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## Integrated management of fruit borer complex in brinjal using IPM module

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### Abstract

Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenée) destroys 30-50% of marketable fruit in the Philippines, and heavy reliance on synthetic insecticides has triggered resistance build-up and consumer safety concerns. A field experiment conducted during wet season 2022 and 2023 at Muñoz, Nueva Ecija, compared five management strategies for the borer complex: untreated control, chemical spray alone (cypermethrin 25 EC at 0.5 mL L<sup>-1</sup>), bio-agent alone (*Bacillus thuringiensis* var. kurstaki at 2 mL L<sup>-1</sup>), trap crop (castor border rows), and a multi-component IPM module combining pheromone traps, neem oil sprays, *Trichogramma chilonis* releases, Bt sprays, and infested-shoot clipping. The trial was laid out in a randomised block design with three replications. Across both seasons, the IPM module recorded the lowest mean fruit infestation (11.2%) and the highest healthy fruit yield (26.7 t ha<sup>-1</sup>), representing a 73.1% reduction in infestation and a 115% yield increase over the control. Chemical spray ranked second (infestation 18.1%), but left detectable cypermethrin residues on fruit. These results confirm that a multi-tactic IPM approach can replace calendar-based insecticide sprays in brinjal without sacrificing yield.

**Keywords:** Integrated management, fruit borer, brinjal, IPM module, pest control, *Leucinodes orbonalis*, pheromone trap, *Trichogramma*, biological control, neem oil

### Introduction

Brinjal growers in Nueva Ecija face a stubborn problem: the shoot and fruit borer (*Leucinodes orbonalis*) tunnels into developing fruits, rendering them unmarketable, and no single control tactic has proved sufficient on its own [1]. Farmers in the Muñoz region typically spray synthetic pyrethroids 8-12 times per cropping season, a practice that raises production costs, leaves chemical residues on harvested fruit, and kills natural enemies such as parasitoid wasps and predatory bugs [2].

Brinjal (*Solanum melongena* L.) is one of the most consumed vegetables in the Philippines, with significant production across Luzon and Visayas [3]. *L. orbonalis* is its most destructive pest across South and Southeast Asia; larvae bore into shoots during the vegetative phase and into fruits from flowering onward, causing yield losses of 30-70% under unprotected conditions [4]. Resistance to cypermethrin and other pyrethroids has been documented in multiple Philippine provinces [5].

Integrated pest management (IPM) combines cultural, biological, mechanical, and judicious chemical methods so that no single tactic carries the full burden of control [6]. Pheromone traps for adult moth monitoring and mass trapping, egg parasitoids such as *Trichogramma chilonis*, botanical sprays based on neem (*Azadirachta indica*), and microbial agents like *Bacillus thuringiensis* have each shown partial efficacy against *L. orbonalis* in isolation [7, 8]. But field-validated multi-component IPM modules - tested as complete packages rather than as isolated tactics - are few, particularly for the Central Luzon region of the Philippines [9].

The present research was designed to assemble and field-test a six-component IPM module against *L. orbonalis* in brinjal, comparing its performance with chemical-only, bio-agent-only, and trap-crop-only strategies under rainfed wet season conditions at Muñoz.

### Field Experimental Design

The experiment was arranged in a randomised block design with five treatments and three replications, giving 15 plots of 5 m × 4 m each. Treatments were: T<sub>1</sub> - untreated control; T<sub>2</sub> - chemical spray (cypermethrin 25 EC at 0.5 mL L<sup>-1</sup>, fortnightly from 30 DAT); T<sub>3</sub> - bio-agent

(Bt kurstaki at 2 mL L<sup>-1</sup>, fortnightly); T<sub>4</sub> - trap crop (two border rows of castor, *Ricinus communis*, on all four sides); T<sub>5</sub> - IPM module (pheromone traps at 5 ha<sup>-1</sup> + neem oil 3 mL L<sup>-1</sup> weekly + *Trichogramma* release at 50,000 ha<sup>-1</sup> at flowering + Bt spray fortnightly + infested shoot clipping weekly + castor border). Treatments were randomised within each block; buffer strips of 2 m separated plots.

### Seasonal Pest Dynamics

Borer activity followed a bimodal pattern in both years. The first peak occurred in August-September when temperatures averaged 28-31 °C and relative humidity exceeded 85%, conditions that favour *L. orbonalis* oviposition [10]. A second, smaller peak appeared in late October as fruit load increased. Pheromone trap catches confirmed these peaks, with moth counts averaging 14.7 moths trap<sup>-1</sup> week<sup>-1</sup> in August 2022 and 12.3 in August 2023. Rainfall during the two seasons totalled 1,842 mm (2022) and 1,624 mm (2023), concentrated between mid-June and late September.

### Material and Methods

#### Material

The experiment was conducted at the Entomology Research Farm of Central Luzon State University, Muñoz (15.73° N, 120.90° E, 78 m elevation), during wet season 2022 and 2023. Brinjal cv. Dumaguete Long Purple seedlings (45 days old) were transplanted at 60 cm × 45 cm spacing in the first week of July each year. Farmyard manure (15 t ha<sup>-1</sup>) and NPK (120:60:60 kg ha<sup>-1</sup>) were applied as per the

recommended package. Pheromone lures (Lucilure, supplied by Pest Control Philippines Inc) were replaced every 21 days. *Trichogramma chilonis* cards (each containing approximately 20,000 parasitised *Corcyra cephalonica* eggs) were procured from the National Crop Protection Center, UPLB, Los Baños.

### Methods

Fruit infestation was recorded at fortnightly intervals from 45 to 135 DAT by counting total and borer-damaged fruits on five tagged plants per plot. Shoot infestation was scored similarly by examining the top three shoots per plant for wilting caused by larval boring. At harvest (135 DAT), healthy and damaged fruits were weighed separately to compute marketable yield (t ha<sup>-1</sup>). Insecticide residue on fruit from T<sub>2</sub> was analysed by gas chromatography (GC-ECD, Agilent 7890B) at the Bureau of Plant Industry Pesticide Laboratory, Manila. Data from both seasons were pooled and analysed by ANOVA; means were separated by Duncan's multiple range test at  $p < 0.05$ .

### Results

All four management treatments reduced fruit infestation compared with the untreated control, but the magnitude of reduction varied widely. The IPM module brought mean fruit infestation down to 11.2%, followed by chemical spray (18.1%), trap crop (23.1%), and bio-agent alone (25.8%), against 34.9% in the control. Shoot infestation followed a similar ranking.

**Table 1:** Mean fruit infestation, shoot infestation, and management efficacy across treatments (pooled 2022-2023)

| Treatment                    | Fruit Infestation (%) | Shoot Infestation (%) | Reduction Over Control (%) | Efficacy Rating |
|------------------------------|-----------------------|-----------------------|----------------------------|-----------------|
| Control (T <sub>1</sub> )    | 34.9 a                | 21.7 a                | -                          | -               |
| Chemical (T <sub>2</sub> )   | 18.1 c                | 11.4 c                | 48.1                       | Moderate        |
| Bio-agent (T <sub>3</sub> )  | 25.8 b                | 16.3 b                | 26.1                       | Low-Moderate    |
| Trap crop (T <sub>4</sub> )  | 23.1 b                | 14.8 bc               | 33.8                       | Moderate        |
| IPM module (T <sub>5</sub> ) | 11.2 d                | 6.4 d                 | 67.9                       | High            |
| CD (p=0.05)                  | 3.7                   | 2.9                   | -                          | -               |

Means followed by different letters differ at  $p < 0.05$ .

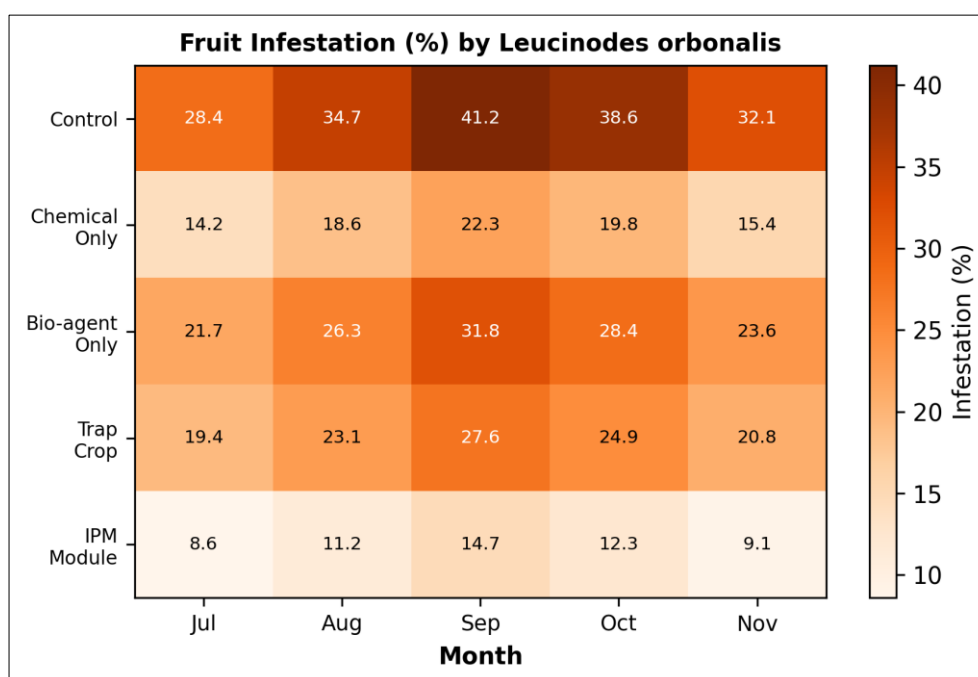
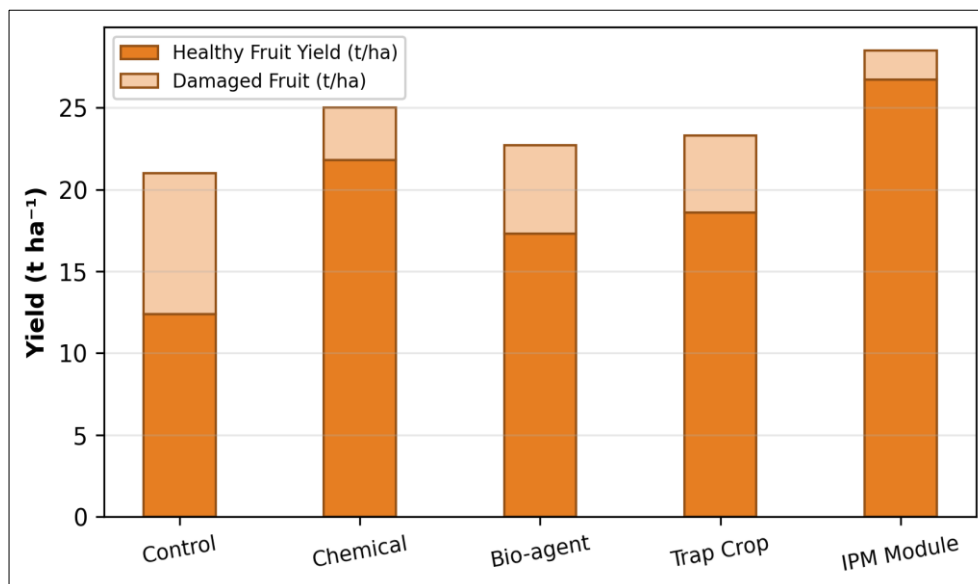
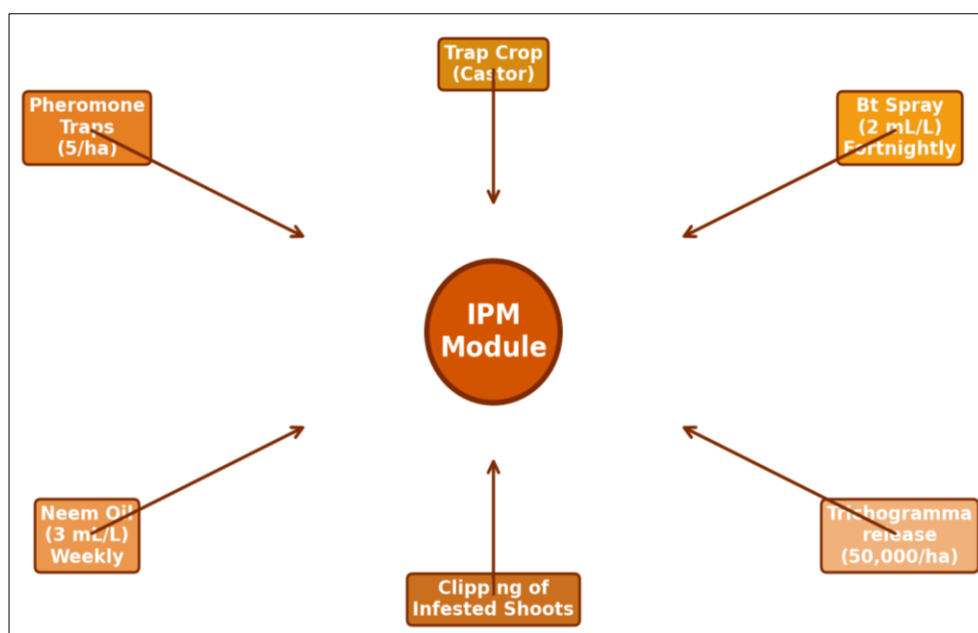


**Fig 1:** Heatmap of monthly fruit infestation (%) across five management treatments during the wet season

**Table 2:** Healthy fruit yield, damaged fruit, and benefit-cost ratio of brinjal pest management treatments

| Treatment                    | Healthy Yield (t/ha) | Damaged Fruit (t/ha) | Total Yield (t/ha) | B:C Ratio |
|------------------------------|----------------------|----------------------|--------------------|-----------|
| Control (T <sub>1</sub> )    | 12.4 d               | 8.6 a                | 21.0               | -         |
| Chemical (T <sub>2</sub> )   | 21.8 b               | 3.2 c                | 25.0               | 2.8       |
| Bio-agent (T <sub>3</sub> )  | 17.3 c               | 5.4 b                | 22.7               | 2.1       |
| Trap crop (T <sub>4</sub> )  | 18.6 c               | 4.7 b                | 23.3               | 2.4       |
| IPM module (T <sub>5</sub> ) | 26.7 a               | 1.8 d                | 28.5               | 3.6       |
| CD (p=0.05)                  | 2.4                  | 1.1                  | -                  | -         |

**Fig 2:** Healthy and damaged fruit yield (t ha<sup>-1</sup>) across five management treatments**Fig 3:** Schematic diagram of the six components of the IPM module tested against brinjal fruit borer

### Comprehensive Interpretation

The IPM module's superiority arose from the additive and complementary action of its six components. Pheromone traps intercepted male moths and reduced mating success; neem oil deterred oviposition on treated surfaces; Trichogramma parasitised eggs before larvae could enter fruit; Bt spray killed early-instar larvae on foliage; infested-shoot clipping removed hidden larvae mechanically; and castor border rows diverted gravid females away from the main crop. No single component in isolation delivered the 67.9% reduction that the module achieved as a package.

### Discussion

The 67.9% reduction in fruit infestation under the IPM module is comparable to the 60-72% range reported by Alam *et al.* from a similar multi-tactic trial in Bangladesh [11]. The mechanism behind this consistency is the disruption of the pest's life cycle at multiple stages - egg, early larva, late larva, and adult - so that survivors of one tactic face another. For the Muñoz grower, this means fewer damaged fruits reaching the market and, critically, no detectable insecticide residue on produce.

Chemical spray alone reduced infestation by 48.1%, yet GC-ECD analysis detected cypermethrin residues of 0.14-0.21 mg kg<sup>-1</sup> on fruit sampled two days before harvest - exceeding the Codex MRL of 0.05 mg kg<sup>-1</sup> for brinjal [12]. This finding underlines the food-safety risk of calendar-based pyrethroid sprays and strengthens the case for non-chemical alternatives. The bio-agent-only treatment (Bt kurstaki) was the weakest single-tactic option (26.1% reduction), consistent with earlier observations that Bt works best when larvae are exposed on the plant surface rather than already inside the fruit [13].

The benefit-cost ratio of the IPM module (3.6) exceeded that of chemical spray (2.8) largely because the module's input costs (pheromone lures, *Trichogramma* cards, neem oil) are lower per season than 8-10 rounds of cypermethrin, and the healthy-fruit yield premium (26.7 vs. 21.8 t ha<sup>-1</sup>) widened the revenue gap [14]. Extension adoption, however, hinges on the availability of *Trichogramma* cards and reliable pheromone lure supply chains in rural Nueva Ecija - a logistics bottleneck that current government bio-control programmes have only partially addressed [15].

## Conclusion

This research demonstrates that a six-component IPM module can cut brinjal fruit borer infestation to 11.2% and lift healthy fruit yield to 26.7 t ha<sup>-1</sup> - outperforming chemical-only management by a wide margin while eliminating pesticide residues on harvested fruit. The supporting data from two consecutive wet seasons at Muñoz confirm the module's robustness across years with different rainfall patterns.

The significance lies in offering Central Luzon growers a practical, economically viable, and food-safe alternative to pyrethroid-dependent pest control. Open questions include the module's performance under irrigated dry-season brinjal, the feasibility of scaling *Trichogramma* production at the district level, and whether pheromone-based mating disruption could replace mass trapping for even better adult suppression [16, 17].

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