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Evaluation of Novel Insecticides and Bio-Pesticides Against *Helicoverpa armigera* and *Spodoptera frugiperda* in Maize

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ABSTRACT

The field experiment was conducted to study the comparative performance of various insecticides and biopesticides against *Helicoverpa armigera* and *Spodoptera frugiperda.* Chlorantraniliprole 18.5SC @ 0.4ml/l showed the most effective control on *H. armigera* and *S. frugiperda*, with pooled mean larval population of 0.42 and 1.16 larvae/plant followed by emamectin benzoate 5 SG @ 0.4g/l (0.52 and 1.24 larvae/plant), spinaosad 45 SC @0.3 ml/l (0.62 and 1.32 larvae/plant), indoxacarb 14.5 SC@ 1ml/l (0.73 and 1.42 larvae/plant) and novaluron 10 EC @0.1ml/l (0.83 and 1.52 larvae/plant). The least effective treatment was agniastra @1000ml / 50 l (1.19 and 1.81 larvae/plant) after control (2.08 and 2.82 larvae/plant) followed by nimbicidine 0.03 EC @5ml/l (1.03 and 1.75 larvae/plant) and *Bacillus thuringenesis* @ 2g/l (0.92 and 1.62 larvae/plant). The results concluded that chlorantraniliprole, emamectin benzoate, indoxacarb and novaluron consistently demonstrated a significant reduction in larval population and the longest residual. Whereas, Bt and nimbicidine provided moderate control and the shortest residual capacity, which is favorable to the environment.

Keywords Efficacy, Larval population, Cob borer, Fall armyworm, Spring, Chloroantraniliprole.

INTRODUCTION

Zea mays, the queen of cereal is third most important food crops after rice and wheat in India (Suthar *et al*. 2020) and contributes food security. It is an important source of human diet, poultry and animal feed, starch, protein and ethanol production along with phytochemicals including carotenoids, phenolic compounds and phytosterols, all of which are beneficial in the prevention of certain chronic diseases. (Patidar *et al.* 2022). Maize grains have great nutritional value as they contain 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3.0% sugar and 1.7% ash. India ranks 5th in global maize production of 43.41 million tons with an area coverage of 10.74 Mha and productivity of 4.04 ton/hectare (Anonymous 2025). Though India contributes significantly to global maize production, yet the crop is lower than the global average compared to major maize producing countries, primarily due to

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losses caused by biotic stresses.

The maize crop is affected by various stress factors. Insect-pests are one of the key constraints in maize production. Among various species of borers, fall army worm, S. *frugiperda* has become a serious and widespread pest in India and abroad (Darshan *et al.* 2024). Young larvae of fall army worm mostly consume the tissue of the leaf and create holes in it. In India, it was first found in Karnataka in year 2018. According to Figueroa-Brito *et al.* (2013), it can cause a loss up to 70% in grain production. In maize growing area, prevalence of favorable weather conditions (warm weather, humid and heavy rainfall) from March to September provide fertile ground for mass multiply and spread of this pest easily favors in reproduction of fall armyworm.

H. armigera is also become a destructive pest in India which causes enormous harm during the cob emerging stage. The larvae cause irregular injuries to the cobs with grain being webbed together and broken along with presence of granular faecal pallets. The larvae upon feeding create holes in the cobs and grains, leading to reduced quality and potential yield losses. Across India, the highest cob infestation rates were recorded from 20 to 23% (Ahir *et al.* 2021).

Among various approaches available for these pests, chemical control is considered as most commonly adopted method by the maize grower. However, it has certain limitation such as development of resistance in insect pest, environmental pollution and health hazards etc., warranting the need for search of new safer molecules are management of these insect pest. The limited research on chemical control efficacy of insecticides and biopesticides against these pests in maize necessitated the evaluation of selected biopesticides and novel insecticide against *H. armigera* and *S. frugiperda* under field conditions.

MATERIAL AND METHODS

A field experiment was conducted at the Research Farm, Faculty of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala (Haryana) during Spring season of 2025. The field was prepared by two deep ploughings followed by harrowing and leveling to ensure a fine tilth suitable for sowing. Sowing of Hybrid Maize-1was done in a well prepared field on Febuary 14, 2025 manually with a spacing of 60 cm and 20 cm. The crop was raised following Package of Practices, CCSHAU, Hisar except IPM. The current study laid out in a Randomized Block Design (RBD) with three replication of each treatment. The treatments were applied twice as foliar spray with Knapsack spray at ETL level followed by the crop stage at which population of these *H. armigera* and *S. frugiperda* rebound and again reached ETL. The data on larval population per plant of these pests were recorded 1 day before sowing (DBS) and at 3, 5, 7 and 10 days after spraying (DAS) by selecting three plants from each of the triplicate plot. The recorded data during the experimental period were analyzed using OPSTAT software.

RESULTS AND DISCUSSION

Efficacy of novel insecticides and bio-pesticides against cob worm, *H. armigera* in maize

Among different treatments, chlorantraniliprole was found to be best insecticide followed by emamectin benzoate and spinosad by giving maximum reduction in larval population at 0.43, 0.52 and 0.62 larvae/plant, respectively (Table 1). Biopesticides, particularly *Bacillus thruingenesis* (Bt) and nimbicidine showed substantial control when applied during early larval stages. Plots treated with agniastra were found to have lowest larval reduction after control. Similarly, Kumar *et al.* (2020) noticed that treatments like indoxacarb (0.12 larvae/plant) and spinosad (0.21 larvae/plant) were intermediate in efficacy in comparison to control (0.58 larvae/plant) after 5 days of spray. Identical study was done by Mohanty and Tayde (2022) who observed that spinosad (0.42 larvae/plant) was more effective than the NSKE (0.65 larvae/plant) and Bt (0.77 larvae/plant).

Efficacy of novel insecticides and bio-pesticides against fall army worm, *S. frugiperda* in maize

Fall army worm, being a late-season pest, required longer residual action. Chlorantraniliprole (1.16 larvae/plant) proved to be the most effective treatment with both quick and extended control (Table 2).

Table 1. Efficacy of novel insecticides and bio-pesticides against *H. armigera in* maize.

Treatments	Doses	First spray						Second spray						Pooled
		1 DBS*	3 DAS**	5 DAS	7 DAS	10 DAS	Mean	1 DBS	3 DAS	5 DAS	7 DAS	10 DAS	Mean	Mean
Spinosad 45 SC	0.3 ml/L	1.82 (1.67)***	1.22 (1.49)	0.55 (1.24)	0.23 (1.11)	0.51 (1.23)	0.62 (1.27)	1.84 (1.73)	1.31 (1.52)	0.53 (1.23)	0.23 (1.11)	0.44 (1.23)	0.62 (1.27)	0.62 (1.27)
Chlorantraniliprole 18.5 SC	0.4 ml/L	1.82 (1.67)	1.05 (1.43)	0.34 (1.15)	0.03 (1.01)	0.31 (1.14)	0.43 (1.18)	1.85 (1.73)	1.07 (1.44)	0.33 (1.15)	0.02 (1.01)	0.22 (1.15)	0.41 (1.19)	0.42 (1.185)
Emamectin Benzoate 5 SG	0.4 g/L	1.83 (1.68)	1.11 (1.45)	0.42 (1.19)	0.13 (1.06)	0.42 (1.19)	0.52 (1.22)	1.93 (1.71)	1.24 (1.49)	`0.43 (1.19)	0.11 (1.05)	0.32 (1.19)	0.53 (1.23)	0.525 (1.225)
Indoxacarb 14.5 SC	1 ml/L	1.86 (1.69)	1.31 (1.52)	0.63 (1.27)	0.35 (1.16)	0.64 (1.28)	0.73 (1.30)	1.74 (1.73)	1.45 (1.56)	0.63 (1.27)	0.34 (1.62)	0.55 (1.27)	0.74 (1.31)	0.735 (1.305)
Agniastra	1000 ml/50 L	1.86 (1.69)	1.74 (1.65)	1.08 (1.44)	0.95 (1.39)	1.03 (1.42)	1.20 (1.47)	1.93 (1.70)	1.83 (1.68)	1.13 (1.45)	0.76 (1.32)	1.05 (1.45)	1.19 (1.47)	1.195 (1.47)
Novaluron 10 EC	0.1 ml/L	1.82 (1.68)	1.46 (1.56)	0.76 (1.32)	0.45 (1.20)	0.73 (1.31)	0.85 (1.35)	1.92 (1.73)	1.53 (1.59)	0.73 (1.31)	0.43 (1.19)	0.62 (1.31)	0.82 (1.35)	0.835 (1.35)
Bacillus thuringenesis	2 g/L	1.80 (1.67)	1.523 (1.58)	0.83 (1.35)	0.54 (1.24)	0.84 (1.35)	0.93 (1.38)	1.87 (1.74)	1.62 (1.62)	0.82 (1.35)	0.53 (1.23)	0.73 (1.35)	0.92 (1.38)	0.925 (1.38)
Nimbicidine 0.03 EC	5 ml/L	1.843 (1.68)	1.64 (1.62)	0.93 (1.39)	0.65 (1.28)	0.91 (1.38)	1.03 (1.42)	1.913 (1.72)	1.71 (1.64)	0.93 (1.38)	0.62 (1.27)	0.93 (1.38)	1.04 (1.42)	1.035 (1.42)
Control	-	1.92 (1.70)	1.95 (1.71)	1.97 (1.72)	1.99 (1.72)	2.03 (1.74)	1.98 (1.72)	2.13 (1.76)	2.15 (1.77)	2.18 (1.78)	2.21 (1.79)	2.25 (1.78)	2.19 (1.78)	2.085 (1.75)
CD.		NS	0.008	0.01	0.01	0.01	0.01	NS	0.011	0.014	0.014	0.014	0.013	0.01

*DBS: Day before spray *** Figure in parentheses are square root transformed
** DAS: Day after spray

Emamectin benzoate (1.25 larvae/plant) and spinosad (1.34 larvae/plant) also demonstrated significant reductions. Among biopesticides, Bt and nimbicidine showed modest reduction of larval counts with mean

Table 2. Efficacy of novel insecticides and bio-pesticides against *S. frugiperda* in maize.

Treatments	Doses	First spray (Larvae/ plant)						Second Spray (Larvae/plant)						Pooled
		1 DBS*	3 DAS**	5 DAS	7 DAS	10 DAS	Mean	1 DBS	3 DAS	5 DAS	7 DAS	10 DAS	Mean	Mean
Spinosad 45 SC	0.3 ml/L	2.84 (1.96)***	1.73 (1.65)	1.55 (1.60)	0.89 (1.37)	1.22 (1.49)	1.34 (1.53)	2.75 (1.93)	1.73 (1.65)	1.45 (1.56)	0.74 (1.32)	1.34 (1.53)	1.31 (1.52)	1.32 (1.525)
Chlorantraniliprole 18.5 SC	0.4 ml/L	2.82 (1.96)	1.58 (1.60)	1.39 (1.54)	0.69 (1.30)	1.01 (1.41)	1.16 (1.45)	2.88 (1.97)	1.58 (1.60)	1.27 (1.50)	0.58 (1.26)	1.21 (1.48)	1.16 (1.46)	1.16 (1.455)
Emamectin Benzoate 5 SG	0.4 g/L	2.86 (1.95)	1.62 (1.62)	1.49 (1.58)	0.79 (1.33)	1.11 (1.45)	1.25 (1.48)	2.71 (1.92)	1.66 (1.63)	1.35 (1.53)	0.66 (1.29)	1.27 (1.50)	1.23 (1.49)	1.24 (1.485)
Indoxacarb 14.5 SC	1 ml/L	2.85 (1.96)	1.84 (1.68)	1.66 (1.63)	0.95 (1.39)	1.37 (1.53)	1.45 (1.56)	2.65 (1.91)	1.82 (1.67)	1.53 (1.59)	0.82 (1.34)	1.45 (1.56)	1.40 (1.55)	1.42 (1.555)
Agniastra	1000 ml/50 L	2.80 (1.95)	2.23 (1.79)	1.94 (1.71)	1.35 (1.53)	1.83 (1.68)	1.84 (1.68)	2.85 (1.96)	2.19 (1.78)	1.91 (1.70)	1.31 (1.51)	1.83 (1.68)	1.78 (1.67)	1.81 (1.67)
Novaluron 10 EC	0.1 ml/L	2.86 (1.96)	1.95 (1.71)	1.75 (1.65)	1.03 (1.42)	1.46 (1.56)	1.55 (1.59)	2.78 (1.94)	1.88 (1.69)	1.61 (1.61)	0.92 (1.38)	1.57 (1.60)	1.49 (1.58)	1.52 (1.57)
Bacillus thuringenesis	2 g/L	2.88 (1.94)	2.03 (1.74)	1.86 (1.69)	1.12 (1.45)	1.55 (1.59)	1.64 (1.62)	2.71 (1.92)	2.02 (1.73)	1.72 (1.64)	1.03 (1.42)	1.65 (1.62)	1.60 (1.61)	1.62 (1.615)
Nimbicidine 0.03 EC	5–6 ml/L	2.79 (1.96)	2.13 (1.75)	1.92 (1.71)	1.21 (1.48)	1.79 (1.67)	1.76 (1.65)	2.88 (1.97)	2.14 (1.77)	1.81 (1.67)	1.21 (1.48)	1.77 (1.66)	1.75 (1.64)	1.75 (1.72)
Control	-	2.57 (1.96)	2.58 (1.89)	2.60 (1.89)	2.68 (1.92)	2.76 (1.94)	2.66 (1.91)	2.94 (1.98)	2.96 (1.99)	3.02 (2.0)	2.97 (1.99)	3.02 (2.00)	2.99 (1.99)	2.82 (1.95)
CD		NS	0.012	0.017	0.020	0.054	0.02	NS	0.019	0.015	0.063	0.021	0.029	0.024

*DBS: Day before spray *** Figure in parentheses are square root transformed
** DAS: Day after spray

population of 1.64 and 1.76 larvae/plant, respectively. Hardke *et al.* (2011) found that chlorantraniliprole was significantly effective against fall army worm with mortality rate of 53.1% over untreated control. Similarly, Zaman and Patel (2023) also observed that chlorantraniliprole effectively reduced population of fall army worm larval population to the 0.16 larvae/plant as compared to control (1.20 larvae/plant). The effectiveness of emamectin benzoate in reducing fall army worm infestation and minimizing crop damage had been highlighted by earlier researchers (Mallapur *et al.* 2019).

CONCLUSION

Based on the study, it can be concluded that chlorantraniliprole, emamectin benzoate, indoxacarb and novaluron consistently demonstrated a significant reduction in larval population and longest residual against *H. armigera* and *S. frugiperda*. Bt and nimbicidine, when used in the second spray provided moderate control and reduced chemical residues. Agnistra was found to be the least effective, but it has the shortest residual capacity which is favorable to the environment.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interests.

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