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Economic assessment of chemical treatments against the invasive fall armyworm, *Spodoptera frugiperda* on *rabi* Maize (*Zea mays* L.) under Prayagraj region of India

Chandan Kumar Panigrahi, Simran Mahapatra and Bijoy Kumar Mishra

Abstract
A Research trial was conducted during *rabi* 2023 at CRF,SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), Prayagraj, Uttar Pradesh (India) to evaluate the cost benefit ratio by using different insecticidal applications which is Chlorantraniliprole-T1@150ml/ha, Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC-T2@200ml/ha, Lambda cyhalothrin 5EC-T3@750ml/ha, Spinosad 45SC-T4 @200ml/ha, Emamectin benzoate 5SG-T5 @200gm/ha, Flubendiamide 49.35SC-T6@ 200ml/ha, *Beauveria bassiana 5% WP* – T7@2.5kg/ha and untreated control, replicated thrice under RBD. The yields of treatments were significant and the highest yield was seen in Emamectin benzoate 5SG (42.5 q/ha), followed by Lambda cyhalothrin 5EC (40.5 q/ha) and Spinosad 45SC (37.8 q/ha) ranked 3rd among the seven treatments. The highest CBR (cost benefit ratio) of (1:2.42) was observed in Emamectin benzoate 5SG followed by Lambda cyhalothrin 5EC (1:2.3) and with Spinosad 45SC (1:1.83).

Keywords: efficacy, insecticides, emmamectin benzoate, cost benefit ratio, lambda cyhalothrin

1. Introduction
Zea mays L. known as maize, is a member of the Poaceae family. Referred as the "Queen of Cereals". [23]. Also known as the "Miracle Crop" because of its high solar use efficiency and immense potential for increased production. India produced 31.51 MT in an area of 9.9 MH in 2020-21,

Its grain contains protein (3.27g), carbohydrates (18.7g), fat (1.35g), oil (4%), fiber (2g) and minerals (2%). India ranks 4th in area and 7th in production of maize globally contributing approximately 4% and 2% of global area and production of maize, respectively [United States Department of Agriculture (USDA) Nutrient Database].

From *Shivamogga district (Karnataka)* during May-June 2018 it was found (Sharanabasappa *et al.* 2018) [22]. It is found in al parts of the India excepts in the Northern states (Rakshit *et al.* 2019) [17], where it has been reported to cause damage to maize, sweet corn and baby corn. After the continuous invasion it is seen to be found in every part of the world (Mahadevaswamy *et al.* 2018; Sharanabasappa *et al.* 2018) [13]. It was first reported Tandulwadi village of Maharastra in 2018 from the district Solapur by Ganesh Babar farmer of Maharastra (Khergamker, 2019) [11].

The term "fall armyworm" 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 (Smith, 1797) [24]. It is a pest of many crops, gregarious and disruptive pest targeting almost about 353 plant species from 76 families (Montezano *et al.*, 2018) [15]. *S. frugiperda* infestations resulted in the yield losses of 15% to 73% when 55% to 100% of the plants were infested at various stages of development (Hruska and Gould, 1997) [10].

As FAW is a new invasive pest and focus of research is on the study of their incidence during the *rabi* season and also to assess the yield losses in different varieties of maize and their management with a different group of insecticides and biopesticides during the *rabi* season is needed. 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. (Rohit Kumar *et al.*, 2021) [28].

2. Materials and Methodology

An experiment conducted at experimental trial plot of the Department of Entomology, Central Research Farm, Sam Higginbottom University of Agriculture Technology and Sciences, during the *rabi-2023*, in a RBD Design with 8 treatments replicated thrice with variety *Shivam* in a plot of size (2×1) m with the spacing of (60×25 cm). The soil of site was well drained. Research field is situated at the river side of Ganga-Yamuna with 25.87 ^{0} N Latitude and 81.15^{0} E longitudes and at an altitude of 98 m above the mean sea level. The maximum temperature reaches up to 47 ºC during summer and falls to 2 ºC in winter.

Pest population and the larval infestation over control against Fall armyworm (*Spodoptera frugiperda*) which was calculated by calculating the mean of 3 observations recorded at 3rd, 7th and 14th days after first and second time of spraying.

The marketable yield obtained from the different treatments was collected and weighed separately. The Insecticidal cost used in the experiment was recorded during *rabi* season. The cost of Insecticides used were collected from the local market of Naini. The total cost of plant protection consisted of cost of treatments, rent of Sprayer and charge of Labour for the consequent sprays. There are two sprays throughout the research and the overall plant protection expenses was calculated. Total income was obtained by multiplying the total yield per hectare by the local market price, while the total net benefit was obtained by reducing the total cost of plant protection from total income. Total Benefit over the control for each sprayed treatment was obtained by reducing the income of the control treatment from that of each sprayed treatment. The CBR was calculated by formula:

Returns (GROSS) = Total Marketable yield × Total Market price

Total Net return = Total Gross return – Total cost

$$\text{Cost benefit ration} = \frac{\text{Gross return}}{\text{Total}}$$

3. Results and Discussion

The Total yields among different treatments were said to be significant. The highest yield seen 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) which was compared to control plot (15 q/ha). These findings are supported by Sangle *et al.* (2018) [19], Suthar *et al.* (2020) [25] & Thumar *et al.* (2019) [26]. All the treatments were said to be superior over the untreated control. The highest yield over control was superiorly recorded in Emamectin benzoate 5SG (27.5 q/ha) following 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).

Finding the CBR it was found that 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 were supported by Ahir *et al.* (2020) [1] and Sangle *et al.* (2018) [19].

Table 1: Insecticidal efficacy against larval population of Fall armyworm *Spodoptera frugiperda* on Maize (overall mean)

S. No.	Treatments	Dose	Yield (quintal/ha)	Total cost of the yield (₹)	Cost of cultivation (₹)	Total Cost of Treatment (₹)	Total cost of cultivation (₹)	C;B R
T1	Chlorantraniliprole 18.5SC	150ml/ha	26.8	54270	33170	6760	39930	1:1.36
T2	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC	200ml/ha	29.2	59130	33170	2080	35250	1:1.68
T3	Lambda cyhalothrin 5EC	750ml/ha	40.5	82012.5	33170	2410	35580	1:2.30
T4	Spinosad 45SC	200ml/ha	37.8	76545	33170	8560	41730	1:1.83
T5	Emamectin benzoate 5%SG	200gm/ha	42.5	86062.5	33170	2360	35530	1:2.42
T6	Flubendiamide 49.35SC	200ml/ha	31.3	63382.5	33170	2160	35330	1:1.79
T7	*Beauveria bassiana* 5% WP	2.5kg/ha	22.4	45360	33170	3360	36530	1:1.24
T8	Control	-	15	30375	33170	-	33170	1:0.91

Table 2: Increase yield of treatments over the untreated

S. No	Treatments	Yield (q/ha)	Increased yield over control (q/ha)
T1	Chlorantraniliprole 18.5SC	26.8	11.8
T2	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC	29.2	14.2
T3	Lambda cyhalothrin 5EC	40.5	25.5
T4	Spinosad 45SC	37.8	22.8
T5	Emamectin benzoate 5%SG	42.5	27.5
T6	Flubendiamide 49.35SC	31.3	16.3
T7	*Beauveria bassiana* 5% WP	22.4	7.4
T8	Control	15	0

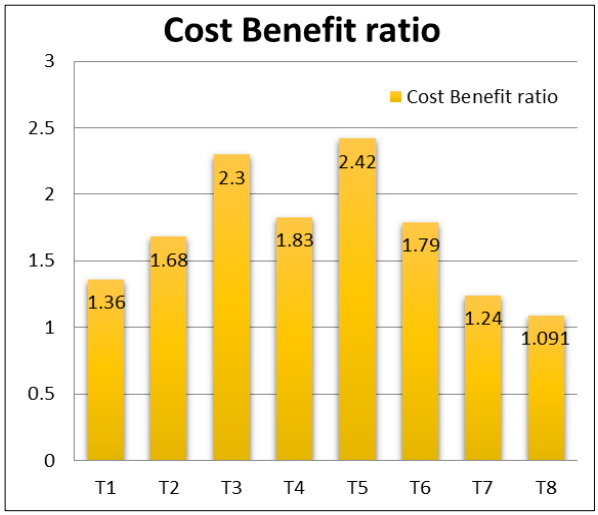

Fig 1: Graph -the cost benefit ratio of treatments

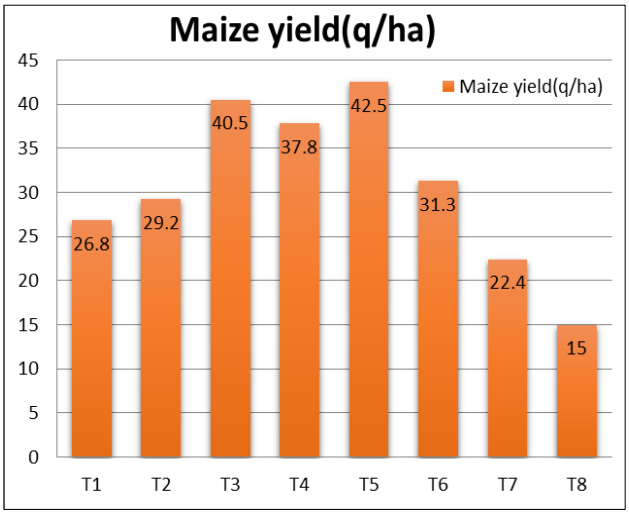

Fig 2: Graph - The Maize Yield of Treatments and the Control Plot

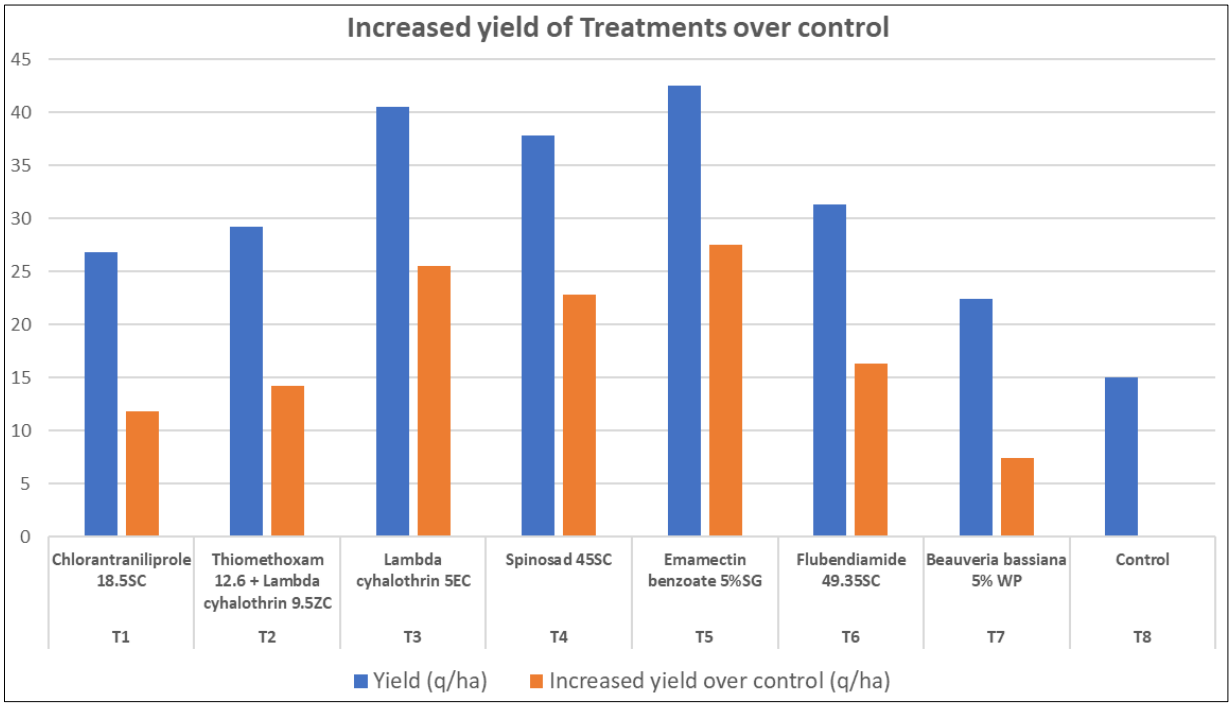

Fig 3: Graph – The increased yield of treatments over the controlled untreated plot

4. Conclusion

From the present findings analysis of the experiment it is said that Lowest larval count of *Spodoptera frugiperda* 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) is found to be the next effective treatment, Thiomethoxam 12.6 + Lambda cyhalothrin 9.5ZC (1.700) is the next effective following 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 of treatments were proven significant. The highest yield seen 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).

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