*. 2011). The infestations with mealybugs on different host plants could be effectively controlled using biological control agents (Mohyuddin *et al*. 1997), plant extracts (Dinesh *et al*. 2003; Sunitha *et al*. 2009), homeo chemicals (Ahmad *et al*. 2011), and synthetic insecticides (Gross *et al*. 2001; Suresh *et al*. 2010). The present study was undertaken to record *P. solenopsis* as a new pest on cotton in Egypt, and to evaluate the efficacy of new and conventional insecticides, mineral oils and antifeedants against *P. solenopsis* attacking cotton plants under field conditions.

Materials and Methods

A few cotton mealybugs were first noticed on cotton plants (*Gossypium barbadense* var. Giza 86) at the farm of the Sakha Agricultural Research Station, Kafr El-Sheikh

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governorate, Egypt during the fieldwork of the first author during its growing season of 2014. During the subsequent cotton growing season (2015), heavy infestations of this pest were observed in the cotton fields. The mealybug specimens were collected from infested cotton plants and identified at the Department of Insect Classification and Surveying, Plant Protection Research Institute, Agricultural Research Center, Egypt. Mealybug specimens were slide-mounted for identification using the method outlined in Williams and Granara (1992). Identification of the genus was done using the keys of the Pseudococcidae family (Hemiptera: Coccoidea) according to Mohammad and Moharum (2012).

Insecticides

Commercial emamectin-benzoate (Proclaim 5% SG, Syngenta Agrosciences, Switzerland), imidacloprid (Ecomida 30.5% SC, Bharat Insecticides Ltd., India), thiamethoxam (Actara 25% WG, Syngenta Agrosciences, Switzerland), flonicamid (Teppeki 50% WG, ISK Biosciences, Belgium), chlorpyrifos (Dursban 48% EC, Dow Agrosciences, USA), methomyl (Neomyl 90% SP, Rotam Agrochemical Co. Ltd., Hong Kong), deltamethrin (Decis 2.5% EC, Bayer Crop Science, Germany) and mineral oil (KZ-oil 95% EC, Kafr EL-Zayat for Chemicals & Insecticides Co. Ltd., Egypt) were obtained and applied at the concentrations presented in Table 1. The concentrations used were based on the recommendations of the Egyptian Ministry of Agriculture for each insecticide to control cotton pests under field conditions.

Experimental layout and sampling

The experiments were conducted at the farm of the Sakha Agricultural Research Station, Kafr EL-Sheikh, Egypt during September 2015. An area of 2,000 m^2 planted with cotton (*Gossypium barbadense* var. Giza 86) and infested with *P. solenopsis* was divided into plots 42 m^2 each. This area did not receive any insecticidal treatments before the start of the experiment. Nine treatments (8 insecticides + control) were tested in a randomized complete block design with four replications. The test insecticides were applied using a Knapsack sprayer, CP3 (Cooper Pegler Co. Ltd., Northumberland, England). Tap water was used for dilutions. The final volume of spray solution represented 476 $l \cdot ha^{-1}$. Twenty cotton plants were randomly chosen from each replication to count the mealybug population. According to the method described by Ahmad *et al*. (2011), mealybugs on the top ten inches of a plant's terminal portion were counted including stems, leaves and fruiting buds irrespective of their life stage. The chosen plants were examined before spraying and 3, 7 and 10 days post spray. The mean number of *P. solenopsis* per cotton plant was recorded. Percentage reduction in mealybug population among treatments in relation to control was estimated using the formula of Fleming and Ratnakaran (1985) as below:

$$\%\text{Population change} = \left\{1 - \frac{\text{Post treatment population in treatment}}{\text{Pre treatment population in treatment}} \times \frac{\text{Pre treatment population in control}}{\text{Post treatment population in control}}\right\} \times 100$$

Statistical analysis

Data on mealybug population was subjected to one way analysis of variance (ANOVA) and the means were compared for significance by Duncan's Multiple Range Test (Duncan 1955) at 0.05 probability level using CoStat system for Windows, Version 6.311.

Results and Discussion

The cotton mealybug *Phenacoccus solenopsis* as a new insect pest on cotton

The present study represents the first record of the cotton mealybug *Phenacoccus solenopsis* as a new insect pest attacking cotton plants (*Gossypium barbadense* var. Giza 86) in Kafr El-Sheikh governorate, Egypt. The cotton mealybug was noticed for the first time on cotton plants at the farm of the Sakha Agricultural Research Station, Kafr EL-Sheikh, Egypt, during the cotton growing season of 2014. In the subsequent season, the infestations increased heavily. Photographs showing the infestation of *P. solenopsis* on different parts of cotton plants are shown in figure 1. Adult females and nymphs of *P. solenopsis* were observed on cotton leaves, fruiting buds, blooms and green bolls (Fig. 1A–D). The infestation started with a few individuals of *P. solenopsis* on the small leaves and apical buds in the terminal portion of the cotton plant, followed by their spread to different parts of the plant. Colonies were formed in a very short period of time. Figure 1E shows the stems and leaves of the cotton plants completely colonized with the mealybug combined with excreted honey dew on the upper surface of leaves and the growth of sooty mold causing deformation, distortion and death of the infested leaves. Heavy infestation of small bolls resulted in the complete damage and death of the infested bolls (Fig. 1F). These findings are similar to previously recorded symptoms (Culik and Gullan 2005; Osborne 2005; Silva 2012; Ibrahim *et al*. 2015). The cotton mealybug *P. solenopsis* had not been previously noted as a pest of cotton in Egypt. The occurrence of its infestation in Egypt was recorded on weeds (Abd-Rabou *et al*. 2010) and tomato plants (Ibrahim *et al*. 2015). This study is the first published record of cotton as a host for *P. solenopsis* in Egypt. This pest has been recorded as a pest of cotton in several countries such as the United States of America (Fuchs *et al*. 1991), Pakistan (Abbas *et al*. 2007), India (Nagrare *et al*. 2009) and Brazil (Silva 2012).

Efficacy of some toxicants against the cotton mealybug

Eight toxicants, from different chemical groups presented in Table 1 were evaluated under field conditions for their efficacy against *P. solenopsis* infesting cotton plants during 2015. The mealybug populations per cotton plant were not the same before application of the tested toxicants. In fact this is a common problem where the crop is grown under natural field conditions and infested plants are randomly chosen and sampled (Hanchinal *et al*. 2009; Ahmad *et al*.

2011). Hence, the formula of Fleming and Ratnakaran (1985) was used to calculate the percentage of mealybug population change using the mean population pre and post sprays in treated and control plots. The results indicated that methomyl, imidacloprid, thiamethoxam and chlorpyrifos effectively controlled the cotton mealybug recording 92.3, 89.2, 84.6 and 80.4% average decrease, respectively, in mealybug populations compared to the untreated plots. On the contrary, the antifeedant compound (flonicamid) and the avermectin derivative (emamectin-benzoate) exhibited significantly lower activity against the cotton mealybug with an average population decrease percentage of 30.8 and 24.0, respectively. The mineral oil (KZ-oil) showed a promising efficacy after three days of application recording 41.1% reduction in the infestation, but its activity declined sharply to give 13.7% average population reduction over an experimental period of 10 days. The conventional insecticides *viz.*, chlorpyrifos and methomyl have been reported to be the best for mealybug control (Saeed *et al*. 2007; Aheer *et al*. 2009). Suresh *et al*. (2010) recommended the neonicotinoid insecticides, imidacloprid and thiamethoxam, as effective control measures against the cotton mealybug. Ahmad *et al*. (2011) reported that the non-insecticidal treatments did not notably lower the cotton mealybug population. The results of the current study suggest that antifeedants, avermectins and mineral oils in the case of low mealybug infestation and chlorpyrifos, methomyl and neonicotinoids during heavy infestations could be recommended for the management of *P. solenopsis*. Further studies are needed to establish an integrated management to face the menace of mealybug to cotton plantations with less use of chemicals.

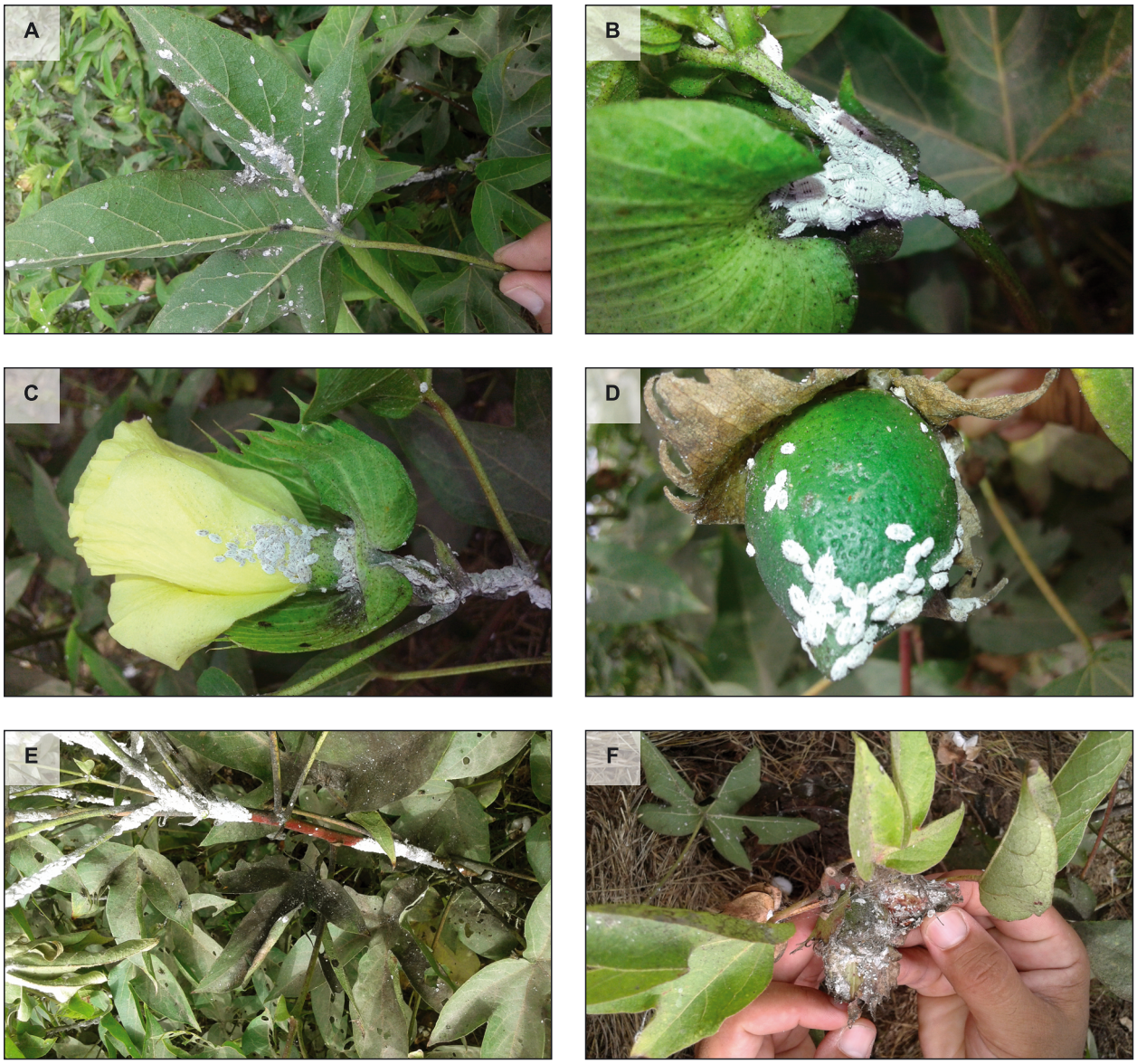

Fig. 1. Infestation of *Phenacoccus solenopsis* on different parts of cotton plants: A – adult females and nymphs of *P. solenopsis* forming the primary infestation on leaves of cotton plants; B – *P. solenopsis* colonizing the fruiting bud of cotton plant; C – the severity infestation of cotton bloom with a population of *P. solenopsis*; D – full-grown boll of cotton infested associated with twisting and death of sepals of the flower calyx; E – stem and cotton plant leaves completely colonized with *P. solenopsis*. Seen are the excreted honey dew on the upper surface of cotton leaves and growth of sooty mold causing deformation, distortion and death of infested leaves; F – small green cotton-boll with heavy infestation of *P. solenopsis* resulting in the complete damage and death of the boll

Table 1. Efficacy of the toxicants against cotton mealybug *Phenacoccus solenopsis* infesting cotton under field condition

Treatments	Chemical group	Used* conc. [mg a.i. · l^{-1}]	Mean population per plant (±SD) and percent reduction of *P. solenopsis*				
			pre-spray	post-spray at indicated days			average of post-spray
				3 days	7 days	10 days	
Imidacloprid	neonicotinoid	183	86.8±6.4	14.4±4.0 (84.2 ab)	7.2±0.8 (92.0 a)	8.4±0.9 (91.3 a)	10.0±1.1 (89.2 ab)
Thiamethoxam	neonicotinoid	62.5	82.9±4.8	24.9±5.4 (71.0 c)	6.7±3.3 (92.4 a)	9.1±3.3 (90.3 a)	13.6±0.6 (84.6 bc)
Flonicamid	pyridinecarbox-amide	225	71.4±5.6	60.0±4.9 (19.9 f)	46.0±5.4 (37.6 c)	51.1±5.6 (35.0 b)	52.3±4.6 (30.8 e)
Chlorpyrifos	organophosphate	2,400	70.4±6.3	16.3±5.6 (78.1 bc)	16.1 ± 1.1 (77.9 b)	11.6±1.2 (85.1 a)	14.6±1.4 (80.4 c)
Methomyl	carbamate	1,350	87.2±5.8	10.5±0.8 (88.4 a)	3.4±1.0 (96.1 a)	6.8±4.0 (92.3 a)	6.9±1.7 (92.3 a)
Deltamethrin	pyrethroid	50	96.0±5.0	45.3±4.6 (55.2 d)	70.0±4.4 (29.6 c)	75.8±5.0 (28.3 bc)	63.7±4.0 (37.7 d)
Emamectin-benzoate	avermectin	15	90.6±3.2	70.5±6.0 (25.9 f)	74.6±2.8 (19.8 d)	73.4±3.7 (26.4 c)	72.8±0.6 (24.0 f)
KZ-oil	mineral oil	9,500	85.6±6.8	52.5±2.3 (41.1 e)	107.1±4.6 (0.0 e)	114.9±3.5 (0.0 d)	91.5±1.5 (13.7 g)
Control	–	–	90.7±5.3	95.9±8.2	94.2±8.6	100.4±8.0	96.8±7.9

*the used concentrations were determined based on the recommendations of Egyptian Ministry of Agriculture
Figures in parentheses refer to the percentages of reduction in mealybug's population comparing to control.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955)

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