

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

ABSTRACT

A field experiment was conducted during rabi 2022 at Central Research Farm, SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), (SHUATS) 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 (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).

Comment [DAO1]: Abbreviation should come after details.

Keywords: Efficacy, Insecticides, Emamectin 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 is an important crop next to rice and wheat grown over a wide range of geographical and environmental conditions in India as compared to other cereal crops (Anonymous, 2013). Among the cereal crops, due to its highest genetic yield potential maize is called as "queen of cereals" (Singh et al., 2012) [23]. It is also known as the "Miracle Crop" because of its high solar use efficiency and immense potential for increased production. About 10 % of the total food grain production in the country is contributed by the maize crop.

Its grain contains protein (3.27g), carbohydrates (18.7g), fat (1.35g), oil (4%), fiber (2g) and minerals (2 %). 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 (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 (Anon., 2018).

In India, it was reported for the first time on maize from *Shivamogga district (Karnataka)* during May-June 2018 (Sharanabasappa et al. 2018) [22]. Now, the presence of this pest is reported in all the states of India except in few northern states (Rakshit et al. 2019) [17], where it has been reported to cause damage to maize, sweet corn and baby corn. Now this pest has spread to many Asian countries (CABI, 2019) [4]. Later, it has spread in other states of India on maize (Mahadevaswamy et al. 2018; Sharanabasappa et al. 2018) [13].

It was first reported in Maharashtra in September 2018 in Tandulwad village, Solapur district by the farmer Ganesh Babar (Khergamker, 2019) [11].

The term "fall armyworm" comes from their existence of destruction, in which their 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 polyphagous, gregarious and disruptive pest that targets 353 plant species from 76 families, with Poaceae (106), Asteraceae (31) and Fabaceae (31) families receiving the bulk of the attacks (Montezano et al., 2018) [15]. *S. 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 (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 *rab* 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 *rab* season is needed.

2. MATERIAL 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 *rab* season of 2022, in a Randomized Block Design with the eight treatments replicated three times using variety *Shivam* seeds in a plot size of 2m x 1m at a spacing of (60 x 25 cm) with a recommended package of practices excluding plant protection. The soil of the experimental site was well drained and medium high. Research fields situated at 25.87° North Latitude and 81.15° East longitude and at an altitude of 98 meters above sea level. The maximum temperature reaches up to 47°C in summer and drops down to 2°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 recorded at 3rd, 7th and 14th days after first and second spraying.

Comment [DA02]: Why anonymous? Please, look for correct and recent work on maize for proper citation

Comment [DA03]: What is this?

Comment [DA04]: Citation required. You made mention of 10%. What is the source?

Comment [DA05]: Same as above

Comment [DA06]: Full meaning when first mentioned.

Comment [DA07]: This is not appropriate.

Comment [DA08]: Meaning what?

Comment [DA09]: Check this sentence very well. You have earlier stated that all the states affected except few northern states. Rakshit et al. 2019.

Comment [DA010]: Same comment above.

The healthy marketable yield obtained from different treatments was collected separately and weighed. The cost of insecticides used in this experiment was recorded during *rab* 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. There are two sprays throughout the research period and the overall plant protection expenses were calculated. Total income was realized by multiplying the total yield per hectare by the prevailing market price, while the net benefit is obtained by subtracting the total cost of plant protection 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:

2.1 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

Among all the treatments lowest larval population of maize fall army worm was recorded in Emamectin benzoate 5SG (1.178). Similar findings made by Bajracharya et al. (2020) [2], Salunkhe et al. (2022) [18] and Bharadwaj et al. (2019) [3]. Lambda cyhalothrin 5EC (1.311) is found to be the next best treatment which is in line with the findings of Deshmukh et al. (2020) [6] and Bharadwaj et al. (2020) [3] 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. (2018) [14] Flubendiamide 49.35SC (1.567) is found to be the next effective treatment which is in line with the findings of Deshmukh et al. (2020). [6] 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. (2021) [16] and Salunkhe et al. (2022) [18]. The result of Chlorantraniliprole 18.5SC (1.833) which is in support with Deshmukh et al. (2020) [6] and Bajracharya et al. (2020) [2]. 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. (2020) [7].

3.1 Cost Benefit ratio and Maize Yield

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 Sangleet. al. (2018) [19], Suthar et al. (2020) [25] and Thumar et al. (2019) [26].

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).

Comment [DAO11]: What?

Comment [DAO12]: What?

Comment [DAO13]: What?

Comment [DAO14]: What?

Comment [DAO15]: No meaning?

Comment [DAO16]: What?

Comment [DAO17]: What?

Comment [DAO18]: What?

Comment [DAO19]: What?

Comment [DAO20]: Confusion?

Comment [DAO21]: Same as above.

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 **Ahiret et al. (2020)**^[1] and **Sangleet et al. (2018)**^[19].

Table 1: Efficacy of Insecticides against larval population of *Spodoptera frugiperda* on Maize (overall mean)

S. No.	Treatments	Larval Population of <i>Spodoptera frugiperda</i> on five plants								Yield (q/ha)	B:C ratio
		First spray				Second spray					
		1 DBS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	Overall mean		
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	<i>Beauveria bassiana</i> 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		

Comment [DA022]: Remove excess roles.

4. CONCLUSION

From the analysis of the present findings, it can be 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) 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).

Comment [DAO23]: Re-cast this sentence please.

Comment [DAO24]: Take all these to your discussion. It has no meaning here.

REFERENCES

Where is your Anonymous?

1. Ahir, K. C., Mahla, M. K., Sharma, K., Babu, S. R., & Kumar, A. (2021). Bio-efficacy of insecticides against fall armyworm. *The Indian Journal of Agricultural Sciences*, 91(12), 1796-1800.
2. Bajracharya, A. S. R., Bhat, B., & Sharma, P. (2020). Field efficacy of selected insecticides against fall armyworm, Spodoptera frugiperda (JE Smith) in maize. *Journal of the Plant Protection Society*, 6, 127-133.
3. Bharadwaj, G. S., Mutkule, D. S., Thakre, B. A., & Jadhav, A. S. (2020). Bio-efficacy of different insecticides against fall armyworm, Spodoptera frugiperda (JE Smith) on Maize. *Journal of pharmacognosy and phytochemistry*, 9(5S), 603-607.
4. CABI. Datasheet. Spodoptera frugiperda (fall army worm). Invasive Species Compendium <http://www.cabi.org/lisc/datasheet/129810>, 2016
5. Day R, Abrahams P, Bateman M, Beale T, Clotey V, Cock M, Witt A. Fall armyworm: Impacts and implications for Africa. *Outlooks on Pest Management*. 2017; 28:196-201.
6. Deshmukh, S., Pavithra, H. B., Kalleshwaraswamy, C. M., Shivanna, B. K., Maruthi, M. S., & Mota-Sanchez, D. (2020). Field efficacy of insecticides for management of invasive fall armyworm, Spodoptera frugiperda (JE Smith) (Lepidoptera: Noctuidae) on maize in India. *Florida Entomologist*, 103(2), 221-227.
7. Dhobi, C. B., Zala, M. B., Verma, H. S., Sisodiya, D. B., Thumar, R. K., Patel, M. B., ... & Borad, P. K. (2020). Evaluation of bio-pesticides against fall armyworm, Spodoptera frugiperda (JE Smith) in maize. *Int. J. Curr. Microbiol. App. Sci*, 9(8), 1150-1160.
8. Goergen, G., Kumar, P. L., Sankung, S. B., Togola, A., & Tamò, M. (2016). First report of outbreaks of the fall armyworm Spodoptera frugiperda (JE Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *PLoS one*, 11(10), e0165632.
9. Hardke, J. T., Temple, J. H., Leonard, B. R., & Jackson, R. E. (2011). Laboratory toxicity and field efficacy of selected insecticides against fall armyworm (Lepidoptera: Noctuidae). *Florida Entomologist*, 272-278.
10. Hruska, A. J. and Gould, F. (1997). Fall armyworm (Lepidoptera: Noctuidae) and Diatraea lineolata (Lepidoptera: Pyralidae): Impact of larval population level and temporal occurrence on maize yield in Nicaragua. *Journal of Economic Entomology*, 90(2):611-622.
11. Khergamker, G. 2019. Fall armyworm attack: Maharashtra grappling with
12. Kumar, R. and Alam, T. 2017. Bio-efficacy of some newer insecticides against maize stem borer, *Chilo partellus* (Swinhoe). *J. Entomol. Zool. Stud.*: 5 (6):1347-1351.
13. Mahadeva Swamy, H. M., Asokan, R., Kalleshwaraswamy, C. M., Sharanbasappa, Prasad, Y. G., Maruthi, M. S., Shashank, P. R., Devi, N. I., Surakasula, A., Adarsha, S., Shrinivas, A., Rao, S., Vidyashekar, Raju, M. S., Reddy, GSS, Nagesh, S. N. 2018. Prevalence of "R" strain and molecular diversity of fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in India. *Indian J. Entomol.* 80(3): 544-553.
14. Mallapur, C. P., Naik, A. K., Hagari, S., Praveen, T., & Naik, M. (2019). Laboratory and field evaluation of new insecticide molecules against fall armyworm, Spodoptera frugiperda (JE Smith) on maize. *J Entomol Zool Stud*, 7(4), 869-875.
15. Montezano, D.G., Specht, A., Sosa-Gomez, D.R., Roque-Specht, V.F., Sousa-Silva, J.C., Paula-Moraes, S.D. and Hunt, T.E. (2018). Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African Entomology*, 26(2):286-300.
16. Phani Kumar, K., Mohan Vishnuvardhan, K., Kamakshi, N., Dakshina Murthy, K., & Mohan Rao, K. (2021). Field efficacy of selected insecticides against invasive pest, fall armyworm Spodoptera frugiperda (JE Smith) on maize

- crop. *Pharm Innov J*, 10(10), 884-889.
17. Rakshit, S. et al., Fight against Fall armyworm *Spodopterafrugiperda* (J. E. Smith). ICAR-Indian Institute of Maize Research, Ludhiana, Punjab, 2019, p. 52.
 18. Salunkhe, A. S., Bade, B. A., & Tamboli, N. D. (2023). Management of fall armyworm infesting maize by sequential application of insecticides and biopesticides.
 19. Sangle SV, Jayewar NE, Kadam DR. Efficacy of insecticides on larval population of fall armyworm, *Spodopterafrugiperda* on maize. *Journal of Entomology and Zoology Studies* 2020;8(6):1831-1834.
 20. Sena, D. G., Pinto F., Queiroz, D. M., Viana, P. A. 2003. Fall armyworm damaged Maize plant identification using digital images. *Biosystems engineering* 85(4):449-454.
 21. Sharanabasappa, Kalleshwaraswamy CM, Asokan R, Mahadevaswamy HM, Maruthi MS, Pavithra HB, et al. First report of the fall armyworm, *Spodopterafrugiperda* (J E Smith) (Lepidoptera: Noctuidae), an alien invasive pest on maize in India. *Pest Management in Horticultural Ecosystems*. 2018; 24(1):23-29.
 22. Sharanbasappa, Kalleshwaraswamy, C. M., Asokan, R., Mahadevaswamy, H. M., Maruthi M.S., Pavithra, H. B., Hegde, K. Navi, S., Prabhu, S. T., Goergen, G. 2018. First report of fall armyworm *Spodopterafrugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), an alien invasive pest on Maize in India. *Pest Manag. Hort. Eco. Syst.* Vol. 24. No. 123-29
 23. Singh, P.K., Singh, A.K., Shahi, J.P. and Ranjan, R. 2012. Combining ability and heterosis in quality protein maize. *The Bioscan*, 7(2):337-340.
 24. Smith, J.E. (1797). First record of the fall armyworm, *Spodopterafrugiperda* (Lepidoptera Noctuidae).
 25. Suthar MB, Zala HS, Varma HS, Lunagariya MV, Patel MB, Patel BN et al. Bioefficacy of granular insecticides against fall armyworm, *Spodopterafrugiperda* (JE Smith) in maize *International journal of chemical sciences* 2020;SP8(4):174-179.
 26. Thumar, R. K., Zala, M. B., Varma, H. S., Dhobi, C. B., Patel, B. N., Patel, M. B., & Borad, P. K. (2020). Evaluation of insecticides against fall armyworm, *Spodopterafrugiperda* (JE Smith) infesting maize. *International Journal of Chemical Studies*, 8(4), 100-104.

DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.

Term: Definition for the term

Comment [DAO25]: Nothing is here...