

Field evaluation of various insecticides against bollworms and sucking pests in colour cotton

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ABSTRACT: A field trial on the comparative performance of insecticides against bollworms and sucking pests of coloured cotton (variety: Vaidehi-95) conducted, revealed significant reductions compared with the control. Flonicamid 50WG proved highly effective in controlling sucking pests, recording lowest mean populations of leafhopper (2.79 per 3 leaves), thrips (7.33 per 3 leaves), aphids (9.46 per 3 leaves) and whitefly (3.89 per 3 leaves), and was statistically on par with Buprofezin 25 EC for most pests. Spinosad 45 SC, Chlorantraniliprole 18.5 SC, Flubendiamide 39.35 SC, and Emamectin benzoate 5 SG demonstrated high efficacy against bollworms. Spinosad 45 SC recorded the lowest American bollworm (2.89 larvae per 10 plants) and pink bollworm (2.24 larvae per 20 bolls) incidence, followed closely by Chlorantraniliprole 18.5 SC. In terms of green boll damage, Spinosad 45 SC (26.08%) and Chlorantraniliprole 18.5 SC (27.74%) were most effective, with Flubendiamide 39.35 SC and Emamectin benzoate 5 SG providing moderate protection. *Beauveria bassiana* was consistently the least effective treatment across all pest groups.

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KEY WORDS: Green boll damage, larval incidence, aphids, leaf hopper, whitefly, bioefficacy

INTRODUCTION

Cotton stands as the most significant natural fibre crop, widely cultivated to fulfil domestic textile needs and support exports. It holds a crucial place in India's economy, offering direct and indirect employment to more than 60 million individuals. With the greatest extent of land under cotton cultivation globally approximately 130.61 lakh ha India also leads in production, yielding around 343.47 lakh bales annually (COCPC, 2023). Notably, it is the sole country cultivating all four domesticated cotton

species: *Gossypium hirsutum*, *G. barbadense*, *G. arboreum*, and *G. herbaceum*, valued for their lint, oil, and feed by-products. The crop is mainly grown across ten major states, Karnataka, Telangana, Andhra Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu, Gujarat, Punjab, Haryana, Rajasthan (Waghmare, 2022). In recent times, coloured cotton, which produces naturally pigmented fibres in shades like brown, green, and red is gaining growing attention for its ecological and sustainable value. Cotton is highly vulnerable to insect pest infestation, with approximately 1,326 arthropod species that

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affect its cultivation (Hargreaves, 1948). In India around 166 insect and mite species infest cotton crops (Khan and Rao, 1960), causing substantial yield loss, estimated at 50–60 percent in severe cases (Puri *et al.*, 1999). The pest complex can be broadly classified into two main groups. The bollworm complex includes key species such as the American bollworm (*Helicoverpa armigera* (Hübner, [1808])), spotted bollworms (*Earias insulana* (Boisduval, 1833) and *E. vittella* (Fabricius, 1794)), and the pink bollworm (*Pectinophora gossypiella*) (Saunders, 1844). The sucking pest complex comprises the leafhopper (*Amrasca biguttula biguttula* (Ishida, 1913)), aphid (*Aphis gossypii* Glover, 1877), thrips (*Thrips tabaci* Lindeman, 1889), and whitefly (*Bemisia tabaci* (Gennadius, 1889) (Nagrare *et al.*, 2023). India continues to experience low average productivity, with lint yields around 451 kg per ha, mainly due to persistent damage inflicted by arthropod pests (CCI, 2021). Naturally coloured cotton, reintroduced in India through research at the ICAR - Central Institute for Cotton Research (CICR), Nagpur, draws from indigenous ‘Desi’ germplasm like Yerrapatti varieties, with renewed focus post-1995 Satyam Committee recommendations to curb dye pollution. Uses span niche eco-textiles for no-fade apparel, upholstery, and handloom products, prized for dye-free processing, breathability, and flavonoid pigments enhancing UV resistance, though wax content aids ginning (Deepak *et al.*, 2022). Recent studies reveal no confirmed correlation lowering pest occurrence compared to white cotton; bollworms, aphids, and whiteflies infest similarly (Naik *et al.*, 2025). The study aims to evaluate the efficacy of various types of chemical insecticides against these pests, in colour cotton pest management.

MATERIALS AND METHODS

A field study was undertaken during 2022–23 at the Entomology Block, ICAR - CICR, Nagpur, to assess the bioefficacy of different insecticides against key pests of cotton. The coloured cotton variety ‘Vaidehi-95 (non-Bt)’ was sown at a spacing of 90 × 60cm, following all recommended agronomic practices. Insecticidal treatments (Table

2) were applied whenever any of the major sucking pests (thrips, leafhoppers, aphids, or whiteflies) or bollworms crossed the economic threshold level (ETL) (Table 1). Two sprays of the respective insecticides were administered at 15-day intervals. Data on sucking pests were collected from the uppermost three fully developed leaves of 10 randomly chosen plants in each treatment, one day prior to spraying and again at 7- and 14-days post-application. American bollworm incidence was assessed on 10 plants per treatment, whereas pink bollworm infestation and green boll damage were determined through destructive sampling of 20 bolls per treatment. The per cent reduction in pest population over the control was calculated using the standard formula.

Reduction over control (%) =

$$\frac{\text{No. of insects in control} - \text{No. of insects in treatment}}{\text{No. of insects in control}} \times 100$$

$$\text{Green boll damage (\%)} = \frac{\text{No. of damaged green bolls}}{\text{Total No. of green bolls}} \times 100$$

The experimental data collected for were analysed using ANOVA under a randomized complete block design, applying appropriate statistical transformations (arc sine or square root) with the aid of R software (R Core Team, 2016).

RESULTS AND DISCUSSION

Bioefficacy of insecticides on sucking pest incidence: Application of insecticides resulted in a marked decline on the incidence of key sucking pests relative to the untreated control. Flonicamid 50WG consistently emerged as the most effective molecule, recording the lowest mean populations of leafhopper (2.79/3 leaves), thrips (7.33/3 leaves), aphids (9.46/3 leaves), and whiteflies (3.89/3 leaves) and was statistically at par with Buprofezin 25 EC for leafhopper (3.13/3 leaves), aphids (10.20/3 leaves), and whiteflies (4.31/3 leaves) and thrips (7.81/3 leaves). Spinosad 45 SC also maintained moderate suppression across pests, particularly against leafhopper (4.40/3 leaves), aphids (13.36/3 leaves), whiteflies (9.03/3 leaves) and thrips (11.04/3 leaves). By contrast, *B. bassiana* consistently recorded the highest pest populations, with mean counts of 8.08, 18.17, 20.49, and 15.32 per 3 leaves

for leafhopper, thrips, aphids, and whiteflies, respectively, showing the least efficacy among all treatments, while the untreated control recorded the maximum infestations by all insect pests (Table 2). This findings are supported by Nemade *et al.* (2017) who reported that Flonicamid 50WG was highly effective against major sucking pests (Akola, Maharashtra), resulting in the highest cotton yield (1681.02 kg ha⁻¹). Similarly, Gaurkhede *et al.* (2015) further validated the efficacy of Flonicamid 50WG in controlling sucking pests of Bt cotton (Akola, Maharashtra), which subsequently resulted in increased seed cotton yield. Further, Sasikumar *et al.* (2018) demonstrated that spraying of Flonicamid 50WG markedly lowered the occurrence of sucking pests in Srivilliputhur (Tamil Nadu), achieving the lowest average populations of leafhopper (1.12 and 1.18/3 leaves), thrips (1.48 and 0.81/3 leaves), and whitefly (0.90 and 0.97/3 leaves). These reports clearly indicated the superior performance of Flonicamid 50WG in managing multiple sucking pests simultaneously. Likewise, Sontakke *et al.* (2013) reported that Buprofezin 25 EC at 150 g a.i. ha⁻¹ was highly effective against thrips, leaf hopper, aphids and whiteflies (Bolangir district, Odisha). Sasikumar *et al.* (2018) further confirmed that Flonicamid 50WG at 100 g a.i. ha⁻¹ consistently reduced pest populations, while Buprofezin 25 SC at 250 g a.i. ha⁻¹ was the next best treatment, recording comparatively higher counts of leafhopper (1.83 and 2.40/ 3 leaves), thrips (0.98 and 0.89/ 3 leaves) and whitefly (1.03 and 1.04/3 leaves). Neem oil effectively controls whiteflies by disrupting

their molting and feeding through azadirachtin, while *B. bassiana* spores readily infect their soft cuticles, resulting in synergistic population reduction. In contrast, aphids resist these treatments due to thicker waxy cuticles that block *Beauveria* penetration, combined with rapid parthenogenetic reproduction that outpaces neem's effects.

Comparable results were reported by Kumar and Dhawan (2011), who found both Dinotefuran 20 SG and Flonicamid 50WG effective in controlling cotton leafhopper. Similar pattern was evident by Sreekanth and Reddy (2011) (Guntur, Andhra Pradesh); Zala *et al.* (2014) (Anand, Gujarat); Bajya *et al.* (2016) (Gurugram, Haryana); Nemade *et al.* (2015) (Akola, Maharashtra); Sreenivas *et al.* (2015) (Raichur, Karnataka) and Navi *et al.* (2021) (Chamarajanagar, Karnataka), who consistently highlighted the effectiveness of Flonicamid 50WG at 150 g ha⁻¹ and related insecticides in reducing sucking pest populations in cotton. Overall, Flonicamid 50 WG was shown to be the most cost-effective treatment, highlighting its potential as a key option to control sucking pests in Bt cotton. Flonicamid is a systemic insecticide that belongs to the pyridinecarboxamide group and represents a new class of chemistry known as chordotonal organ modulators (IRAC Group 29). Its unique mode of action involves disrupting the function of chordotonal organs sensory structures responsible for balance, movement, and coordination resulting in starvation through inhibition of stylet penetration into plant tissues. This effectively

Table 1. Economic threshold for major insect pests in cotton

No	Pest	Economic threshold level (ETL)
1	<i>Amrasca biguttula biguttula</i>	2 jassids per leaf or appearance of yellowing/cupping symptoms
2	<i>Aphis gossypii</i>	10–15 aphids per leaf or 50 aphids per 10cm terminal shoot
3	<i>Thrips tabaci</i>	8–10 thrips per leaf
4	<i>Bemisia tabaci</i>	6–8 adults per leaf (middle canopy)
6	<i>Pectinophora gossypiella</i>	10% green boll/flower damage or 8–10 moths/trap/night
7	<i>Helicoverpa armigera</i>	5 larvae per 100 plants or 10% boll damage

Table 2. Efficacy of insecticides against sucking pests in coloured cotton

Treatments/Dose ha ⁻¹	Leafhopper		Thrips		Aphids		Whiteflies	
	Mean*	(%) [#]	Mean*	(%) [#]	Mean*	(%) [#]	Mean*	(%) [#]
Neem oil 3000ppm/ 7.5L	5.70 (2.49) ^c	61.75	11.61 (3.48) ^b	64.14	16.75 (3.86) ^c	58.85	11.07 (3.40) ^c	55.88
Flonicamid 50 WG/ 150g	2.79 (1.81) ^a	81.26	7.33 (2.80) ^a	77.37	9.455 (2.80) ^a	76.76	3.89 (2.09) ^a	84.51
Chlorantraniliprole 18.5 SC/150mL	6.87 (2.71) ^d	53.90	16.65 (4.14) ^d	48.58	18.69 (4.11) ^d	54.06	13.44 (3.73) ^d	46.44
Flubendiamide 39.35 SC/250mL	6.98 (2.73) ^d	53.16	16.38 (4.11) ^d	49.41	18.97 (4.14) ^d	53.39	13.37 (3.72) ^d	46.70
Spinosad 45 SC/ 220mL	4.40 (2.21) ^b	70.48	11.04 (3.40) ^b	65.90	13.36 (3.40) ^b	67.18	9.03 (3.09) ^b	64.01
Emamectin benzoate 5 SG/200g	4.54 (2.24) ^b	69.54	14.43 (3.86) ^c	55.44	13.93 (3.48) ^b	65.78	9.48 (3.16) ^b	62.24
Buprofezin 25 EC/ 1000mL	3.13 (1.90) ^a	79.01	7.81 (2.88) ^a	75.87	10.20 (2.88) ^a	74.93	4.31 (2.19) ^a	82.84
Fenvalerate 20 EC/ 500mL	5.80 (2.51) ^c	61.08	14.70 (3.90) ^c	54.60	17.02 (3.90) ^c	58.18	11.43 (3.45) ^c	54.46
<i>Beauveria bassiana</i> 10 ⁸ /2500g	8.08 (2.93) ^e	45.77	18.17 (4.32) ^e	43.89	20.49 (4.32) ^e	49.66	15.32 (3.95) ^e	38.93
Control	14.89 (3.92) ^f	0.00	32.38 (5.73) ^f	0.00	40.69 (5.73) ^f	0	25.09 (5.06) ^f	0.00
CD at 5%	0.12		0.15		0.16		0.18	
CV (%)	5.72		7.19		5.86		4.46	

* Mean incidence per 3 leaves and mean of two sprays at 7 and 14 DAS; (%)[#]- Reduction (%) over control; In a column means followed by different letters are significantly different by DMRT (p=0.05) ; Values in parentheses are transformed values

prevents pests such as thrips, leafhoppers, aphids, and whiteflies from feeding. Upon exposure, Flonicamid 50WG rapidly induces cessation of feeding by both contact and ingestion, ultimately leading to pest mortality. For example, aphids treated with Flonicamid 50WG show marked inhibition of salivation and sap uptake even after attaching to leaf surfaces (Morita *et al.*, 2007). Unlike widely used insecticides including neonicotinoids, pymetrozine, or pyrifluquinazon, Flonicamid operates through a distinct mechanism

and importantly, so far, no instances of cross-resistance with conventional insecticides have been documented.

Bioefficacy of insecticides bollworms incidence: All insecticidal treatments significantly lowered bollworm incidence in coloured cotton compared to the untreated control. Against American bollworm, Spinosad 45 SC showed the lowest larval population (2.89 larvae/10 plants) with 81.69 percent reduction over control, and its efficacy was statistically on par with Chlorantraniliprole 18.5

SC (3.24 larvae/10 plants). This was trailed by Flubendiamide 39.35 SC (4.36 larvae/10 plants) and Emamectin benzoate 5 SG (4.50 larvae/10 plants). Less suppression was evident with Flonicamid 50 WG (5.66 larvae/10 plants) and Fenvalerate 20 EC (5.76 larvae/10 plants). In contrast, *B. bassiana* recorded the highest larval incidence (8.85 larvae/10 plants) with only 43.93 percent reduction, while the untreated control registered 15.78 larvae/10 plants (Table 3). A similar trend was observed for pink bollworm. Spinosad 45 SC again proved most effective (2.24 larvae/20 bolls; 84.82% reduction), and its performance was at par with Chlorantraniliprole 18.5 SC (2.59 larvae/20 bolls). These were followed by Flubendiamide 39.35 SC (3.71 larvae/20 bolls) and Emamectin benzoate 5 SG (3.85 larvae/20 bolls). Conversely, *B. bassiana* showed the least effectiveness (8.20 larvae/20 bolls), whereas the control recorded the maximum infestation (14.76 larvae/20 bolls) (Table 3). These results are in line with the findings of Divya *et al.*

(2020), who reported that Chlorantraniliprole 18.5 SC recorded the lowest larval population with the highest reduction over control (71.00%) from Chamarajanagar (Karnataka). Likewise, the current findings align with the reports of Bhute *et al.* (2023) and Pathan *et al.* (2021) as they recorded lowest larval incidence of 3.67 and 3.09/ 20 bolls, respectively in Chlorantraniliprole 18.5 SC treated plots as compared to all other treatments (Rahuri, Maharashtra). Rakhesh *et al.* (2024) in Raichur (Karnataka) observed that Chlorantraniliprole 18.5 SC resulted in the lowest average incidence of pink bollworm (3.26 larvae/10 bolls; 74.32% reduction over control), which was statistically on par with Spinosad 45 SC (3.45 larvae/10 bolls) and Flubendiamide 39.35 SC (3.53 larvae/10 bolls). Similarly, Prasad and Rao (2010) found that Chlorantraniliprole at 40 g a.i. ha⁻¹ and Spinosad at 75 g a.i. ha⁻¹ minimized square and boll damage by *H. armigera*. The present results are in agreement with the findings of Bhute *et al.* (2023), Pathan *et al.*

Table 3. Efficacy of various insecticides against larval incidence of bollworm in cotton

Treatments	American bollworm		Pink bollworm		Green boll damage	
	Mean*	(%) [#]	Mean*	(%) [#]	Mean*	(%) [#]
Neem oil 3000ppm	6.10 ^c (2.57)	61.34	5.45 ^c (2.44)	63.08	41.29 ^c (39.98)	41.12
Flonicamid 50 WG	5.66 ^c (2.48)	64.13	5.01 ^c (2.35)	66.06	40.26 ^c (39.38)	42.59
Chlorantraniliprole 18.5 SC	3.24 ^a (1.93)	79.47	2.59 ^a (1.76)	82.45	27.74 ^a (31.78)	60.45
Flubendiamide 39.35 SC	4.36 ^b (2.20)	72.37	3.71 ^b (2.05)	74.86	33.89 ^b (35.60)	51.68
Spinosad 45 SC	2.89 ^a (1.84)	81.69	2.24 ^a (1.66)	84.82	26.08 ^a (30.71)	62.82
Emamectin benzoate 5 SG	4.50 ^b (2.24)	71.48	3.85 ^b (2.09)	73.92	34.55 ^b (36.00)	50.73
Buprofezin 25 EC	7.34 ^d (2.80)	53.49	6.69 ^d (2.63)	54.67	46.65 ^d (43.08)	33.48
Fenvalerate 20 EC	5.76 ^c (2.50)	63.50	5.11 ^c (2.37)	65.38	40.86 ^c (39.73)	41.74
<i>Beauveria bassiana</i> 10 ⁸	8.85 ^c (3.06)	43.93	8.20 ^c (2.75)	44.46	52.20 ^c (46.26)	25.57
control	15.78 ^f (4.03)	0.00	14.76 ^f (3.91)	0.00	70.13 ^f (56.87)	-
CD at 5%	0.21		0.11		1.52	
CV (%)	5.22		3.61		6.28	

* Mean of two sprays at 7 and 14 DAS; (%)[#]- Reduction (%) over control; In a column means followed by different letters are significantly different by DMRT (p=0.05) ; Values in parentheses are transformed values

al. (2021), and Sarode *et al.* (2019), who also observed the lowest green boll damage 11.33, 8.78 and 3.50 percent, respectively—in Bt cotton plots treated with chlorantraniliprole 18.5 SC compared with other treatments.

Bioefficacy of insecticides on green boll damage: All insecticidal treatments markedly reduced green boll damage compared to the untreated control. Among them, Spinosad 45 SC recorded the lowest damage (26.08%), achieving a 62.82 per cent reduction over the control, and was statistically at par with Chlorantraniliprole 18.5 SC (27.74%), followed by Flubendiamide 39.35 SC and Emamectin benzoate 5 SG (with 33.89 and 34.55 % damage respectively). A moderate level of protection was obtained with Flonicamid 50 WG (40.26 %), Neem oil 3000 ppm (41.29 %) and Fenvalerate 20 EC (40.86 %). Buprofezin 25 EC was relatively less effective, recording 46.65 per cent boll damage with only 33.48 per cent reduction over control (Table 3). *B. bassiana* was the least effective treatment, resulting in the highest boll damage and the lowest damage reduction (52.20 and 25.57%, respectively). In comparison, the untreated control exhibited maximum boll damage of 70.13 per cent. These findings are in agreement with the observations reported by Rakhesh *et al.* (2024), who observed the lowest pink bollworm damage in plots treated with Chlorantraniliprole 18.5 SC (16.5% boll damage; 77.34% reduction over control), Spinosad 45 SC (16.62%) and Flubendiamide 39.35 SC (17.54%). Similarly, present results corroborate the findings of Bhute *et al.* (2023), Pathan *et al.* (2021), and Sarode *et al.* (2019), who observed minimum green boll damage of 11.33, 8.78 and 3.50 percent, respectively, in Chlorantraniliprole 18.5 SC at 150 ml ha⁻¹ treated Bt cotton plots compared with other treatments.

Spinosad targets the insect nervous system by binding to nicotinic acetylcholine receptors at unique sites (different from neonicotinoids) and partly affecting GABA-gated chloride channels. This dual action causes neural hyperexcitation, leading to tremors, paralysis, rapid feeding cessation, and eventual death within hours to a few days. It is

highly effective against *H. armigera*, *P. gossypiella*, and other lepidopterans, while remaining relatively safe to beneficial arthropods. Whereas, Chlorantraniliprole and Flubendiamide are anthranilic diamides, acts on ryanodine receptors in muscle cells, triggering uncontrolled calcium release, depletion of calcium stores, and disruption of muscle function. Larvae quickly stop feeding, become lethargic, and die from paralysis and exhaustion. Its long residual activity, systemic/translaminar movement, and high selectivity make it effective against lepidopterans with minimal impact on non-target organisms.

Flonicamid 50 WG excels in suppressing sucking pests like leafhoppers, thrips, aphids, and whiteflies in coloured cotton, outperforming others with the lowest mean populations and matching with the efficacy of Buprofezin. Whereas, Spinosad 45 SC and Chlorantraniliprole 18.5 SC dominate bollworm control and green boll damage reduction. Integrated use of Flonicamid for sucking pests alongside Spinosad and Chlorantraniliprole for bollworms offers optimal, cost-effective IPM in coloured cotton, boosting yields as per regional studies.

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