Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2527

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (1):** 42-47 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Effect of Application of Biopesticides and Insecticides on Stem Borers and Yield of Maize (*Zea mays* L.)

Kavita Hegde*, Manjunatha M., Sharanabasappa, Kalleshwaraswamy, C. M. and Adarsha S. K.

Department of Agricultural Entomology, College of Agriculture,

University of Agricultural and Horticultural Sciences, Shivamogga-577 225, Karnataka

*Corresponding Author E-mail: kavitahegde10@gmail.com

Received: 12.01.2017 | Revised: 23.01.2017 | Accepted: 25.01.2017

ABSTRACT

The field efficacy of different bio pesticides and insecticides was studied on number of larvae per plant, also on grain and fodder yield against stem borers (Chilo partellus and Sesamia inferens) in Kharif maize in Shivamogga, Karnataka. All the treatments were found significantly effective in reducing the infestation of stem borers and increasing the yield compared with control. Treatment Chlorpyriphos 20 EC (Seed treatment-ST + Foliar spray-FS) was found best among all the treatments by recording lowest mean number of larvae per plant (2.80) followed by azadirachtin (4.47). Similarly, chlorpyriphos ST + FS was found to be most effective by recording highest grain yield (30.47q ha^{-1}) and fodder yield (42.06q ha^{-1}).

Key word: *Chilo partellus, Sesamia inferens, Chlorpyriphos, grain yield*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because of its highest genetic yield potential among the cereals. Global production of the maize is 967 million tonnes occupying an area of 177 million hectares with the productivity of 5.5 t ha^{-1} [1]. Insect- pests are the major factors responsible for low productivity of maize in India. In India, stem borers (*Chilo partellus* and *Sesamia inferens*) have become regular pests of maize crop in the recent past, with severe outbreaks becoming a common feature in the state. Yield losses in different agro climatic regions of India due to *C. partellus* and *S. inferens* ranged from 26.7 to 80.4 and 25.7 to 78.9 per cent, respectively [2]. The number of several bio-insecticides, consisting of viruses, bacteria, fungi, protozoa, nematodes and plant materials, has increased to prominence since the marketing of insecticides composed of the bacterium (*Bacillus thuringiensis*). The shift, from conventional synthetic insecticides to biological control agents, has been due to environmental concerns and difficulties with insecticides resistance, thus bio-insecticides are virtually considered to be safe and environment friendly insect control agents[3]. Hence, the present investigation was planned with an attempt to manage the stem borers using bio pesticides and insecticides.

Cite this article: Hegde, K., Manjunatha, M., Sharanabasappa, Kalleshwaraswamy, C.M. and Adarsha, S.K., Effect of Application of Biopesticides and Insecticides on Stem Borers and Yield of Maize (*Zea mays* L.), *Int. J. Pure App. Biosci.* **5(1):** 42-47 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2527

MATERIAL AND METHODS

Effect of bio pesticides and insecticides against stem borers in maize

To evaluate the effect of different bio pesticides and insecticides as seed dressers and foliar formulations against stem borers in maize crop, the experiment was conducted at College of Agriculture, Shivamogga during *kharif*, 2014-15. Chemicals and seeds were obtained from local authorized dealers. The field experiment was conducted in randomized complete block design (RCBD) with three replications and the plot size was 3mx2.7 m with 1.0 m replication border and 0.5 m treatment border between the plots. Experimental plots were separated by raised bunds of about 0.6 m height all around each plot.

The furrows were opened as per the spacing. Maize hybrid Pioneer 3501 was sown at a spacing of 45x20 cm during last week of July on a well-prepared seedbed. The crops were raised adopting a standard package of practices except plant protection measures.

The fertilizer dose of 100:50:25 N P_2O_5 K_2O kg ha^{-}, were applied to the crop. Fifty per cent of nitrogen and full quantity of P_2O_5 and K_2O applied just before the sowing as basal application and the remaining 50 per cent of nitrogen was top dressed at 30 days after sowing through urea. Gap filling was done immediately at 10 DAS to maintain uniform plant population wherever necessary. The weeding operation was carried out by passing hoe at 20 DAS followed by one hand weeding at 30 DAS removed all the weeds from the plots. Earthing up was done at 30 DAS after top dressing with nitrogenous fertilizer.

There were four bio pesticides treatments with foliar applications and four insecticidal treatments comprising of one foliar application, two seed treatment and one with seed treatment followed by foliar spray, along with one untreated control. All the treatments were left to natural infestation. The seed dressers were applied one hour prior to sowing and the insecticides and bio pesticides were applied as foliar spray at 40 DAS to strike the activity of stem borers on the crop. The bio pesticides and insecticides were sprayed at 40 DAS to strike the activity of stem borers on the crop. High volume knapsack sprayer was used for spraying different insecticides. Efficacy of the treatments was judged based on the larval population of the stem borers before and after treatment application. Pre count on larval population was taken one day before treatment application on five randomly selected plants by destructive sampling in each plot. Post count was taken at three, seven, 14 and 21 days after application. Also observations were recorded one day before treatment and five, 10 and 15 days after treatment on percentage of plants showing pinholes and per cent dead hearts.

The grain yield and fodder yield from individual treatment was recorded separately and expressed as q ha^{-1}. The data obtained were subjected to statistical analysis after suitable transformation.

Economic analysis

Cost of cultivation

The cost of cultivation was worked out considering the material inputs like seeds, fertilizers, plant protection chemicals and the labour input for all the operations. Treatment wise cost of cultivation was worked out with prevailing price of input materials and labour cost were considered for computing the cost of cultivation which was expressed in Rs ha^{-1}.

Gross return

The price of maize prevailing in the market was obtained from the Agricultural Produce Market Committee, Shivamogga and was used for the calculation of gross return (Rs ha^{-1}).

Gross return = Marketable yield x Market price

Net Return

Net return (Rs ha^{-1}) was calculated by subtracting the cost of cultivation (Rs ha^{-1}) from the gross return (Rs ha^{-1}).

Net return = Gross return – Cost of cultivation

Benefit: Cost ratio

B: C ratio was calculated by dividing the cost of cultivation from the gross returns.

$$\text{Benefit : Cost ratio} = \frac{\text{Gross returns (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})}$$

RESULTS

Number of larvae per plant

Effect of bio pesticides and insecticides on number of larvae per plant under field condition at five, 10 and 15 days after sowing are presented in table 1. The pre-treatment population of the stem borers larvae was uniform in all the treatments a day before, which varied from 5.47 to 6.53 except chlorpyriphos ST + FS (4.07) and chlorpyriphos ST (4.43) (Table 1). At three days after treatment, the number of larvae per plant varied from 2.80 to 7.20. Chlorpyriphos ST + FS was found to be best among all the treatments by recording lowest of2.80. It was followed by azadirachtin (4.47), chlorpyriphos seed treatment ST (4.53), *B. bassiana* (5.20), fipronil (5.33), *B. thuringiensis* (5.47), *M. anisopliae* (5.53) and imidacloprid ST (5.67) which were found to be equally effective. However, untreated check registered highest number of larvae per plant (7.20). At seven days after treatment, chlorpyriphos ST + FS registered lowest number of larvae per plant (2.07) being significantly superior to all other treatments.The number of larvae per plant was same in treatments viz. *B. bassiana* (3.40), azadirachtin (3.47), *B. thuringiensis* (4.07), fipronil (4.20) and chlorpyriphos ST (4.60) being statistically on par with each other. *M. anisopliae* and imidacloprid ST were found to be same in terms of effectiveness by recording 5.27 and 5.80 larvae per plant, respectively. While, untreated check was found to be least effective by registering highest number of larvae per plant (7.33). At 14 DAT, the results indicated that chlorpyriphos ST + FS (1.93) and *B. bassiana* (2.67) were found to be significantly superior by recording lowest number of larvae per plant compared to rest of the treatments. Azadirachtin (3.07), *B. thuringiensis* (3.13) and fipronil (3.87) were found to be equally effective being on par with each other. This was followed by chlorpyriphos ST (4.65) and *M. anisopliae* (4.67) which were statistically on par but differed significantly from rest of the treatments. Whereas, imidacloprid ST proved to be ineffective (5.80) being on par with untreated check (7.33). The observations recorded at 21 DAT revealed that, chlorpyriphos ST + FS recorded lowest of 1.97 larvae per plant being statistically superior to all other treatments. *B. bassiana* (2.73), azadirachtin (2.90) and *B. thuringiensis* (3.10) were on par and significantly differed from former treatment. The treatments viz. Fipronil, chlorpyriphos ST and *M. anisopliae* were found to be least effective compared to other treatments by recording 3.93, 4.40 and 4.47 larvae per plant, respectively. Imidacloprid ST registered 5.27 larvae per plant and differed significantly being inferior to former treatments. However, all treatments recorded lower number of larvae per plant and significantly superior over untreated check (7.20) (Table 1).

The overall mean larval population per plant revealed that chlorpyriphos ST + FS was found to be significantly superior by registering lowest of 2.57 larvae per plant. Azadirachtin (4.01), *B. bassiana* (4.11), *B. thuringiensis* (4.35), chlorpyriphos ST (4.52) and fipronil (4.71) were found to be equally effective by recording lower number of larvae per plant which ranged from 4.01 to 4.71. *M. anisopliae* (5.29) and imidacloprid ST (5.60) were found to be same in terms of effectiveness being statistically on par with each other. Whereas, untreated check was found to be ineffective by recording highest of 7.11 larvae per plant (Table 1).

The number of larvae per plant was significantly influenced by the application of bio pesticides and insecticides. The lowest number of larvae per plant was observed in chlorpyriphos ST + FS (2.57). Comparable but significantly higher number of larvae per plant was observed in azadirachtin (4.01), *B. bassiana* (4.11), *B. thurngiensis* (4.35) and chlorpyriphos ST (4.52). The highest number of larvae per plant was recorded in untreated check (7.11) (Fig 1). Chlorpyriphos ST + FS was most promising by recording lowest damage in terms of pinholes and dead hearts[4].

Yield and cost economics

The Effect of bio pesticides and insecticides on yield and cost economics is presented in table 2. Chlorpyriphos ST + FS recorded highest grain yield of 30.47q ha^{-1} being statistically superior to rest of the treatments. Other promising treatments were azadirachtin (25.40 q ha^{-1}), *B. bassiana* (24.46 q ha^{-1}), chlorpyriphos ST (23.33q ha^{1}), *B. thuringiensis* (22.54q ha^{-1}), fipronil (22.33q ha^{-1}), *M. anisopliae* (20.91q ha^{-1}) and imidacloprid ST (19.07q ha^{-1}) which were found to be on par with each other and differed significantly from other treatments. However, all treatments recorded higher yield and significantly superior over untreated check (14.39q ha^{-1}). Similarly, chlorpyriphos ST + FS was found to be most effective by recording highest grain yield (42.06q ha^{-1}).The other treatments succeeding the former were azadirachtin (39.35 q ha^{-1}), *B. bassiana* (38.06q ha^{-1}), fipronil (37.12 q ha^{-1}), chlorpyriphos ST (36.91q ha^{-1}), *B. thuringiensis* (36.40q ha^{-1}), *M. anisopliae* (35.46q ha^{-1}) and imidacloprid ST (35.36q ha^{-1}) were found to be equally effective but differed significantly from former treatment recording slightly lower fodder yield. While, all other treatments were significantly superior compared to untreated check (30.42q ha^{1}). Chlorpyriphos ST + FS recorded highest B:C ratio of 1:1.91compared to rest of the treatments. This was followed by azadirachtin (1:1.58), *B. bassiana* (1:1.58), chlorpyriphos ST (1:1.53), fipronil (1:1.41), *M. anisopliae* (1:1.38), *B. thuringiensis* (1:1.37) and imidacloprid ST (1:1.26). Untreated check recorded lowest B:C ratio of 1:0.99 (Table 2).

In the present study, all the treatments were found superior to suppress population of stem borer with increased grain yield compared to untreated control (14.39q ha^{-1}). Chlorpyriphos (ST + FS) (30.47 q ha^{-1}) was most promising among all the treatments. Next promising treatments were azadirachtin (25.40 q ha^{-1}), *B. bassiana* (24.46 q ha^{-1}), chlorpyriphos ST (23.33q ha^{-1}) and *B. thurngiensis* (22.54q ha^{-1}) (Fig 2).

The fodder yield data also revealed that all the bio pesticides and insecticides treatments were significantly superior to untreated control (30.42q ha^{-1}). The maximum yield was obtained with maize crop treated with chlorpyriphos ST + FS (42.06q ha^{-1}) followed by azadirachtin (39.35q ha^{-1}), *B. bassiana* (38.06 q ha^{-1}), fipronil (37.12q ha^{-1}) and chlorpyriphos ST (36.91q ha^{-1}) compared to untreated check (30.42q ha^{-1}). Similarly B:C ratio was higher in chlorpyriphos ST + FS (1:1.91), followed by azadirachtin and *B. bassiana* (1:1.58), chlorpyriphos ST (1:1.53) and fipronil (1:1.41). Least B:C ratio (1:0.99) was recorded in untreated check (Fig 2).

In the present study seed treatment and immediate foliar spray of chlorpyriphos at 40 DAS was found to be superior in its efficacy against maize stem borers. The present findings on efficacy of chlorpyriphos ST is in agreement with the seed treatment with chlorpyriphos 3ml and 5ml/ kg seed had given good control of the population of stem borers up to 42 days in maize[5]. The pest was effectively controlled for further 15 days due to the foliar spray of chlorpyriphos at 40 days after treatment (DAS).

Table 1: Efficacy of bio pesticides and insecticides on the number of larvae per plant

Sl. No.	Treatments	Dosage	Number of larvae per plant at					
			1 DBT	3 DAT	7 DAT	14 DAT	21 DAT	Mean
1	*Beauveria bassiana*	2.0 g/l	6.53 (2.65)^{c}	5.20 (2.39)^{b}	3.40 (1.97)^{b}	2.67 (1.78)^{ab}	2.73 (1.80)^{b}	4.11 (2.15)^{b}
2	*Bacillus thuringiensis* var *kurstaki*	2.0g/l	6.00 (2.55)^{bc}	5.47 (2.44)^{b}	4.07 (2.13)^{bc}	3.13 (1.90)^{b}	3.10 (1.90)^{b}	4.35 (2.20)^{b}
3	*Metarrhizium anisopliae*	2.0 g/l	6.53 (2.65)^{c}	5.53 (2.46)^{b}	5.27 (2.40)^{c}	4.67 (2.27)^{cd}	4.47 (2.23)^{cd}	5.29 (2.41)^{cd}
4	Azadirachtin 0.03%	5.0 ml/l	6.13 (2.57)^{bc}	4.47 (2.23)^{b}	3.47 (1.99)^{b}	3.07 (1.89)^{b}	2.90 (1.84)^{b}	4.01 (2.12)^{b}
5	Chlorpyriphos 20EC (seed treatment)	3.0 ml/kg seeds	4.43 (2.22)^{a}	4.53 (2.24)^{b}	4.60 (2.26)^{bc}	4.65 (2.27)^{cd}	4.40 (2.21)^{c}	4.52 (2.24)^{bc}
6	Chlorpyriphos 20 EC (seed treatment + foliar spray)	3.0 ml/kg seeds and 2.0 ml/l	4.07 (2.13)^{a}	2.80 (1.81)^{a}	2.07 (1.58)^{a}	1.93 (1.56)^{a}	1.97 (1.57)^{a}	2.57 (1.75)^{a}
7	Imidacloprid 600 FS (seed treatment)	5.0 ml/kg seeds	5.47 (2.44)^{b}	5.67 (2.47)^{b}	5.80 (2.51)^{cd}	5.80 (2.51)^{de}	5.27 (2.40)^{d}	5.60 (2.47)^{d}
8	Fipronil 5SC	2.0 ml/l	6.20 (2.59)^{bc}	5.33 (2.41)^{b}	4.20 (2.17)^{bc}	3.87 (2.09)^{bc}	3.93 (2.10)^{c}	4.71 (2.28)^{bc}
9	Untreated check	-	6.47 (2.64)^{c}	7.20 (2.77)^{c}	7.33 (2.78)^{d}	7.33 (2.78)^{e}	7.20 (2.77)^{e}	7.11 (2.75)^{e}
	SEm±	-	0.06	0.08	0.11	0.09	0.05	0.05
	CD@5%	-	0.18	0.24	0.33	0.28	0.14	0.14

( ) Square root transformed values;
DAT= Days after treatment; DBT= Day before treatment;
Values in each column superscripted by same letter do not differ significantly

Table 2: Cost economics of different bio pesticides and insecticides against maize stem borer

Sl. No.	Treatments	Dosage	Grain Yield (q ha^{-1})	Fodder Yield (q ha^{-1})	B:C ratio
1	*Beauveria bassiana*	2.0 g/l	24.46^{ab}	38.06^{ab}	1:1.58
2	*Bacillus thuringiensis* var *kurstaki*	2.0g/l	22.54^{b}	36.40^{b}	1:1.37
3	*Metarrhizium anisopliae*	2.0 g/l	20.91^{bc}	35.46^{b}	1:1.38
4	Azadirachtin 0.03%	5.0 ml/l	25.40^{ab}	39.35^{ab}	1:1.58
5	Chlorpyriphos 20EC (seed treatment)	3.0 ml/kg seeds	23.33^{b}	36.91^{b}	1:1.53
6	Chlorpyriphos 20 EC (seed treatment + foliar spray)	3.0 ml/kg seeds and 2.0 ml/l	30.47^{a}	42.06^{a}	1:1.91
7	Imidacloprid 600 FS (seed treatment)	5.0 ml/kg seeds	19.07^{bc}	35.36^{b}	1:1.26
8	Fipronil 5SC	2.0 ml/l	22.33^{b}	37.12^{b}	1:1.41
9	Untreated check	-	14.39^{c}	30.42^{c}	1:0.99
	SEm±	-	2.13	1.48	-
	CD@5%	-	6.39	4.45	-

Values superscripted by same letter do not differ significantly

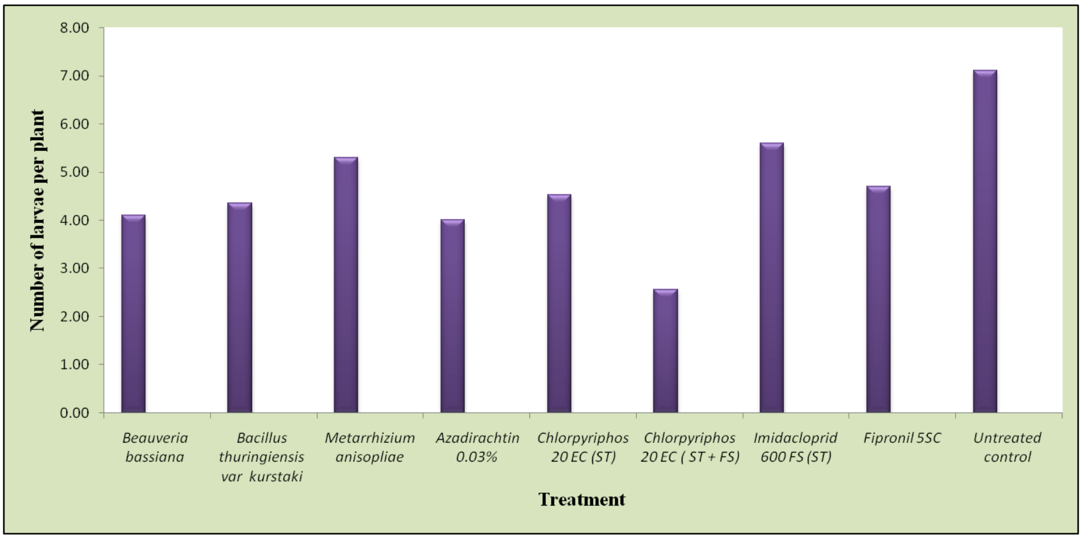

Fig. 1: Efficacy of bio pesticides and insecticides on number of larvae per plant

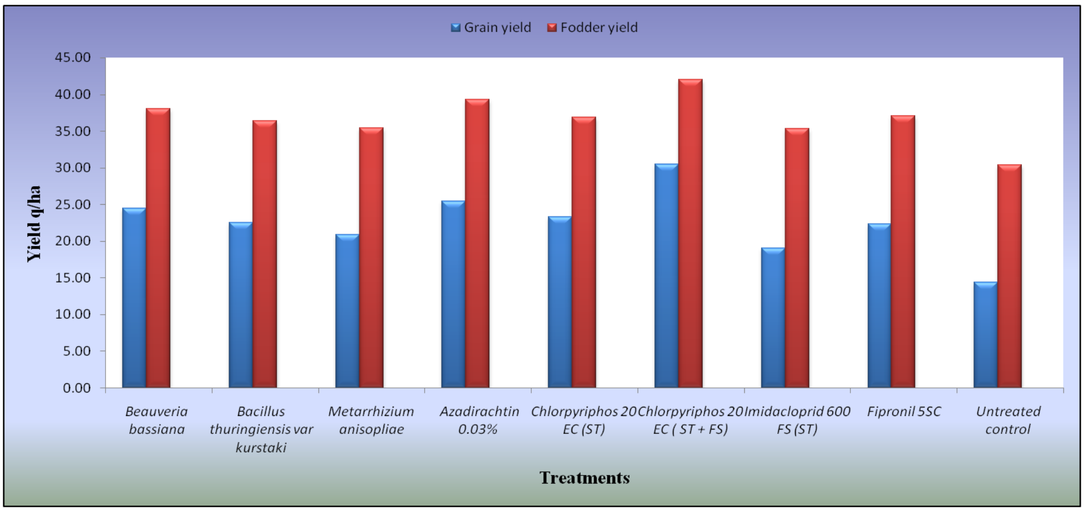

Fig. 2: Efficacy of bio pesticides and insecticides on grain yield and fodder yield

CONCLUSION

The biopesticides and insecticides were found to be effective against maize stem borers and consequently it was reflected in yield as well. In view of the efficacy of these biopesticides and insecticides against maize stem borers, they can be incorporated in the integrated pest management programme.

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