International Journal of Environment and Climate Change

Volume 13, Issue 9, Page 1207-1215, 2023; Article no.IJECC.103286
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Field Efficacy of Certain Insecticides against Fall Armyworm, *Spodoptera frugiperda (J. E. Smith)* on Maize (*Zea mays* L.) under Prayagraj Region of India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i92346

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103286

Original Research Article

Received: 09/05/2023
Accepted: 12/07/2023
Published: 17/07/2023

ABSTRACT

A field experiment was conducted during *rabi* 2022 at Central Research Farm, SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), Prayagraj, Uttar Pradesh (India) using Randomized Block Design with eight treatments and replicated thrice. The Result showed that the effects of Insecticides against *Spodoptera frugiperda*, among the different treatments, Lowest larval population of maize fall army worm was recorded in Emamectin benzoate 5SG

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(1.178), Lambda cyhalothrin 5EC (1.311) is found to be the next best treatment following Spinosad 45SC (1.445) and Flubendiamide 49.35SC (1.567) is found to be the next effective treatment, Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (1.700) is found to be the next effective treatment followed by Chlorantraniliprole 18.5SC (1.833) , *Beauveria bassiana* 5% WP (2.134) is found to be least effective but comparatively superior over the control, The yields among the different treatments were significant. The highest yield was recorded in Emamectin benzoate 5SG (42.5 q/ha) with highest cost benefit ratio of (1:2.42) followed by Lambda cyhalothrin 5EC (40.5 q/ha and 1:2.3), Spinosad 45SC (37.8 q/ha and 1:1.83), Flubendiamide 49.35SC (31.3 q/ha and 1:1.79), Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (29.2 q/ha and 1:1.68), Chlorantraniliprole 18.5SC (26.8 q/ha and 1:1.36), *Beauveria bassiana 5% WP* (22.4 q/ha and 1:1.24) as compared to Control (15 q/ha and 1:1.091).

Keywords: Efficacy; insecticides; emmamectin benzoate; cost benefit ratio; Lambda cyhalothrin.

1. INTRODUCTION

"Maize (*Zea mays* L.) is important cereal crop grown all over the world as food for human consumption, animal feed, fodder and as an industrial product. It has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices" [1].

Among the cereal crops, due to its highest genetic yield potential maize is called as "queen of cereals" [2]. It is also known as the "Miracle Crop" because of its high solar use efficiency and immense potential for increased production. "India produced 31.51 million tonnes in an area of 9.9 million hectares in 2020-21, whereas in *kharif* 2021-22, maize production was 21.24 million tonnes (1st advance estimates) in an area of 8.15 million hectares" [3].

Its grain contains protein (3.27g), carbohydrates (18.7g), fat (1.35g), oil (4%), fiber (2g) and minerals (2%) [United States Department of Agriculture (USDA) Nutrient Database]. "Globally, India ranks 4th in area and 7th in production of maize contributing approximately 4% and 2% of global area and production of maize, respectively (Department of Agriculture and Cooperation" (DACNET) 2020). "In India, area under maize crop is 9.63 million hectare with production and productivity of 25.90 million tones and 2.68 T/ha respectively during 2016-17" [4].

During May-June 2018 it was reported on maize from *Shivamogga district (Karnataka)* for the first time in India since then, it has been spread to several states in the country causing havoc to the maize growing areas [5]. "Now, the presence of this pest is reported in all the states of India except in few northern states" [6,7,8]. where "it has been reported to cause damage to maize, sweet corn and baby corn. Now this pest has spread in many Asian countries" [9]. "It was first reported in Maharashtra in September 2018 in Tandulwadi village, Solapur district by the farmer Ganesh Babar" [10].

The term "fall armyworm" (FAW) comes from their existence of destruction, in which the infestations will mimic an army when travelling through vast agricultural fields by eating all the green matter they come across [11,12,13,14]. It is a polyphagous, gregarious and disruptive pest that targets 353 plant species from 76 families, with Poaceae (106), Asteraceae (31) and Fabaceae (31) receiving the bulk of the attacks [15]. *Spodoptera frugiperda* infestations resulted in the yield losses of 15 to 73 per cent when 55 to 100 per cent of the plants were infested at various stages of development [16].

As FAW is a new invasive pest and seems to create havoc by their voracious nature their management with a different group of insecticides and biopesticides during the *rabi* season is needed, ensuring that the farmers avoids the economic loss and so the cost benefit ratio is calculated to prove that the use of following treatments is economical and sustainable [17,18,19].

2. MATERIALS AND METHODS

2.1 Methodology

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 *rabi* season of 2022. In a Randomized Block Design,

Table 1. Particulars of the treatments

S. No.	Treatments	Dose / ha
T1	Chlorantraniliprole 18.5SC	150 ml/ha
T2	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC	200 ml/ha
T3	Lambda cyhalothrin 5EC	750 ml/ha
T4	Spinosad 45SC	200 ml/ha
T5	Emamectin benzoate 5%SG	200 gm/ha
T6	Flubendiamide 49.35SC	200 ml/ha
T7	*Beauveria bassiana* 5% WP	2.5kg/ha
T8	Control	-

eight treatments were replicated thrice using variety *Shivam* seeds in a plot size of 2m×1m at a spacing of (60×25cm) with a recommended package of practices excluding plant protection. The experimental site has medium high fertility value with well drained soil . The research field is situated at 25.87^0 North Latitude and 81.15^0 East longitudes and at an altitude of 98 meter above sea level. The maximum temperature reaches up to 47 ^{0}C in summer and drops down to 2 ^{0} C in winter.

Pest population was estimated by observing five plants selected randomly from each treatment for presence of Larval population and larvae at one day prior to insecticide application and at 3rd, 7th and 14th days after each application. The percent infestation over control against Fall armyworm (*Spodoptera frugiperda*) was calculated by considering the mean of three observations recordedat 3rd, 7th and 14th days after first and second spraying.

The healthy marketable yield obtained from different treatments was collected separately and weighed. The cost of insecticides used in this experiment was recorded during *rabi* season. The cost of Insecticides used was obtained from nearby market. The total cost of plant protection consisted of cost of treatments, sprayer rent and labour charges for the spray. Throughout the research time, two sprays are applied, and the total plant protection expenses are calculated. Total earnings was calculated by multiplying total yield per hectare by the current market price, while net benefit was calculated by subtracting total income from total income. Benefit over the control for each sprayed treatment was obtained by subtracting the income of the control treatment from that of each sprayed treatment. The B:C ratio was calculated by formula:

2.2 Benefit Cost Ratio

Gross return was calculated by multiplying total yield with the market price of the produce. Cost benefit ratio by following formula

Gross return = Marketable yield × Market price

Net return = Gross return – Total cost

$$\text{Benefit cost Ratio} = \frac{\text{Gross return}}{\text{Total Cost}}$$

3. RESULTS AND DISCUSSION

3.1 Reduction of Larval Population

Among all the treatments lowest larval population of maize fall armyworm was recorded in Emamectin benzoate 5SG (1.178) , Similar findings made by Bajracharya et al. [20], Salunkhe et al. [21] and Bharadwaj et al. [22]. Lambda cyhalothrin 5EC (1.311) is found to be the next best treatment which is in line with the findings of Deshmukh et al. [23] and Bharadwaj et al. [22] they reported that Lambda cyhalothrin 5EC was found most effective in reducing larval population reduction of maize fall army worm as well as increasing the yield.

Spinosad 45SC (1.445) is found to be the next best treatment which is in line with the findings of Mallapur et al. [24]. Flubendiamide 49.35SC (1.567) is found to be the next effective treatment which is in line with the findings of Deshmukh et al. [23]. Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (1.700) is found to be the next effective treatment which is in line with the findings of Phani et al. [25] and Salunkhe et al. [21]. The result of Chlorantraniliprole 18.5SC (1.833) which is in support with Deshmukh et al. [23] and Bajracharya et al. [20]. Beauveria bassiana 5% WP (2.134) is found to be least effective but comparatively superior over the control, these findings are supported by Dhobi et al. [26].

3.2 Maize Yield with Respect to Treatments

The yields among the different treatments were significant. The highest yield was recorded in

Emamectin benzoate 5SG (42.5 q/ha) followed by Lambda cyhalothrin 5EC (40.5 q/ha), Spinosad 45SC (37.8 q/ha), Flubendiamide 49.35SC (31.3 q/ha), Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (29.2 q/ha), Chlorantraniliprole 18.5SC (26.8 q/ha), Beauveria bassiana 5% WP (22.4 q/ha) as compared to control plot (15 q/ha). These findings are supported by Sangle et al. [27], Suthar et al. [28] and Thumar et al. [29].

The increased percent yield over control treatment was different. All the treatments were superior over control. The highest increased yield over control was recorded in Emamectin benzoate 5SG (27.5 q/ha) followed by Lambda cyhalothrin 5EC (25.5 q/ha), Spinosad 45SC (22.8 q/ha), Flubendiamide 49.35SC (16.3 q/ha), Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (14.2 q/ha), Chlorantraniliprole 18.5SC (11.8 q/ha), Beauveria bassiana 5% WP (7.4 q/ha).

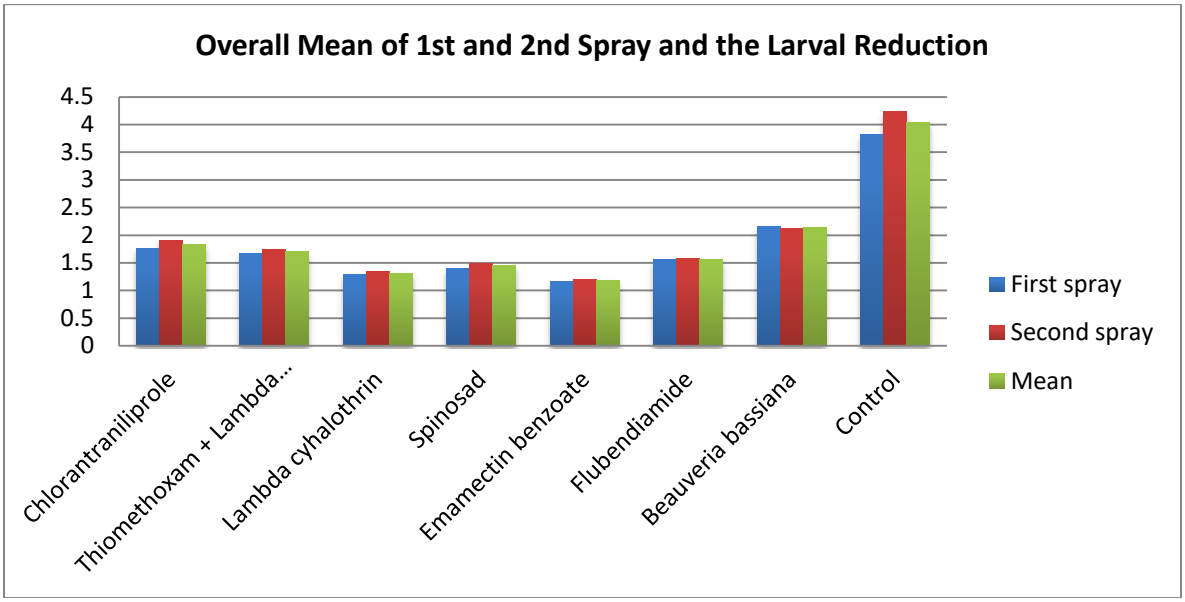

Fig. 1. Comparative efficacy of certain insecticides against fall army worm, *Spodoptera frugiperda* on maize – Larval population reduction after 1st and 2nd spray (Mean)

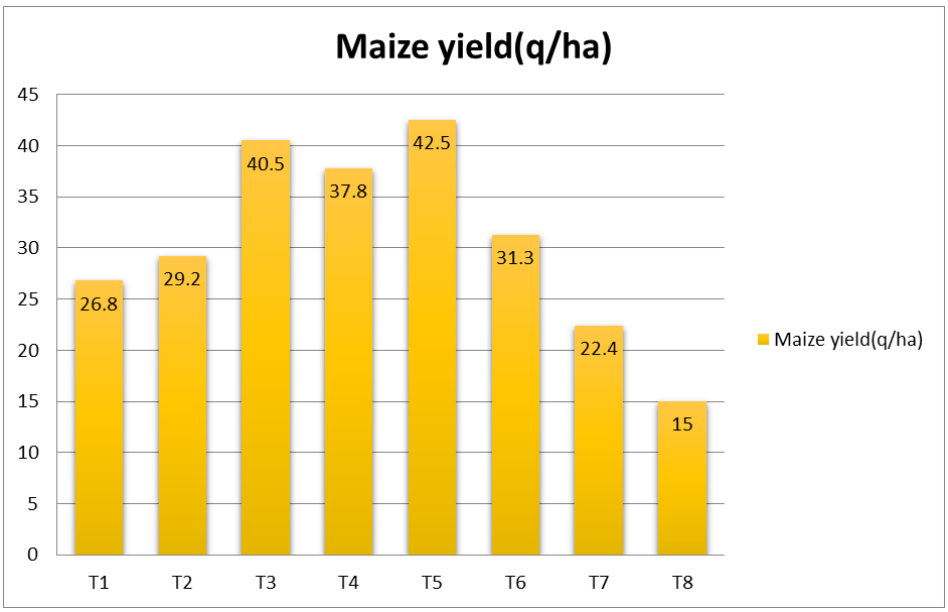

Fig. 2. Maize yield (q/ha) with respect to all the treatments

Table 2. Efficacy of insecticides against larval population of *Spodoptera frugiperda* on Maize (overall mean)

S. No.	Treatments	Larval Population of *Spodoptera frugiperda* /five plants								Yield (q/ha)	B:C ratio
		First spray				Second spray			Overall mean		
		1 DBS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS			
T1	Chlorantraniliprole 18.5SC	3.333	1.733	1.533	2.000	2.000	2.000	1.800	1.833	26.8	1:1.36
T2	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC	3.133	1.600	1.467	1.933	2.267	1.800	1.667	1.700	29.2	1:1.68
T3	Lambda cyhalothrin 5EC	3.000	1.267	1.133	1.467	1.933	1.467	1.200	1.311	40.5	1:2.3
T4	Spinosad 45SC	3.067	1.333	1.267	1.600	1.800	1.533	1.333	1.445	37.8	1:1.83
T5	Emamectin benzoate 5%SG	2.800	1.133	1.067	1.267	1.600	1.267	1.133	1.178	42.5	1:2.42
T6	Flubendiamide 49.35SC	3.400	1.533	1.333	1.800	1.267	1.600	1.467	1.567	31.3	1:1.79
T7	*Beauveria bassiana* 5% WP	3.467	2.333	1.867	2.267	1.467	2.200	2.000	2.134	22.4	1:1.24
T8	Control	3.200	3.467	3.933	4.067	4.067	4.133	4.200	4.033	15	1:1.03
	F-test	NS	S	S	S	NS	S	S	S		
	S. Ed (±)	0.21	0.14	0.15	0.16	0.16	0.17	0.15	0.10		
	C.D. (P = 0.5)	____	0.306	0.312	0.345	____	0.373	0.323	0.238		

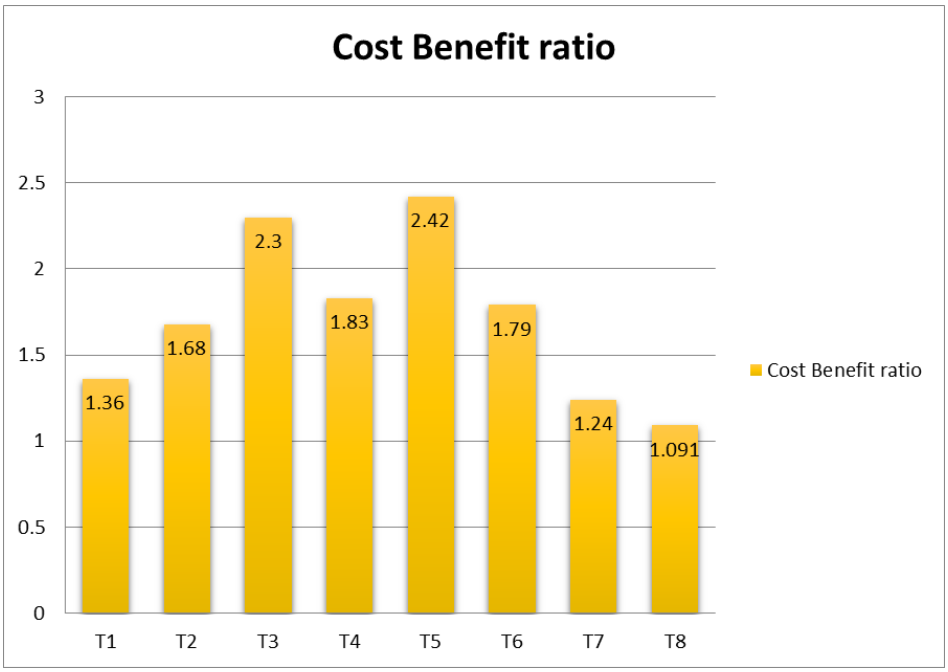

Fig. 3. Cost benefit ratio of all

Fig. 4. *Spodoptera frugiperda (J.E.Smith)*

3.3 Cost Benefit Ratio of Treatments

When cost benefit ratio was worked out, interesting result was achieved. Among the treatments studied, the best and most economical treatment was Emamectin benzoate 5SG (1:2.42) followed by Lambda cyhalothrin 5EC (1:2.3), Spinosad 45SC (1:1.83), Flubendiamide 49.35SC (1:1.79), Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (1:1.68), Chlorantraniliprole 18.5SC (1:1.36), *Beauveria bassiana 5% WP* (1:1.24), as compared to control plot (1:1.091). These findings are supported by Ahir et al. [30] and Sangle et al. [27].

Fig. 5. Spraying of treatments

4. CONCLUSION

The study concluded that Lowest larval population of maize fall army worm was recorded in Emamectin benzoate 5SG (1.178), Lambda cyhalothrin 5EC (1.311) is found to be the next best treatment following Spinosad 45SC (1.445) and Flubendiamide 49.35SC (1.567) . Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (1.700) is found to be the next effective treatment followed by Chlorantraniliprole 18.5SC (1.833), *Beauveria bassiana* 5% WP (2.134) is found to be least effective but comparatively superior over the control.

The yields among the different treatments were significant. The highest yield was recorded in Emamectin benzoate 5SG (42.5 q/ha) with highest cost benefit ratio of (1:2.42) and the lowest with *Beauveria bassiana 5% WP* with yield of 22.4 q/ha and Cost Benefit Ratio of 1:1.24 as compared to Control (15 q/ha and 1:1.091).

ACKNOWLEDGEMENTS

I am very thankful to my Advisor Dr.(Mrs.) Usha Yadav, Assistant Professor, Department of Entomology and Dr. Ashwani Kumar, Associate Professor and Head, Department of Entomology, Sam Higginbottom University of Agriculture Technology And Sciences for providing the required facilities for performing the current work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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