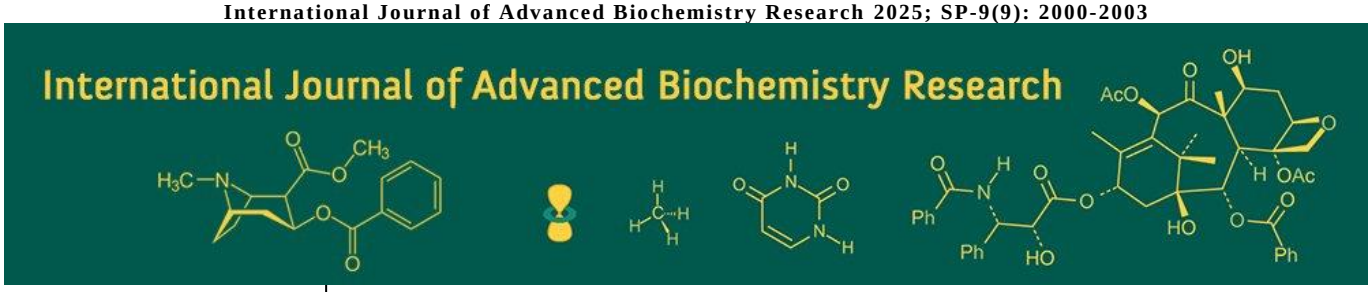

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Comparative bio-efficacy of various botanicals against fall armyworm, *Spodoptera frugiperda* JE Smith on Maize crop

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Abstract
Maize, an essential cereal crop for global food security, is highly vulnerable to pests, especially the fall armyworm (*Spodoptera frugiperda*), which poses a major threat by causing substantial yield losses. This study evaluated botanical extracts as eco-friendly alternatives to synthetic insecticides. Conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur, during the 2021–22 *Rabi* season, the experiment used maize variety TA5084 in a Randomized Block Design with seven treatments and five replications. Six botanical extracts were evaluated in comparison to an untreated control. *Cleistanthus collinus* (10%) demonstrated the highest effectiveness, reducing larval populations by 43.54% after the first spray, 29.77% after the second, and 58.39% after the third, with a grain yield of 3.68 t/ha. *Azadirachta indica* (10%) and Neem Seed Kernel Extract (5%) also exhibited significant efficacy. The study highlights the potential of plant-based insecticides as sustainable pest management solutions and calls for further research on optimizing their application and economic viability for large-scale use.

Keywords: Botanicals, fall armyworm, integrated pest management, *Zea mays*

Introduction
Maize (*Zea mays* L.), a vital cereal crop of the grass family Poaceae, is among the world's top four crops alongside sugarcane, rice and wheat, contributing nearly half of global primary crop production. In 2020, global maize output surpassed 2 billion tonnes (FAO, 2023) [3]. Maize provides significant nutritional, health and economic value, offering proteins, carbohydrates, dietary fiber, oils, vitamins and antioxidants (Huma *et al*., 2019; Kazerooni *et al*., 2019) [6, 7]. In India, maize is cultivated mainly during the *Kharif* (rainy) and *Rabi* (winter) seasons, with *Kharif* maize covering 83% of the area but vulnerable to rainfed conditions, while *Rabi* maize, benefiting from irrigation and favorable weather, is growing in popularity. India's maize production stands at 34.5 million metric tonnes annually (FAO, 2023) [3]. Despite its importance, maize faces significant pest challenges, particularly from the invasive fall armyworm (*Spodoptera frugiperda*), which first appeared in India in 2018 (Sharanabasappa *et al*., 2017) [13]. Feeding on over 80 crop species, the fall armyworm is highly destructive, capable of traveling 100 kilometers daily, with aggressive feeding, rapid reproduction, and no diapause phase, leading to severe yield losses of 8.3 to 20.6 million tonnes annually if unmanaged (Day *et al*., 2017) [2]. Other major pests, including maize stalk borer, pink stem borer and shoot fly, further exacerbate the threats to maize cultivation in India.

The reliance on synthetic chemical insecticides to control fall armyworm and other pests endangers food safety, the environment and human health. Prolonged use leads to pesticide residues in food and water, disrupts ecological balance and harms beneficial insects (Chirinos *et al*., 2020) [1]. Synthetic pesticides like organophosphates and carbamates can block essential enzymes in humans, causing health issues (Mdeni *et al*., 2022) [10]. Many small-scale farmers cannot afford safer alternatives and resort to hazardous substances like soaps and petroleum by-products. In contrast, plant-based insecticides offer a sustainable and eco-friendly alternative, acting quickly by blocking spiracles and inducing insect suffocation. Historically effective in both subsistence and commercial farming, these natural extracts utilize compounds that repel, attract, inhibit feeding, or disrupt growth (Ngegba *et al*., 2022) [12]. With increasing adoption of botanical extracts for pest control (FAO, 2018) [4], this study

explores the potential of plant-based insecticides to develop sustainable, cost-effective pest management strategies for maize cultivation in India.

Materials and Methods

A field experiment was conducted during the Rabi season of 2021–22 at the Agricultural College Farm, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, to evaluate the efficacy of botanical extracts against fall armyworm in maize. The maize variety TA5084 was grown in 4m × 4m plots with a spacing of 75 cm × 20 cm, following a Randomized Block Design (RBD) with seven treatments and five replications. Treatments included six botanical extracts—*Datura metel* (Dhatura) @10%, *Cleistanthus collinus* (Kharra) @10%, *Azadirachta indica* (Neem) @10%, *Millettia pinnata* (Karanj) @10%, *Calotropis gigantea* (Madar) @10%, Neem Seed Kernel Extract (5%) and an untreated control.

Botanical extracts were prepared by collecting fresh leaves, washing, shade-drying, and blending 500g of leaves with 500ml of water. The mixture was filtered through muslin cloth, re-blended with another 500ml of water, and diluted to yield 5 liters of solution, with Teepol added at 1ml per liter to enhance dispersion and adhesion. Treatments were applied using a high-volume knapsack sprayer at seven-day intervals for three applications. Observations of fall armyworm populations were recorded from five randomly selected plants per plot before and after treatment, with data collected on the 1st, 3rd, 7th and 10th days after application. Grain yield per hectare was calculated by adjusting field weights to a 12-13% moisture content. The recorded data were statistically analyzed after square root transformation ($\sqrt{x} + 0.5$) and subjected to variance analysis using the "F" test at a 5% significance level, to evaluate treatment efficacy.

Results and Discussion

The study evaluated the bio-efficacy of various botanical extracts against fall armyworm in maize after the first spray. Pre-treatment observations showed larval populations ranging from 0.7 to 2.92 larvae per five plants, with no significant differences among treatments. Post-treatment results indicated varying levels of effectiveness. By the third day, Kharra extract was the most effective, reducing the population to 1.34 larvae, followed by Neem at 1.42 larvae. Seven days after spraying, Madar had the lowest larval count (1.38), while the untreated control had the highest (4.48) larvae by the tenth day, Kharra extract again proved to be the most effective (1.28 larvae), with the control maintaining the highest count (4.64 larvae). The per cent reduction of *S. frugiperda* population ranged from 23.2% to 43.54% across the various treatments. The highest reduction in larval population was achieved with Kharra (43.54%), followed by NSKE (34.83%). Dhatura showed the lowest efficacy, with a reduction of only 23.22% in the insect population (Table 1 & Fig 1).

During the second spray, the pre-treatment larval population ranged from 1.84 to 3.22 larvae per five plants. By the third day, NSKE was most effective (2.04 larvae), followed by Kharra extract (2.28 larvae), while the untreated control had the highest count (3.02 larvae). After ten days, Kharra extract showed the greatest reduction (1.76 larvae), followed by neem (2.22 larvae) and Kharra (2.28 larvae), with the control recording the highest population (2.82 larvae). The highest percentage reduction over the control was observed in Kharra extract (29.77%), followed by neem (18.12%) and NSKE (16.50%), while Dhatura showed the lowest reduction (11.32%) (Table 2 & Fig 1).

The observations recorded after the third spray showed that pre-treatment larval populations ranged from 0.9 to 3.16 larvae per five plants. By the third day, Kharra extract was most effective (1.54 larvae), followed by Neem (1.76 larvae) and Karanj (2.22 larvae), while the untreated plot had the highest infestation (6.36 larvae). After ten days, Kharra extract remained the most effective (1.14 larvae), with neem (1.24 larvae) and Karanj (1.32 larvae) also showing significant reductions. Kharra extract recorded the highest percentage reduction over control (58.39%), followed by Neem (52.79%), Karanj (47.93%) and NSKE (43.79%), with Dhatura showing the lowest reduction (42.09%) (Table 3 & Fig 1).

The grain yield varied significantly across different treatments. The highest yield was recorded with Kharra (3.68 t/ha), followed by Neem (3.32 t/ha) and Karanj (3.16 t/ha). Other treatments, such as NSKE (2.81 t/ha) and Madar (2.53 t/ha), showed moderate yield increases compared to the control (2.04 t/ha). The lowest yield was observed in the Dhatura treatment (2.49 t/ha), though it was still higher than the control.

The present study demonstrated that botanical extracts, particularly Kharra (10%), Neem (10%) and NSKE (5%), are effective in reducing fall armyworm populations in maize, with Kharra consistently showing the highest efficacy across all three spray applications. These results align with findings by Sunitha *et al*. (2022) [14] and Mukanga *et al*. (2022) [11], who reported significant reductions in pest infestations with neem and NSKE, emphasizing the importance of multiple applications for effective pest control. Studies by Kebede *et al*. (2024) [8] and Hail *et al*. (2015) [5] further corroborate neem's insecticidal properties, including feeding inhibition and growth disruption. The comparatively lower efficacy of Dhatura observed in this study contrasts with Maurawa *et al*. (2021) [9], highlighting the need for further research on its optimal usage. Overall, the significant larval reduction and improved yields confirm the potential of botanical extracts as sustainable alternatives in Integrated Pest Management (IPM). Future work should refine application techniques, explore combinations of botanicals, and assess their cost-effectiveness for large-scale maize cultivation.

Table 1: The bio-efficacy of different botanicals against fall armyworm of maize after first spray

S. No.	Treatment	Pre-treatment	Post-treatment				Mean of fall armyworm larvae/plant	Percent reduction of insect population over control
			1DAS	3DAS	7DAS	10DAS		
1	*Datura metel* @ 10%	2.08 (1.72)	4.04 (2.24)	1.96 (1.64)	1.96 (1.72)	1.84 (1.68)	2.38	23.22
2	*Cleistanthus collinus* @ 10%	2.28 (1.81)	2.32 (1.78)	1.34 (1.52)	1.44 (1.54)	1.28 (1.5)	1.75	43.54
3	*Azadirachta indica* @ 10%	2.92 (1.97)	3.14 (2.03)	1.42 (1.54)	1.46 (1.57)	1.38 (1.52)	2.04	34.19
4	*Millettia pinnata* @ 10%	2.72 (1.93)	3.18 (2.04)	1.64 (1.58)	1.66 (1.62)	1.36 (1.53)	2.11	31.93
5	*Calotropis gigantea* @ 10%	2.84 (1.95)	3.10 (2.02)	2.04 (1.74)	1.38 (1.52)	1.82 (1.66)	2.24	27.74
6	NSKE @ 5%	1.72 (1.62)	3.32 (2.08)	1.82 (1.65)	1.54 (1.59)	1.68 (1.64)	2.02	34.83
7	Control	0.70 (1.66)	0.28 (1.13)	3.46 (2.33)	4.48 (2.34)	4.64 (2.38)	3.10	
	SE (m)±	0.10	0.11	0.15	0.09	0.10		
	CD at 5%	NS	NS	0.43	0.27	0.28		

Figures in parentheses are square root (x + 0.5) transformed values

Table 2: The bio-efficacy of different botanicals against fall armyworm of maize after second spray

S. No.	Treatment	Pre-treatment	Post-treatment				Mean of fall armyworm larvae / plant	Per cent reduction of insect population over control
			1DAS	3DAS	7DAS	10DAS		
1	*Datura metel* @ 10%	2.48 (1.86)	2.42 (1.85)	2.64 (1.91)	3.54 (2.13)	2.58 (1.99)	2.74	11.32
2	*Cleistanthus collinus* @ 10%	1.84 (1.65)	2.08 (1.75)	2.28 (1.81)	2.88 (1.97)	1.76 (1.62)	2.17	29.77
3	*Azadirachta indica* @ 10%	2.44 (1.84)	2.44 (1.85)	2.92 (1.97)	2.64 (1.90)	2.22 (1.80)	2.53	18.12
4	*Millettia pinnata* @ 10%	2.72 (1.93)	2.18 (1.77)	2.72 (1.93)	2.96 (1.99)	2.28 (1.84)	2.57	16.82
5	*Calotropis gigantea* @ 10%	2.84 (1.95)	2.01 (1.73)	2.52 (1.88)	3.12 (2.03)	2.54 (1.91)	2.61	15.53
6	NSKE @ 5%	2.46 (1.86)	2.44 (1.85)	2.04 (1.74)	3.36 (2.08)	2.52 (1.86)	2.58	16.50
7	Control	3.22 (1.74)	2.34 (1.82)	3.02 (2.00)	4.04 (2.24)	2.82 (2.60)	3.09	
	SE (m)±	0.14	0.08	0.04	0.07	0.09		
	CD at 5%	NS	NS	0.12	0.21	0.26		

Figures in parentheses are square root (x + 0.5) transformed values

Table 3: The bio-efficacy of different botanicals against fall armyworm of maize after third spray

S. No	Treatment	Pre-treatment	Post-treatment				Mean of fall armyworm larvae / plant	Percent reduction of insect population over control
			1DAS	3DAS	7DAS	10DAS		
1	*Datura metel* @ 10%	3.16 (2.04)	2.72 (1.93)	2.42 (1.85)	1.86 (1.69)	1.76 (1.65)	2.38	42.09
2	*Cleistanthus collinus* @ 10%	2.32 (1.77)	2.28 (1.8)	1.54 (1.57)	1.26 (1.48)	1.14 (1.44)	1.71	58.39
3	*Azadirachta indica* @ 10%	2.44 (1.85)	2.68 (1.91)	1.76 (1.63)	1.58 (1.58)	1.24 (1.49)	1.94	52.79
4	*Millettia pinnata* @ 10%	3.16 (2.03)	2.28 (1.81)	2.22 (1.79)	1.68 (1.62)	1.32 (1.51)	2.14	47.93
5	*Calotropis gigantea* @ 10%	2.78 (1.94)	3.48 (2.11)	2.36 (1.82)	1.72 (1.64)	1.44 (1.56)	2.36	42.57
6	NSKE @ 5%	2.98 (1.99)	3.48 (2.11)	2.26 (1.80)	1.48 (1.56)	1.36 (1.52)	2.31	43.79
7	Control	0.90 (2.33)	4.28 (2.21)	6.36 (2.71)	4.84 (2.65)	4.18 (2.24)	4.11	
	SE (m)±	0.17	0.15	0.10	0.11	0.12		
	CD at 5%	NS	NS	0.29	0.33	0.35		

Figures in parentheses are square root (x + 0.5) transformed values

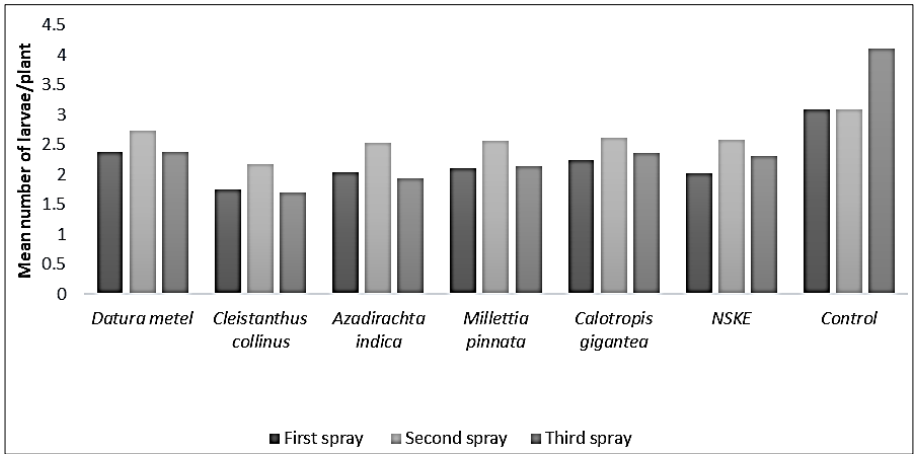

Fig 1: Efficacy of botanical extracts against *S. frugiperda* across three sprays

Conclusion

This study highlights the effectiveness of botanical extracts as a sustainable way to manage fall armyworm in maize. Kharra @10% was the most effective, reducing larval populations and increasing grain yield. Neem @10% and NSKE@5% also showed strong insecticidal activity. These plant-based solutions can be a cost-effective alternative to synthetic pesticides, benefiting small-scale farmers. However, plant extracts alone are not enough and should be used with other control methods for better results. At least three sprays may be needed for effective control. Widespread use of botanical pesticides can reduce the use of synthetic chemicals, helping the environment and promoting sustainable maize farming. Future research should focus on improving application rates, testing combinations and assessing economic feasibility for large-scale use.

Authors' contribution

Authors conceived and designed the study (AN, SG). Conducted the experiments, analyzed the data and wrote the paper (AN). Contributed to manuscript revisions (KA). Authors approved the final version of the manuscript and agree to be held accountable for the content therein (AN, KA, SD)

Declaration

The authors declare that they have no conflict of interests.

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References

1. Chirinos DT, Castro R, Cun J, Castro J, Peñarrieta S, Solis L, *et al*. Insecticides and agricultural pest control: the magnitude of its use in crops in some provinces of Ecuador. Cienc Tecnol Agropecuaria. 2020;21:1276.
2. Day R, Abrahams P, Bateman M, Beale T, Clottey V, Cock M, *et al*. Fall armyworm: impacts and implications for Africa. Outlooks Pest Manag. 2017;28:196-201.
3. FAO Y. Agricultural production statistics 2000–2022. FAOSTAT Anal Briefs. 2023;79.
4. FAO N. Integrated management of the fall armyworm on maize: a guide for farmer field schools in Africa. Rome: FAO; 2018. p. 1-139.
5. Hail KS, John LC, Nawaf MF. Effects of neem-based insecticides on consumption and utilization of food in larvae of *Spodoptera eridania* (Lepidoptera: Noctuidae). J Insect Sci. 2015;15:152.
6. Huma B, Hussain M, Ning C, Yuesuo Y. Human benefits from maize. Scholar J Appl Sci Res. 2019;2:4-7.
7. Kazerooni EG, Atia Sharif HN, Rehman R, Nisar S. Maize (corn)—a useful source of human nutrition and health: a critical review. IJCBS. 2019;15:35-41.
8. Kebede M, Getu E, Wakgari M, Kassie A, Goftishu M, Fite T. Evaluation of neem (*Azadirachta indica*) seed extract against fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in maize fields. 2024.
9. Maurawa K, Makaza K, Sakadzo N, Mubvuma M, Chidoko P, Nyamusamba R. Bioactive leaf extracts of thorn apple (*Datura stramonium* L.) as an alternative to synthetic pesticides for fall armyworm (*Spodoptera frugiperda* (J.E. Smith)) management in maize (*Zea mays* L.). Octa J Biosci. 2021;9.
10. Mdeni NL, Adeniji AO, Okoh AI, Okoh OO. Analytical evaluation of carbamate and organophosphate pesticides in human and environmental matrices: a review. Molecules. 2022;27:618.
11. Mukanga M, Machuku O, Chipabika G, Matimelo M, Mumba K, Mabote ND, *et al*. Bio-efficacy of crude aqueous leaf extracts against the fall armyworm (*Spodoptera frugiperda*) and maize ear rots in Zambia. ABR. 2022;3:38-49.
12. Ngegba PM, Cui G, Khalid MZ, Zhong G. Use of botanical pesticides in agriculture as an alternative to synthetic pesticides. Agriculture. 2022;12:600.
13. Sharanabasappa CM, Kalleshwaraswamy R, Asokan HM, Mahadeva MS, Marutid HB, Pavithra Hegde K, *et al*. First report of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), an alien invasive pest on maize in India. Pest Manag Hortic Ecosyst. 2017;24:23-9.
14. Sunitha SVL, Swathi M, Madhumathi T, Kumar PA. Efficacy of botanicals against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in sorghum. J Exp Zool India. 2023;26.