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Research Article

Integrated biocontrol of *Thrips parvispinus* Karny in bitter gourd: Synergistic effect of a liquid soap made of herbal essential oils

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ABSTRACT: Invasive thrips, *Thrips parvispinus* Karny, have been causing immense damage to bitter gourd (*Momordica charantia*) crops. The International Phytosanitary Research and Services, under the BIRAC Department of Biotechnology program, developed a liquid soap formulation comprising essential oils and an herbal liquid soap (*Rashvee*) to combat sucking pests. Preliminary evaluations demonstrated that Rashvee exhibited excellent adjuvant effects when combined with Entomopathogenic Fungi (EPF)—*Beauveria bassiana*, *Metarhizium anisopliae*, and *Verticillium lecanii*—as well as with insecticides. To further assess its efficacy, an integrated field trial was conducted in Vijayapura and Devanahalli, Karnataka, where farmers expressed dissatisfaction with insecticides. Thrips populations were monitored pre- and post-treatment in bitter gourd fields. The results indicated that the combination of the adjuvant herbal soap with entomopathogenic fungi significantly reduced thrips populations, achieving mean counts of approximately 5.2 and 5.8 thrips per plant, respectively, in two fields after one week of spray. Notably, effective control was only obtained when all three entomopathogenic fungi were used in combination, while insecticides alone proved ineffective. In contrast, the untreated control group exhibited a natural increase in population, rising from 97.20 thrips at the initial count to 123 per ten flowers in a week.

KEYWORDS: *Beauveria bassiana*, herbal liquid soap, *Metarhizium anisopliae*, *Thrips parvispinus*, *Verticillium lecanii*

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INTRODUCTION

The invasive pest *Thrips parvispinus* (Karny) was first documented in India by Tyagi *et al.* (2015). Subsequent reports have confirmed its presence on several crops, including papaya (Rachana *et al.*, 2018), *Dalhia rosea*, Brugmansia sp. (Roselin *et al.*, 2021), and chilli (Verghese, 2021). In addition to these hosts, *T. parvispinus* has been documented on cotton, bitter gourd, chrysanthemum, watermelon, mango, tamarind, and marigold (Nagaraju *et al.*, 2021; Sireesha *et al.,* 2021; Rachana *et al.*, 2022). This rapid expansion of host range underscores the adaptive potential of the species and highlights its significant threat to agricultural production and integrated pest management frameworks.

Thrips parvispinus is an emerging invasive pest impacting bitter gourd (*Momordica charantia*) crops, which are valued worldwide for their nutritional and medicinal properties. This pest causes significant yield losses through direct feeding damage and by transmitting plant viruses, posing severe economic challenges to growers (Rachana *et al.*, 2022). The widespread use of conventional chemical insecticides to manage *T. parvispinus* is problematic due to environmental risks and the increasing occurrence of insecticide resistance (Ataide *et al.,* 2024). Consequently, there is an urgent need to develop eco-friendly and sustainable alternatives.

Integrated Pest Management (IPM) strategies that incorporate biological control agents and botanical formulations offer promising solutions for sustainable crop protection (Mouden *et al.*, 2017). Entomopathogenic Fungi (EPF), such as *Beauveria bassiana, Metarhizium anisopliae,* and *Verticillium lecanii*, have gained prominence as biocontrol agents because they selectively target pest insects

while minimising detrimental effects on non-target organisms (Singh *et al.*, 2011; Murai *et al.*, 2010). In parallel, herbal soaps have emerged as innovative botanical formulations capable of disrupting pest behaviour when synergised with EPF. When used in synergy with entomopathogenic fungi, these formulations may enhance pest suppression, offering a dual mode of action that is both effective and environmentally benign (Maniania *et al.*, 2003; Panyasiri *et al.*, 2022; Amouzou *et al.*, 2022; Ain *et al.*, 2021). This study was initiated because farmers complained about the ineffectiveness of several insecticides on bitter gourd, especially warranting the use of commercial EPFs.

This study investigates the efficacy of integrating herbal soap with beneficial entomopathogenic fungi, commercially available, to control *T. parvispinus* populations in bitter gourd fields. By evaluating this combined biocontrol approach, the research aims to establish an economically viable and sustainable method for managing an emerging pest, thereby contributing to enhanced yield and long-term crop protection.

MATERIALS AND METHODS

The experiment was conducted in two one-acre bitter gourd fields located in Vijayapura, Devanahalli (13.287308, 77.804938, 13.293762, 77.806030). Each field had approximately 1,200 plants of the variety Prakriti Seeds *Pragati 065 F1*, arranged in rows of 30 plants per row (Figure 1). A systematic sampling approach was employed, wherein every third plant in each row was selected. From each chosen plant, one flower was randomly sampled, ensuring that 10 vines were included, with each vine constituting a replicate. This method resulted in 10 flower samples per treatment group, yielding a total of 110 flowers across the eleven treatment conditions for each observation (Figures 2 and 3).



Figure 1. Bitter gourd field A.

Treatment application

Eight treatments were evaluated as follows:

i. *Beauveria bassiana* **– @ 5 ml/L of water**
ii. *Verticillium lecanii* – @ 5 ml/L of water
iii. *Metarhizium anisopliae* – @ 5 ml/L of water
iv. Combination 1 – A mixture of *Beauveria bassiana* and *Verticillium lecanii,* each @ 5 ml/L of water, and the herbal soap, @ 1 ml/L of water
v. Combination 2 – A mixture of *Beauveria bassiana*, *Metarhizium anisopliae*, and *Verticillium lecanii,* each @ 5 ml/L of water, herbal soap, @ 1 ml/L of water
vi. Chemical Treatments – Fluxametamide, 10 EC @ 0.8ml/L of water
vii. Thiomethoxam @ 75% 0.5gms/L of water
viii. Spinetoram, 11.7% SC @ 1ml/L of water
ix. Fipronil 15% + Flonicamid 15% @ 0.8gms/L of water
x. Herbal Soap*– @ 5 ml/L of water
xi. Control – No treatment applied

(*Herbal soap is a product developed using a combination of essential oils under BIRAC, DBT by Rashvee International Phytosanitary Research and Services and has been patented.)

Following treatment applications, the sampled flowers were collected and individually labelled before being transported to the laboratory. In the laboratory, thrips were rendered immobile by exposure to ethyl acetate. Each flower was then gently tapped onto a white cardboard surface, and thrips were counted using a hand lens (magnoscope). Representative specimens were preserved in 80% ethanol for



Figure 2. Bitter gourd field B.



Figure 3. Bitter gourd flowers with *Thrips parvispinus*.

further analysis. Observations were recorded at four intervals: pre-treatment (baseline), 48 h post-treatment, 72 h post-treatment, and one week post-treatment. In all, we sampled 110 random flowers in each of the fields. The data were subjected to one-way Analysis of Variance (ANOVA) followed by Least Significant Difference (LSD) test to examine if the means were significantly different (SYSTAT 13.0).

RESULTS AND DISCUSSION

All treatments began with a similar baseline of approximately 93–97 thrips per 10 flowers, ensuring a comparable initial pest load across all plots. In the untreated control group, the thrips population increased steadily from 97.20 at the pre-count to 123 in one week, confirming the natural trend of population growth in the absence of intervention.

Treatments using individual entomopathogenic fungi-*Beauveria bassiana*, *Verticillium lecanii*, and *Metarhizium anisopliae* (Treatments 1–3) — resulted in moderate reductions over time. For example, *B. bassiana* decreased the thrips count from 97.00 pre-treatment to 82.3 after one week. Similarly, employing an herbal soap alone (Treatment 10) led to a notable decline, with thrips counts dropping to 52.9 after one week (Table 1).

Combining treatments improved efficacy further. When *Beauveria* and *Verticillium* were used together with herbal soap (Treatment 4), the thrips numbers decreased to 57.3 at 72 h and further to 51.9 at one week, suggesting that the combination of bioagents with the herbal soap acted as an adjuvant in thrips.

In our trials in Devanahalli, *B. bassiana, M. anisopliae,* and *Verticillium lecanii* were combined for optimal efficacy against *T. parvispinus*. While individual fungi showed promising results, the study confirmed that combining all three entomopathogens was necessary to achieve the desired suppression levels, similar to the findings of Ain *et al.* (2021), where *B. bassiana* proved superior in onion crops. Additionally, our results indicated that conventional insecticides failed to provide effective control, further supporting the need for biocontrol solutions.

Ataide *et al.* (2024) found that chlorfenapyr, sulfoxaflor-spinetoram, and spinosad demonstrated the highest efficacy among conventional insecticides, while mineral oil (3%) and sesame oil were the most effective biorational alternatives. A rotation program integrating these insecticides could mitigate resistance development and enhance pest control outcomes. This approach aligns with sustainable pest management principles, ensuring both efficacy and environmental safety.

Panyasiri *et al.* (2022) identified fungal biocontrol agents as viable and sustainable alternatives to chemical insecticides for controlling *Scirtothrips dorsalis* infestations. Their research highlighted *Beauveria bassiana* BCC48145 as a promising entomopathogenic fungus; however, *Purpureocillium lilacinum* TBRC 10638 demonstrated superior efficacy in thrips suppression, particularly in greenhouse and field trials.

Most remarkably, the integrated treatment comprising *Beauveria*, *Metarhizium*, *Verticillium,* along with herbal soap (Treatment 5) showed a dramatic effect. Starting with a similar baseline of 97.00 thrips, the count dropped sharply to 92.8 at 48 h, fell to 20.5 at 72 h, and reached an exceptionally low 5.2 after one week. This striking reduction, which greatly exceeded the critical difference values at each interval (*e.g.*, CD = 7.74 at one week), highlights the superior efficacy of this integrated approach.

Our results align with Ain *et al.* (2021), who demonstrated that *Beauveria bassiana* can significantly reduce *Thrips tabaci* populations, providing a sustainable and long-term management strategy for onion crops. Their study found that *B. bassiana* exhibited greater toxicity against thrips offspring production compared to *Metarhizium anisopliae* under field conditions. Efficacy trials conducted over two years on three onion varieties confirmed its effectiveness. These findings further support the potential of entomopathogenic fungi as reliable biocontrol agents for managing thrips in commercial onion cultivation.

In contrast, the commercial chemical treatments yielded mixed results. Fluxametamide (Treatment 6) reduced the thrips count to 61.4 at 48 h, though the effect was less pronounced later, showing 63.7 after one week. Other chemical treatments — Thiomethoxam (Treatment 7), Spinetoram (Treatment 8), and the combination of Fipronil with Flonicamid (Treatment 9) — did not perform as effectively as the integrated biocontrol method. In some cases, such as with Thiomethoxam and Spinetoram, the thrips counts either increased or remained high by the one-week mark, indicating limitations in their residual or contact efficacy against the pest. This was expressed by all the farmers cultivating bitter gourd in Dodaballapura, Kolar, South Karnataka in India (Table 1).

Table 1. Efficacy of herbal essential oils liquid soap in combination with entomopathogenic fungi and commercial insecticides on *Thrips parvispinus* on bitter gourd field

(a) *Field A*

S. No.	Treatments	Pre-count	48 H	72 H	1 week
		(Mean No. of thrips in 10 flowers)			
1	*Beauveria bassiana* @ 5 ml/lt	97.00	99.4	77.3	82.3
2	*Verticillium lecanii* @ 5 ml/lt	95.00	96.1	63	75.3
3	*Metarhizium anisopliae*@ 5 ml/lt	93.90	89.8	58	73.7
4	*Beauveria + Verticillium+ Herbal Soap* @ 5 ml/lt	93.90	93.6	57.3	51.9
5	*Beauveria + Metarhizium + Verticillium+ Rashvee Herbal essential oil liquid soap* @ 5 ml/lt	97.00	92.8	20.5	5.2
6	*Fluxametamide* 10 EC 0.8 ml/lt	95.20	61.4	76.8	63.7
7	*Thiomethoxam* 75% 0.5 g/lt	95.40	69.6	87.6	102.5
8	*Spinetoram 11.7% SC @ 1 ml/lt*	95.30	81.8	98.6	106.2
9	*Fipronil 15% + Flonicamid 15%* @ 0.8 g/lt	97.30	86.3	95.5	112.8
10	*Herbal Soap* @ 5ml/lt	97.20	90.7	58.4	52.9
11	*Control*	97.20	105.8	114.6	123
	CD	7.24	16.18	14.35	7.74

p<0.01

(b) Field B

S. No.	Treatments	Pre-count	48 H	72 H	1 week
		(Mean No. of thrips in 10 flowers)			
1	*Beauveria bassiana* @ 5 ml/lt	99.50	103.4	57.4	79.7
2	*Verticillium lecanii* @ 5 ml/lt	98.10	102.3	59.5	76.1
3	*Metarhizium anisopliae* @ 5 ml/lt	98.80	98.8	57	78.3
4	*Beauveria + Verticillium+ Herbal Soap* @ 5 ml/lt	98.10	96.7	51.9	51.9
5	*Beauveria + Metarhizium + Verticillium+ Rashvee Herbal essential oil liquid soap* @ 5ml/lt	99.80	87.9	23.5	5.8
6	*Fluxametamide* 10 EC 0.8 ml/lt	96.70	51.8	56.2	76.8
7	*Thiomethoxam* 75% 0.5 g/lt	99.90	66.7	67.5	104.4
8	*Spinetoram 11.7% SC @ 1 ml/lt*	99.30	71.4	71.9	103.6
9	*Fipronil 15% + Flonicamid 15%* @ 0.8 g/lt	98.40	84.1	88.5	109.6
10	*Herbal Soap* @ 5 ml/lt	96.50	98.8	51.9	49.9
11	*Control*	97.50	104.2	107.3	126.6
	CD	11.47	12.14	13.58	8.63

p<0.01

Field A Observations

The combination of *Beauveria* + *Metarhizium* + *Verticillium* + Herbal Soap exhibited the most significant reduction in thrips populations, dropping from a mean of 97 thrips per 10 flowers to just 5.2 thrips per 10 flowers in one week. The control group showed continuous pest increase, reaching 123 thrips per 10 flowers, indicating the effectiveness of biological control agents compared to untreated conditions.

Field B Observations

A similar trend was observed in Field B, with the *Beauveria* + *Metarhizium* + *Verticillium* + Rashvee Herbal Essential Oil Liquid Soap treatment reducing thrips numbers from 99.8 thrips per 10 flowers to 5.8 thrips per 10 flowers in one week. Chemical insecticides showed fluctuating efficacy, with some leading to pest resurgence.

Conclusion

The results indicated that integrated approach combining *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii*, and Rashvee Herbal Essential Oil Liquid Soap (Treatment 5) was most effective in reducing the thrips population than individual treatments and chemical insecticides. The synergistic action of the herbal soap as adjuvant with entomopathogenic fungal agents resulted in a desirable reduction of thrips from 97.0 to almost 5 thrips per 10 flowers over one week in both the fields, far outperforming both the individual treatments and the chemical insecticides. The significant differences observed (as gauged by the provided CD $p<0.01$ values) confirm the statistical reliability of these findings. The study clearly shows that the herbal soap, as an adjuvant, exhibited synergestic effect with EPF to give good control of thrips and perhaps can be used in control of similar sucking insects.

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