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Research Article

CONTROL STRATEGIES OF PAPAYA MEALYBUG, PARACOCCUS MARGINATUS WILLIAMS AND WILLINK IN THE LABORATORY CONDITION

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Abstract

The laboratory experiment was conducted at the laboratory of the Department of Entomology, Bangladesh Agricultural University to determine the effectiveness of polythene band, predatory ladybird beetles (available species found in Bangladesh viz. *Coccinella transversalis* (F.), *Micraspis discolor* (F.), *Menochilus sexmaculatus* (F.), *Cyclonida sanguinea, Adalia bipunctata, Coccinella novemnotata* and *Illeis koebelei*), four chemical insecticides and three botanical oils in controlling papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink. The chemical insecticides were Sevin 85 SP, Dimethoate 40 EC, Fipronil 50 EC, Deltamethrin 2.5 EC, and the botanical oils were Neem oil, Mahogany oil and Karanja oil. In the laboratory experiment, polythene banding failed to prevent the plant from the infestation of papaya mealybug. Seven commonly available species of ladybird beetles in Bangladesh did not provide any control to papaya mealybug. Among the chemical insecticides, Sevin 85 SP and Dimethoate 40 EC showed significant mortality of papaya mealybug. Deltamethrin 2.5 EC and Neem oil (2%) provided moderate control of the pest. The remaining insecticides and botanical oils were less effective to control papaya mealybug.

Keywords: Papaya mealybug; Sevin 85 SP; Neem oil; Ladybird beetle.

Introduction

The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink is a small, soft bodied insect pest belongs to the Family Pseudococcidae under the Order Hemiptera. According to Williams *et al.*, (1992), *Paracoccus marginatus* was first recorded in Mexico during 1955. Walker *et al.,* (2003) stated that *Paracoccus marginatus* was recorded from the 14 Caribbean countries. Invasion of papaya mealybug in Asia was first reported by Muniappan *et al*., (2008) from Java, Indonesia and Tamil Nadu in India. Papaya mealybug was first reported in Bangladesh in 2009 (Muniappan, 2010). Within a short period of time, the papaya mealybug is now spread all over the country. The papaya mealybug, *Paracoccus marginatus* feeds on the sap of plants by inserting its stylets into the epidermis of the leaf and also into fruits and stem. At the time of feeding, it injects a toxin into the plant which causes chlorosis, stunting, leaf deformation and heavy build-up of honeydew ultimately leading to the death of the plant. Honey dew produced by this bug results in the development of sooty mould that covers the leaves, fruits and stems, obstructing photosynthesis and gaseous exchange. Heavy infestations are capable of rendering fruit inedible due to the buildup of thick white wax. Heavily attacked plants were killed (Walker et al., 2003; Hue et al., 2007). The papaya mealybug, *Paracoccus marginatus* is a noxious insect pest attacking papaya and other agricultural plants of economic importance (Miller & Miller, 2002). It is therefore necessary to find out appropriate management strategies to control this insect in Bangladesh.

Materials and Methods

Laboratory Experiments for Controlling Papaya Mealybug

Host plant

The Sinta papaya seed variety of Lal Teer Company was used for raising seedlings in polythene bags (12 x 8 cm size with 3-4 holes at the bottom) filled with prepared soil media. The soil media was prepared with the mixture of loam soil and well decomposed cowdung in equal proportion. Two seeds were sown per bag at 1cm depth in the soil media and watered regularly to keep the media moist for higher germination. The seedlings were grown at 28±2^{0}C temperature with the photoperiod 12L: 12D in the IPM lab. Thirty five (35) days old seedlings were used in this experiment to study the effectiveness of different control approaches.

Rearing of papaya mealybug

Papaya mealybugs were collected from the papaya field and reared on papaya plant in the insect rearing room of the department of Entomology, Bangladesh Agricultural

University. New plants were added roughly every 4 weeks, and old plants were removed after the mealybug had settled on the new plants. Population of the papaya mealybug was maintained until completion of the research work. The reared mealybugs were used in this experiment to perform different treatments.

Treatments

Use of polythene band

In this experiment three types of plants were used such as mealybug infested plants as source of mealybug, uninfested plants with polythene band as treatment, and uninfested plants without polythene banding as control plants. In polythene banding, the trunk of papaya plants were covered with 3 inch polythene band at the base, 1 inch apart from the soil surface. Total five plants were banded with polythene sheet. Later on, plants were arranged in three rows, where mealybug infested plants were placed in left row, the ploythene banded plants were kept in middle row, and the uninfested control plants were kept in right row.The distances between plant rows were 35 cm. All plants were carefully observed for the next 60 days to observe the movement of mealybug and their possible infestation.

Use of predatory ladybird beetles to control papaya mealybug

Free choice test

In the free choice test experiment for the selected ladybird beetles, both papaya mealybug and cowpea aphids were provided together to feed on. In a 15 cm petridishes, ten papaya mealybugs were kept at one side and ten cowpea aphids were kept on another side along with their host plant parts, where one ladybird beetle was released in the middle. Continuous observation on feeding behavior of ladybird beetle was made for the next 6 hours and data were recorded.

Forced feeding experiment

In force feeding experiment, a pair of adult beetle was released in a petridesh and ten mealybugs/petridesh were supplied as food for the predator. The supplied mealybugs were tiny immature stages to adult. Predation behavior of the selected ladybird beetle was observed hourly for the first 12 hours, and after wards observation was made at every 24 hours.

Methodology for testing botanicals and chemical insecticides

Four synthetic insecticides such as Sevin 85 SP, Dimethoate 40 EC, Fipronil 50 EC, Deltamethrin 2.5 EC and three botanical oils viz. Neem oil, Mahogany oil and Karanja oil were evaluated to compare their efficacy against papaya mealybug. The doses of insecticides were according to the manufacturer recommendations and presented in table 1. In case of botanical oils, 2% solution was prepared by adding 2 ml oils in 100 ml water with detergent powder at the rate of 1 gram/L.

The efficacy of insecticides and botanical oils was tested against papaya mealybug on standing papaya plant organized according to a Randomized Complete Block Design in the laboratory. Ten mealybugs per plant were released on papaya plant from the cultured populations with the help of a fine camelhair brush and special care was taken during transferring mealybugs to avoid injury. After the release of mealybugs, each plant was placed individually on a special plastic tray with an inner and outer ring. The plant was place on inner ring and the outer ring was filled with detergent water to prevent mealybugs escaping. *When* all mealybugs were properly settled on experimental plants within 3 days, different treatments were employed. Five plants per treatment were used and plants were sprayed 2 times at 15 days interval. The first and the second spraying were made on 26 January 2014 and 10 February 2014, respectively with the help of a hand-operated sprayer. Care was taken to avoid spray drift on adjacent plants. The spraying was done in such a way that the whole plant was thoroughly covered by spray material. The control plants were sprayed only with water.

Table 1: Overview of insecticide application rates and dose in laboratory experiments

Chemical Name	Trade Name	Application rate and dose
Carbaryl	Sevin 85 SP	2 times at the rate of 3.44gm/liter of water
Deltamethrin	Major 2.5 EC	2 times at the rate of 1 ml/liter of water
Dimethoate	Biesterthoate 40 EC	2 times at the rate of 2.25ml/liter of water
Fipronil	Aroma 50 SC	2 times at the rate of 1 ml/liter of water
Neem oil	Neem oil	2 times at the rate of 20 ml/liter of water
Karanja oil	Karanja oil	2 times at the rate of 20 ml/liter of water
Mahogany oil	Mahogany oil	2 times at the rate of 20 ml/liter of water

Pre-treatment data were collected one hour before application of insecticides and botanical oils. For recoding the data all plants parts along with polythene bag and soil media were observed. The number of mealybugs and its progeny were counted using magnifying glass. The data on the number of adults survived per plant under different treatments were recorded after one, seven and fifteen days of the first and second spraying. The number of offspring per plant for each treatment was recorded on the last date of data collection (after fifteen days of the second spraying).

Statistical analysis

Results were subjected to a one-way analysis of variance. Differences between mean values were tested using Tukey's-HSD-test at $p = 0.05$.

Results and Discussions

Effectiveness of polythene band to prevent papaya mealybug

Infestation of papaya mealybug was first noticed in control plants on 30 days, while mealybugs were first noticed in polythene banded plants little bit later on 36 days and subsequently attacked all of the polythene banded plants. Visual observation showed that polythene band can prevent the climbing of only mature mealybug to the papaya plant and they remained on the stem below the band and suck sap from there (Fig. 1). However the tiny immature stage can easily walk onto the polythene band and established successfully to the top of the plant (Fig. 2). Therefore, polythene band did not prevent the plant from the infestation of papaya mealybug. In India, some of the farmers attempted to stem banding by tying black polythene paper around stem above ground level to prevent the migration from infested material (Ayyasamy & Regupathy 2010). But the efficacy was limited similar to the present study. Tanwar *et al.*, (2010) reported that application of sticky bands or alkathene sheet or a band of insecticide on arms or on main stem can prevent movement of crawlers. The findings of this study revealed that polythene band alone cannot prevent the movement of tiny crawlers. However, any sticky substances on the polythene band may prevent the infestation.

Effectiveness of ladybird beetle to control papaya mealybug

Seven ladybird beetle species such as *Coccinella transversalis* (F.), *Micraspis discolor* (F.), *Menochilus sexmaculatus* (F.), *Cyclonida sanguinea*, *Adalia bipunctata*, *Coccinella novemnotata* and *Illeis koebelei* were used as bio control agent to control the papaya mealybug. In the free choice test, it was found that three species of lady bird beetles prefer aphids to feed on and did not feed any papaya mealy bug. The other four species neither prefer aphids nor mealy bugs to eat (Fig. 3). In the force feeding experiment with papaya mealybug only, it was observed that adult of the selected seven ladybird beetles did not feed on papaya mealybug and all were died due to starvation. Therefore, the commonly available ladybird beetle in Bangladesh did not provide any control to papaya mealybug.

Fig. 1: Infestation of adult papaya mealybug below the polythene band.

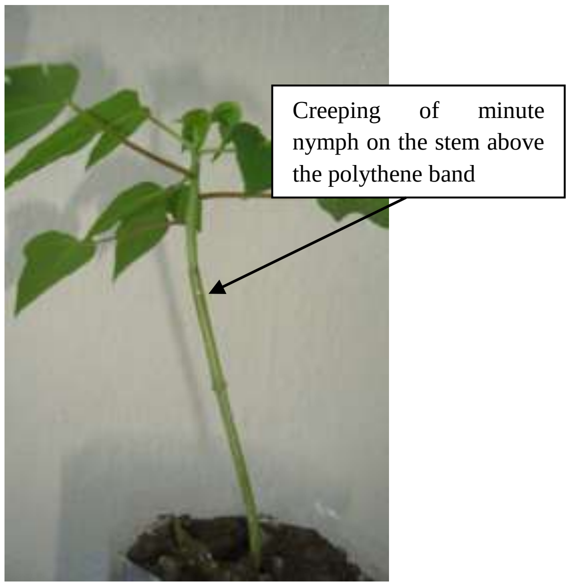

Fig. 2: Crawling of tiny papaya mealybug on to polythene band.

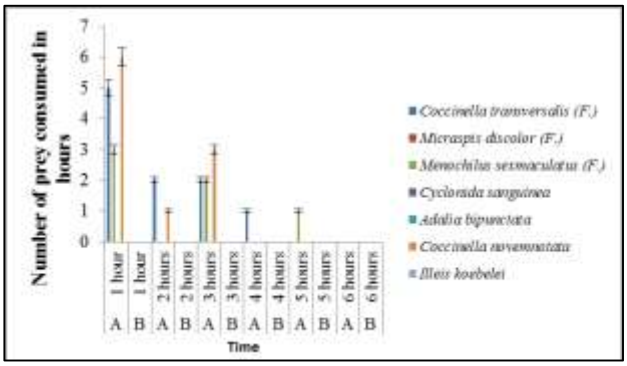

Fig. 3: Prey preference of different ladybird beetle species (where A= *Aphis craccivora* and B= *Paracoccus marginatus*).

Table 2: Mortality of the papaya mealybug, *Paracoccus marginatus* at different times following insecticides

Treatments	Mortality of papaya mealybug (%)					
	First spraying			Second spraying		
	1 DAS	7 DAS	14 DAS	1 DAS	7 DAS	14 DAS
Sevin 85 SP	88a	100a	100a	100a	100a	100a
Dimethoate 40 EC	96a	100a	100a	100a	100a	100a
Fipronyl 50 SC	10bc	38de	40de	40de	40de	52cd
Deltamethrin 2.5 EC	20b	62bc	66bc	68bc	70bc	78ab
Control	0c	0f	0f	16f	16e	28d

Mean values followed by different letters within a column for one sampling day indicate significant differences for treatments (Tukey's HSD: P<0.05). DAS indicate days after spraying.

Table 3. Mortality of the papaya mealybug P. marginatus at different times following botanical treatments

Treatments	Mortality of papaya mealybug (%)					
	First spraying			Second spraying		
	1 DAS	7 DAS	14 DAS	1 DAS	7 DAS	14 DAS
Neem oil (2%)	0c	48cd	52cd	52cd	58cd	64bc
Karanja oil (2%)	0c	32de	34de	42d	42de	50cd
Mahogany oil (2%)	0c	22ef	24e	24ef	28e	48cd
Control	0c	0f	0f	16f	16e	28d

Mean values followed by different letters within a column for one sampling day indicate significant differences for treatments (Tukey's HSD: P<0.05). DAS indicate days after spraying.

Several natural enemies of papaya mealybug exist and are commercially available including the mealybug destroyer/Australian mealybug ladybird (*Cryptolaemus montrouzieri*), lacewings, hover flies, Scymnus sp. and some hymenopteran and dipteran parasitoids (Tanwar *et al*., 2010). Importation and conservation of new predator, particularly the mealybug destroyer *Cryptolaemus montrouzieri* which is widely used in foreign countries such as Australia, USA and India may be helpful to control this noxious insect in Bangladesh.

Efficacy of chemical insecticides and botanical oils on papaya mealybug:

Effect on mortality

The result of the experiments after 1day, 7days and 14 days of first and second spraying of chemical insecticides and botanicals is represented in Table 2 and Table 3 respectively.

Efficacy of all chemical insecticides and botanical oils were increased with the progress of post treatment time and application frequency. Instant mortality was achieved within 1 day for the application of Sevin 85 SP and Dimethoate 40 EC, where the mortality percentage was 88 and 96, respectively. Among the four chemical insecticides, Sevin 85 SP and Dimethoate 40 EC provided 100% control while Deltamethrin 2.5 EC provided moderate control. The chemical insecticide Fipronil 50 SC did not control papaya mealybug successfully and no statistical difference was found compared to control plant. Among the botanical oils, Neem provided moderate control while Mahogany and Karanja oil were less effective.

Effect on reproduction capability

Sevin 85 SP and Dimethoate had 100% lethal effect on papaya mealybug as a result no alive female was found and consequently second generation did not originate in the treated plants. On the other hand Deltamethrin 2.5 EC had less lethal effect compared to Sevin 85 SP and Dimethioate 40 EC, but this insecticide ceased the reproduction capability of papaya mealybug. No new generation was produced by the Deltamethrin 2.5 EC treated papaya mealybug. Among the botanical oils, Neem oil comparatively prevents the flourish of second generation compared to Mahogani and Karanja oil (Table 4). Anuradha and Annadurai (2008), cited that azadirachtin disrupts the juvenile hormone titers and ovarian ecdysteroid production, leading to a reduction in the number of viable eggs and live progeny. Azadirachtin affects the formation of spermatozoa. Although Neem had less effect on mortality, it can be used to suppress the population increase when the number of papaya mealybug remains below economic injury level. In severe attack, Sevin 85 SP or Dimethoate 40EC can be used for immediate control of this insect pest.

Table 4: Effect of different insecticides and botanicals on the reproduction capability of *Paracoccus marginatus*

Treatments	Number of nymphs in second generation
Sevin 85 SP	0.0a
Dimethoate 40 EC	0.0a
Fipronyl 50 SC	318.0b
Deltamethrin 2.5 EC	0.0a
Neem oil (2%)	49.6a
Karanja oil (2%)	161ab
Mahogany oil (2%)	197.4ab
Control	265.6b

Mean values followed by different letters indicate significant differences in nymph number among treatments (Tukey's HSD: $P<0.05$).

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