International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(6): 97-99
www.biochemjournal.com
Received: 04-03-2024
Accepted: 11-04-2024

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Comparative efficacy of selected chemicals and biopesticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize

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DOI: https://doi.org/10.33545/26174693.2024.v8.i6Sb.1258

Abstract
The field experiment was conducted in *kharif* season of 2023-24 at Central Research Farm (CRF), SHUATS, Uttar Pradesh, India. The experiment was laid in Randomized Block Design with eight treatments each replicated thrice *viz*., Lambda cyhalothrin 2.5% EC @ 1ml/l, *Metarhizium anisopliae* 5.8×10^4 @ 2.5 ml/l, Flubendiamide 480% SC @ 0.24ml/l, Emamectin benzoate 5% SG @ 0.4 g/l, Neem oil 1500 ppm @ 5 ml/l, Spinosad 45% SC @ 0.25 ml/l, Chlorantraniliprole 18.5% EC @ 0.4 ml/l and Untreated control. The data on larval population of *Spodoptera frugiperda* after first and second spray mean revealed that all the treatments were significantly superior over control. Among all the treatments, Chlorantraniliprole 18.5% EC (3.62) recorded lowest larval population of *Spodoptera frugiperda* after both sprays followed by Spinosad 45% SC (4.04), Emamectin benzoate 5%SG (4.53), Lambda cyhalothrin 2.5% EC (4.85), Flubendiamide 480% SC (5.25), Neem oil (5.65) respectively *Metarhizium anisopliae* 5.8×10^4 (6.07) was the least effective among all treatments. While, the highest yield and cost benefit ratio was obtained from Chlorantraniliprole 18.5% EC (42.72q/ha and 1:1.94) followed by Spinosad 45% SC (40.80 q/ha and 1:1.89), Emamectin benzoate 5% SG (37.44q/ha and 1:1.71), Lambda cyhalothrin 2.5% EC (34.79q/ha and 1:1.62), Flubendiamide 480% SC, (31.68q/ha and 1:1.49), Neem oil (28.54q/ha and 1:1.33), *Metarhizium anisopliae* 5.8×10^4 (26.49q/ha and 1:1.25) and control (23.57q/ha and 1:16).

Keywords: Cost ratio, biopesticide, chemicals, *Spodoptera frugiperda*

Introduction

Maize (*Zea mays* L.) is the third major and most important cereal crop of the world after wheat and rice and is grown in tropical, subtropical and temperate regions of the world (Hussain *et al*., 2016) [5]. It has been referred as the "Queen of cereals" due to its highest yield potential among all the cereals. It has short growing season and is drought resistant that make it very easy to grow everywhere in different climatic conditions of the world. (Chouraddi *et al*., 2017) [3].

Maize has high nutritious value in human diet as well as in poultry and livestock feed due to valuable components such as starch, fibre, protein, fats, oil, vitamins and minerals. It is a good source of high-quality edible oil. Due to high yielding capacity and short growth duration, maize increasingly gaining important position and is also used as a fodder crop for silage. (Iqbal *et al*., 2017) [6].

India is the fifth largest producer of Maize in the world contributing 3 percent of the global production. At present, out of the total maize produced, 55% is used for food purpose, about 14% for livestock, 18% for poultry feed, 12% for starch and one percent as seed. (Kumar and Kumar, 2017) [9]. It is also grown in Andhra Pradesh (20.9%), Maharashtra (9.1%), Karnataka (16.5%), Rajasthan (9.9%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%). Maize is the principal cereal crop of Sikkim occupying nearly 37percent of the area under cultivation with annual production of 66,192 tons (Rameash *et al*., 2012) [15].

Among the various insect pests, fall armyworm, *Spodoptera frugiperda* is the most dominant contributing 90-95 percent of the total damage in *Kharif* season (Jalali and Singh, 2002) [8]. Maize is most vulnerable to *Spodoptera frugiperda* (Lepidoptera: Crambidae) which causes severe losses to it (Songa *et al*., 2001) [19].

In recent years various types of insecticides belonging to different chemical group were used as spray to manage the pest complex. Sometimes we don't know about best insecticide for Fall armyworm control, so best one can be identified for the management of Fall armyworm on maize by potential evaluation of few selected insecticides and biopesticides through their comparative effectiveness.

Materials and Methods

The experiment was conducted at the experimental research plot of the Department of Entomology, Central Research Farm, Sam Higginbottom University of Agriculture Technology and Sciences, during the *Kharif* season of 2023. The experimental design was Randomized Block Design with 8 treatments, each replicated thrice. The plot size was 2m × 1m with a spacing of 60×20 cm. The treatments included Lambda cyhalothrin 2.5% EC @ 1ml/lit., *Metarhizium anisopliae* 5.8×10^4 @ 2.5ml/lit., Flubendiamide 480% SC @ 0.24ml/lit., Emamectin benzoate 5% SG @ 0.4ml/lit., Neem oil 1500ppm @5ml/lit.,Spinosad 45% SC @ 0.25ml/lit., Chlorantraniliprole18.5% SC @ 0.4ml/lit. and a control.

Application of the two rounds of Insecticidal treatments were applied at 15 days interval. The numbers of larvae were counted on 5 randomly selected plants in each plot. The pre – treatment count was made a day before the spray whereas, the post-treatment count were made on 3rd, 7th and 14th day after each spray. The larval population over control against fall armyworm was calculated by the mean of three observations recorded at 3rd, 7th and 14th day after spray.

Cost benefit ratio

$$\textit{Gross return} = \textit{Marketable Yield x Market price}$$

$$\textit{Net return} = \textit{Gross return} - \textit{Total cost}$$

$$\textit{Cost benefit ratio} = \frac{\textit{Gross return}}{\textit{Cost of cultivation}}$$

(Sidar *et al.*, 2017) [18].

Results and Discussion

The data on the larval population of fall armyworm on 3rd, 7th and 14th day after first spray revealed that all treatments were significantly superior over control. Among all the treatments lowest larval population of fall armyworm was recorded in Spinosad 45% SC (5.45) but it was higher than the check treatment i.e Chlorantraniliprole 18.5% EC (5.13) followed by Emamectin benzoate 5%SG (6.20), Lambda cyhalothrin (6.33), Flubendiamide (6.73), Neem oil 1500 ppm (7.13) and *Metarhizium anisopliae* (7.53) found the highest population of fall armyworm and is population significantly superior over the control (12.53).

After second spray the data revealed that all treatments were significantly superior over control. Among all the treatments lowest larval population of fall armyworm was recorded in Spinosad 45% SC (2.60) but it was higher than the check treatment i.e Chlorantraniliprole 18.5% EC (2.17) followed by Emamectin benzoate 5%SG (2.97), Lambda cyhalothrin (3.38), Flubendiamide (3.77), Neem oil 1500 ppm (4.17) and *Metarhizium anisopliae* (4.62) found the highest population of fall armyworm and is population significantly superior over the control (15.75).

The yield among the treatments were significant. The highest yield was recorded in Chlorantraniliprole 18.5% EC (42.72 q/ha) followed by Spinosad 45% SC (40.80 q/ha), Emamectin benzoate 5%SG (37.44 q/ha), Lambda cyhalothrin 2.5%EC (34.79 q/ha), Flubendiamide 480% SC (31.68 q/ha), Neem oil 1500ppm (28.54 q/ha), *Metarhizium anisopliae* 5.8 $\times10^4$ (26.49 q/ha) as compared to Control (23.57 q/ha).

Among the treatment studied the best and most economical treatment was Chlorantraniliprole 18.5% EC (1:1.94), Spinosad 45% SC (1:1.89), Emamectin benzoate 5% SC (1:1.71), Lambda cyhalothrin 2.5%EC (1:1.62), Flubendiamide 480% SC (1:1.49), Neem oil 1500ppm (1:1.33), *Metarhizium anisopliae* 5.8 $\times10^4$ (1:1.25) as compared to control ie (1:1.16).

Table 1: Efficacy and economics of selected biopesticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith)"

S. No.	Treatments	Larval population of Fall armyworm (*S. frugiperda*)										Yield (q/ha)	C:B ratio
		1st Spray					2nd Spray				Overall mean (1st and 2nd spray)		
		1 DBS	3 DAS	7 DAS	14 DAS	Mean	3 DAS	7 DAS	14 DAS	Mean			
T_1	Lambda cyhalothrin 2.5%EC @ 1ml/l	8.53	7.20^{de}	5.40^{e}	6.40^{bcde}	6.33^{cd}	4.36^{e}	2.40^{e}	3.40^{e}	3.37^{cde}	4.85	34.79	1:1.62
T_2	*Metarhizium anisopliae* 5.8 $\times10^4$ @ 2.5 ml/l	9.00	8.40^{b}	6.60^{b}	7.60^{b}	7.53^{b}	5.53^{b}	3.73^{b}	4.60^{b}	4.62^{b}	6.07	26.49	1:1.25
T_3	Flubendiamide 480% SC @ 0.24ml/l	8.93	7.60^{cd}	5.80^{d}	6.80^{bcd}	6.73^{bc}	4.73^{d}	2.80^{d}	3.80^{d}	3.77^{bcd}	5.25	31.68	1:1.49
T_4	Emamectin benzoate 5%SG @ 0.4gm/l	8.0	6.80^{ef}	5.00^{f}	6.00^{cde}	6.10^{cde}	3.93^{f}	2.00^{f}	3.00^{f}	2.97^{def}	4.53	37.44	1:1.71
T_5	Neem oil 1500ppm @ 5ml/l	9.06	8.00^{bc}	6.20^{c}	7.20^{bc}	7.13^{bc}	5.13^{c}	3.20^{c}	4.20^{c}	4.17^{bc}	5.65	28.54	1:1.33
T_6	Spinosad 45% SC @ 0.25ml/l	8.20	6.40^{fg}	4.53^{g}	5.53^{de}	5.48^{de}	3.53^{g}	1.60^{g}	2.66^{g}	2.60^{ef}	4.04	40.80	1:1.89
T_7	Chlorantraniliprole 18.5%EC @ 0.4ml/l	8.40	6.00^{g}	4.20^{h}	5.20^{e}	5.13^{e}	3.13^{h}	1.20^{h}	2.20^{h}	2.17^{f}	3.62	42.72	1:1.94
T_0	Control	10.0	11.26^{a}	12.53^{a}	12.46^{a}	12.53^{a}	14.60^{a}	15.66^{a}	17.0^{a}	15.75^{a}	14.14	23.57	1:1.16
	F- test	NS	S	S	S	S	S	S	S	S			
	CD.at 0.05%		0.68	0.10	1.43	1.17	0.28	0.24	0.13	1.22			
	S. Ed. (+)		0.31	0.07	0.06	0.54	0.14	0.15	0.11	0.53			

DBS- Day Before Spraying; DAS- Day After Spraying; CBR- Cost Benefit Ratio

All insecticides were significantly superior over control in reducing the larval population of fall armyworm recorded at 3rd,7th and 14th day after first and second spray. Among all these Chlorantraniliprole 18.5% EC (3.6) was most effective similar findings were reported by Amjad *et al.*, (2001) [2], Konar *et al.*, (2013) [10], Neupane *et al.*, (2016) [14]. Followed by Spinosad 45% SC (4.04), was found to be the next effective treatment and its results are supported by Kurl and Kumar (2021) [11], Neuptane *et al.*, (2016) [14]. Emamectin benzoate 5%SG obsreved (4.53) larval population and it is supported by Reddy and Kumar (2021) [16], Aher *et al.*, (2022) [1], Krishna and Kumar (2018) [12].

Higher yield (42.72q/ha) and high-cost benefit ratio (1:1.94) was obtained from Chlorantraniliprole 18.5% EC and lowest in control plot. Similar findings made by Konar *et al.*, (2013) [10] and Krishna and Kumar (2018) [12]. Kurl and

Kumar (2021) [11] and Aher *et al.*, (2022) [1] who reported Chlorantraniliprole 18.5% EC and Spinosad 45% SC was the best and most economical treatment recorded 40q/ha. Emamectin benzoate 5% SG and Flubendiamide 480%SC recorded the yield and cost benefit ratio of 34q/ha(1:1.71) and 31 q/ha (1:1.49) respectively which was reported by Kulkarni *et al.*, (2015) [13] and Ilyas and Ajab (2019) [7]. Sranya and Samiayyan (2016) [17] and Choudhary *et al.*, (2017) [4] reported that Neem oil 1500ppm (28q/ha) and *Metarhizium anisopliae* 5.8 $\times 10^{4}$ (26q/ha) was best economical treatment.

Conclusion

The study conducted at the Central Research Farm in Uttar Pradesh, India, during the 2023-24 Kharif season assessed the efficacy of different insecticides against the fall armyworm (*Spodoptera frugiperda*) on maize. The experiment, utilizing a Randomized Block Design with eight treatments replicated thrice, highlighted the effectiveness of various chemical and biopesticides in reducing the larval population of the fall armyworm and improving maize yield. Among the treatments, Chlorantraniliprole 18.5% EC exhibited the lowest larval population of *Spodoptera frugiperda* after both sprays, followed closely by Spinosad 45% SC and Emamectin benzoate 5% SG. Additionally, Chlorantraniliprole 18.5% EC demonstrated the highest yield and cost-benefit ratio, indicating its effectiveness and economic viability in managing fall armyworm infestations on maize.

The findings of this study contribute valuable insights into the selection of appropriate insecticides for fall armyworm control, with Chlorantraniliprole 18.5% EC emerging as a promising option for farmers seeking efficient and economically viable pest management strategies. This research underscores the importance of integrated pest management approaches that incorporate both chemical and biological control measures to sustainably mitigate the impact of fall armyworm on maize production.

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