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Efficacy of certain insecticides on papaya mealybug, *Paracoccus marginatus* Williams & Granara de Willink (Hemiptera: Pseudococcidae)

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Abstract
The papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae) has emerged as the most devastating pest of papaya recently. It is the necessity of time to stay well equipped to conquer such pest by using potential insecticides. Certain newer insecticides along with some conventional insecticides were assayed using potato dip method against female *P. marginatus*. After 24 hours, chlorpyriphos 20 EC (LC_{50} 21 µl/l) and thiamethoxam 25 WG (LD_{50} 44 mg/l) were the most effective and Buprofezin 25 SC (LC_{50} 1000 µl/l) proved to be the least effective among the insecticides tested in bioassay test. Whereas in case of field trials, Thiamethoxam 25 WG, Spirotetramat 240 EC, Imidacloprid 17.8 SL, Dimethoate 30 EC, Lamda-cyhalothrin 5 EC and Buprofezin 25 SC were found to be very effective for management of the pest.

Keywords: Bioassay, chlorpyriphos, field trials, papaya mealybug, thiamethoxam

1. Introduction
The papaya mealybug, *Paracoccus marginatus* is a native of Mexico and/or Central America [9] and it was described by Williams & Granara de Willink in 1992 [1] from the specimens collected in Mexico. It was first reported in St. Martin in the Caribbean in 1995 and since then has spread to 13 countries in the Caribbean, Florida in the US, and three countries each in Central and South America by 2000 [5, 9]. In 2002, it was reported in the Pacific Islands [11, 13] and in 2008 in Indonesia, India, and Sri Lanka [12]. In 2009, it was reported from Bangladesh and Maldives and in 2010 in Cambodia, Philippines and Thailand [10, 15].
P. marginatus is a hemipteran insect and belongs to family Pseudococcidae and can be distinguished by its greenish yellow body [9] colour with large amounts of white waxy secretion. It is polyphagous [8] in nature and sucks the sap of the leaves, stems, fruits of plant and even on seedling. It causes deformation, wrinkling and rolling of the leaf edges and early leaf drop [15]. Further this, it causes blemishes on fruits resulting reduce the market value. The leaves become crinkled, yellowish and wither. The honey dew excreted by the bug and the associated black sooty mould formation impairs photosynthetic efficiency of the affected plants. In India it has caused havoc in agricultural and horticultural crops ever since its first report from Coimbatore in 2007 [19]. It has a wide host range of over 60 species of plants including economically important plants such as *Annona squamosa*, *Carica papaya*, *Hibiscus rosa-sinensis*, *Ipomoea* spp., *Manihot esculenta* and *Solanum melongena* [2, 15] and completes upto 11 generations in a year [16]. It assumed the status of a major pest in India in 2009 when it caused severe damage to economically important crops and huge losses to farmers in Coimbatore, Erode, Tirupur and Salem districts of Tamil Nadu [19]. In the same year, standing mulberry crop over 1,500 hectares in Tirupur was destroyed by the pest leading to enormous financial losses to mulberry growers across the district [19].
Pollution of pesticides residues and high cost of chemical control, which are resulted from misusing of the pesticides, push us to eliminate the use of pesticides but solely biological control at a high level of pest is not enough to suppress the population [14]. Papaya mealybug has the capability to increase their population and spread rapidly within very short span of time in favourable condition. For this, other control measures except chemical control is time consuming. So, chemical control is the last resort to check the mealybug population within short period of time.
Keeping in view, the present study aims to evaluate the efficacy of certain new and conventional insecticides against papaya mealybug, *P. marginatus* in order to identify the potential molecules for developing proper management strategy against this pest.

2. Materials and Methods

The present investigation was carried out at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur; West Bengal during 2011 and 2012.

Test insect

The mealybugs were collected from Mohanpur, Nadia, West Bengal from papaya plant and later reared on sprouted potato tubers in the laboratory at 25-34˚C temperature and 84-93% RH. The first instar nymphs hatched within 24 hrs. Were reared. The cultures were maintained in a beaker, the mouth of which was covered and secured with a piece of cloth and rubber band. Then the insect cultures were maintained for future use.

Source of the insecticides

Commercial formulations of chlorpyriphos 20 EC (Dow Agro-Science), thiamethoxam 25 WG (Syngenta Ltd.), profenophos 50 EC (PI Industries Ltd.), Lamda cyhalothrin 5 EC (Sh. Ramcides Chemicals Pvt. Ltd.) imidacloprid 17.8 SL and Spirotetramat 240 EC (Bayer Crop Science Ltd.), dimethoate 30 EC and Buprofezin 25 SC (Rallis India Ltd.) were obtained from respective principal manufactures. The proprietary products were used to prepare stock solution in distilled water from which further concentrations were prepared subsequently by serial dilution (six different concentrations were used for bioassay). Each treatment including untreated control was replicated thrice.

Bioassay test

Potato dip method

Medium size fresh sprouted potatoes dipped in six different doses of insecticide solution for 5 minutes. Then, potatoes were removed from test solutions and keep them drying under fan for 2 hours inside the room. After that, treated potatoes placed in glass container and twenty third instar female mealybugs were released within that container. Mouth of container was covered with the muslin cloth and kept them at room temperature at 27±2 °C and 60±5% RH. Then, mealybug mortality rate was counted by taking out them on black paper at 1, 2 And 3 days after treatment.

Field test

The papaya seedlings were transplanted at a spacing of 1.5 meter x 1.5 meter in each plots after final land preparation. Selected insecticides were evaluated with two sprays for control of the papaya mealybug at C farm, BCKV, Kalyani. All recommended agricultural practices were followed from time to time to raise the crop successfully. When plants were 80 cm to 1 meter in height, mealybugs were brought from the laboratory and ovisacs placed on top of the leaves.

Count of mealybug population

Four weeks after infestation, mealybug populations (number of mealybugs per 75 cm^2 leaf area) were counted on under surface of leaf by (magnified glass) hand lens. A pretreatment count was taken on one day before spraying insecticides. Spray treatments were applied using hand sprayers. Each treatment was replicated three times with each replicate being an individual plant. Treatments were evaluated 1, 3, 7, 10 and 15 days after spraying.

Data analysis

Probit analysis and lethal concentrations were calculated according to Finney's method by using Polo plus software. The per cent reduction in mealy bug population was calculated by Abbott's formula and the pre and post treatment population of mealybug was subjected to ANOVA test and the means were separated by Duncan's Multiple Range Test (DMRT) using SPSS. Percent reduction or corrected mortality was done by the following formula

Percent reduction or corrected mortality =

$$\frac{X-Y}{X} \times 100$$

Where

X= the percent living in check

Y= the percent living in treatment

3. Results and Discussion

In bioassay test it is found that chlorpyriphos was relatively more toxic than other insecticides after 24 and 48 hrs of treatment followed by thiamethoxam, profenophos, imidacloprid, lamda-cyhalothrin, spirotetramat and dimethoate respectively in a descending order against third instar nymph of papaya mealybug. Buprofezin exhibited lowest level of toxicity after 24 hrs, taking as the standard (Table 1 & 2).

Table 1: Dosage mortality response and LC_{50} values of different insecticides for *P. marginatus* after 24 hours of exposure

Insecticide	Heterogeneity	Regression equation (Y=)	LC_{50} (ppm)	Fiducial limits	Relative toxicity
Thiomethoxam	0.37	2.78x- 4.56	44	33-57	22.73
Dimethoate	0.45	3.95x- 9.46	247	198-301	4.05
Imidacloprid	0.23	2.22x- 4.37	92	69-128	10.87
Profenophos	1.42	2.25x- 4.00	62	34-105	16.13
Chlorpyriphos	0.96	1.43x- 1.91	21	12-33	47.62
Lamda cyhalothrin	0.42	3.54x- 8.17	203	161-256	4.93
Spirotetramat (Movento)	0.27	3.52x- 8.13	204	162-260	4.90
Buprofezin	0.70	2.17x- 6.51	1000	714-2019	1

Table 2: Dosage mortality response and LC_{50} values of different insecticides for *P. marginatus* after 48 hours of exposure

Insecticide	Heterogeneity	Regression equation (Y=)	LC_{50} (ppm)	Fiducial limits	Relative toxicity
Thiomethoxam	0.30	3.07x- 4.23	24	17-31	36.42
Dimethoate	0.43	3.09x- 6.62	138	104-175	6.33
Imidacloprid	0.19	2.68x- 4.42	45	33-59	19.42
Profenophos	0.24	2.23x- 3.31	31	20-42	28.19
Chlorpyriphos	0.08	2.06x- 2.12	10	5-16	87.40
Lamda cyhalothrin	0.67	4.54x- 9.53	125	101-154	6.99
Spirotetramat (Movento)	0.43	3.63x- 8.23	184	147-232	4.75
Buprofezin	0.89	2.37x- 6.97	874	650-1522	1

In field condition, the mealybug population were recorded one day before spray and it was found that their population varied from 79 to 91/75 sq. cm of leaf area. Observations recorded on the 1st day after application of first insecticidal sprays showed that, the maximum mean nymphal reduction was recorded in the plants receiving lamda cyhalothrin @ 37.50 g a.i./ha (18.53%) followed by thiamethoxam @ 62.5 g a.i./ha (13.2%), dimethoate @ 300 g a.i./ha (12.88%), profenophos @ 500 g a.i./ha (12.14%), chlorpyriphos @ 200 g a.i./ha (9.62%), spirotetramat @ 59.95 g a.i./ha (8.09%) and imidacloprid @ 44.48 g a.i./ha (7.82%) respectively but buprofezin @ 250 g a.i./ha had no effect on mealybug mortality after 24 hrs. After 3days of treatment it was found that maximum mortality occurred in lamda cyhalothrin treated plant (75.67%) followed by thiamethoxam (68.8%), dimethoate (59.85%), chlorpyriphos (56.48%), spirotetramat (54.04%), profenophos (51.82%), imidacloprid (48.15%) and buprofezin (8.81%) respectively although profenophos, chlorpyriphos and spirotetramat effects on mealybug mortality was statistically at par with each other. Whereas after 7 days of insecticide treatment maximum mortality found in spirotetramat treated plant and least was found in buprofezin treated plant. In this experiment no mortality of mealybug was found in lamda cyhalothrin treated plant after 3 days onwards. After 10 days imidacloprid treated plant caused 78.19% mortality and buprofezin caused 74.71% mortality and they were statistically at par with each other.

The buildup of PMB population after 15 days of first spray increased steadily in control plot (from 83 to 102) and population increase almost 23% of previously present population. But in treated plant insect number before one day of second spray (Table 3) was varied from 35 to 61/75 sq. cm of leaf area. Observations recorded on the 1st day after application of second insecticidal sprays showed that, the maximum mean nymphal reduction was recorded in the plants receiving lamda cyhalothrin @ 37.5 g a.i/ha (24.83%) and least by imidacloprid @ 44.48 g a.i/ha (7.43%) whereas buprofezin @ 250 g a.i/ha had no effect on insect mortality although thiamethoxam, chlorpyriphos and dimethoate effects on mealybug mortality was statistically at par with each other. After third day of spraying, maximum mealybug mortality was found in lamda cyhalothrin (100%) treated plant followed by thiamethoxam @ 62.5 g a.i/ha (97.06%), dimethoate @ 300 g a.i/ha (95.06%), spirotetramat @ 59.95 g a.i/ha (77.34%), chlorpyriphos @ 200 g a.i/ha (77.06%), profenophos @ 500 g a.i/ha (74.72%), imidacloprid @ 44.48 g a.i/ha (66.23%), and buprofezin @ 250 g a.i/ha (8.57%) respectively. After 7 days cent per cent mortality of mealybug was found in maximum above mentioned insecticides except chlorpyriphos, profenophos and buprofezin treated plant whereas cent per centage of mortality occurred after 10 days of buprofezin treated plant.

Table 3: Field efficacy of insecticides against *Paracoccus marginatus* on papaya

SL. No.	Treatments	Dose g a.i/ha	Percentage mortality					
			PTC*	1DAT	3DAT	7DAT	10DAT	15DAT
1	Thiamethoxam 25 WG	62.50	45	23.53 (29)^{ab}	97.06 (81)^{b}	100 (90)^{a}	Nil	Nil
2	Dimethoate 30 EC	300	52	19.74 (27)^{ab}	95.54 (78)^{b}	100 (90)^{a}	Nil	Nil
3	Imidacloprid 17.8 SL	44.48	49	7.43 (16)^{c}	66.23 (55)^{c}	100 (90)^{a}	Nil	Nil
4	Profenophos 50 EC	500	61	16.85 (25)^{b}	74.72 (60)^{c}	96.07 (79)^{b}	Nil	Nil
5	Chlorpyriphos 20 EC	200	57	22.35 (28)^{ab}	77.06 (62)^{c}	98.23 (83)^{ab}	Nil	Nil
6	Lamda cyhalothrin 5 EC	37.50	48	24.83 (30)^{a}	100 (90)^{a}	Nil	Nil	Nil
7	Spirotetramat 240 EC (Movento)	59.95	43	10.16 (19)^{c}	77.34 (62)^{c}	100 (90)^{a}	Nil	Nil
8	Buprofezin 25 SC	250	35	0 (4)^{d}	8.57 (17)^{d}	76.19 (61)^{c}	100 (90)^{a}	Nil
9	Control		102	0 (4)^{d}	0 (4)^{g}	0 (4)^{c}	0 (4)^{b}	0 (4)^{a}
	CD (P=0.05)			4.51	6.98	7.52	-	-

*Insect population on 75 cm^2 leaf area before 2nd spray (PTC – Pretreatment Count)

From the result of bioassay test it was found that after 24 hours, chlorpyriphos 20 EC (LC_{50} 21 µl /l) and thiamethoxam 25WG (LD_{50} 44 mg/l) were the very effective and Buprofezin 25SC (LC_{50} 1000 µl/l) the least among the eight insecticides tested. Whereas, in case of insecticides evaluation in field it is observed that thiamethoxam 25WG @ 62.5 g a.i./ha, Spirotetramat 240 EC @ 59.95 g a.i./ ha, Imidacloprid 17.8SL @ 44.48 g a.i./ha, Dimethoate 30EC @ 300 g a.i./ ha, Lamda-cyhalothrin 5EC @ 37.50 g a.i./ha and Buprofezin 25SC @ 250 g a.i./ha were found effective insecticides for control of this mealybug. Although all the tested insecticides reduced PMB population significantly but thiamethoxam showed best results in all the experiment. Lamda cyhalothrin @ 37.50 g a.i/ha also gave quick knockdown effect to PMB than other tested insecticides. Shukla and Tandon [17] also observed the effectiveness of sprays of ten insecticides for the control of *Planococcus pacificus* on custard apple both in laboratory and field in Karnataka. The result showed that, dimethoate, phosphamidon, dichlorvos and monocrotophos, all at 0.05 per cent gave the best control. Su and Wang [18] reported that the pseudococcid, *P. citri* infesting grape vine in Taiwan was effectively controlled by the application of Malathion 40 EC and dimethoate 44 EC causing 93-100 per cent mortality of the pest. Hatta and Hara [4] reported that spraying with chlorpyriphos (0.03%) totally eliminated pseudococcid on ginger in Hawaii. Galanihe *et al*. [3] recommended thiamethoxam and imidacloprid insecticides for PMB control in Srilanka. Mansour *et al.* [7] reported that the new systemic insecticide Spirotetramat (Movant® 150 OD) showed very effective results for the control of vine mealybug, *Planococcus ficus* populations. Here our findings are in accordance with the Mansour *et al*. result. Kumar *et al*. [6] tested acephate and chlorpyriphos against *Phenacoccus solenopsis* and found that both the chemicals were quite effective in mealybug management than other tested biopesticides. Although all the tested insecticides has the capability to significantly reduce mealybug population, but further research is necessary to recommended grade specific insecticide doses as well as their residual effect for their effective control. The above mentioned insecticides are highly effective in suppressing the mealybug population but should not use repeatedly without any alternate eco-friendly strategies. The mealybug population in field is associated with many species of parasitoids and predators. So, if these insecticides are rotated with other ecofriendly as well as compatible biopesticides that will surely help to conserve natural regulators of mealybug population. At last, Although chemical control measures is the last option for mealybug control but commercial growers in the infested areas should

employ good IPM practices such as sanitation, scouting and prevention.

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