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Efficacy of Selected Insecticides on Brinjal Shoot and Fruit Borer and the Status of Natural Enemies with Respect to Them

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Abstract

This study intended to find out the efficacy of insecticides on Brinjal Shoot and Fruit Borer (BSFB) and the effects of them on natural enemies in the brinjal field. Based on the questionnaire survey, five insecticides those were highly used by farmers were selected for this study. These five insecticides and an untreated control treatment were tested in the field by arranging them with seven replicates in a completely randomized design. Laboratory study was conducted to test the efficacy of insecticides on the larva of the BSFB. The presence of natural enemies were monitored in the field, two one day before and after the application of insecticide. Analysis was done by using SAS and compared with Duncan's Multiple Range Test.

Acetamiprid was effective in the laboratory study and Chlorpyrifos was found to be most applicable in the field. Ladybird beetles were most abundant and long lasting predators in the brinjal fields. Spiders and ants were having predatory activities in the field next to Ladybird beetles. The effect of Carbofuran on the predators of brinjal pests was very minimal.

On the other hand, the activities of natural enemies were poor in the treatments of Chlorpyrifos and Acetamiprid while Carbofuran was least effective in the control of brinjal pests.

Introduction

Eggplant, *Solanum melongena* (L), is being cultivated all around the world [1]. In Sri Lanka, brinjal is being cultivated as the second larger extent of vegetables; recommended for cultivation in both *Yala* and *Maha* seasons. In the Batticaloa district, the Palukamam purple variety has been identified as high yielding with lesser damages of Brinjal Shoot and Fruit borer [2] and intensively cultivated in Kalutavalai, Kaluvanchikudy, Vakarai, Mandoor, Vellaveli and Eravur.

Insect pests are being the most limiting factors for the cultivation of brinjal. Even though brinjal is reported to be damaged by over 70 species of pests through out the world, only 46 species of brinjal pests are reported in Sri Lanka among which, Brinjal Shoot and fruit Borer (*Leucinodes orbonalis*), Leaf hopper (*Amrasca* sp.), Whiteflies (*Bemisia tabaci*) and Mite (*Tetranychus* sp.) have drawn the major concern [3]. Brinjal Shoot and Fruit borer is agreed as the most serious pest causing severe yield losses upto 70% in all Asian cultivating countries, except in Malaysia and Indonesia. In the Batticaloa district, especially in the Kalutavalai, Brinjal Shoot and Fruit borer, Brinjal Stem Borer, Whitefly and Leaf Eating Caterpillar are identified as the most damaging pests respectively, through questionnaire survey.

Use of resistant varieties, biological, chemical, cultural, physical and the integrated pest management methods adopted by the farmers to combat the Brinjal Shoot and Fruit borer as the larva damages the shoots, flowers and especially the fruits by boring into these tender tissues [4], [5] & [6]. Majority of them use insecticides for easiness, neglecting the effective physical control. The Department of Agriculture has recommended Carbofuran 3% GR, Carbaryl 85% WP, Carbaryl 480 g/l SC, Etofenprox 100 g/l EC, Permethrin 25 g/l EC, Esfenvalerate 75 g/l EC, Fenvalarate 200 g/l EC, Cyfluthrin 50 g/l EC and Deltamethrin 25 g/l EC chemicals against the pest [8]. Indiscriminate use of these chemicals allows the borer to become tolerant to these chemicals. Neonicotinoid

(Acetamiprid), Chloronicotinyl (Imidacloprid) and Organophosphate (Chlorpyrifos) are the chemical classes of the most popular chemicals (with common name in brackets) among the farmers of Kaluthavalai at present. Monocrotopos, Deltamethrin and Permethrin are out of use among the farmers to date.

Pest resistance is one of the major problems in Agriculture through out the world in an increasing manner [1]. The factors contributing to the resistance and in turn to resurgence of pest are categorized into insecticide related factors, insect pest related factors, host plant related factors and other factors. The, insecticide related factors are type of insecticide, dosage of insecticide (dilution and application rates of) insecticide, persistence of pesticide, selectivity of pesticide, timing, method and number of application. Type of insect, feeding rate, fecundity, life span, developmental stage or reproductive stage, insect biology, sex ratio and competition with other insects are insect related factors. Nutritional status of plant and architecture of plant are host plant related factors while, other factors are destruction of natural enemies and displacement of competitive species.[5] & [4]. The resistance of *Leucinodes orbonalis* Guen. has identified and subjected to further studies and firstly documented in the resistance newsletter from Bangladesh [9].

AVRDC in consultation with national agricultural research and extension systems of Bangladesh, India and Sri Lanka, as well as the Natural Resources Institute in the United Kingdom have undertaken a 3 year collaborative research was not much effective as expected in controlling the pest problem [17]. As brinjal is being one of the important and popular vegetables in Sri Lanka and the Brinjal Shoot and Fruit borer (BSFB) is being the most serious pest all around the country causing heavy losses, the control or delaying of the pest resistance and resurgence is essential for the continuous cultivation of brinjal. But in Sri Lanka, studies in the vegetables are lacking, as they are not cash crops and the results are not available to farmers regarding the proper control of pest. Further, the studies undertaken were regarding the efficacy of insecticides in controlling the pest. Thus, the information regarding the efficient insecticide for BSFB is lacking. Therefore, this study attempts;

to test the efficacy of insecticides being used in our country to control the pest, as well as their effect on resistance and resurgence of the pest. Thereby, better insecticide for which the BSFB is not yet developed resistance and with the minimal effect on resurgence of the same or other pests' and also harmless to natural enemies found in the field can be identified, to be used in the Batticaloa region.

Objectives of this Study are:

- To find out the effective insecticide to control the *Leucinodes orbonalis*.
- To find out the insecticide having least hazards for the natural enemies in the field or compatible insecticide pertaining to the natural enemies of the brinjal fields

Methods

This study consisted of three components, viz. questionnaire survey in the Kaluthavalai village; laboratory studies in the Agricultural Biology Laboratory of the Faculty of Agriculture, Eastern University of Sri Lanka and field experiment in the Agronomy farm of the Eastern university of Sri Lanka during the period of May – September 2006.

Questionnaire Survey

50 farmers were selected by Stratified random sampling to cover the seaside cultivators and the cultivators of the dried pond during the Yala season for survey. Questionnaire was pre tested from two farmers and filled up by interviewing the respondent in their mother tongue. Data collected from farmers were analyzed using MS Excel package with special reference to treatment of insecticides for the Brinjal Shoot and Fruit Borers. Based on the findings the different insecticide treatments were included in the study.

Field Experiment

Treatment

Treatments were assigned as the way to cover one from each major insecticide classes, namely, Organophosphate, Carbamate, Pyrethroid and Neonicotinoid; compared without insecticide. Thus each control plant was sprayed with 125 ml of water used for the dilution of the insecticide treatments, with the washed clean hand sprayer. The treatment insecticides and their details are tabulated below in Table 1.

Methodology

Seeds were treated with captain at the rate of 2 g per kg seeds and row sown on seedbed around 15 cm apart. The seed rate is 350 –375 grams per ha [8]. Pots were prepared for planting by making holes at the base to drain the excessive water and filled with the potting medium of 18 litres, that is the mixture of redsoil: regosol: cowdung in the ratio of 10:06:03. Healthy and vigorous plants were selectively uprooted from the seedbed and transplanted in individual pots (1 plant per pot), at three leaves stage and provided shade till 7 days. Pots for treatments with insecticides were placed in the field in a Completely Randomized Design (CRD) with the spacing of 1 m between rows and 75 cm within rows, 7 plants in all 5 rows as shown in figure 1. The seven control plants were kept separately to prevent the migration of pest during sprayings of insecticide treatments at the same spacing.

Fertilizer application was based on the recommendations of the Department of Agriculture (DOA), Sri Lanka [8]. The insecticides were applied only against the Brinjal Shoot and Fruit Borer, at fortnightly thrice during the experiment and all other pests were controlled by cultural methods such as brush out the aphid colonies from each plant, removal of bored shoots, watering by sprinkling the water and picking of the caterpillars.

Observation

Two days before and after each insecticide spraying, field monitoring was carried out in the leaf turn method using hand magnifying glass (×10) pest populations were counted. Natural enemy population per plant was also counted down during monitoring and the number of wilted shoots and the fruits with holes were also counted.

Analysis

The differences among the treatments in the population of natural enemies, number of bored fruits and wilted shoots were analyzed by

ANOVA and compared with Duncan's Multiple Range Test (DMRT). For these analyses Statistical Analysis System (SAS version 6.12) was used.

Laboratory Experiment

Materials and Methods

Laboratory experiment was carried out in a Completely Randomized Design including the control with four replicates for all the six treatments, as used for field studies. Fruits affected by Brinjal Shoot and Fruit borer were collected from Kaluthavalai, where the survey was carried out and the brinjal is being traditionally cultivated for years. From the fruits the larvae of searnel instars were separated carefully and cultured together in the insect cages, with the provision of food as fresh brinjal fruits, water and soil for pupation. Likewise, different stages of larvae were cultured in separate insect cages. The new generation of larvae cultured in the laboratory at it's second instars stage was used for the experiment in the laboratory.

Six trays were taken and disinfected with 90% alcohol and labeled. The brinjal leaves of equal leaf area (275 cm2), as the way to cover the bottom of the tray were placed in each tray. The area of the tray used for laboratory experiment was 285 cm2. The selected insecticides were having different dilution rates and application rates, as their strength and units vary widely, tabulated in Table 2.

The insecticides were measured with micropipettes during preparation and then the insecticide mixtures were sprayed with different disposable syringes on the leaves in the trays as the amount used for spraying is showed in the table 02. Separate new disposable syringe was used to spray the distilled water of 2 ml for the control treatment and to the granular insecticide treatment. Soon after the application of insecticides, five larvae of equal size were placed on the leaf in each tray, using larval forceps. Small pieces of brinjal fruits were provided as feed for larvae and moist cotton was kept to prevent drying. The experimental unit of the laboratory experiment is illustrated in figure -02.

Observation

The observation on the mortality of the larvae was made at hourly intervals for the first six hours and the final readings were obtained after 24 hours.

Analysis

Percentage values of survival rates for each treatment was calculated and subjected to analysis by ANOVA and compared with Duncan's Multiple Range Test (DMRT).

Results

Resurgence Assessment of Pests in the Field

Jayaraj and Regupathy (1986) have suggested the following simple formula to evaluate percent efficacy of insecticide resurgence of sucking pests making slight modifications in the Henderson- Tilton (1955) formula.

$$\text{Resurgence} = \left[\frac{TS}{CS} \times \frac{CF}{TF} - 1 \right] \times 100$$

Where, *TS* –Damage in treated pots subsequent count.

CS –Damage in control pots subsequent count.

TF –Damage in treated pots first count.

CF –Damage in control pots first count.

The Resurgence of sucking pests in this study calculated using the above formula, on the monitoring of before and after each insecticide applications is tabulated in Table 3.

Red spider mites were of much higher values in Acetamiprid and Imidacloprid respectively while Mealy bugs were having moderate values in Deltamethrin followed by whiteflies in Deltamethrin.

Status of Natural Enemies in the Field

Repeated applications of insecticides can lead to the development of resistance in the target pest and can reduce the natural enemy populations, leading to resurgence of the target pest(s) and outbreaks of secondary pests, i.e. those normally kept under control by their natural enemies. Therefore, knowledge not only of the effect of an insecticide on the target pest but also on non-target natural enemies is essential.. Ladybird beetles, spiders, ants, wasps and damselflies were found in the field and among them, wasps and damselflies showed poor responses. The monitoring-analysed data of the natural enemies is summarized in Table 4. Predominantly *Menichilus sexmaculatus* was significantly high in control. The mean population of Spiders was significantly ($P<0.05$) high in the control plants, followed by, Carbofuran, Acetamiprid, Deltamethrin, Imidacloprid and chlorpyrifos. The population was significantly ($P<0.05$) higher in Carbofuran than other insecticides.

Efficacy of Insecticides on *Lucinodes orbonalis* in Laboratory Study

Studies were conducted to test the efficacy of insecticides Brinjal Shoot and Fruit Borer larvae in the laboratory. Survival rate of larvae during the 24 hours from the application of insecticides, in the laboratory, is shown in Figure 3. Due to the inconvenience of over night observation, the readings were obtained for the first six hours and then from 19 hours after application of treatments.

50% survival rate means, survival of only half of the total numbers of the larvae. Time to reach 50% survival rate was compared for the treatments. Acetamiprid was quickly achieved this, within one and a half hours from the application of treatment. Next, Carbofuran took two hours to bring 50% survival rate. Chlorpyrefos and Deltamethrin reduced the survivorship of Brinjal Shoot and Fruit Borer by 50%, within twenty hours from the application of treatments. All these insecticides were having only 25% survival at twenty four hours after application of treatments. Imidacloprid did not reach the 50% survival till this time and was observed to have 75% survival as control The control treatment showed 75% survival.

Discussion

Imidacloprid and Carbofuran were found to be fast acting on the Brinjal Shoot and Fruit Borer larvae and therefore of high efficacy. Chlorpyrifos and Deltamethrin were moderately effective on the larvae as they brought down the survival rate to 25% within a day. The Imidacloprid treatment was not brought down to 50% survival rate, till twenty four hours after application of treatment.

Carbofuran is applied to the soil in the field. This needs more time to penetrate into the system of the larvae. But in the laboratory it's easily brought in contact with the larvae as spraying and it might be the reason for the reduced activity of the Carbofuran in the field compared to the laboratory study. It's a study initiated to find out the resistance of Brinjal Shoot and Fruit Borer and to draw a firm conclusion. This needs to be repeated for many generations.

In contrast to this result, Agnihotri et al. (1990) found that Cypermethrin (0.01%) and Deltamethrin (0.00125%) were the most effective synthetic pyrethroids controlling the pest [12]. Thankili and Patel (1991), Srinivas and Peter (1993) and Bustamante et al., (1994) have reported that Deltamethrin was very effective against Leucinodes orbonalis [11].

Imidacloprid is a newly introduced broad-spectrum chloronicotinyl insecticide and will find its way in agricultural production, particularly in Asia. However, information on the fate of imidacloprid in crop plants is lacking [10].

Supportive to the result of this study, Jagan Mohan et al. (1980) suggested that, although pyrethroids were effective in controlling this pest their continuous use might lead to the development of insecticide resistance. Deltamethrin was found to be lesser effective than Acetamiprid, Carbofuran and Chlorpyrifos.

Mote (1976) observed Carbaryl at 0.2% was found to be most promising and gave significantly higher yield of brinjal than other insecticides tested in Maharashtra. Krishnaiah et al. (1976) studied the efficacy of 18 different insecticides on the control of Brinjal Shoot and Fruit Borer and found that Carbaryl at 1 kg a.i./ha was most effective than other tested insecticides. Gahukar and Bagal (1976) confirmed that Carbaryl at 0.25% was the best chemical in controlling the pest. Phorate and Disulfoton were found to be ineffective while soil application of Carbofuran at 6.0 kg/ha was successful [15]. In this study also

Carbofuran was effective than Deltamethrin, Chlorpyrifos, imdacloprid and Control treatments.

Resistance by the two-spotted spider mite to many insecticides has been reported (Osborne et al., 1985). The widespread use of non specific insecticides has killed beneficial insect populations leading to a resurgence of thrip and mite populations [16]. This study also proves these reviews, that Red Spider Mites were resurged in the brinjal in the Batticaloa district.

The reasons for the highest mean population in the control plants are; ladybird beetles were prevented from the toxic effects of insecticides and also they enjoyed enough pests as their prey in the control plants. The Coccinellid predator was found to be least affected by some pyrethroids. But, Carbofuran was found to be least affect on Coccinelid predator than Deltamethrin (pyrethroid). Spiders are actually very effective predators. Ladybird beetles, spiders, damselflies, wasps, praying-mantids and Ants were not seen in the fields of sea side, where year round cultivation is practiced. This shows the effect of insecticides on natural enemies have prevented the natural biological control in the field.

Conclusions

Carbofuran proved to favour natural enemies and failed to control the *Leucinodes orbonalis* in the field, even though successfully control the larvae in the laboratory study. Chlorpyrifos was least prone to resurgence of other pests while have a better control on Leucinodes orbonalis. Red spider mites resurged to Acetamiprid & Imidacloprid while. Mealy bugs showed the potential to resurge to Deltamethrin. Ladybird beetle was the significantly most abundant predator in the control plants. Spiders and Ants were found to be next to Ladybird beetle in predation, especially in control plants and insignificant among the insecticide treated plants. Carbofuran treatment was favourable for natural enemies compared to other treatments.

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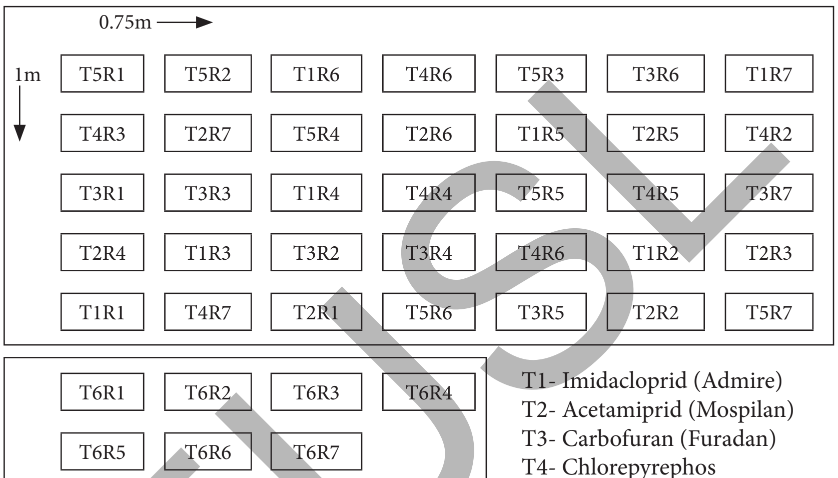
Figures



T1- Imidacloprid (Admire)
T2- Acetamiprid (Mospilan)
T3- Carbofuran (Furadan)
T4- Chlorepyrephos
T5- Deltamethrin (Delta)
T6- Control.

Figure 1: Field lay out

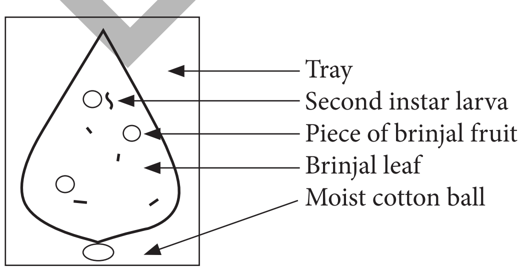
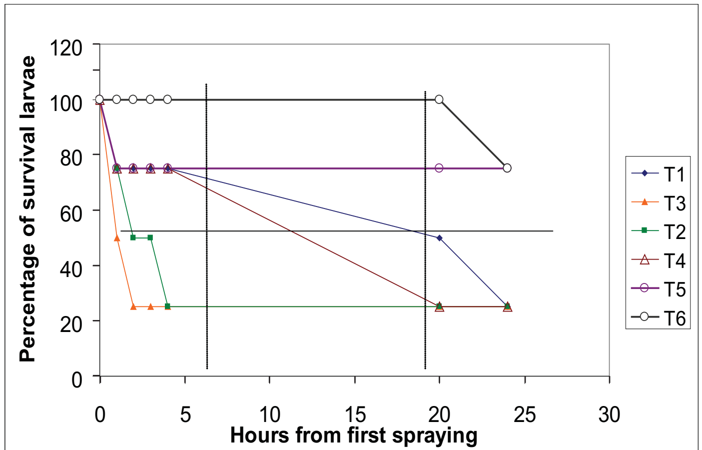


Figure 2: The experimental unit in the Laboratory



T1- Deltamethrin
T2- Carbofuran
T3- Acetamiprid
T4- Chlorpyrifos
T5- Imidacloprid
T6- Control (without insecticides)

Figure 3: Survival of Brinjal Soot and Fruit Borer larvae during laboratory study

Table 1: Details of insecticide treatments

Treatment (Trade name)	Chemical name	Strength and Unit of Active Ingredient	Application Rate	Dilution Rate
Mospilan	Acetamiprid	20% Soluable powder	400 g/ha	10g/10 litre water
Pattaas	Chlorpyrifos	400 g/l Emulcifiable concentrate	1500 ml/ha	33 ml/10 litre water
Furadan 3GR	Carbofuran	3% Granular	20 kg/ha	-
Delta	Deltamethrin	25 g/l Emulcifiable concentrate	300 ml/ha	10 ml/10 litre water
Admire	Imidacloprid	200 g/l NL	175 ml/ha	4 ml/10l water

Table 2: Dilution and Application Rates of Treatments

Treat-ment	Name of the treatment	Application rate	Dilution Rate ml in 10 liter water	Amount pre-pared in 100 ml water*	Amount need to spray ml/ml water
T1	Deltamethrin	300 ml/ha	10ml	0.1 ml*	8.55×10^{-4}ml/ 0.855 ml H_2O
T2	Chlorepyriphos	1500 ml/ha	33ml	0.33ml*	4.275×10^{-3}ml/ 1.295 ml H_2O
T3	Acetamiprid	400g/ha	10 g	0.1 g*	1.14 g/ 1.14 ml H_2O
T4	Carbofuran	20 kg/ha	-	0.057 g	2.00 ml H_2O
T5	Imidachloprid	175 ml/ha	4 ml	0.04ml/ 100*	4.99×10^{-5} ml 1.247 ml H_2O
T6	Control	-	-	-	2.00 ml H_2O

Table 3: Calculated resurgence of sucking pests

Treatment	MEALY BUG		
	Resurgence 1st spraying	Resurgence 2nd spraying	Resurgence 3rd spraying
T1	0	0	1.61
T2	0	-0.24	0.48
T3	0	-1.91	0.15
T4	0	-0.65	0.24
T5	0	-6.3	-0.18
Treatment	RED SPIDER METES		
	Resurgence 1st spraying	Resurgence 2nd spraying	Resurgence 3rd spraying
T1	0	0	561.48
T2	0	0	128.79
T3	0	0	15858.9
T4	0	0	166.32
T5	0	0	764.96
T4	0	5.4	0
T5	0	-0.17	-0.08

Table 4: Mean population of natural enemies (N=7)

Treatment	Mean population of Lady bird Beetles	Mean population of Spiders	Mean population of Ants	Mean population of Wasps	Mean population of Damselflies
Deltamethrin (T1)	1.286 bc	0.143 bc	9.429 b	0.143 b	0.000 b
Carbofuran (T2)	3.571 b	0.714 b	3.286 b	0.143 b	0.000 b
Acetamiprid (T3)	0.857 c	0.286 bc	0.000 b	0.000 b	0.000 b
Chlorpyrifos (T4)	0.571 c	0.000 c	0.000 b	0.000 b	0.000 b
Imidacloprid (T5)	0.929 bc	0.143 bc	2.714 b	0.000 b	0.000 b
Control (T6)	13.143 a	1.714 a	18.286 a	0.286 a	0.429 a

Means in the same column followed by same letter are not significantly different based on P<0.05 DMRT.

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