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Efficacy of Different IPM Modules on Onion Thrips (Thrips tabaci) and Their Influence on Predators in Northern India

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Abstract

A field study was conducted during the Rabi seasons of 2020-21 and 2021-22 at the Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), to evaluate the effectiveness of different Integrated Pest Management (IPM) modules against onion thrips, *Thrips tabaci* Lindeman, and their impact on primary natural enemies, particularly spiders and coccinellids, in the onion (*Allium cepa* L.) crop. The experiment was arranged in a randomized block design with five treatments: Farmers' Practice Module (FPM), Bio-intensive Module, Chemi-intensive Module, Adaptable IPM Module, and an untreated control, each replicated four times. Over both years, the Chemi-intensive module significantly reduced *T. tabaci* populations, recording the lowest average number of thrips per plant (10.86), followed by the Adaptable IPM (12.17), Farmers' Practice (15.13), and Bio-intensive (21.83) modules. The untreated control consistently showed the highest thrips population (60.38 per plant). Conversely, natural enemy counts exhibited an opposite trend. The Bio-intensive module and untreated plots supported significantly higher populations of spiders and coccinellids, indicating their relative safety for beneficial arthropods. In contrast, the Chemi-intensive module had the most negative impact on predator populations. These findings suggest that while the Chemi-intensive module offers the most effective thrips control, the Adaptable IPM module provides a more balanced approach by achieving moderate pest suppression with minimal harm to natural enemies. The study emphasizes the importance of adopting environmentally safer pest management practices in onion cultivation to promote sustainable pest control.

Introduction

Onion (*Allium cepa* L.) is an economically vital vegetable crop in India, ranking second in both cultivation area and production. It is also recognized as a traditional nutraceutical and protective food with well documented health benefits (Singh and Khar, 2022). Its productivity is frequently constrained by biotic stresses, notably the onion thrips (*Thrips tabaci* Lindeman). This polyphagous pest damages crops by rasping the leaf surface and sucking sap, resulting in characteristic symptoms such as leaf silvering, curling, and reduced photosynthetic activity (Nault and Hessney, 2010; Boateng et al. 2014; Gill et al. 2015). Severe infestations lead to poor bulb development, lower yields, and reduced market value, with reported losses ranging from 30 to 50 percent depending on climate and crop growth stage (Nault and Shelton, 2010; Nault et al. 2012; Karar et al. 2014).

Chemical control with neonicotinoids, organophosphates, and pyrethroids is widely used for onion thrips management due to their rapid efficacy. However, this reliance has led to significant challenges, including insecticide resistance in *T. tabaci*, pest resurgence, secondary outbreaks, and harm to beneficial natural enemies. Moreover, the accumulation of pesticide residues contributes to soil and water contamination, raising serious environmental and health concerns (Shelton et al. 2003; Morse and Hoddle, 2006; Mishra et al. 2017; Shah, 2020; Rani et al. 2021). The addition of surfactants improves spray deposition and significantly enhances thrips control and crop performance in onion (Gangwar et al. 2016).

Integrated Pest Management (IPM) combines ecological strategies, using bio-intensive modules with botanicals and adaptable modules with selective chemicals, for sustainable pest control that safeguards beneficial species and environmental health. However, field evaluations in Indian onion cultivation remain limited, particularly those assessing both pest suppression and the conservation of key natural enemies like spiders and coccinellids (Nathan et al. 2004; Halingali, 2019).

MATERIALS AND METHODS

Field experiments were conducted during the Rabi seasons of 2020-21 and 2021-22 at the Vegetable Research Centre, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand. The soil was sandy loam with a pH of 6.8. The site experiences a sub-humid subtropical climate, with an average annual rainfall of 2382 mm, summer temperatures reaching up to 46°C, and winter temperatures dropping as low as 2°C.

The experiment was conducted using a Randomized Block Design (RBD) with five treatments and four replications. The treatments included:

M1 - Farmers' Practice Module: This involved four rotational foliar sprays administered at 10-day intervals when the thrips population exceeded the Economic Threshold Level (ETL) of 20-30 thrips per plant. The sprays consisted of Imidacloprid 17.8 SL @ 25 gm *a.i.*/ha (1 ml/2.5 L) and Dimethoate 30 EC @ 200 gm *a.i.*/ha (1 ml/L).

M2 - Bio-intensive Module: This treatment began with a soil application of Neem cake at 250 kg/ha during transplanting. Following this, foliar sprays were applied at ETL and subsequently at 10-day intervals. The sprays included *Pseudomonas fluorescens* 1.0% WP @ 5 kg/ha (5 gm/L), Azadirachtin 1500 ppm @ 2 L/ha (3 ml/L), Jeevamruta @ 8 L/ha (20 ml/L), and *Lecanicillium lecanii* (2 x 10^8 CFU/gm) @ 1 kg/ha (2 gm/L).

M3 - Chemi-intensive Module: This module started with a foliar spray of Lambda-cyhalothrin 5 EC @ 15 gm *a.i.*/ha (1 ml/L) at ETL. This was followed by sprays of Chlorpyriphos 20 EC @ 200 gm *a.i.*/ha (2 ml/L), Flonicamid 50% WG @ 75 gm *a.i.*/ha (0.25 g/L), and Acetamiprid 20% SP @ 15 gm *a.i.*/ha (0.3 g/L) at 10-day intervals.

M4 - Adaptable IPM (AIPM) Module: This integrated approach combined a soil application of neem cake @ 250 kg/ha at transplanting with foliar sprays. At ETL, *Pseudomonas fluorescens* 1.0% WP @ 5 kg/ha (5 gm/L) was applied. Subsequent sprays at 10-day intervals included Lambda-cyhalothrin 5 EC @ 15 gm *a.i.*/ha (1 ml/L), *Lecanicillium lecanii* (2 x 10^8 CFU/gm) @ 1 kg/ha (2 gm/L), and Flonicamid 50% WG @ 75 gm *a.i.*/ha (0.25 g/L).

M5 - Untreated Control: This plot received only water spray.

Each plot measured 5 m × 4 m. The onion variety Agrifound Light Red was raised in a nursery and transplanted 30 days after sowing at a spacing of 20 × 15 cm. A recommended dose of 15 t/ha FYM, 75

kg N, 40 kg P_2O_5, and 40 kg K_2O was applied. Half of the nitrogen and the full doses of phosphorus and potassium were applied as basal fertilizers, with the remaining nitrogen top-dressed at 30 days after transplanting (DAT). Irrigation and weeding were performed as needed.

Foliar sprays were applied using a knapsack sprayer when the thrips population exceeded the economic threshold level (ETL). Four sprays were administered at 10-day intervals. In the bio-intensive module, Jeevamruta was prepared by mixing cow dung (500 g), cow urine (500 ml), jaggery (100 g), and gram flour (100 g) in 10 liters of water and fermenting the mixture for 48 hours.

Observations

Thrips Population

Observations of *T. tabaci* (both larvae and adults) were recorded visually from ten randomly selected onion plants per plot using a 4× magnifying lens. A pre-treatment count was taken before each spray. Post-treatment observations were conducted on the 3^{rd}, 7^{th}, and 10^{th} days after each spray. The count on the 10^{th} day served as the pre-treatment count for the subsequent application.

Natural Enemies

Populations of key natural enemies, including spiders and coccinellid beetles, were recorded from the same ten randomly selected plants in each plot. These observations were made 10 days after each spray to assess the impact of the treatments on beneficial natural enemies.

RESULTS AND DISCUSSION

Efficacy of IPM Modules Against *Thrips tabaci*

All treatments significantly reduced thrips populations compared to the untreated control, with consistent performance trends observed across both years (Tables 1 and 2; Figures 1 and 2). During 2020-21, pre-treatment thrips populations ranged from 22.95 to 25.10 per plant. After the first spray, the chemi-intensive module (M3) recorded the lowest thrips population (4.25 per plant at 3 days after spraying [DAS]), followed by the adaptable IPM module (M4, 6.95 per plant) and the farmer's practice module (M1, 7.40 per plant). The bio-intensive module (M2) showed moderate suppression (10.85 per plant), while the untreated control plot recorded the highest population (34.30 per plant). This trend continued across subsequent sprays. Representative pest stages, feeding symptoms and predator activity are illustrated in Supplementary Figures S3-S5 (online only).

The overall mean thrips population during 2020-21 was lowest in M3 (16.13 per plant), followed by M4 (18.71), M1 (19.02), and M2 (20.55), while the untreated control exhibited a significantly higher mean population of 72.15 thrips per plant (Table 1; Figure 1).

Similarly, in 2021-22, M3 again provided the best control, with thrips populations decreasing from 5.65 to 3.10 per plant across sprays. M4 and M1 followed in efficacy, while M2 remained moderately effective. The control plots showed a progressive increase, reaching 140.60 thrips per plant at the final spray. The overall means were: M3 (10.86) < M4 (12.17) < M1 (15.13) < M2 (21.83) < Control (60.38) (Table 2; Figure 2).

These findings align with recent literature on chemical-intensive strategies for onion thrips management. Saw *et al*. (2025) found an integrated chemical module most effective, recording the lowest thrips population (4.11 mean thrips/3 leaves/plant), a result statistically similar to a standalone chemical module (4.53). This supports earlier studies where chemical-based IPM modules provided superior thrips suppression compared to conventional practices (Kumar et al. 2022; Dwivedi et al. 2017; Tripathy et al. 2014).

The reliable knockdown effect of synthetic insecticides is underscored by specific efficacy data. Against *Thrips palmi*, profenofos and spinetoram are highly effective, with fipronil and cypermethrin also providing strong suppression, whereas flonicamid and buprofezin are less effective (Rao et al. 2022). This efficacy can be enhanced by improving spray coverage on onion foliage using surfactants with insecticides (Gangwar et al. 2016).

Influence of IPM Modules on Natural Enemies

Populations of spiders and coccinellids were recorded to assess the ecological impact of each module (Tables 3 and 4; Supplementary Tables S1-S2; Supplementary Figures S1-S2). The bio-intensive module (M2) and the untreated control supported significantly higher densities of natural enemies throughout both years. For instance, in 2020-21, the highest spider population at 55 DAT was observed in M2 (1.60 per plant), followed by the control (1.90 per plant), while the lowest was in M3 (0.55 per plant). A similar pattern was recorded for coccinellids, with the control and M2 showing 1.00 and 1.70 per plant, respectively (Table S1 and Figure S1).

In 2021-22, M2 again recorded the highest populations of spiders (1.70 per plant) and coccinellids (1.30 per plant). In contrast, M3 consistently recorded the lowest numbers, followed by M4 (Table 4 and Supplementary Table S2; Supplementary Figure S2). These results indicate that bio-intensive strategies better conserve predator populations. This aligns with the recent finding by Saw et al. (2025) that a bio-intensive module in chilli maximized the survival of predatory coccinellid grubs. This pattern supports earlier work by Halingali (2019), Yadav et al. (2017), Sharma et al. (2017), and Sardana et al. (2006), who collectively reported that botanical and organic inputs help maintain ecological balance by enhancing natural enemy activity.

Detailed year-wise data on coccinellid populations and additional graphical representations of predator dynamics are provided as Supplementary Tables S1-S2 and Supplementary Figures S1-S2 (online only).

Although the chemi-intensive module (M3) provided the most effective suppression of *T. tabaci*, its adverse impact on natural enemies raises concerns about long-term sustainability. The bio-intensive module (M2), while moderately effective against thrips, was clearly superior in conserving beneficial arthropods. The adaptable IPM module (M4), which integrates selective chemical use with biological and cultural practices, emerged as a balanced strategy by achieving acceptable pest suppression with minimal harm to natural enemies.

These findings highlight the importance of integrating pest control efficacy with ecological safety. IPM approaches that promote natural enemy conservation help maintain biological control, reduce reliance on chemical insecticides, and delay resistance development (Kogan, 1998; Furlong et al. 2013; Tabashnik et al. 2013). Selective insecticides combined with botanicals and conservation biological control, as demonstrated in the adaptable IPM module, can stabilize predator-prey dynamics and minimize ecological disruption (Kumar et al. 2023; Saw et al. 2025).

The study showed that integrated pest management modules differed markedly in their ability to suppress onion thrips while conserving beneficial arthropods. The chemi-intensive module achieved the highest pest reduction but caused substantial decline in predator populations. The bio-intensive module conserved natural enemies most effectively, although pest control was moderate. The adaptable module provided the best balance between thrips suppression and ecological safety. These findings emphasize the need to integrate selective insecticides with biological and cultural practices for sustainable onion production and reduced dependence on chemicals.

Declarations

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Author Contribution Statement R.M. conceptualized and designed the study. S.S. conducted the experiments, analyzed the data, and wrote the manuscript. S.N. assisted with manuscript drafting and preparation. The research article was read and approved by all authors.

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Data availability Data are available on request by the authors.

Competing Interests The authors declare that they have no financial or proprietary interests in any of the materials discussed in this article.

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Figures

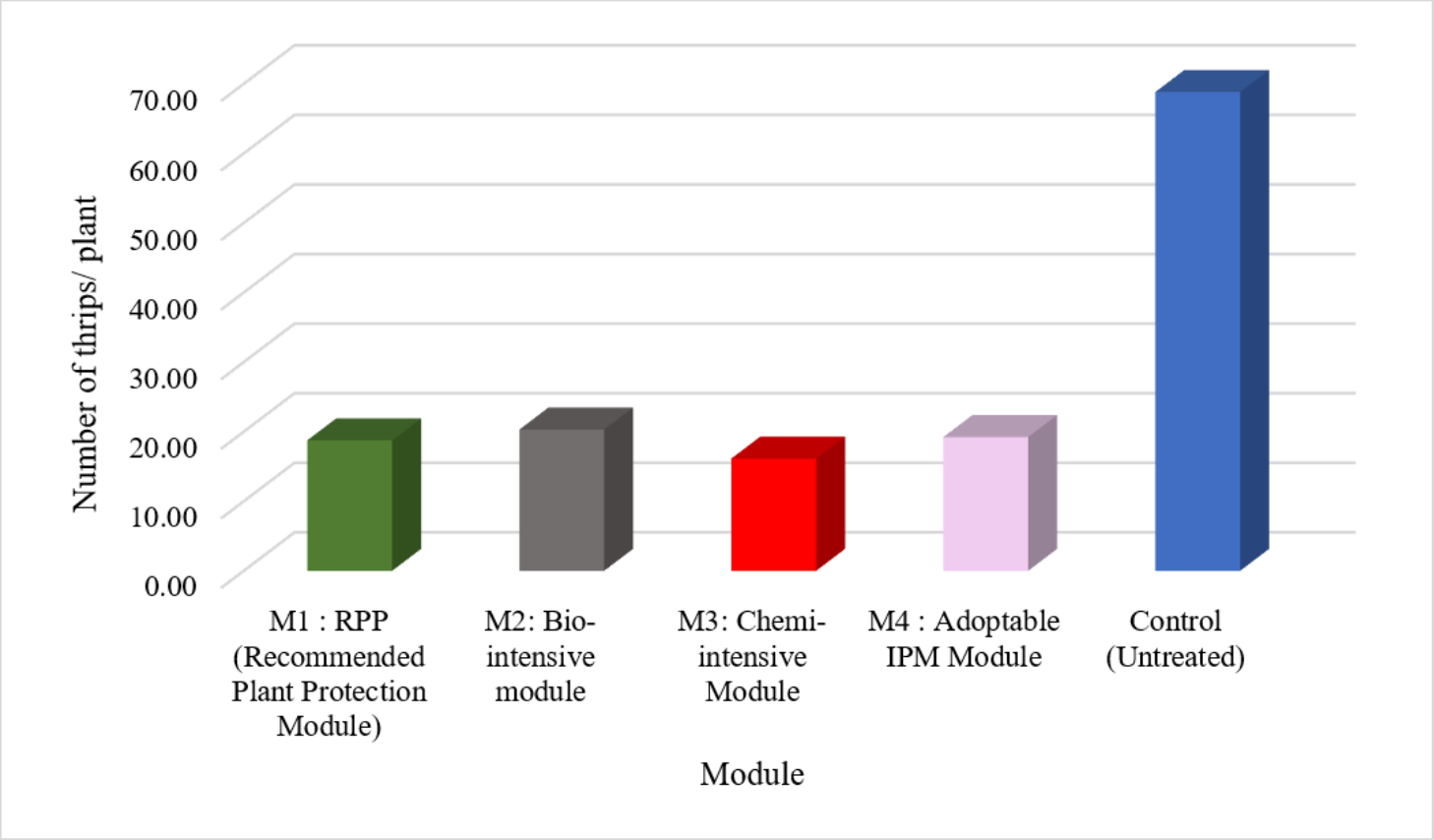


Figure 1

Thrips population dynamics under different modules, 2020-21.

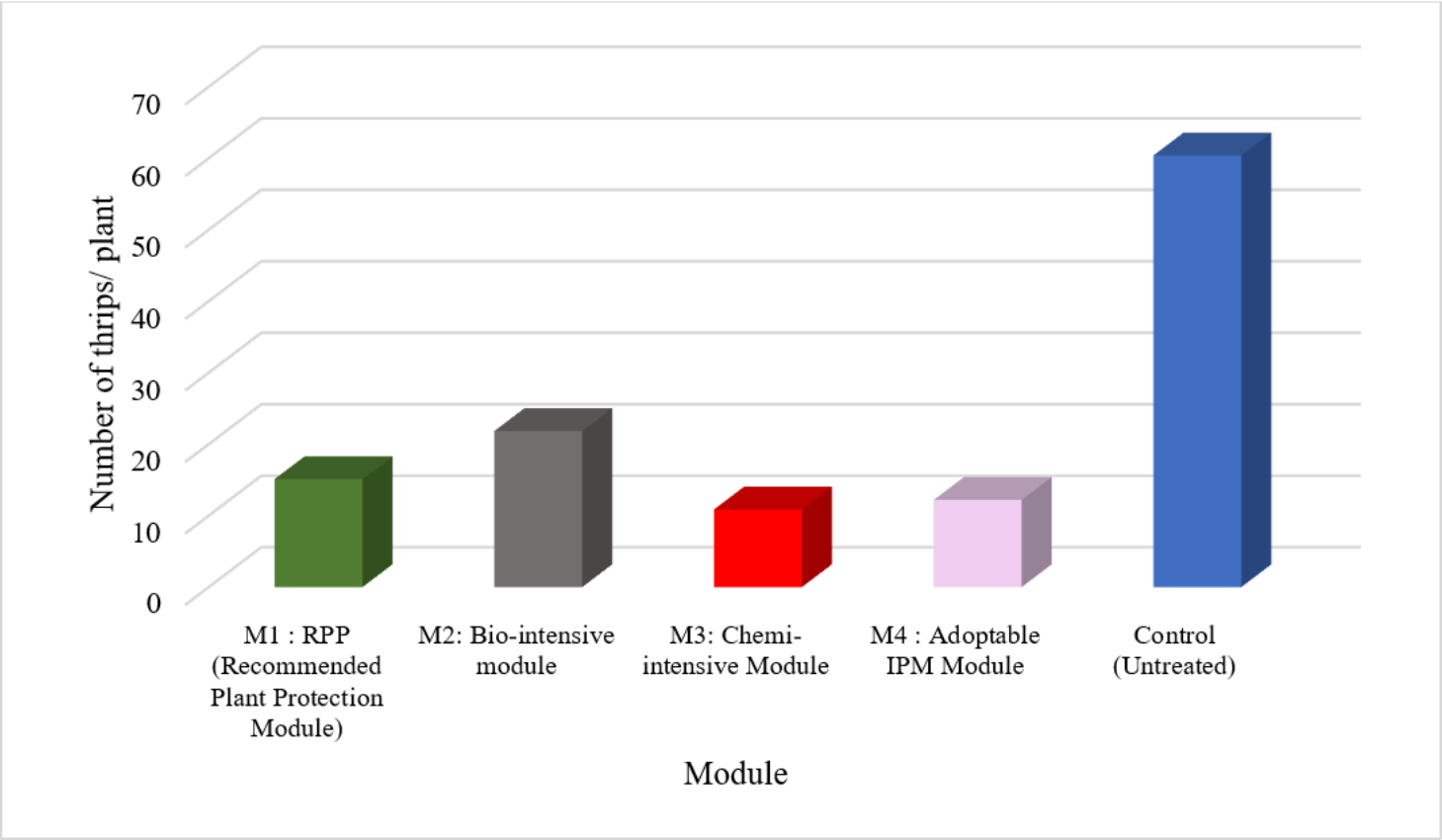


Figure 2

Thrips population dynamics under different modules, 2021-2022.

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