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COMPARATIVE EFFICACY OF CHEMICAL INSECTICIDES AND BIOAGENTS AGAINST THRIPS (*Thrips tabaci*) AND TOBACCO STREAK VIRUS IN COTTON

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ABSTRACT

The present investigationoncomparative efficacy of chemical insecticides and bioagents against thrips (*Thrips tabaci*Lindeman) and tobacco streak virus in cotton was conductedat RARS, Warangal during *kharif* 2024 and 2025 to evaluate the efficacy of selected insecticides and bioagents against thrips, their influence on TSV incidence under field conditions. Seven treatments *viz.,Metarhizium anisopliae* @ 5g l^{-1}, *Lecanicilliumlecanii*@ 5g l^{-1}, Azadirachtin 1500 ppm @ 5ml l^{-1}, Spinetoram 11.7 SC @ 0.9ml l^{-1}, Fipronil 5 SC @ 2ml l^{-1}, Sulfoxaflor 21.8 SC @ 0.75ml l^{-1}, and an untreated control were evaluated.The pooled results revealed that, Spinetoram 11.7 SC @ 0.9 ml l^{-1} was the most effective against thrips, recording the lowest thrips population of 2.33 thrips per three leaves at 10 days after second spray, with the highest 73.38 per cent reduction over control. It also recorded the lowest Tobacco Streak Virus incidence (4.46%) with the highest (76.66 per cent) disease reduction andrealized the maximum seed cotton yield (1968 kg ha^{-1}). Fipronil 5 SC and Sulfoxaflor 21.8 SC were the next best treatments, whereas Azadirachtin 1500 ppm provided moderate suppression of thrips and disease. The entomopathogenic fungi,*Metarhizium anisopliae* and *Lecanicilliumlecanii*, were comparatively less effective than the chemical insecticides, but performedsignificantly better than the untreated control. However, Fipronil 5 SC @ 2ml l^{-1} registered the highest incremental benefit ratio (8.85:1) owing to its lower treatment cost.

Key Words: Cotton, thrips, tobacco streak virus, spinetoram, sulfoxaflor, bioagents, seed cotton yield

Cotton (*Gossypium hirsutum*L.) is one of the most important fibre crops cultivated worldwide. India occupies the largest area under cotton cultivation and is one of the leading producers globally, contributing substantially to the textile industry and rural economy. However, cotton productivity is frequently constrained by several insect pests and diseases, resulting in considerable economic losses. Among these, sucking pests have gained prominence during the last two decades due to changes in crop production systems, climatic variability and indiscriminate use of insecticides (Naranjo, 2021; Fand and Suroshe, 2022). Thrips (*Thrips tabaci*Lindeman) is an important early-season sucking pest of cotton causing severe damage from seedling to squaring stages. Both nymphs and adults feed on tender leaves and terminal buds by rasping the epidermal tissues and sucking the cell sap, resulting in silvery streaks, upward leaf curling, reduced leaf expansion, stunted plant growth and poor crop establishment, ultimately leading to significant yield losses (Cook *et al*., 2022; Huseth *et al*., 2021). In recent years, thrips infestation has become increasingly severe in cotton-growing regions of Indiaowing to prolonged dry spells, high temperatures and intensive cultivation practices (Fand and Suroshe, 2022). Besides causing direct feeding damage, thrips play an important role in the epidemiology of Tobacco Streak Virus (TSV), an emerging disease affecting cotton in India.

Studies have demonstrated that thrips facilitate TSV transmission by carrying virus-contaminated pollen from infected weed hosts, particularly *Parthenium hysterophorus*, to cotton flowers and young tissues, thereby enhancing disease spread within the crop ecosystem (Muppudathi *et al*., 2020; Rageshwari *et al*., 2021). Recent reports also indicatethe expansionof TSV in major cotton-growing regions of India, emphasizing the need for effective vector management strategies (Gawande *et al*., 2026). Management of thrips largely depends on chemical insecticides because of their rapid knockdown effect and high efficacy. New-generation insecticides such as Spinetoram, Sulfoxaflor and Fipronil have shown excellent activity against sucking pests owing to their

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novel modes of action and favourable environmental profiles(Sparks *et al*., 2020a; Sparks *et al*., 2020b). However, continuous dependence on chemical insecticides has resulted in insecticide resistance, pest resurgence, residue concerns and adverse effects on natural enemies. These challenges necessitate the integration of safer alternatives into cotton pest management programmes (Naranjo, 2021).

Biological control agents and botanicals have emerged as promising components of integrated pest management (IPM). Entomo pathogenic fungi such as *Metarhiziumanisopliae*and *Lecanicilliumlecanii* infect and kill insect pests through cuticular penetration and have been reported to suppress several sucking pests under field conditions. Similarly, azadirachtin, aneem-based botanical insecticide, acts as an antifeedant, growth regulator and oviposition deterrent, providing environmentally safe pest suppression (Arthurs and Dara, 2020; Dara, 2021). Although these bioagents are environmentally benign, comparative information on their performance against thrips and their influence on TSV incidence under field conditions remains limited.

Considering the increasing importance of thrips and Tobacco Streak Virus in cotton production, identification of effective and sustainable management options is essential. Therefore, the present study was undertaken to evaluate the efficacy of selected insecticides and bioagents against thrips, assess their effect on Tobacco Streak Virus (TSV) incidence and determine their influence on seed cotton yield under field conditions during *kharif* 2024 and 2025.

MATERIAL AND METHODS

A field experiment was conducted during kharif, 2024 and 2025 at the Regional Agricultural Research Station ((18°014 N, 78°603 E), Warangal, Professor Jayashankar Telangana Agricultural University (PJTAU), Telangana, India, to evaluate the efficacy of selected insecticides and bioagents against thrips (Thrips tabaciLindeman) and Tobacco Streak Virus (TSV) in cotton. The experiment was laid out in Randomized Block Design (RBD) with seven treatments replicatedthrice. Cotton hybrid Jaadoo was raised by following the recommended package of practices of PJTAU, except for plant protection measures against thrips. All agronomic practices,

Table1. Efficacy of insecticidal treatments and bioagents against thrips population in cotton during *kharif* 2024 and 2025

Treatments	Thrips population (no./3leaves) - First spray					
	Before	1DAS	3 DAS	5 DAS	7 DAS	10 DAS
T1:*Metarhiziumanisopliae*@5g/l	27.43 (5.33)	25.67 (5.16)	18.10 (4.37)	16.90 (4.23)	9.57 (3.25)	5.70 (2.59)
T2:*Lecanicillium lecanii* @ 5g/l	25.20 (5.12)	24.53 (5.05)	17.87 (4.34)	15.27 (4.03)	9.83 (3.29)	5.67 (2.58)
T3:Azadirachtin1500ppm@5ml/l	33.60 (5.88)	25.17 (5.12)	17.20 (4.27)	16.07 (4.13)	9.70 (3.27)	4.93 (2.44)
T4:Spinetoram11.7SC@0.9ml/l	28.80 (5.46)	20.00 (4.58)	13.17 (3.76)	10.13 (3.34)	7.43 (2.90)	3.27 (2.07)
T5:Fipronil 5%SC@2ml/l	24.97 (5.10)	22.23 (4.82)	17.07 (4.25)	13.00 (3.74)	9.47 (3.24)	3.83 (2.20)
T6:Sulfoxaflor21.8SC@0.75ml/l	28.83 (5.46)	26.20 (5.22)	15.87 (4.11)	11.97 (3.60)	9.10 (3.18)	3.73 (2.18)
T7:Untreated Control	26.30 (5.22)	30.37 (5.60)	22.77 (4.88)	19.67 (4.57)	14.87 (3.98)	8.93 (3.15)
CD(p=0.05)	NS	0.47	0.43	0.59	0.30	0.31
SEm(±)	0.18	0.15	0.14	0.19	0.09	0.10
CV(%)	5.84	5.14	5.69	8.37	5.05	7.04

DAS: Days after Spray, NS: Non Significant, Figures in parenthesis are square root transformed values including irrigation, nutrient management and intercultural operations, were carried out uniformly in all the experimental plots throughout the crop season. The selected insecticides, bio agents and botanicals viz., Metarhizium anisopliae, Lecanicilliumlecanii, Azadirachtin 1500 ppm, Spinetoram 11.7 SC, Fipronil 5 SC, Sulfoxaflor 21.8 SC were evaluated.Treatments were imposed during peak incidence (above ETL) of thrips followed by second application at 15 days interval. Data on thrips incidence was recorded from five plants at before application of treatments and 1,3,5,7,10 days after spraying. The mean thrips population was expressed as number of thrips per three leaves.

Data on percent disease incidence of Tobacco Streak Virus was recorded in each treatment before and after 7 and 14 days after spray. Disease incidence was determined by counting the number of plants showing characteristic TSV symptoms.Percent disease incidence (PDI) wascalculated using the following formula:

PDI(%)=(No.of infected plants/Total No.of Plants)X100

Seed yield was recorded and benefit cost ratio was calculated. Thrips count data were subjected to square-root transformation before statistical analysis, whereas Tobacco Streak Virus incidence data were angular (arcsine) transformed to stabilize variance. The transformed data were analyzed by analysis of variance(ANOVA) appropriate for a Randomized Block Design as described by Gomez and Gomez (1984). Treatment means were compared using the Critical Difference (CD) test at the 5% level of significance (P = 0.05).

RESULTS AND DISCUSSION

Efficacyof insecticides and bioagents against thrips(*Thripstabaci*) in cotton

The pooled data of *kharif* 2024 and 2025 revealed that all the insecticidal and bioagent treatments significantly reduced the thrips population compared with the untreated control after both sprays. The pre-treatment thrips population did not differ significantly among treatments before the first spray, indicating uniform pest distribution in the experimental plots.

Following the first spray, significant differences among treatments were observed from 1 DAS onwards. At 10 DAS, Spinetoram 11.7 SC @ 0.9 ml l^{-1} recorded the lowest thrips population (3.27 thrips per three leaves), followed by Sulfoxaflor 21.8 SC @ 0.75 ml l^{-1} (3.73 thrips per three leaves) and Fipronil 5 SC @ 2 ml l^{-1} (3.83 thrips per three leaves). Among the bioagents, Azadirachtin 1500 ppm was comparatively more effective (4.93 thrips per three

Table 2. Efficacy of insecticidal treatments and bioagents against thrips population in cotton during *kharif* 2024 and 2025

Treatments	Thrips population (no./3 leaves) - Second spray						% ROC	Yield (Kgha^{-1})
	Before	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS		
T1:*Metarhiziumanisopliae*@5g/l	7.60 (2.93)	7.00 (2.83)	5.23 (2.50)	5.70 (2.59)	5.57 (2.56)	5.53 (2.56)	36.88	1529
T2:*Lecanicilliumlecanii*@ 5g/l	7.23 (2.87)	6.50 (2.74)	6.33 (2.71)	5.10 (2.47)	5.37 (2.52)	4.93 (2.44)	43.73	1432
T3:Azadirachtin1500ppm@5ml/l	7.07 (2.84)	6.60 (2.76)	6.33 (2.71)	4.97 (2.44)	4.73 (2.39)	3.77 (2.18)	57.03	1492
T4:Spinetoram11.7SC@0.9 ml/l	5.60 (2.57)	5.07 (2.46)	4.30 (2.30)	4.07 (2.25)	3.03 (2.01)	2.33 (1.83)	73.38	1968
T5:Fipronil 5%SC@2ml/l	6.23 (2.69)	5.60 (2.57)	4.93 (2.44)	5.10 (2.47)	4.33 (2.31)	2.93 (1.98)	66.54	1917
T6:Sulfoxaflor21.8SC@ 0.75ml/l	6.70 (2.77)	5.47 (2.54)	4.90 (2.43)	5.07 (2.46)	4.17 (2.27)	2.93 (1.98)	65.78	1868
T7:Untreated Control	9.33 (3.21)	10.90 (3.45)	10.70 (3.42)	9.27 (3.20)	8.53 (3.09)	8.77 (3.13)	-	1109
CD(p=0.05)	0.24	0.24	0.31	0.16	0.19	0.28	-	313.59
SEm(+)	0.07	0.07	0.10	0.05	0.06	0.07	-	100.05
CV(%)	5.78	6.92	6.65	5.53	6.50	5.54	-	10.78

DAS: Days after Spray, NS: Non Significant, %ROC: Percent Reduction over control Figures in parenthesis are square root transformed values leaves), where as *Lecanicilliumlecanii* (5.67 thrips per three leaves) and *Metarhizium anisopliae* (5.70 thrips per three leaves) recorded relatively higher pest populations. The untreated control consistently recorded the highest thrips population (8.93 thrips per three leaves).

A similar trend was observed after the second spray. Spinetoram maintained its superiority by recording the lowest thrips population (2.33 thrips per three leaves at 10 DAS), followed by Fipronil and Sulfoxaflor, each recording 2.93 thrips per three leaves. Azadirachtin reduced the thrips population to 3.77 thrips per three leaves, while *Metarhizium* and *Lecanicillium* recorded 5.53 and 4.93 thrips per three leaves, respectively. The untreated control recorded the highest population (8.77 thrips per three leaves). Spinetoram also recorded the highest reduction over untreated control (73.38%), followed by Fipronil (66.54%) and Sulfoxaflor(65.78%), where as Azadirachtin, *Lecanicillium* and *Metarhizium* recorded 57.03, 43.73 and 36.88 percent reduction over control, respectively.

The superior efficacy of Spinetoram may be attributed to its translaminar activity and unique mode of action on nicotinic acetylcholine and γ-aminobutyric acid (GABA) receptors, resulting in rapid feeding cessation and mortality of thrips (Sparks *et al*., 2020). Likewise, Sulfoxaflor, a sulfoximine insecticide, effectively controls sap-feeding insects by acting on nicotinic acetylcholine receptors and has been reported to provide prolonged protection against thrips (Sparks *et al*., 2020). The present findings are in agreement with those of Cook *et al*. (2022), who reported excellent suppression of tobacco thrips with Spinetoram under field conditions. Similar observations were also reported by Huseth *et al*. (2021), who concluded that newer insecticides provide superior management of cotton thrips compared with conventional insecticides. The comparatively lower efficacy of entomopathogenic fungi under field conditions may be attributed to slower infection processes and their dependence on favourable environmental conditions such as high relative humidity and moderate temperatures (Arthurs and Dara, 2020; Dara, 2021).

Effect of insecticidal treatments and bioagents on Tobacco Streak Virusincidence

The pooled analysis showed no significant differences among the treatments in terms of Tobacco Streak Virus (TSV) incidence before application, indicating uniform disease distribution among the experimental plots. However, significant differences were observed after the imposition of treatments during both the spray schedules.

Table 3. Efficacy of insecticidal treatments and bioagents against Tobacco Streak Virus incidence in cotton during *kharif* 2024 and 2025

Treatments	Tobacco Streak Virus Incidence(PDI)						PDC
	First Spray			Second Spray			
	Predata	7 DAS	14 DAS	Predata	7 DAS	14DAS	
T1: *Metarhiziumanisopliae*@5g/l	0.25 (2.85)	2.22 (8.56)	1.52 (7.08)	4.21 (11.84)	7.54 (15.94)	12.23 (20.4)	36.08
T2: *Lecanicilliumlecanii* @ 5g/l	0.17 (2.38)	2.01 (8.15)	1.40 (6.79)	6.40 (14.66)	8.10 (16.53)	10.56 (18.96)	44.79
T3: Azadirachtin1500ppm@5ml/l	0.72 (4.87)	2.29 (8.70)	1.70 (7.49)	3.18 (10.28)	5.57 (13.65)	9.47 (17.93)	50.47
T4: Spinetoram11.7SC@0.9ml/l	0.62 (4.50)	1.98 (8.10)	1.46 (6.93)	3.08 (10.11)	3.23 (10.35)	4.46 (12.20)	76.66
T5: Fipronil 5%SC@2ml/l	1.42 (6.83)	2.75 (9.55)	2.28 (8.68)	6.03 (14.22)	8.00 (16.43)	6.78 (16.20)	64.56
T6: Sulfoxaflor21.8SC@0.75ml/l	0.67 (4.69)	1.66 (7.40)	1.23 (6.37)	2.71 (9.48)	2.97 (9.92)	5.32 (13.34)	72.17
T7: Untreated Control	0.54 (4.21)	5.18 (13.16)	3.77 (11.19)	10.50 (18.91)	16.47 (23.9)	19.13 (25.94)	-
CD(p=0.05)	NS	NS	1.52	2.34	2.50	2.70	-
SEm(+)	1.44	0.93	0.48	0.75	0.80	0.86	-
CV(%)	14.98	15.78	10.90	10.24	9.16	8.44	-

PDI: Percent Disease Incidence; DAS: Days after Spray, NS: Non Significant, PDC: Percent Disease Control, Figures in parenthesis are angular transformed values

Table 4. Economics of different insecticides and bioagents on cotton during *kharif* and 2024 and 2025

Treatments	Cotton yield (kgha^{-1})	Incremental yield over control (kg ha^{-1})	Value of incremental yield over control (Rs.ha^{-1})	Cost of treatments (Chemical cost + labour cost) ((Rs.ha^{-1})	Net profit (Rs.ha^{-1})	Incremental Benefit: Cost ratio
T1: *Metarhiziumanisopliae*@5g/l	1529	420	30234	5375	24859	4.62:1
T2: *Lecanicilliumlecanii*@5g/l	1432	323	23236	6000	17236	2.87:1
T3: Azadirachtin1500ppm@5ml/l	1492	382	27538	6750	20788	3.07:1
T4: Spinetoram 11.7SC@0.9ml/l	1968	859	61813	8950	52863	5.90:1
T5: Fipronil5%SC@2ml/l	1917	808	58172	5900	52272	8.85:1
T6: Sulfoxaflor21.8SC@0.75ml/l	1868	759	54619	7375	47244	6.40:1
T7: Untreated Control	1109	-	-	-	-	

After the first spray, Sulfoxaflor recorded the lowest TSV incidence (1.23%) at 14 DAS, followed by *Lecanicilliumlecanii* (1.40%), Spinetoram (1.46%), *Metarhizium anisopliae*(1.52%) and Azadirachtin (1.70%), whereas the untreated control recorded the highest incidence (3.77%). During the second spray, Spinetoram proved to be the most effective treatment by recording the lowest disease incidence (4.46%) and the highest disease control (76.66%), followed by Sulfoxaflor (5.32%; 72.17% disease control) and Fipronil (6.78%; 64.56% disease control). The untreated control exhibited the highest disease incidence (19.13%).

The reduction in TSV incidence in insecticide-treated plots can be attributed to effective suppression of thrips, thereby reducing vector-mediated transmission of the virus. Rageshwari *et al.* (2021) reported that effective management of thrips significantly reduces secondary spread of Tobacco Streak Virus under field conditions. Recent reports by Gawande *et al*. (2026) further highlighted the increasing importance of TSV in Indian cotton production and emphasized the need for efficient vector management strategies. The present findings clearly indicate that apart from suppression of thrips population by newer insecticides,TSV incidence was also effectively minimized.

Effect of treatments on cotton yield

Significant differences in cotton yield were observed among the treatments. Spine to ram 11.7 SC recorded the highest cotton yield (1968 kg ha^{-1}), followed by Fipronil 5 SC (1917 kg ha^{-1}) and Sulfoxaflor 21.8 SC (1868 kg ha^{-1}). Among the bioagents, *Metarhizium anisopliae* recorded the highest yield (1529 kg ha^{-1}), followed by Azadirachtin (1492 kg ha^{-1}) and *Lecanicilliumlecanii*(1432 kg ha^{-1}), whereas the untreated control produced the lowest yield (1109 kg ha^{-1}).

Regarding the benefit cost ratio, Fipronil 5 SC @ 2 ml l^{-1} registered the highest incremental benefit cost ratio **(**8.85:1**)** followed by Sulfoxafl or 21.8SC@0.75 ml l^{-1} (6.40:1).

Among the bioagents, Metarhizium anisopliae recorded higher incremental benefit cost ratio 4.62:1 than Azadirachtin 1500 ppm(3.07:1) and Lecanicilliumlecanii (2.87:1).

Higher seed cotton yield in Spinetoram-treated plots can be attributed to effective suppression of thrips during the critical vegetative stage, resulting in reduced feeding damage, lower TSV incidence and improved plant growth. Similar relationships between effectivesucking pest management and increased cotton productivity have been reported by Naranjo (2021), who emphasized the importance of integrating effective insecticides within IPM programmes. Oliveira *et al*. (2021) also reported that effective management of early-season insect pests substantially improves crop productivity by minimizing economic losses associated with pest damage.

CONCLUSION

The pooled results clearly demonstrated that Spinetoram 11.7 SC @ 0.9 ml l^{-1} was the most effective treatment for managing cotton thrips, reducing Tobacco Streak Virus incidence and improving seed cotton yield. Sulfoxaflor 21.8 SC and Fipronil 5 SC were the next best treatments. Although Azadirachtin, *Metarhizium anisopliae*, and *Lecanicilliumlecanii* reduced thrips populations compared with the untreated control, their efficacy was comparatively lower than that of the synthetic insecticides. These findings suggest that Spinetoram can be recommended as an effective component of integrated pest management for sustainable thrips management and enhanced cotton productivity.

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