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Efficacy of insect growth regulator Buprofezin against Papaya mealybug

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Abstract
The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) is a serious insect pest causing severe damage to papaya plants. To find out suitable biorational insecticides for this insect, several experiments were conducted in the laboratory with different groups of insecticides such as carbamates- Carbaryl, growth regulators- Buprofezin, microbial derivatives- Spinosad, and Neem oil. Efficacy trial revealed that Carbaryl and Buprofezin caused significant mortality of papaya mealybug, while the mortality was 100% and 96%, respectively. Treatment with Neem oil (2%) provided moderate control of papaya mealybug, while 60% mortality was achieved. The Spinosad was found less effective against papaya mealybug which caused 40% mortality. Due to complete death of mealybug in Carbaryl treated plants, no progeny was found. The number of mealybug progeny was significantly low in Buprofezin and neem oil treated plants, while the nymph number per plant was 22 and 39, respectively. In contrast, mealybug progeny in the Spinosad treated plants was similar to that of control plants. The potentiality of buprofezin to integrate in the IPM program against papaya mealybug is discussed.

Keywords: Biorational insecticide, neem oil, spinosad, mortality, progeny reduction

1. Introduction

The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) is a small, soft bodied noxious insect pest attacking papaya and other economically important crop plants [1, 2]. *P. marginatus* is first recorded in Mexico in the year 1955 and afterwards this insect pest invaded in different tropical and sub-tropical countries including Central America, Caribbean countries, Africa and Asia [3]. In its native habitat the Papaya mealybug is not a serious pest, possibly due to the presence of natural enemies [4]. This pest got introduced without their native natural enemies and posed a potential threat to papaya in India and Bangladesh [5]. The invasion of papaya mealybug in Bangladesh is first reported in the year 2009 [6]. Within a short period of time, the newly introduced papaya mealybug is now spread many part of the country and emerged as a major threat to papaya along with different crops [7]. A drop in papaya production is recorded in the recent years assumed that infestation of papaya mealybug is responsible and causing huge economic losses to farmers [8]. A recent survey in Bangladesh found that about 40% papaya plants are attacked with mealybug in the orchards and farmers are applying different chemical insecticides indiscriminately which do not provide effective control [9]. Also 80% nurseries have the sign of papaya mealybug infestation in the seedlings, which is a potential source for dispersal of this insect to different fields.

In general, chemical control is not particularly effective against mealybugs because of the waxy covering over their bodies, and higher rates are typically needed and multiple applications may be required for full control [4]. However, several active ingredients are registered worldwide for mealybug control (though not specifically for papaya mealybug) including: acephate, carbaryl, chlorpyrifos, diazinon, dimethoate, malathion, and white mineral oils. In various reports, the chemical insecticides such as profenophos 50 EC, chlorpyrifos 20 EC, dimethoate 30 EC, thiamethoxam 25 WG, and imidacloprid 17.8 SL are recommended as the last weapon in the suppression of the papaya mealybug [1, 10]. These broad spectrum insecticides may cause toxicity to non target animals, including predator and parasites of papaya mealybug [11]. Considering the hazardous impact of chemical insecticides, currently different bio-rational insecticides including insect growth regulator (IGR) molecules, microbial derivatives, and botanical insecticides are using against major insect pests which are reduced risk, eco-friendly, and highly selective to target insect [12].

It has been found that the chitin synthesis inhibitor IGR molecules, buprofezin caused significant mortality of papaya mealybug in the field experiment [13]. Although buprofezin has multiple effects on the target pests like reduction of fecundity, egg hatchability, and egg sterility [14, 15], the effect of buprofezin on the reproduction capability of papaya mealybug remained unknown which is investigated in this research work. In addition, research work with spinosad (a fermentation product from soil actinomycete) to determine mortality and subsequent population buildup of papaya mealybug is very few. Therefore, the present research work was planned to evaluate the efficacy of three biorational insecticides such as buprofezin, spinosad, and neem oil on the mortality and progeny production of papaya mealybug under laboratory conditions. The efficacy of these selected biorational insecticides are compared to the broad spectrum Carbaryl which is an effective insecticide against papaya mealybug [16].

2. Materials and Methods

The research work was carried out in the laboratory of the Department of Entomology, Bangladesh Agricultural University, Mymensingh and all experiments were repeated twice to fulfill the research objectives.

2.1 Host Plant

The Papaya plant (*Carica papaya*) variety Sinta (Lal Teer Seed Limited, Bangladesh) was used as host plant and grown in pots (12 x 10 cm size) filled with prepared soil media. The soil media was prepared with the mixture of loam soil and well decomposed cow dung in equal proportion. Two seeds were sown per pot and after ten days of seedling germination, only one plant/pot was allowed to grow. The seedlings were grown at 28±2^{0}C temperature with the photoperiod 14L:10D. Thirty five (35) days old seedlings were used in this research work to study the effectiveness of different insecticides for the management of papaya mealybug.

2.2 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. The reared mealybug was used in the experiments to perform different treatments and population of the papaya mealybug was maintained until completion of the research work.

2.3 Insecticides and botanical oil tested

Three insecticides such as carbamates (Carbaryl), buprofezin and spinosad, and a botanical oil such as Neem oil (*Azadirachta indica*) 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 neem oil, 2% solution was prepared by adding 20 ml oil in 1 L of water, while 2.5 ml liquid detergent was added as emulsifier. To prepare the solution, firstly liquid detergent was added to water and agitated well until the detergent gets completely dissolved in water. Later on, neem oil was added to this solution and agitated well until a pale yellowish white emulsion is formed.

2.4 Experimental procedure

To test the efficacy of selected insecticides and botanical oil, 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 placed 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 2 days, different treatments were employed. Five plants per treatment were used and plants were sprayed twice at 15 days interval 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 frequency and dose in laboratory experiments

Chemical Name	Trade Name	Application frequency and dose
Carbaryl	Sevin 85 SP	2 times @ 3.44gm/liter of water
Buprofezin	Award 40 SC	2 times @ 0.5 ml/liters of water
Spinosad	Tracer 45 SC	2 times @ 0.4 ml/liters of water
Neem oil	Neem oil	2 times @ 20 ml/liter of water

Pre-treatment data on the number of mealybug in each plant was collected one hour before application of insecticides and botanical oil. For recoding the data, all plants parts along with pot and soil media were observed carefully. The number of mealybug and its progeny were counted using magnifying glass. The data on the number of adult survived per plant under different treatments were recorded after one, seven and fourteen days of the first and second spraying. Finally, the mortality of papaya mealybug was calculated with the following formula:

$$\% \text{ Mortality} = \frac{\text{Number of dead mealybug}}{\text{Number of total mealybug}} \times 100$$

The number of offspring per plant for each treatment was recorded on the last date of data collection (after fourteen days of the second spraying). To count the number of offspring, the tiny insects were brushed off on a paper and then counted.

2.5 Statistics

The statistical difference in mortality of mealybug and population establishment between treatments were determined using one-way-analysis of variance (ANOVA), followed by the post hoc test Tukey's HSD at a significance level of $P<0.05$ in the statistical program SPSS, version 20.0. The figures and graphs were prepared by Microsoft Office 2007 (Power Point and Excel).

3. Results

Efficacy of insecticides and neem oils on the mortality of papaya mealybug

The efficacy of selected insecticides and neem oil were increased with the progress of post treatment time and application frequency (Table 2). Significant instant mortality was achieved within 1 day for the application of Carbaryl, where the mortality was 86%. Among the insecticides, Carbaryl provided complete (100%) control of mealybug after the first spraying and no mealybug was recorded in the treated plants. Among the remaining insecticides, Buprofezin provided slight control of papaya mealybug at the early stage of treatment but significant reduction of mealybug was recorder after 7 and subsequent days (Table 2). The mortality of papaya mealybug after first and second spraying of Buprofezin was 82% and 96%, respectively (Figure 1). The Spinosad was found less effective to control papaya mealybug which caused 36% and 40% mortality after first and second spraying, respectively. In contrast, Neem oil provided moderate control of mealybug, where the mortality was 50% and 60% after first and second spraying, respectively (Figure 1).

Table 2: Status of papaya mealybug on treated plants at different times following insecticides and botanical oils application

Treatments	Number of papaya mealybug/plant (Mean±SE)					
	First spraying			Second spraying		
	1 DAS	7 DAS	14 DAS	1 DAS	7 DAS	14 DAS
Carbaryl	1.4±0.24a	0.4±0.24a	0.0±0.00a	0.00±0.00a	0.0±0.00a	0.0±0.00a
Buprofezin	8.0±0.54b	2.4±0.74a	1.8±0.66a	1.4±0.51a	1±0.31a	0.4±0.24a
Spinosad	8.4±0.67bc	6.6±0.24b	6.4±0.40b	6.4±0.40b	6.2±0.48bc	6.0±0.63bc
Neem oil	10.0±0.00c	5.4±0.81b	5.0±0.71b	4.8±0.86b	4.2±0.96b	4.0±0.83b
Control	10.0±0.00c	9.8±0.20c	9.6±0.24c	8.4±0.24c	8.2±0.37c	7.4±0.24c

Mean values followed by different letters within a column for a sampling day indicate significant differences in number of papaya mealybug for different treatments (Tukey's HSD test: $P \leq 0.05$). DAS indicate days after spraying.

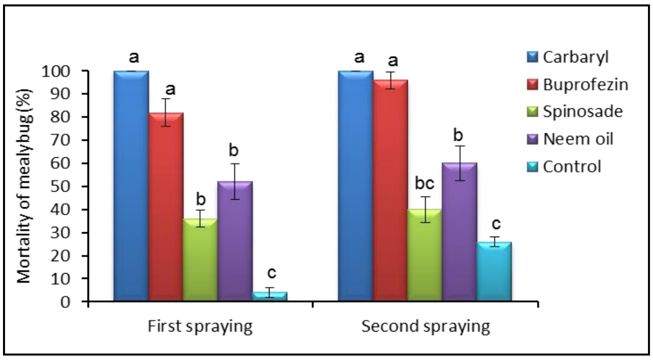

Fig 1: Mortality of the papaya mealybug after insecticides and neem oil application at two spray frequencies. Different letters capping bars within spray schedule indicate significant differences in mortality of papaya mealybug for different treatments (Tukey's HSD test: $P \leq 0.05$).

3.1 Effect of insecticides and neem oils on progeny generation of papaya mealybug

Due to complete death of mealybug in Carbaryl treatments, no progeny was found in the treated plants (Figure 2). The number of mealybug progeny (nymph) on the Buprofezin and neem oil treated plants was significantly low. Whereas, the number of mealybug progeny on the Spinosad treated plants were similar to that of control plants (Figure 2). The average number of nymphs per plat was 22, 39, 147 and 249 in Buprofezin, Neem oil, Spinosad and control treatments, respectively.

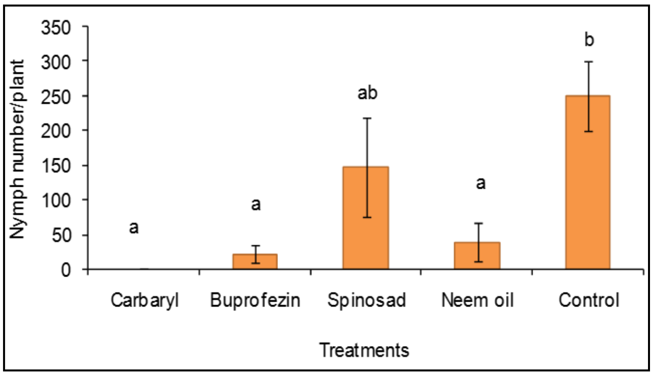

Fig 2: Effect of different insecticides and neem oils on the number of papaya mealybug progeny. Different letters capping bars indicate significant differences in nymph number among treatments (Tukey's HSD: $P<0.05$)

4. Discussion

In general, it is thought that chemical control may not effective enough to manage mealybugs due to have waxy covering over their bodies. However, this study revealed that chemical insecticide Carbary killed all the treated mealybug under laboratory condition. In a recent study, complete control of papaya mealybug under laboratory conditions is achieved with the use of carbaryl and dimethoate [16], which is confirmatory to the results of the present research where complete death of papaya mealybug was achieved with Carbaryl insecticide only with single spray frequency.

Neem oil is now emerging as a valuable component of IPM strategies in many crops due to its efficacy to insect pests and safety to the natural enemies. In this study, neem oil with 2% concentration control papaya mealybug moderately. Similar observation also reported, where neem oil provided 64% mortality of papaya mealybug far below the expectation [16]. In contrast, 90.11% mortality of papaya mealybug was achieved when treated with 5% Neem oil [17]. High mortality compared to the present research might be related to the higher concentration of neem oils used. As papaya plant is highly sensitive at early stage of growth, there is a possibility of phytotoxicity with the application of Neem oil at higher concentration (>3%) [18] and our pre-experiment result confirm the sign of injury in the leaf (data not published).

The main active component of neem oil is azadirachtin which cause disruption in the post embryonic development, ovipositional defects, anti-fertility effects, chitin and enzyme inhibition, leading to a reduction in the number of viable eggs and live progeny [19]. In the present research it was found that Neem oil affected the reproduction of papaya mealybug resulting fewer progeny in the treated plants. Although, Neem oil treatment prevents the flourish of second generation, but it cannot provide sole protection as remarkable adults remained active in the treated plants. Consequently, there will be a possibility of population buildup of papaya mealybug in the long run if papaya plants only sprayed with Neem oil. In the IPM program, Neem oil can be integrated with other insecticides as an additional treatment to suppress the flourish of mealybug population and to reduce insecticide pressure to the environment.

The insect growth regulator Buprofezin caused remarkable mortality of papaya mealybug which is almost similar to the effectiveness of Carbaryl. Also, very few progeny were recorded in the buprofezin treated plants. Although initial mortality was low, but with the progress of post treatment time significant mortality was achieved after 7 and 14 days of first spraying. This finding suggests that buprofezin needs comparatively longer time to kill papaya mealybug. Also, this finding unrevealed the cause of less efficacy of Buprofezin in the bioassay test conducted for short time and mortality counted for 3 days after treatment imposition [13]. However, field efficacy of buprofezin with long time observation (upto 10 days) showed significant mortality (100%) of papaya mealybug [13], which is in accordance with the present findings. Therefore, Buprofezin can be an alternative to the toxic broad spectrum insecticides like carbaryl as buprofezin is less toxic to the non-target insects and safer to the Coccinellid predator *Cryptolaemus montrouzieri* (Mulsant), which is a potential biological control agent of papaya mealybug [11].

Since Spinosad was found less effective to control papaya mealybug which caused only 40% mortality after twice application, it cannot be recommended to use for the control of papaya mealybug.

The mealybug population in the field is associated with many species of parasitoids and predators. From the findings of the present research it can be suggested that rotation of Buprofezin and neem oil treatments in the IPM program may help to control papaya mealybug as well as conserve natural regulators of mealybug population. At last, chemical control measures with carbaryl can be the last option for mealybug control when above biorational insecticides do not work properly.

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6. References

1. Galanihe LD, Jayasundera MUP, Vithana A, Asselaarachchi N, Watson GW. Occurrence, distribution and control of papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), an invasive alien pest in Sri Lanka. Tropical Agricultural Research & Extension 2010; 13(3):81-86.
2. Chellappan M, Lawrence L, Indhu P, Cherian T, Anitha S, Jimcymaria T. Host range and distribution pattern of papaya mealy bug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) on selected Euphorbiaceae hosts in Kerala. Journal of Tropical Agriculture. 2013; 51(1-2):51-59.
3. Muniappan R, Shepard BM, Watson GW, Carner GR, Sartiami D, Rauf A *et al.* First report of the papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), in Indonesia and India. Journal of Agricultural and Urban Entomology. 2008; 25:37-40.
4. Walker A, Hoy M, Meyerdirk D. Papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Insecta: Hemiptera: Pseudococcidae). IFAS Extension publication, University of Florida, 2003. Available at http://edis.ifas.ufl.edu/in579 (Search date: 10 April 2016).
5. Regupathy A, Ayyasamy R. Initiatives of papain industry by private-public-farmer linkages in classical biocontrol program for papaya mealybug in Tamil Nadu. The Journal of Plant Protection Sciences. 2012; 4(1):1-14.
6. Muniappan R, Shepard BM, Watson GW, Carner GR, Rauf A, Sartiami D *et al.* New Records of Invasive Insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa. J. Agric. Urban Entomol. 2011; 26:167-174.
7. Karim ANM, Alam SN, Dutta NK. Papaya mealybug, *Papracoccus marginatus* (Hemiptera: Pseudococcide): A new record in Bangladesh and their infestation status. Annual Report, 2010-2011. Entomology Division, BARI, Gazipur. Available at http://180.211.164.225/rmis/index.php?t=detail_info&linkid=10680 (search date: 10 July 2014).
8. Helemul A. Mealy bug threatens papaya production. The Daily Star, Published: Wednesday, 2013. Available at http://archive.thedailystar.net/beta2/news /mealy-bug-threatens-papaya-production/ (Search date: 15 January 2014).
9. Khan MAM, Biswas MJH, Ahmed KS, Sheheli S. Outbreak of *Paracoccus marginatus* in Bangladesh and its control strategies in the fields. Progressive Agriculture 2014; 25:17-22.
10. Tanwar RK, Jeyakumar P, Vennila S. Papaya mealybug and its management strategies, Technical Bulletin No. 22, National Centre for Integrated Pest Management, New Delhi 2010, 1-20.
11. Alexander A, Krishnamoorthy SV, Kuttalam S. Toxicity of Insecticides to the Coccinellid Predators, *Cryptolaemus montrouzieri* Mulsant and *Scymnus coccivora* Ayyar of Papaya Mealybug, *Paracoccus marginatus* Williams and Granara De Willink. Journal of Biological Control 2013; 27:18-23.
12. Srinivasan R, Lin M, Yule S. Biorational pest management in tropical and sub-tropical vegetable production systems. 9th Biennial conference, Bangladesh entomological society. BARI, Gazipur, Bangladesh. 2014, 36-50.
13. Seni A, Sahoo AK. Efficacy of certain insecticides on papaya mealybug, *Paracoccus marginatus* Williams & Granara de Willink (Hemiptera: Pseudococcidae). Journal of Entomology and Zoology Studies 2015; 3(4):14-17.
14. Liu TX, Stansly PA. Lethal and sublethal effects of two insect growth regulators on adult Delphastus catalinae (Coleoptera: Coccinellidae), a predator of whiteflies (Homoptera: Aleyrodidae). Biological Control 2004; 30:298-305.
15. Tunaz H. Insect growth regulators for insect pest control. Turk J Agric Sci. 2004; 28:277-287.
16. Biswas MJH, Khan MAM, Ahmed KS. Control strategies of papaya mealybug, *Paracoccus marginatus* williams and willink in the laboratory condition. Int J Appl Sci Biotechnol. 3(4):687-691.
17. Ahmed KN, Al-Helal MA, Khanom NEP, Bulbul S. Control strategies of papaya mealybug, *Paracoccus marginatus* Williams & Willink infesting vegetable crops in Bangladesh. The Journal of Plant Protection Sciences. 2011; 3(1):44-47.
18. Soon LG, Bottrel DG. Neem pesticides in rice: potential and limitations. IRRI, 1099 Manila, Philippens. 1994, 45.
19. Anuradha A, Annadurai RS. Biochemical and molecular evidence of azadirachtin binding to insect actins. Current Science. 2008; 95(11):1588-1593.