International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 30-10-2025, Accepted: 29-11-2025, Published: 15-12-2025
Volume 10, Issue 12, 2025, Page No. 65-67

Evaluating Next-Generation Insecticides for Improved Management of Tomato Sucking Pests and Fruit Borer

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Abstract

Tomato (*Solanum lycopersicum*) is a major vegetable crop globally, but its productivity is significantly affected by key insect pests such as whiteflies (*Bemisiatabaci*), jassids (*Amrascabiguttulabiguttula*) and fruit borer (*Helicoverpa armigera*). The limitations of conventional insecticidesparticularly resistance development, environmental concerns, and non-target effectshave necessitated the evaluation of newer, more selective molecules. This study assessed the efficacy of seven modern insecticides: Chlorantraniliprole 18.5% SC, Flubendiamide 39.5% SC, Emamectin benzoate 5% SG, Spinosad 45% SC, Indoxacarb 14.5% SC, Abamectin 1.9% EC, and Lambda-cyhalothrin 5% EC against major tomato pests. Field experiments were conducted during the *Kharif* 2019–20 using a randomized block design with three replications. Pest populations were recorded before spraying and at 1, 3, 7, and 10 days after application, while fruit borer infestation was assessed through damaged fruit counts.

Results revealed that all insecticides significantly reduced pest populations compared to the untreated control. Spinosad 45 SC consistently demonstrated the highest efficacy against whiteflies and jassids, followed by abamectin. For fruit borer management, chlorantraniliprole 18.5 SC was most effective, reducing infestation to approximately 11.6%, followed by flubendiamide and emamectin benzoate. Indoxacarb showed comparatively lower performance against sucking pests.

The study highlights that differential efficacy among insecticides can be strategically leveraged within an integrated pest management (IPM) framework. Rotational use of these insecticidesparticularly spinosad for sucking pests and diamides for fruit boreroffers a sustainable approach to delay resistance development while ensuring effective pest suppression in tomato cultivation.

Keywords: Tomato, Chlorantraniliprole, Spinosad, Flubendiamide, Emamectin benzoate, Whitefly, Jassid, *Helicoverpaarmigera* and IPM

Introduction

Tomato (*Solanum lycopersicum*) is one of the world's most important vegetable crops, valued for its nutritional quality, yield potential and diverse uses in fresh and processed forms. However, its production is severely constrained by a complex of insect pests, among which whiteflies (*Bemisiatabaci*), jassids (leafhoppers), and fruit borer (*Helicoverpa armigera* and related species) are particularly damaging (Kumar *et al.,* 2022). These pests reduce yield both by direct feeding damage and by transmitting viral diseases, leading to economic losses and increased production costs.

Managing these pests effectively is therefore central to sustaining tomato productivity. Over the decades, control efforts have involved various chemical insecticides, but concerns about resistance development, environmental safety, non-target effectsand pesticide residues have driven the search for newer, more selective and efficacious molecules (Yadav *et al.*, 2022) [8]. In particular, novel insecticides such as Chlorantraniliprole, Flubendiamide, Emamectin benzoate, Spinosad, Indoxacarb, Abamectin and Lambda-cyhalothrin represent different modes of action and have shown promise in pest control.

Chlorantraniliprole (an anthranilic diamide) acts by activating insect ryanodine receptors, causing unregulated calcium release in muscle cells, leading to feeding cessation and death. It has demonstrated effectiveness in several crops with relatively low non-target toxicity (Majumder *et al.,* 2020) [4]. Flubendiamide, another diamide insecticide, also targets ryanodine receptors and has shown high efficacy in lepidopteran pest control (Balaji *et al.,* 2025) [2]. Emamectin benzoate (an avermectin) and abamectin are macrocyclic lactones that open glutamate-gated chloride channels; indoxacarb (an oxadiazine) blocks voltage-dependent sodium channels; spinosad (a spinosyn) acts on nicotinic-acetylcholine and GABA receptors; and lambda-cyhalothrin (a pyrethroid) targets sodium channels (IRAC Mode of Action classification).

Although prior studies have assessed individual molecules (e.g., Kooner *et al.,* 2016; Patidar *et al.,* 2024; Wasu *et al.,* 2020) [3, 5, 6], systematic field evaluations comparing a broad set of these insecticides under the same experimental conditions, specifically on tomato pests such as whiteflies, jassids, and fruit borer, remain limited. Furthermore, rotations and judicious use of insecticides with different modes of action are increasingly recommended to delay resistance development.

Material Methods

The experiment was conducted during the *Kharif* season of 2019-2020 to study the seasonal incidence of major insect pests on tomato and their correlation with climatic parameters. The tomato crop (variety: *Lakshmi*) was sown on 5th July 2019 and transplanted on 3rd August 2019, with a spacing of 60 cm × 60 cm in a plot size of 15 m × 6 m, consisting of 10 rows. The crop was cultivated following standard agronomic practices in Madhya Pradesh, India.

Observations on pest populations were recorded at weekly intervals on randomly selected ten plants per plot. The population of sucking pests, such as Jassids

(*Amrascabiguttulabiguttula*) and Whiteflies (*Bemisiatabaci*), was assessed by counting individuals present on three leaves (upper, middle, and lower) of each plant. The incidence of Fruit borer (*Helicoverpa armigera*) was monitored from the vegetative stage onward, and during the fruiting stage, the number of healthy and damaged fruits was counted at each picking. The correlation between major pest populations and weather parameters, including temperature, relative humidity, wind speed, sunshine hours, evaporation, and rainfall, was analysed statistically.

To evaluate the efficacy of insecticides against major pests, a randomized block design (RBD) was employed with three replications and eight treatments. The insecticides tested were Chlorantraniliprole 18.5% SC (162 ml/ha), Flubendiamide 39.5% SC (152 ml/ha), Emamectin Benzoate 5% SG (200 g/ha), Spinosad 45% SC (278 ml/ha), Indoxacarb 14.5% SC (276 ml/ha), Abamectin 1.9% EC (158 ml/ha), and Lambda Cyhalothrin 5% EC (400 ml/ha), along with an untreated control. The experimental plots measured 4.2 m × 3 m, with a spacing of 60 cm × 60 cm between plants, 1 m between replications, and 0.5 m between plots. Fertilizer application was done in two stages: half of the nitrogen and full doses of phosphorus and potassium as basal application (100:80:60 NPK kg/ha), while the remaining nitrogen was applied as a top dressing at 45 days after sowing (DAS).

Pest observations were taken before and after insecticide application. The population of sucking pests was recorded 1 day before spraying and then at 1, 3, 7, and 10 days after spraying. Fruit borer larval counts were also recorded at each picking, and the percentage of fruit damage was calculated. The first insecticide spray was applied when pest populations reached the economic threshold level (ETL), followed by a second spray 15 days after the first application using a knapsack sprayer at 500 L/ha.For statistical analysis, method used to suggest by Pradhan (1969). The obtained results were analysed to identify the most effective and economically viable insecticide for controlling major tomato pests.

Results and Discussion

1. Efficacy against Whiteflies (*Bemisiatabaci*)

Statistical analysis of whitefly populations at 1, 3, 7, and 10 DAS after both sprays showed that all insecticides significantly reduced whitefly numbers compared to the untreated control. Spinosad (45 SC) was the most effective treatment, consistently recording the lowest whitefly counts, followed by Abamectin (1.9 EC). Indoxacarb (14.5 SC) performed the least effectively among the tested insecticides, though it still outperformed the control. These findings align with earlier studies reporting strong efficacy of spinosad and abamectin against whiteflies. Spinosad's superior performance can be attributed to its dual action on nicotinic acetylcholine and GABA receptors, offering rapid knockdown and sustained mortality while being relatively safe to beneficial insects. Abamectin, though effective, acts more slowly, resulting in moderate suppression. Indoxacarb's lower efficacy suggests limited suitability for whitefly management under the present field conditions. Overall, spinosad and abamectin remain promising options, with insecticide rotation essential to delay resistance development.

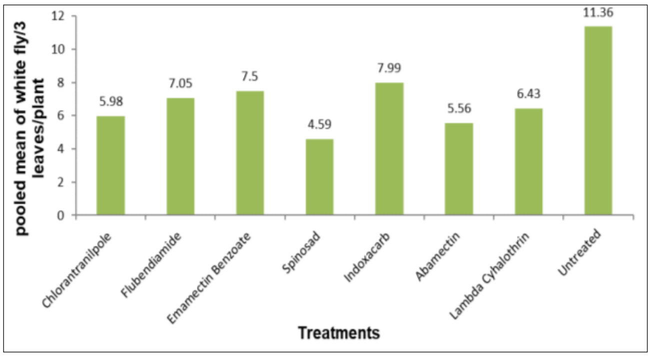

Fig 1: Efficacy of Different Insecticide on population of Whitefly on tomato (pooled mean of 1st and 2nd spray)

2. Efficacy against Jassids

Across all observation intervals (1, 3, 7, and 10 DAS), every insecticidal treatment significantly reduced jassid populations compared to the untreated control. Spinosad 45 SC proved most effective, consistently recording the lowest jassid counts, followed by Abamectin 1.9 EC. Chlorantraniliprole (CTPR) and Lambda-cyhalothrin provided moderate suppression, whereas Indoxacarb was least effective, showing the highest jassid numbers. These findings align with earlier reports by Kalawate and Dethe (2006) and Raghuvanshi *et al.* (2014), who highlighted the strong efficacy of spinosad and pyrethroids against sucking pests. Spinosad's superior performance may be attributed to its feeding-disruption mode of action, while abamectin's notable results support its use as a reliable rotational partner. The moderate impact of CTPR and lambda-cyhalothrin reflects their limited lethality on hemipterans, though some feeding inhibition occurs. Indoxacarb's weak performance suggests inadequate exposure or suboptimal dosing. Rotational use of spinosad, abamectin, and CTPR can enhance efficacy while minimizing resistance risks.

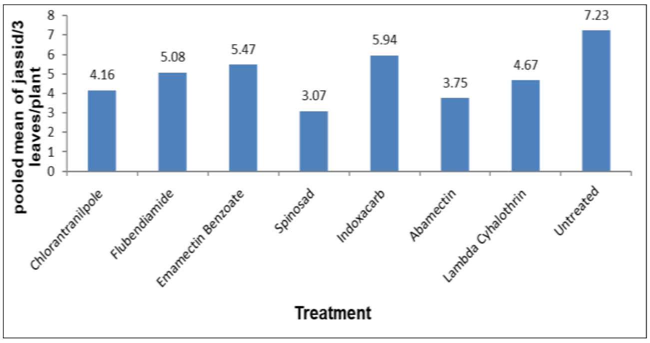

Fig 2: Efficacy of different incecticide on population of Jassids on tomato (pooled mean of 1st and 2nd spray)

3. Efficacy against Fruit Borer (*Helicoverpa armigera*)

Monitoring fruit borer incidence at 1, 3, 7, and 10 DAS showed that all insecticidal treatments significantly reduced infestation compared to the untreated control. After the second spray (pooled data), chlorantraniliprole (18.5 SC @ 162 ml/ha) was the most effective, limiting fruit damage to about 11.61%, followed closely by flubendiamide (39.5 SC @ 152 ml/ha) at 13.26%. Emamectin benzoate (5 SG @ 200 g) recorded 14.73% infestation, while abamectin (1.9 EC) was least effective among the tested insecticides (17.85%) but still superior to the control.

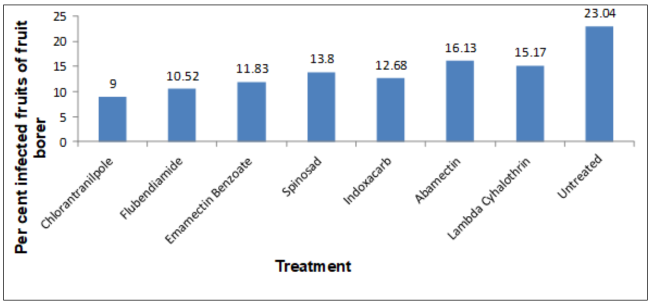

Fig 3: Efficacy of different insecticide on population of Fruit borer on tomato (pooled mean of 1st and 2nd spray)

These results are consistent with earlier studies. Wasu *et al.* (2020) [6] reported that chlorantraniliprole led to the lowest *H. armigera* larval populations, followed by flubendiamide and indoxacarb. Similar trends were noted by Hivare*et al.* (2019) [7] and Kumar *et al.* (2022), who found that chlorantraniliprole provided significantly lower borer damage and higher yields. The strong performance of chlorantraniliprole and flubendiamide is attributed to their diamide chemistry, which ensures rapid feeding cessation and long residual control. Emamectin benzoate also performed well due to its fast action and translaminar movement. Although abamectin ranked lower, its distinct mode of action makes it useful in rotation within an IPM framework, reducing resistance risks and sustaining long-term pest management efficacy.

Limitations and considerations

- Although our design used two sprays, pest pressure, environmental conditions, and application timing all influence efficacy; efficacy under different agroecological zones may vary.
- Residue dynamics and non-target risk were not assessed in this trial. While other studies (e.g., Majumder *et al.,* 2020) [4] report favorable residue dissipation, specific data for tomato under these exact concentrations would strengthen the risk assessment.
- Economic analysis (cost-benefit ratio) was not part of this study; such analysis would be critical for recommending these treatments to farmers.

Conclusion

This field evaluation demonstrates that newer insecticide molecules exhibit strong, differential efficacy against major tomato pests:

1. **Whiteflies and jassids:** Spinosad 45 SC (278 ml/ha) was most effective, with abamectin 1.9 EC as a close second. These insecticides can serve as frontline agents against sap-feeding pests in tomato IPM programs.

2. **Fruit borer (*Helicoverpa armigera*):** Chlorantraniliprole 18.5 SC (162 ml/ha) was superior in reducing fruit infestation, followed by flubendiamide 39.5 SC, then emamectin benzoate 5 SG.

3. **Rotation importance:** Given the varied modes of action, these compounds can be effectively rotated to reduce selection pressure and delay resistance development. For instance, spinosad (for sucking pests) followed by diamide insecticides (for borer), with occasional use of emamectin or abamectin, can create a balanced, effective IPM itinerary.

4. **Sustainability considerations:** While efficacy is high, integrating these treatments with biological control, regular monitoring, and economic analyses will be necessary to ensure long-term, sustainable pest management. Future work should examine residue levels, non-target effects, and cost-benefit ratios under farmer field conditions.

Our study provides strong evidence in favor of incorporating these newer molecule insecticides into tomato pest management strategies. By exploiting their specificities and combining them intelligently, it is possible to achieve effective pest suppression while managing resistance and minimizing ecological risk.

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