ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(11): 367-373
www.agriculturaljournals.com
Received: 14-09-2025
Accepted: 17-10-2025

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Management of thrips (*Scirtothrips dorsalis* H.) infesting grapevine (*Vitis vinifera* L.) using biorationals after October pruning

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DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i11e.978

Abstract
A field investigation entitled, "Management of thrips (*Scirtothrips dorsalis* H.) infesting grapevine (*Vitis vinifera* L.) using biorationals after October pruning" was conducted during 2024–25 at the All India Co-ordinated Research Project on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The study evaluated the efficacy of various biorationals, *viz.*, *Beauveria bassiana* 1.15 % WP, *Metarhizium anisopliae* 1.15 % WP, *Lecanicillium lecanii* 1.15 % WP, Azadirachtin 10000 ppm, Karanj oil, Silicon, Spinosad 45 % SC and an untreated control, against thrips infesting grapevine after October pruning. The results revealed that Spinosad 45 % SC was significantly superior in reducing the thrips population (1.54 thrips/shoot/vine) and minimizing berry damage, which resulted in the highest fruit yield (21.85 t/ha). This was followed by Azadirachtin 10000 ppm (2.94 thrips/shoot/vine) and Karanj oil (3.04 thrips/shoot/vine), which were statistically at par. Although Spinosad 45 % SC was the most effective treatment, its higher cost led to a lower ICBR (1:6.78). In contrast, the entomopathogenic fungi *Lecanicillium lecanii* (1:26.80) and *Metarhizium anisopliae* (1:25.55) recorded the highest ICBR values due to their lower input cost. Thus, Spinosad 45 % SC is recommended for high-value vineyards, whereas microbial formulations are more suitable for cost-sensitive growers.

Keywords: Grapes, Spinosad, thrips, *Lecanicillium lecanii*, biorationals, *Scirtothrips dorsalis* H.

Introduction
Grape (*Vitis vinifera* L.) is one of the most commercially significant and widely cultivated fruit crops globally, valued for both table use and wine production. Though native to temperate regions, its cultivation has successfully expanded into tropical and subtropical climates, including India, through the adoption of appropriate agronomic practices (Bose *et al.*, 1999). In India, grapes are predominantly grown in states such as Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu, with Maharashtra alone contributing over 67% to the national production. As of 2023–24, grape cultivation in India covers 175.93 thousand hectares with a production of 2634.74 thousand metric tonnes and an average productivity of 19.74 MT/ha (APEDA, 2023).

Among the major constraints in grape production, insect pests are second only to diseases. Globally, over 130 insect pests have been reported to affect grapevines (Bournier, 1977) [7], while in India, 85–94 species have been documented (Atwal & Dhaliwal, 2005; Tandon & Verghese, 1994) [4, 27]. Notable among these are the flea beetle (*Scelodonta strigicollis*), mealy bug (*Maconellicoccus hirsutus*), shot hole borer (*Xylosandrus crassiusculus*) and thrips species such as *Rhipiphorothrips cruentatus* and *Scirtothrips dorsalis*. Thrips, once considered minor pests, have gained major economic importance due to their polyphagy, rapid reproduction and adaptability to new hosts (Dahiya *et al.*, 1995) [9]. Their feeding activity, particularly on the abaxial surface of leaves, leads to curling, scarring and reduced fruit quality, ultimately lowering market value (Kulkarni *et al.*, 2007; Patil *et al.*, 2017) [15, 19].

Chemical control has long been the primary strategy for managing thrips. However, concerns over pesticide residues, resistance development and environmental hazards have led to a shift towards safer alternatives. Biorational insecticides, including botanicals, microbial agents and insect growth regulators, are gaining prominence due to their eco-friendly nature, safety to non-target organisms and compatibility with integrated pest management (IPM) systems.

These products are increasingly seen as viable options for sustainable agriculture, particularly in export-oriented crops like grapes, where residue limits are strictly regulated.

In this context, the present study was undertaken to evaluate the efficacy of selected biorational insecticides against grape thrips. The aim is to identify effective, residue-free alternatives that can be integrated into holistic pest management strategies for sustainable grape cultivation.

Materials and methods

A field experiment was conducted during 2024–25 at the vineyard of AICRP on Fruits, Department of Horticulture, MPKV, Rahuri, to evaluate the "Management of thrips (*Scirtothrips dorsalis* H.) infesting grapevine (*Vitis vinifera* L.) using biorationals after October pruning". The experiment was established on the Thompson Seedless grapevine variety after October pruning, with all recommended viticultural practices adhered to throughout the study period.

Methodology

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments, including an untreated control, replicated three times. Each replication consisted of three vines. Biorational insecticides were applied as foliar sprays, with a total of three applications at ten-day intervals following the October (fruit/forward) pruning. Thrips populations were assessed by tapping five shoots per treated vine. Pre-treatment counts were recorded before insecticide application and post-treatment counts were taken at 3, 5, 7 and 10 days after spray (DAS) (Duraimurugan and Jagadish, 2004). Data expressed as counts were square root transformed ($\sqrt{x+0.5}$) (Gomez and Gomez, 1984) prior to statistical analysis. The transformed data were subjected to ANOVA using RBD to determine significant differences among treatments at the 5% significance level.

Population reduction relative to the control was calculated using Modified Abbott's formula (Flemming and Retnakaran, 1985) [11]:

$$\text{Per cent reduction over control} = \frac{(\text{Population in control} - \text{Population in treatment})}{\text{Population in control}} \times 100$$

To assess damage severity, 15 days before harvest, five bunches per vine were randomly selected, labeled and evaluated for thrips damage. Observations included the total number of berries per bunch and the number of damaged berries. Percent berry damage was calculated as:

$$\text{Per cent berry damage} = \frac{\text{Number of damaged berries}}{\text{Total number of berries}} \times 100$$

Grape bunches were harvested separately from each treatment and yield was recorded. Yield per treatment was converted to kilograms per hectare (kg/ha) using the formula:

$$\text{Yield } (kg\ ha^{-1} = \frac{\text{Yield per treatment (kg)}}{\text{Net area of plot (ha)}} \times 10{,}000$$

The incremental cost-benefit ratio was calculated considering prevailing market prices for inputs, produce and labor charges.

Treatments details

Sr. No.	Biorationals with their formulations	Trade name	Dose (g or ml/l)	Source
1.	*Beauveria bassiana* 1.15 % WP (1×10^8 CFU/g)	Phule *Beauveria*	5	Biocontrol laboratory, Department of Entomology, MPKV, Rahuri
2.	*Metarhizium anisopliae* 1.15 % WP (1×10^8 CFU/g)	Phule *Metarhizium*	5	Biocontrol laboratory, Department of Entomology, MPKV, Rahuri
3.	*Lecanicillium lecanii* 1.15 % WP (2×10^8 CFU/g)	Phule Bugicide	5	Biocontrol laboratory, Department of Entomology, MPKV, Rahuri
4.	Azadirachtin 10000 ppm	Nimbecidine	2	T. Stanes and Co. Ltd., Coimbatore
5.	Karanj oil	Supreme No. 1	2	Venkatesh Agro Tech, Musalgaon, Sinnar, Nashik, Maharashtra
6.	Silicon (Silicic Acid)	Orthol	2	CROPEX LIMITED, Tubinakere, Mandya, Karnataka
7.	Spinosad 45 % SC	Tracer	0.5	M/s. Dow Agro-sciences India Pvt. Ltd., Mumbai

Results and Discussion

Management of thrips (*Scirtothrips dorsalis* H.) infesting grapevine (*Vitis vinifera* L.) using biorationals after October pruning

Three sprays were given; the first spray was given after crossing ETL and the next two sprays were given at 10-days interval. The pre-count was recorded at 1 DBS and the surviving pest population was recorded at 3, 5, 7 and 10 DAS. The mean surviving population was calculated to assess the effectiveness of each spray treatment and the overall mean pest population, along with the per cent reduction over control, was computed to evaluate the performance of different biorationals

First Spray

The results of the efficacy of biorational treatments against thrips after the first spray presented in Table 1. The thrips population recorded one day before spraying (DBS) ranged from 6.33 to 7.93 thrips per shoot per vine, with no significant differences among treatments, indicating a homogeneous distribution of the thrips population across the experimental area. Post treatment population counts were taken at 3 DAS, 5 DAS, 7 DAS and 10 DAS. It was seen that all the biorational treatments were significantly superior over to the untreated control.

The mean thrips population after the first spray, Spinosad 45 % SC proved to be the significantly most effective treatment, with the lowest population of 1.63 thrips per shoot per vine. This was followed by Azadirachtin 10000 ppm (3.14 thrips/shoot/vine) and Karanj oil (3.27 thrips/shoot/vine), which were statistically at par with each other. In descending order of efficacy, the remaining treatments were *Lecanicillium lecanii* 1.15 % WP (4.64 thrips/shoot/vine), *Metarhizium anisopliae* 1.15 % WP (4.83

thrips/shoot/vine), Silicon (4.92 thrips/shoot/vine) and *Beauveria bassiana* 1.15 % WP (5.07 thrips/shoot/vine), all of which were statistically at par.

Analysis of the data revealed that Spinosad 45 % SC (81.12 %) achieved the highest reduction in thrips population compared to an untreated control, followed by Azadirachtin 10000 ppm (63.69 %) and Karanj oil (62.19 %). The subsequent treatments, ranked in decreasing order of efficacy, were *Lecanicillium lecanii* 1.15 % WP (46.24 %), *Metarhizium anisopliae* 1.15 % WP (44.12 %), Silicon (43.00 %) and *Beauveria bassiana* 1.15 % WP (41.29 %).

Table 1: Efficacy of biorationals against grape thrips after first spray (October pruning)

Tr. No.	Treatment details	Dose (ml/g/lit)	Average survived population of thrips (nymphs and adults) per shoot per vine					Mean	Per cent reduction of thrips over control
			Pre- count	3 DAS	5 DAS	7 DAS	10 DAS		
T_1	*Beauveria bassiana* 1.15 % WP	5 g	7.80 (2.87)*	6.80 (2.70)	4.98 (2.33)	4.52 (2.24)	3.98 (2.12)	5.07 (2.35)	41.29
T_2	*Metarhizium anisopliae* 1.15 % WP	5 g	7.62 (2.85)	6.40 (2.62)	4.70 (2.27)	4.38 (2.20)	3.82 (2.07)	4.83 (2.29)	44.12
T_3	*Lecanicillium lecanii* 1.15 % WP	5 g	6.33 (2.61)	5.97 (2.54)	4.57 (2.24)	4.28 (2.19)	3.75 (2.05)	4.64 (2.26)	46.24
T_4	Azadirachtin 10000 ppm	2 ml	6.73 (2.68)	4.05 (2.13)	3.07 (1.88)	2.98 (1.85)	2.44 (1.71)	3.14 (1.89)	63.69
T_5	Karanj oil	2 ml	6.87 (2.70)	4.27 (2.18)	3.20 (1.92)	3.05 (1.87)	2.54 (1.74)	3.27 (1.93)	62.19
T_6	Silicon (Silicic Acid)	2 ml	7.21 (2.77)	6.52 (2.65)	4.82 (2.31)	4.45 (2.22)	3.90 (2.10)	4.92 (2.32)	43.00
T_7	Spinosad 45 % SC	0.5 ml	7.08 (2.75)	2.02 (1.57)	1.83 (1.53)	1.22 (1.31)	1.45 (1.40)	1.63 (1.45)	81.12
T_8	Untreated control	–	7.93 (2.89)	8.88 (3.06)	8.27 (2.96)	8.52 (3.00)	8.87 (3.06)	8.64 (3.02)	0.00
S.E. ±			0.15	0.11	0.09	0.10	0.08	0.10	–
CD at 5%			NS	0.33	0.28	0.30	0.25	0.29	–
CV (%)			9.26	7.75	7.45	8.00	7.03	7.56	–

*****Figures in parenthesis represents $\sqrt{x + 0.5}$ transformed values; DAS – Days After Spray

Second Spray

The efficacy of biorational treatments against thrips following the second spray is summarized in Table 2. Observations after treatment indicated that all insecticidal treatments performed significantly better than the untreated control.

Considering the mean thrips population following the second spray, Spinosad 45 % SC emerged as the most promising treatment, recording the lowest population of 1.55 thrips per shoot per vine compared to all other treatments, which were followed by Azadirachtin 10000 ppm (2.95 thrips/shoot/vine) and Karanj oil (3.04 thrips/shoot/vine), and were statistically comparable in their efficacy. The next effective treatments were *Lecanicillium lecanii* 1.15 % WP (4.48 thrips/shoot/vine) found to be at par with *Metarhizium anisopliae* 1.15 % WP, Silicon and *Beauveria bassiana* 1.15 % WP, which recorded 4.57, 4.65 and 4.74 thrips/shoot/vine, respectively. However, an untreated recorded highest thrips population of 8.59 thrips/shoot/vine.

The cumulative effect of the treatments revealed that, the highest reduction in thrips population over an untreated control was recorded in plots treated with Spinosad 45 % SC (81.96 %), followed by the Azadirachtin 10000 ppm (65.70 %) and Karanj oil (64.59 %). The subsequent treatments, in decreasing order of effectiveness, were *Lecanicillium lecanii* 1.15 % WP, *Metarhizium anisopliae* 1.15 % WP, Silicon and *Beauveria bassiana* 1.15 % WP which recorded 47.92, 46.81, 45.94 and 44.86 per cent reduction over control, respectively.

Table 2: Efficacy of biorationals against grape thrips after second spray (October pruning)

Tr. No.	Treatment details	Dose (ml/g/lit)	Average survived population of thrips (nymphs and adults) per shoot per vine				Mean	Per cent reduction of thrips over control
			3 DAS	5 DAS	7 DAS	10 DAS		
T_1	*Beauveria bassiana* 1.15% WP	5 g	5.94 (2.53)*	4.72 (2.28)	4.38 (2.20)	3.91 (2.09)	4.74 (2.28)	44.86
T_2	*Metarhizium anisopliae* 1.15% WP	5 g	5.77 (2.50)	4.55 (2.24)	4.21 (2.16)	3.75 (2.05)	4.57 (2.24)	46.81
T_3	*Lecanicillium lecanii* 1.15% WP	5 g	5.70 (2.49)	4.40 (2.21)	4.12 (2.15)	3.68 (2.04)	4.48 (2.22)	47.92
T_4	Azadirachtin 10000 ppm	2 ml	3.70 (2.05)	2.90 (1.84)	2.82 (1.82)	2.37 (1.69)	2.95 (1.85)	65.70
T_5	Karanj oil	2 ml	3.82 (2.07)	2.98 (1.87)	2.90 (1.84)	2.47 (1.72)	3.04 (1.88)	64.59
T_6	Silicon (Silicic Acid)	2 ml	5.82 (2.51)	4.64 (2.26)	4.29 (2.18)	3.83 (2.07)	4.65 (2.26)	45.94

T_7	Spinosad 45 % SC	0.5 ml	2.00 (1.56)	1.67 (1.47)	1.15 (1.28)	1.38 (1.37)	1.55 (1.42)	81.96
T_8	Untreated control	–	8.84 (3.06)	8.34 (2.97)	8.47 (2.99)	8.72 (3.03)	8.59 (3.01)	0.00
S.E. ±			0.10	0.10	0.09	0.10	0.10	–
CD at 5%			0.30	0.31	0.27	0.31	0.30	–
CV (%)			7.36	8.35	7.43	8.82	7.99	–

***Figures in parenthesis represents $\sqrt{x+0.5}$ transformed values; DAS – Days After Spray

Third Spray

Results on the performance of biorational treatments after the third spray are presented in Table 3. All treatments exhibited significant superiority over the untreated control.

Based on the mean thrips population recorded after the third spray, it was observed that Spinosad 45 % SC maintained its superiority and recorded lowest population of 1.45 thrips/shoot/vine. Among the next treatments, Azadirachtin 10000 ppm and Karanj oil were the next effective treatments, which recorded 2.73 and 2.81 thrips/shoot/vine. The next treatments in effectiveness were *Lecanicillium lecanii* 1.15 % WP, *Metarhizium anisopliae* 1.15 % WP, Silicon and *Beauveria bassiana* 1.15 % WP which recorded 4.28, 4.36, 4.43 and 4.55 thrips/shoot/vine, respectively. However, an untreated control recorded 8.64 thrips per shoot per vine.

Cumulative data from all treatments demonstrated that the highest reduction in thrips population compared to the untreated control was observed in plots treated with Spinosad 45 % SC (83.22 %), which was followed by Azadirachtin 10000 ppm and Karanj oil, which recorded 68.44 % and 67.49 % reduction over control, respectively. The subsequent treatments, in decreasing order of efficacy, were *Lecanicillium lecanii* 1.15 % WP (50.48 %), *Metarhizium anisopliae* 1.15 % WP (49.53 %), Silicon (48.72 %) and *Beauveria bassiana* 1.15 % WP (47.33 %).

Table 3: Efficacy of biorationals against grape thrips after third spray (October pruning)

Tr. No	Treatment details	Dose (ml/g/lit)	Average survived population of thrips (nymphs and adults) per shoot per vine				Mean	Percent reduction of thrips over control
			3 DAS	5 DAS	7 DAS	10 DAS		
T_1	*Beauveria bassiana* 1.15 % WP	5 g	5.83 (2.51)*	4.54 (2.24)	4.12 (2.14)	3.72 (2.05)	4.55 (2.24)	47.33
T_2	*Metarhizium anisopliae* 1.15 % WP	5 g	5.68 (2.48)	4.26 (2.17)	3.93 (2.10)	3.58 (2.01)	4.36 (2.19)	49.53
T_3	*Lecanicillium lecanii* 1.15 % WP	5 g	5.61 (2.47)	4.20 (2.16)	3.82 (2.08)	3.49 (1.99)	4.28 (2.17)	50.48
T_4	Azadirachtin 10000 ppm	2 ml	3.61 (2.03)	2.75 (1.80)	2.33 (1.68)	2.22 (1.65)	2.73 (1.79)	68.44
T_5	Karanj oil	2 ml	3.73 (2.05)	2.82 (1.82)	2.41 (1.71)	2.28 (1.67)	2.81 (1.81)	67.49
T_6	Silicon (Silicic Acid)	2 ml	5.73 (2.49)	4.35 (2.19)	4.00 (2.12)	3.65 (2.03)	4.43 (2.21)	48.72
T_7	Spinosad 45 % SC	0.5 ml	1.95 (1.57)	1.50 (1.41)	1.08 (1.26)	1.27 (1.33)	1.45 (1.39)	83.22
T_8	Untreated control	–	8.91 (3.06)	8.51 (3.00)	8.21 (2.95)	8.94 (3.07)	8.64 (3.02)	0.00
S.E. ±			0.10	0.11	0.08	0.10	0.10	–
CD at 5%			0.32	0.33	0.26	0.31	0.31	–
CV (%)			7.74	8.95	7.28	9.02	8.25	–

***Figures in parenthesis represents $\sqrt{x+0.5}$ transformed values; DAS – Days After Spray

Cumulative mean of spray

The cumulative mean data on the efficacy of various biorational treatments against thrips on grapevine, assessed over the first, second and third sprays after October pruning, are presented in Table 4. The results demonstrated that all biorational treatments were significantly more effective than the untreated control

Analysis of the cumulative results across the three sprays revealed that Spinosad 45 % SC consistently emerged as the significantly most promising treatment which recorded the lowest population of 1.54 thrips/shoot/vine, among all other treatments. The next effective treatments were Azadirachtin 10000 ppm (2.94 thrips/shoot/vine) and Karanj oil (3.04 thrips/shoot/vine), which were statistically at par with each other. However, the next effective treatment was *Lecanicillium lecanii* 1.15 % WP (4.46 thrips/shoot/vine), which was found at par with *Metarhizium anisopliae* 1.15 % WP, Silicon and *Beauveria bassiana* 1.15 % WP, which recorded 4.59, 4.67 and 4.79 thrips/shoot/vine, respectively. However, an untreated control recorded highest thrips population of 8.62 thrips per shoot per vine.

The data further indicated that the highest percentage reduction in population compared to an untreated control was observed in plots treated with Spinosad 45 % SC, which recorded 82.10 % reduction over control. This was followed by Azadirachtin 10000 ppm (65.95 %) and Karanj oil (64.76 %). However, the subsequent treatments in order of effectiveness were *Lecanicillium lecanii* 1.15 % WP, *Metarhizium anisopliae* 1.15 % WP, Silicon and *Beauveria bassiana* 1.15 % WP which recorded 48.23, 46.82, 45.89 and 44.49 per cent reduction over control, respectively.

Table 4: Cumulative mean efficacy of biorationals against grape thrips (October pruning)

Tr. No.	Treatment details	Dose (ml/g/lit)	Average survived population of thrips (nymphs and adults) per shoot per vine				Mean	Percent reduction of thrips over control
			3 DAS	5 DAS	7 DAS	10 DAS		
T_1	*Beauveria bassiana* 1.15 % WP	5 g	6.19 (2.58)*	4.75 (2.28)	4.34 (2.19)	3.87 (2.09)	4.79 (2.29)	44.49
T_2	*Metarhizium anisopliae* 1.15 % WP	5 g	5.95 (2.53)	4.50 (2.23)	4.17 (2.15)	3.72 (2.04)	4.59 (2.24)	46.82
T_3	*Lecanicillium lecanii* 1.15 % WP	5 g	5.76 (2.50)	4.38 (2.20)	4.07 (2.14)	3.64 (2.03)	4.46 (2.22)	48.23
T_4	Azadirachtin 10000 ppm	2 ml	3.79 (2.07)	2.91 (1.84)	2.71 (1.79)	2.34 (1.68)	2.94 (1.84)	65.95
T_5	Karanj oil	2 ml	3.94 (2.10)	3.00 (1.87)	2.79 (1.81)	2.43 (1.71)	3.04 (1.87)	64.76
T_6	Silicon (Silicic Acid)	2 ml	6.02 (2.55)	4.60 (2.25)	4.25 (2.17)	3.79 (2.07)	4.67 (2.26)	45.89
T_7	Spinosad 45 % SC	0.5 ml	1.99 (1.56)	1.67 (1.47)	1.15 (1.28)	1.37 (1.36)	1.54 (1.42)	82.10
T_8	Untreated control	–	8.88 (3.06)	8.37 (2.98)	8.40 (2.98)	8.84 (3.05)	8.62 (3.02)	0.00
S.E. ±			0.10	0.10	0.09	0.09	0.10	–
CD at 5%			0.32	0.31	0.28	0.29	0.30	–
CV (%)			7.62	8.25	7.57	8.29	7.93	–

***Figures in parenthesis represents $\sqrt{x + 0.5}$ transformed values; DAS – Days After Spray

The present study findings are strongly supported by earlier research work highlighting the effectiveness of Spinosad, botanical insecticides and entomopathogenic fungi in managing thrips populations, particularly in grape cultivation.

Among bio-insecticides, Spinosad has shown consistent performance in reducing thrips infestation and enhancing grape yield. Kulkarni (2012) [14] reported that Spinosad 45 % SC @ 25 ml/100 L was highly effective in controlling thrips in grapes, with no phytotoxic effects and no adverse impact on natural enemies, indicating its compatibility with vineyard ecosystems. Similarly, Bangosavi (2009) [5] found Spinosad (0.0135%) as the most effective treatment against *Rhipiphorothrips cruentatus*, maintaining effective control up to 14 days after application. Caputo *et al.* (2005) [8] further validated its efficacy on table grapes infested with *Frankliniella occidentalis*, especially at a dose of 11.05 ml/L.

These studies establish Spinosad as a reliable, selective and IPM-compatible option for thrips control in grape ecosystems. Its consistent efficacy, residue safety and preservation of natural enemies make it ideal for sustainable vineyard management.

Botanical insecticides have also demonstrated moderate effectiveness in thrips suppression while offering ecological safety. Narvaria (2003) [18] reported that Karanj oil at 5 % achieved a 63 % reduction in thrips population, while Aliakbarpour *et al.* (2011) [1] found neem oil (2 %) effective with minimal toxicity to pollinators. Reddy *et al.* (2022) [22] also confirmed the effectiveness of Neem oil, Karanj oil and Neemazol in reducing thrips on grapevines, emphasizing their potential in eco-friendly IPM programs. Additionally, Kulkarni *et al.* (2008) [16] recommended biointensive IPM modules integrating neem formulations with biopesticides and minimal chemical use to manage pests while reducing pesticide residues in grapes.

Biological control agents such as *Metarhizium anisopliae*, *Beauveria bassiana* and *Lecanicillium lecanii* have emerged as promising components in grape IPM strategies. Rami Reddy *et al.* (2019) [20] demonstrated that *Metarhizium anisopliae* provided 82–84 % thrips population reduction and protected against berry scarring. Reddy *et al.* (2022) [22] highlighted *Lecanicillium lecanii* as the most effective entomopathogen among those tested. Additionally, Lopes *et al.* (2002) [17] showed that combining *Metarhizium anisopliae* with Methiocarb resulted in 95.5 % control and significantly reduced berry damage on table grapes.

An integrated approach to thrips management using Spinosad, botanicals and biological control agents is further validated by Arthurs *et al.* (2013) [3], who compared IPM-compatible options and found Spinosad to the most effective (94–99 % reduction), followed by *Metarhizium brunneum* and *Beauveria bassiana*. Their results reinforce the importance of using selective, residue-free products that are safe to beneficial organisms and effective over multiple application intervals.

Collectively, these studies emphasize that Spinosad, botanical insecticides and entomopathogenic fungi are not only effective but also environmentally safe and compatible with IPM programs in grape production. Their consistent performance, selective action and minimal ecological impact make them key tools in the development of sustainable, residue-conscious thrips management strategies for vineyards.

Per cent berry damage

The data on percent berry damage across different treatments, recorded at veraison stage, revealed that the untreated control exhibited the highest berry damage (31.29 %), as presented in Table 5. Significantly lower berry damage was observed in Spinosad 45 % SC (7.05 %) compared to all other treatments. The next most effective treatments were Azadirachtin 10000 ppm (11.10 %), which was statistically at par with Karanj oil (12.21 %). This was followed by *Lecanicillium lecanii* 1.15 % WP (17.52 %), *Metarhizium anisopliae* 1.15 % WP (19.06 %), Silicon (21.17 %) and *Beauveria bassiana* 1.15 % WP (24.04%).

Table 5: Efficacy of biorationals on berry damage and grape fruit yield during 2024-25 (October pruning)

Tr. No.	Treatments	Per cent berry damage	Per cent reduction over control	Fruit yield		
				kg/ vine	t/ha	Per cent increase over control
T_1	*Beauveria bassiana* 1.15 % WP	24.04 (29.34)*	23.18	5.75	12.78	20.08
T_2	*Metarhizium anisopliae* 1.15 % WP	19.06 (25.84)	39.10	7.18	15.95	49.86
T_3	*Lecanicillium lecanii* 1.15 % WP	17.52 (24.55)	44.01	7.29	16.20	52.21
T_4	Azadirachtin 10000 ppm	11.10 (19.38)	64.54	8.70	19.33	81.65
T_5	Karanj oil	12.21 (20.45)	60.97	8.42	18.71	75.82
T_6	Silicon (Silicic Acid)	21.17 (27.39)	32.35	6.67	14.83	39.37
T_7	Spinosad 45 % SC	7.05 (15.28)	77.47	9.98	21.85	105.29
T_8	Untreated control	31.29 (34.01)	0.00	4.79	10.64	0.00
S.E. ±		1.26	–	0.31	0.64	–
CD at 5%		3.83		0.93	1.95	
CV (%)		8.91		7.25	6.84	

*Figures in parenthesis are angular transformation (arcsine) values.

Fruit yield

The data on fruit yield (Table 5.) indicated that Spinosad 45 % SC produced the highest grape yield of 21.85 t/ha, demonstrating its superior efficacy among all treatments. The next best-performing treatments were Azadirachtin 10000 ppm and Karanj oil, which recorded yields of 19.33 and 18.71 t/ha, respectively, and were statistically at par with each other. In terms of decreasing effectiveness, the subsequent treatments were *Lecanicillium lecanii* 1.15 % WP (16.20 t/ha), *Metarhizium anisopliae* 1.15 % WP (15.95 t/ha), Silicon (14.83 t/ha) and *Beauveria bassiana* 1.15 % WP (12.78 t/ha). The current observations align with previous studies demonstrating the efficacy of Spinosad in managing *Scirtothrips dorsalis* and improving grape yield and quality. Bangosavi (2009) [5] reported that Spinosad 0.0135 % resulted in the highest grape yield (27.35 MT/ha) with minimal berry scarring, emphasizing its dual role in pest suppression and fruit quality enhancement. Similarly, Goutham (2009) [13] found Spinosad 0.012 % to be significantly superior to all other treatments, achieving complete protection against berry damage (0.00 %) and recording the highest yield of 24,656 kg ha⁻¹. These consistent findings across studies confirm that Spinosad is a highly effective insecticide for integrated pest management in grape cultivation, offering both economic and qualitative benefits. These results confirm Spinosad's effectiveness in enhancing grape productivity while managing thrips.

Economics of grapevine production under biorational treatments for thrips control after October pruning

Table 6: Economics of grape production influenced by treatment of biorationals for thrips management (October pruning)

Tr. No.	Treatments	Dosage (ml/g/lit)	Quantity of insecticide for 3 sprays	Yield / ha (tonnes)	Gross Returns (Rs. /ha)	Incremental yield over control (t/ha) A	Incremental Benefit over control (Rs/ha) B	Cost of plant protection C	Additional Net profit D= B-C	ICBR E= D/C
T_1	*Beauveria bassiana* 1.15 % WP	5 g	15 kg/ha	12.78	383400	2.14	64200	6000	58200	1:9.70
T_2	*Metarhizium anisopliae* 1.15 % WP	5 g	15 kg/ha	15.95	478500	5.31	159300	6000	153300	1:25.55
T_3	*Lecanicillium lecanii* 1.15 % WP	5 g	15 kg/ha	16.2	486000	5.56	166800	6000	160800	1:26.80
T_4	Azadirachtin 10000 ppm	2 ml	6 L/ha	19.33	579900	8.69	260700	19320	241380	1:12.49
T_5	Karanj oil	2 ml	6 L/ha	18.71	561300	8.07	242100	14700	227400	1:15.47
T_6	Silicon (Silicic Acid)	2 ml	6 L/ha	14.83	444900	4.19	125700	7842	117858	1:15.03
T_7	Spinosad 45 % SC	0.5 ml	1.5 L/ha	21.85	655500	11.21	336300	43200	293100	1:6.78
T_8	Untreated control	–	–	10.64	319200	–	–	–	–	–

B. bassiana: Rs. 200/kg	*M. anisoplae*: Rs. 200/kg	*L. lecanii*: Rs. 200/kg	Azadirachtin 10000 ppm: Rs. 2720/L
Karanj oil: Rs. 1950 /L	Silicon (Silicic Acid): Rs. 807/L	Spinosad 45 % SC: Rs. 26800/L	Grapes: Rs 30000/tonne
Cost of labour: Rs. 1000/ha/spray	ICBR – Incremental Cost Benefit Ratio		

The cost-effectiveness of the various biorational treatments evaluated for thrips management in grapes was assessed and is summarized in Table 6. The ICBR of treatments ranged from 6.78 to 26.80, indicating considerable variation in economic returns relative to the cost of application. Among the evaluated treatments, the highest ICBR was observed in the entomopathogenic fungi, with *Lecanicillium lecanii* 1.15 % WP (1:26.80) and *Metarhizium anisopliae* 1.15 % WP

(1:25.55). The superior cost-benefit of these treatments can be attributed to their low purchase price coupled with their effective control of thrips populations. In contrast, although Spinosad 45 % SC resulted in a substantial reduction in thrips population, its ICBR was lower (1:6.78) due to the relatively high cost of the insecticide, highlighting that efficacy alone does not determine economic feasibility. These findings suggest that integrating low-cost biorational agents such as entomopathogenic fungi can provide sustainable and economically viable options for thrips management in grape cultivation.

Conclusion

The incidence of thrips infestation was recorded after October pruning, with Spinosad 45% SC proving the most effective among the biorational treatments. It resulted in the lowest thrips population, minimum berry damage and highest yield. This was followed by Azadirachtin 10000 ppm and Karanj oil. Although Spinosad recorded superior efficacy, its high cost resulted in a lower ICBR compared to entomopathogenic fungi, which, despite being relatively less effective, provided higher returns due to their lower input cost. These findings suggest that Spinosad 45% SC is suitable for high-value vineyards, whereas microbial treatments are more appropriate for cost-sensitive growers.

Acknowledgement

The authors gratefully acknowledge the Head, Department of Entomology and Officer In charge, AICRP on Fruits, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, for extending the necessary facilities and constant encouragement throughout the course of the investigation.

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