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Original Article

Efficacy of Novel Insecticides and Biopesticides Against *Chilo partellus* (Swinhoe) and *Sesamia inferens* (Walker) in Maize

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Abstract

A field experiment was conducted at the Research Farm, Faculty of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala (Haryana), India, to study the impact of five novel insecticides (spinosad 45 SC (suspension concentrate) @ 0.3 mL/L, chlorantraniliprole 18.5 SC @ 0.4 mL/L, emamectin benzoate 5 SG (soluble granules) @ 0.4 g/L, indoxacarb 14.5 SC @ 1 mL/L, and novaluron 10 EC (emulsifiable concentrate) @ 0.1 mL/L) and three biopesticides (agniastra @ 1,000 mL/5 L, *Bacillus thuringiensis* @ 2 g/L, and nimbicidine @ 5-6 mL/L) against *Chilo partellus* and *Sesamia inferens*, which cause significant qualitative and quantitative losses in spring maize crops. The experiment was laid out in a randomized block design, and the treatments were applied as foliar sprays when the pests reached the economic threshold level (10% dead hearts). The efficacy of various treatments was assessed on the basis of larval counts of these pests under different treatments. Among the various treatments, chlorantraniliprole 18.5 SC was found to be the most effective treatment, reducing the mean larval populations of *C. partellus* and *S. inferens* to 1.00 and 1.41 larvae/plant, respectively, followed by emamectin benzoate 5 SG (1.08 and 1.52 larvae/plant) and spinosad 45 SC (1.20 and 1.62 larvae/plant), as against the control (2.67 and 4.46 larvae/plant), respectively. Indoxacarb 14.5 SC (1.30 and 1.73 larvae/plant) and novaluron 10 EC (1.40 and 1.85 larvae/plant) were next in order of efficacy. The biopesticides, viz., Bt (1.50 and 1.95 larvae/plant) and nimbicidine 0.03 EC (1.60 and 2.05 larvae/plant), were found to be moderately effective against *C. partellus* and *S. inferens*. However, these were statistically inferior to the insecticides with regard to their efficacy. Chlorantraniliprole-treated plots gave the highest grain yield of 61.67 q/ha, followed by emamectin benzoate (58.06 q/ha) and spinosad (56.04 q/ha), and also increased the plant height of the maize hybrid. Based on the present findings, the foliar application of chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG, and spinosad 45 SC is advocated for the eco-friendly management of *C. partellus* and *S. inferens* in spring maize owing to the limited residual effects of these insecticides.

Categories: Agricultural and food economics, Disease & pests of crops, Insecticide resistance

Keywords: spring, maize, larval population, yield, plant height, treatment, effectiveness, chloroantraniliprole, bt, neem oil

Introduction

Maize (*Zea mays* L.) is an essential cereal crop generally cultivated for food grain, livestock fodder [1], and as a viable source of bioenergy [2]. Maize is known as the "Queen of Cereals" due to its high genetic yield potential among cereal crops [3]. India ranks fifth in global maize production, with 43.41 million tonnes produced from an area of 10.74 million ha and a productivity of 3.54 tonnes/hectare [4]. The major maize-growing states in India are Madhya Pradesh, Karnataka, Bihar, Maharashtra, Telangana, and West Bengal. Maize is traditionally grown during the *Kharif* season, but owing to assured irrigation facilities, the area under spring maize has also increased recently in northern India, including Haryana.

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Numerous insect pests infest maize crops and cause significant qualitative and quantitative losses in production [5]. Among them, the stem borer *Chilo partellus* is a significant pest across India. *Chilo partellus* lays eggs on the lower surface of leaves 10 to 25 days after germination, and the larvae penetrate the whorl and damage the leaves [6]. It causes 90-95% of the damage to maize crops and infests them from the seedling stage to maturity [7]. In addition, the pink stem borer, *Sesamia inferens*, is also emerging as an important pest in the north-western plains of India [8]. Pink stem borer larvae cause damage to the stem and lead to dead-heart symptoms. It has more extensive occurrence during the winter season and may cause grain losses of up to 12-95% [9, 10]. The attack of these borers can cause lodging, stem breakage, and dead-heart symptoms in maize plants, ultimately reducing crop production. Effective pesticides and their timely application at the early whorl stage are important for managing maize borers because these pests are internal feeders, and control at later stages offers only a limited window of opportunity for chemical intervention [11].

Generally, synthetic pesticides are used to manage these pests. Nowadays, the use of effective and environmentally safe insecticides with novel modes of action needs to be prioritized, as they play a vital role in insecticide resistance management strategies. Botanicals such as neem oil, neem leaf extract, neem seed kernel extract, and Jatropha leaf extract have exhibited higher efficacy in deterring oviposition by these borer adults. Moreover, resistance to *C. partellus* and *S. inferens* in commercially grown cultivars and hybrids is rarely recorded. The search for new insecticides with varying modes of action and biopesticides is a continuous process for the effective management of insect pests and for overcoming the problem of pesticide resistance development. Keeping in view the economic importance of these insect pests in Haryana and the above facts, the current study was conducted to identify the most effective treatment among various insecticides and biopesticides for the management of maize borers.

Materials And Methods

A field experiment was conducted at the Research Farm, Faculty of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala (Haryana), during the spring season of 2025. The experiment was designed in a randomized block design with eight treatments listed in Table *1*, each replicated three times. The field was prepared by two deep ploughings followed by harrowing and levelling to ensure a fine tilth suitable for sowing. Sowing of the maize hybrid, namely HM-1, was done manually on February 14, 2025, with a spacing of 60 cm × 20 cm (row-to-row and plant-to-plant, respectively). All cultivation practices, except Integrated Pest Management, were followed to raise the crop according to the Package of Practices of Chaudhary Charan Singh Haryana Agricultural University, Hisar. The first application of treatments was done when the pest reached the economic threshold level (10% deadhearts), and the second application was done when the larval population of borer species rebounded and reached the economic threshold level. Spraying was done with a knapsack sprayer using the required concentration of insecticides. In each treatment, data on the larval population of borer pests were recorded one day before spraying and subsequently at 3, 5, 7, and 10 days after spraying. Three plants were selected from each of the three replicate plots to record the larval population per plant [7]. At the time of harvesting, cob yield per plot was recorded and converted to quintals per hectare for comparison. The data recorded during the experimental period were analyzed using OPSTAT software.

Results And Discussion

The data presented in Table *1* revealed that the insecticides performed better than the biopesticides in reducing the larval population of *C. partellus* in maize. The first application of treatments, carried out at the commencement of the economic threshold level, resulted in a rapid reduction of active larval populations.

Upon the first and second sprays, chlorantraniliprole showed the most effective control of *C. partellus*, with mean larval populations of 0.98 and 1.03 larvae/plant, respectively, as against 2.71 and 2.87 larvae/plant, respectively, in the untreated plot. Emamectin benzoate (1.02 and 1.12 larvae/plant) and spinosad (1.17 and 1.23 larvae/plant) were also highly effective and significantly reduced the larval population. The least effective treatment was agniastra (1.67 and 1.79 larvae/plant) after the control (2.71 and 2.87 larvae/plant), followed by nimbicidine (1.58 and 1.61 larvae/plant) and Bt (1.48 and 1.53 larvae/plant). However, novaluron (1.38 and 1.42 larvae/plant) and indoxacarb (1.27 and 1.33 larvae/plant)

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were found to be moderately effective against *C. partellus*. Earlier researchers have also established the effectiveness of chlorantraniliprole [12] and emamectin benzoate [7] against *C. partellus* in maize. Among biopesticides, neem-based treatments were found to be moderately effective, with 0.97 larvae/plant [13].

Treatments	Doses	First Spray (Larvae/Plant)						Second Spray (Larvae/Plant)						Pooled Mean
		1 DBS	3 DAS	5 DAS	7 DAS	10 DAS	Mean	1 DBS	3 DAS	5 DAS	7 DAS	10 DAS	Mean	
Spinosad 45 SC	0.3 mL/L	2.70	1.53	1.31	0.41	1.43	1.17	2.68	1.52	1.43	0.44	1.55	1.23	1.20
		(1.93)	(1.59)	(1.52)	(1.18)	(1.56)	(1.46)	(1.91)	(1.59)	(1.56)	(1.20)	(1.59)	(1.48)	(1.47)
Chlorantraniliprole 18.5 SC	0.4 mL/L	2.68	1.36	1.15	0.21	1.22	0.98	2.75	1.33	1.22	0.24	1.33	1.03	1.00
		(1.97)	(1.53)	(1.46)	(1.10)	(1.49)	(1.39)	(1.93)	(1.52)	(1.49)	(1.11)	(1.52)	(1.41)	(1.40)
Emamectin Benzoate 5 SG	0.4 g/L	2.71	1.46	`1.25	0.32	1.30	1.02	2.71	1.43	`1.33	0.32	1.41	1.12	1.08
		(1.92)	(1.56)	(1.50)	(1.15)	(1.51)	(1.43)	(1.92)	(1.55)	(1.52)	(1.14)	(1.55)	(1.44)	(1.43)
Indoxacarb 14.5 SC	1 mL/L	2.74	1.63	1.43	0.50	1.52	1.27	2.70	1.64	1.53	0.52	1.62	1.33	1.30
		(1.91)	(1.62)	(1.56)	(1.22)	(1.58)	(1.49)	(1.92)	(1.62)	(1.59)	(1.23)	(1.62)	(1.51)	(1.50)
Agniastra	1,000 mL/50 L	2.69	2.02	1.81	0.93	1.94	1.67	2.74	2.04	1.91	0.93	2.29	1.79	1.72
		(1.96)	(1.73)	(1.67)	(1.38)	(1.71)	(1.62)	(1.93)	(1.74)	(1.70)	(1.38)	(1.81)	(1.66)	(1.64)
Novaluron 10 EC	0.1 mL/L	2.70	1.73	1.53	0.63	1.65	1.38	2.71	1.72	1.62	0.62	1.72	1.42	1.40

		(1.94)	(1.65)	(1.59)	(1.27)	(1.63)	(1.53)	(1.92)	(1.65)	(1.62)	(1.27)	(1.65)	(1.55)	(1.54)
Bacillus thuringiensis	2 g/L	2.73	1.86	1.63	0.72	1.73	1.48	2.75	1.83	1.73	0.73	1.83	1.53	1.50
		(1.92)	(1.69)	(1.62)	(1.31)	(1.65)	(1.57)	(1.93)	(1.68)	(1.65)	(1.31)	(1.68)	(1.58)	(1.57)
Nimbicidine 0.03 EC	5–6 mL/L	2.70	1.91	1.71	0.83	1.85	1.58	2.77	1.90	1.81	0.82	1.92	1.61	1.60
		(1.97)	(1.70)	(1.64)	(1.35)	(1.68)	(1.59)	(1.94)	(1.70)	(1.67)	(1.34)	(1.70)	(1.60)	(1.59)
Control	-	2.67	2.68	2.71	2.73	2.74	2.71	2.83	2.84	2.86	2.88	2.90	2.87	2.79
		(1.98)	(1.92)	(1.92)	(1.93)	(1.93)	(1.91)	(1.95)	(1.96)	(1.96)	(1.97)	(1.97)	(1.96)	(1.93)
CD (P = 0.05)		NS	0.012	0.011	0.011	0.011	0.011	NS	0.010	0.071	0.004	0.013	0.008	0.009

TABLE 1: Efficacy of novel insecticides and biopesticides against stem borer in maize

Figures in parentheses are square root transformed.
CD, Critical Difference; DBS, Day Before Spray; DAS, Day After Spray; EC, Emulsifiable Concentrate; NS, Not Significant; SC, Suspension Concentrate; SG, Soluble Granules

Chlorantraniliprole showed the highest efficacy against the larvae of pink stem borer, with a population of 1.46 larvae/plant even after the first spray application (Table *2*). Emamectin benzoate and spinosad also demonstrated positive results, with reductions in larval population to 1.58 and 1.69 larvae/plant, respectively. Indoxacarb, novaluron, Bt, nimbicidine, and agniastra also reduced the larval population significantly. However, agniastra showed the least efficacy. Almost similar results were obtained after the application of the second spray. The results demonstrated that, 5 days after spraying, chlorantraniliprole minimized *S. inferens* incidence by about 30% [14]. Chlorantraniliprole was found to be the most effective treatment against pink stem borer, followed by emamectin benzoate [15]. Spraying the crop twice with chlorantraniliprole resulted in a 30% reduction in larval population. Similar observations also emphasized the need for two sprays for consistent reduction in the larval population of pink stem borer [16].

Treatments	**Dose**	**First Spray (Larvae/Plant)**						**Second Spray (Larvae/Plant)**						**Pooled Mean**
		1 DBS	3 DAS	5 DAS	7 DAS	10 DAS	Mean	1 DBS	3 DAS	5 DAS	7 DAS	10 DAS	Mean	

		4.51	2.42	1.54	0.44	2.34	1.69	4.65	2.44	1.34	0.22	2.25	1.56	1.62
Spinosad 45 SC	0.3 mL/L	(2.34)	(1.85)	(1.59)	(1.20)	(1.82)	(1.61)	(2.37)	(1.85)	(1.53)	(1.10)	(1.80)	(1.57)	(1.59)
		4.50	2.24	1.35	0.23	2.05	1.46	4.67	2.26	1.12	0.05	2.05	1.37	1.41
Chlorantraniliprole 18.5 SC	0.4 mL/L	(2.34)	(1.80)	(1.53)	(1.11)	(1.74)	(1.54)	(2.38)	(1.80)	(1.45)	(1.02)	(1.74)	(1.50)	(1.52)
		4.52	2.32	1.45	0.35	2.22	1.58	4.70	2.36	1.26	0.13	2.12	1.46	1.52
Emamectin Benzoate 5 SG	0.4 g/L	(2.35)	(1.82)	(1.56)	(1.16)	(1.79)	(1.59)	(2.38)	(1.83)	(1.50)	(1.06)	(1.76)	(1.53)	(1.56)
		4.53	2.52	1.64	0.57	2.53	1.81	4.64	2.54	1.41	0.35	2.35	1.66	1.73
Indoxacarb 14.5 SC	1 mL/L	(2.35)	(1.87)	(1.62)	(1.25)	(1.88)	(1.65)	(2.37)	(1.88)	(1.55)	(1.16)	(1.83)	(1.60)	(1.63)
		4.51	2.95	2.07	0.93	2.92	2.21	4.65	2.93	1.86	0.94	2.95	2.17	2.19
Agniastra	1,000 mL/50 L	(2.34)	(1.98)	(1.75)	(1.39)	(1.98)	(1.78)	(2.37)	(1.98)	(1.69)	(1.39)	(1.98)	(1.76)	(1.77)
		4.52	2.64	1.73	0.63	2.64	1.91	4.61	2.63	1.54	0.46	2.54	1.79	1.85
Novaluron 10 EC	0.1 mL/L	(2.34)	(1.90)	(1.65)	(1.27)	(1.90)	(1.68)	(2.36)	(1.90)	(1.59)	(1.21)	(1.88)	(1.64)	(1.66)
		4.51	2.75	1.86	0.74	2.72	2.01	4.62	2.71	1.65	0.566	2.65	1.89	1.95

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Bacillus thuringiensis	2 g/L	(2.34)	(1.93)	(1.69)	(1.31)	(1.93)	(1.71)	(2.37)	(1.92)	(1.62)	(1.25)	(1.91)	(1.67)	(1.69)
		4.48	2.84	1.94	0.82	2.82	2.10	4.62	2.86	1.72	0.65	2.73	1.99	2.05
Nimbicidine 0.03 EC	5–6 mL/L	(2.34)	(1.96)	(1.71)	(1.35)	(1.95)	(1.74)	(2.37)	(1.96)	(1.64)	(1.28)	(1.93)	(1.70)	(1.72)
		4.46	4.48	4.55	4.58	4.58	4.54	4.63	4.66	4.68	4.71	4.73	4.69	4.61
Control	-	(2.33)	(2.34)	(2.35)	(2.36)	(2.36)	(2.35)	(2.37)	(2.38)	(2.38)	(2.39)	(2.39)	(2.38)	(2.36)
CD (P = 0.05)		NS	0.013	0.014	0.014	0.007	0.012	NS	0.008	0.013	0.018	0.010	0.012	0.012

TABLE 2: Efficacy of novel insecticides and biopesticides against pink stem borer on maize

Figures in parentheses are square root transformed.
CD, Critical Difference; DBS, Day Before Spray; DAS, Day After Spray; EC, Emulsifiable Concentrate; NS, Not Significant; SC, Suspension Concentrate; SG, Soluble Granules

In addition to reducing larval populations, two sprays of insecticides and biopesticides significantly improved both grain yield and plant height in maize (Table *3*). Untreated control plots averaged 41.57 q/ha grain yield and 142.29 cm plant height at maturity, whereas the top-performing treatments produced significantly higher yields along with increased plant height. Chlorantraniliprole gave the highest grain yield (61.67 q/ha) and plant height (165.8 cm). In a previous study, treatment of maize with chlorantraniliprole resulted in a 17-20% yield improvement and a 10-12 cm increase in plant height under high borer infestation [12]. Emamectin benzoate resulted in a grain yield of 58.06 q/ha and a plant height of 163.66 cm. Almost similar results were obtained, with an 11% yield uplift and a 10 cm increase in plant height when emamectin benzoate was applied at early stages. Spinosad resulted in a 35.66% yield increase over the control, along with a plant height of 161.26 cm [17]. Similarly, a 45% yield gain and significant enhancement in plant height benefited from the application of spinosad in borer-infested maize [18]. However, neem-based treatments provided environmentally safe options, though their yield benefits were lower compared to synthetic insecticides [19].

Treatments	Dose	Yield (q/ha)	Yield Increased Over Control (%)	Plant Height (cm)
Spinosad 45 SC	0.3 mL/L	56.04	35.66	161.26
		(7.57)		(12.73)

Chlorantraniliprole 18.5 SC	0.4 mL/L	61.67	48.32	165.8
		(7.91)		(12.91)
Emamectin Benzoate 5 SG	0.4 g/L	58.06	39.64	163.66
		(7.68)		(12.83)
Indoxacarb 14.5 SC	1 mL/L	54.68	31.52	159.6
		(7.46)		(12.65)
Agniastra	1,000 mL/50 L	46.83	12.64	145.03
		(6.91)		(12.08)
Novaluron 10 EC	0.1 mL/L	53.41	28.47	155.13
		(7.37)		(12.49)
Bacillus thuringiensis	2 g/L	51.45	23.74	151.33
		(7.24)		(12.34)
Nimbicidine 0.03 EC	5–6 mL/L	50.62	21.76	149.41
		(7.18)		(12.26)
Control	-	41.57	-	142.29
		(6.52)		(11.97)
CD		0.01		0.08

TABLE 3: Impact of novel insecticides and biopesticides on total grain yield and plant height of maize

Figures in parentheses are square root transformed.
CD, Critical Difference; EC, Emulsifiable Concentrate; SC, Suspension Concentrate; SG, Soluble Granules

Conclusions

Based on the above findings, it can be concluded that the first application of spray resulted in a 60-90% reduction in larval population up to 10 days after spraying. Chlorantraniliprole, emamectin benzoate, spinosad, indoxacarb, and novaluron demonstrated a reduction in larval population and the longest residual control against *C. partellus* and *S. inferens*. Bt and nimbicidine, when used in the second spray, provided moderate control and reduced chemical residues. Agnistra was found to be the least effective; however, it is an eco-friendly treatment due to its shortest residual capacity.

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Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Sonu Kumari, Sunaina Malik, Rakesh Kumar, Amit Dhankar

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Supervision: Sonu Kumari

Disclosures

Plant subjects: All authors have confirmed that this study did not involve any herbarium specimen.

Human subjects: All authors have confirmed that this study did not involve human participants or tissue.

Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

- **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work.
- **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
- **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

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