



Comparative Study on the Efficiency of Pheromone Traps, *Trichogramma* cards and Bio control Methods for Managing Sugarcane Top Borer and Stem Borer.

Muhammad Moanum Khan^{1*}, Sohaib Abbas², Ali Hassan³, Dilawar Aslam⁴, Izhar ul Haq Awan⁵, Khadija Ahmad⁶

¹Department of Agriculture engineering University of agriculture Faisalabad, Faisalabad 38000, Pakistan

²Department of Agronomy, Faculty of Agriculture and Environment, The Islamia University of Bahawalpur, Bahawalpur 63100, Pakistan

³Department of Agriculture engineering University of agriculture Faisalabad, Faisalabad 38000, Pakistan

⁴Department of Plant Breeding & Genetics University of agriculture Faisalabad, Faisalabad 38000, Pakistan

⁵PepsiCo International, Lahore, Pakistan

⁶AgNovate Consulting pvt Ltd, Lahore, Pakistan

Corresponding Author: Muhammad Moanum Khan uafmoanumkhan@gmail.com Department of Agriculture engineering, University of agriculture Faisalabad, Faisalabad 38000, Pakistan

Abstract

Sugarcane is an important cash crop in the tropics and subtropics, but its production is threatened badly by lepidopteran borers, most notably the stem and top borer. Traditional use of broad spectrum insecticides has raised issues on environment pollution, health risks, and the development of resistance. This research was carried out to assess the usefulness of pheromone trapping along with biological control using *Trichogramma chilonis* in three different areas of Chiniot district, Punjab, Pakistan in the field condition. To preserve the integrity of the experiment, randomized complete block design (RCBD) was applied with four treatments, which are pheromone traps, *Trichogramma* cards, agrochemical spray as well as untreated control. Monitoring once a week showed a high decrease in pest percentages all treatments except untreated control. The level of injuries to the plants linked to borers was lower in fields where bio control was used and significantly higher still in case of pesticide use, whose temporal effects proved to be temporary only, with the rise in the number of pests still evident. Entomological surveys done in non-target insects showed only slight collateral effect had occurred in bio control plots as compared to that in fields that were chemically treated. Yield data revealed that biological and pheromone strategy could sustain yield up to 28 to 29 ton/acre similar to chemical controls. In general, a combination of pheromone monitoring and releases of *T. chilonis* is an ecologically sustainable, Bonsucro-compliant solution to pest management that both minimizes the usage of hazardous chemicals and guarantees sustainable and environmentally safe sugarcane production.

Keywords Sugarcane borers, Pheromone traps, *Trichogramma chilonis*, Integrated Pest Management

Introduction

Sugarcane (*Saccharum spp.*) is a staple cash crop in the tropics and subtropics supporting livelihoods and national economies through sugar, bioethanol and variety of byproducts. Its productivity and profitability are however persistently endangered by a medley of lepidopteran borers, with the top borer *Scirpophaga excerptalis* and the stem borer *Chilo auricilius* being among the worst offenders in South and Southeast Asia. These pests cut the millable cane volume, affect juice quality, and fatten the sugar recovery losses which penetrate mills and markets (Li et al., 2024). In contrast, their cryptic larval behavior within leaf and stem tissues impairs the effectiveness of contact insecticides and slow the time to control (Achiri et al., 2022). In the traditional managements of cane belts, the use of frequent insecticides with a broad spectrum had been the main aspect of management. Though these inputs might have short term

suppressive effects, they have severe side effects namely exposure hazards by farm workers, pollution of soil and water bodies, non-specific actions on natural enemies, and the selection pressure that results in resistance development in target pests (Wan et al., 2025). Meanwhile, occupational health research records elevated risk to the cane workers who are exposed to pesticides further increasing the need to have transition pathways that can aid in reduction of hazardous inputs (Pathak et al., 2022). In this context Bonsucro have set out expectations on the responsible management of pest. The Bonsucro production standard v5.2 coming into operation December 2023 insists on an Integrated Pest Management (IPM) program designed to prevent pests, monitor, and reduce the use of hazardous agricultural chemicals (Bonsucro, 2023). The two relevant pillars of IPM that deserve special consideration are *S. excerptalis* and *C.*

auricilius complex which act semiochemical tools and biological control. To start with, pheromone based approaches provide a residue free and species specific suppression. In *Chilo spp.* its sex pheromone components are well known and field deployable, so growers can follow their flight phenology very carefully, and implement them as needed (Sithanantham and Prabakaran, 2020).

Augmentative biological control with parasitoid wasps aims at addressing the weakest periods of development of cane borers. Ovipositor success of top and stem borers can be suppressed by inundated release of egg parasitoids such as *Trichogramma chilonis*, its application has already spread throughout Asian cropping systems and new technologies are emerging that can enhance field efficacy (Pawar et al., 2023). Mass action farmer participatory schemes illustrate that synchronized releases of *Trichogramma spp.* and *C. flavipes*, along with scouting and cultural controls, can be used to reduce borer damage and produce beneficial cost effective ratios associated with the use of a normal spraying program. Keeping into view all above mentioned current work is designed with objective to evaluate effectiveness of pheromone traps along with bio-control agents including *Trichogramma chilonis* and *Cotesia flavipes*. A comparison was drawn to access the pest reduction and expected yield recovery with strictly adhere to Bonsucro-compliant pest management strategy.

Material and methodology

Treatment plan

Standardized bio control technology like pheromone traps and trichogramma cards in terms of dose, timing and frequency of release was validated at large scale under field conditions of farmers over a period of 5 weeks. The trials were carried out in safina sugarcane farms in various tehsils of Chionoit district i.e., Ahmad Nagar, Lalian and Sangra in Punjab, Pakistan, having suitable agro-climatic conditions for cultivating sugarcane. Block of four acre in each designated area was used to design the research work;

Treatment 1: Pheromone traps

Treatment 2: Trichogramma cards

Treatment 3: Untreated control

Treatment 4: Agro-chemical pest

Each treatment was applied to an acre (plot) in various areas where pheromone traps were separately used for stem borer and top borer while *Trichogramma chilonis* is used for trichogramma cards which is the only viable option to bio-control plot compared to untreated or agro-chemical spray controlled plot. Already synthesized *Trichogramma chilonis*

was taken from National Institute of Biotechnology and Genetics Engineering (NIBGE), Faisalabad. Pheromone traps were built with a plastic container, holes cut to make it possible to enter the trap, a soapy water solution is added so the trapped insects cannot escape, and a pheromone lure is placed in the trap, where it will attract insects. In Trichogramma cards treatment, the strips containing approximately 500 parasitized eggs were divided into strips of 100 and uniformly stapled to the underside of the leaves at 50 spots per acre in the evening's hours. Isolation was made with a distance of approximately 50 m between treated and untreated fields to rule out any risk among treatments in the fields.

Pest prevalence

The biocontrol (pheromone traps and trichogramma cards), untreated control fields and agro-chemical pest spray field were collectively called as block. Pest incidence for bio-control, untreated and spray treated were visualized each week. Non-destructive visual estimation of plant was determined as percent by pest scouting in each plot. Non-target insect survey was also estimated quantitatively. Cane yield estimation was calculated in bio-control, uncontrolled and pesticide spray controlled plot.

Statistical analysis

The results related to bio-control, untreated control and treated spray were analyzed through the analysis of variance (ANOVA), using the randomized complete block design (RCBD) in statistics 8.1 software to make a comparison of the treatment used in the separate fields. Two factor factorial RCBD was applied to data obtained from pheromone traps. Treatment means were compared by tukey's highest significant difference test (HSD) at P value 0.05 (Gomez and Gomez, 1984). Data was subjected to origin 2021 software to generate figures.

Results

Pest incidence in sugarcane field

Pheromone traps clearly reveals weekly population fluctuations of the stem borers and the top borers as exhibited in figure 1. Among all stem borer weekly data collected from Lalian gives highest stem borer incidence in pheromone trap/field (11) followed by Ahmad Nagar and Sangra which gives 9 stem borer traps per week. Among top borer highest pest incidence/field per week was given by Ahmad Nagar (7), followed by Sangra (6) and Lalian (5). Significant variation in stem and top borer weekly data was recorded which was demonstrated by line on the bar chart.

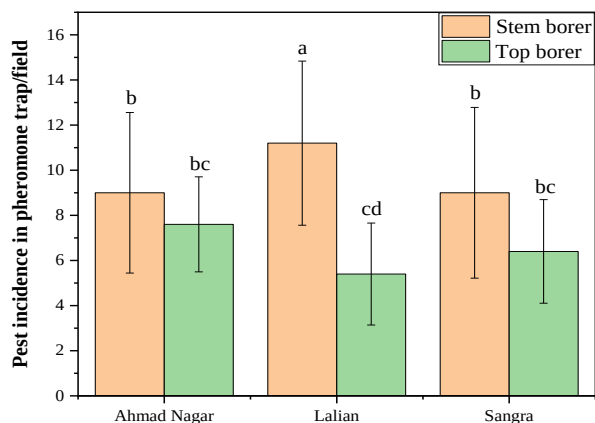


Figure 1. Indicates weekly stem borer and top borer data in pheromone traps

A steady decline in population of the both stem and top borers was observed aimed trichogramma cards releases in three selected sites from Chiniot (Figure 2). Monitoring conducted on a weekly basis demonstrated that the activity of the parasitoids was associated with a depreciated pest population especially during maximum infestations. Weekly trichogramma cards data reveals that pest control was up to 5 after installation of cards from Ahmad Nagar and Sangra while only 3 was recorded in Lalian. Line present at the top of bar chart at Ahmad Nagar represents significant variation among weekly collected data as given in figure 2.

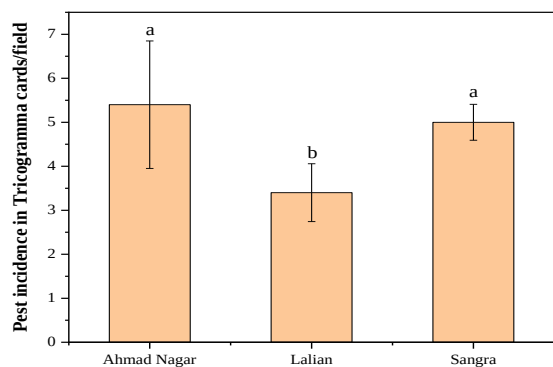


Figure 2. Weekly pest control data by using trichogramma cards from three locations of district Chiniot

Joint pest incidence records for Ahmad Nagar, Lalian and Sangra showed differences as per location given in figure 3. Data illustrated in figure 3 describes highest pest incidence in Sangra followed by Ahmad Nagar and Lalian. Highest pest incidence in all locations of district Chiniot is due to controlled condition.

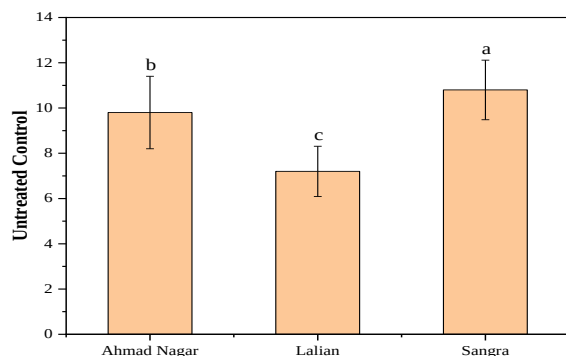


Figure 3. Weekly pest data (stem borer & top borer) from three locations of district Chiniot

Significant decline in sugarcane borer was observed after foliar application of pesticide as given in figure 4. Average pest incidence was recorded in Ahmad nagar field area followed by Sangra. Lalian gives least pest incidence which is 3 pest per week after spray

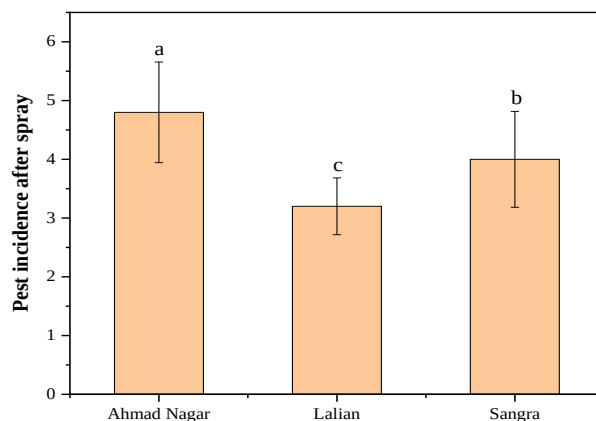


Figure 4. Weekly pest incidences after pesticide application

Non-destructive visual estimation of sugarcane

Visual analysis of sugarcane stalks which does not affected by stem and top borer exhibit significant differences between treatments. The consequences are that pheromone traps and trichogramma card managed fields exhibited significantly less percentage of borer induce damages in comparison with untreated control and chemically induced pesticide applied field as given in figure 5.

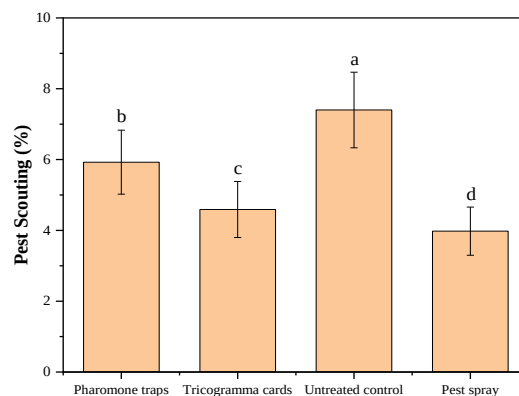


Figure5. Non-destructive visual estimation of sugarcane damage by stem and top borer by applying various techniques

Weekly pest scouting

Field scouting confirmed significant variation in pest management practices. Higher pest numbers were recorded in untreated control in relation to pheromone traps and trichogramma cards which recorded the least pest counts. Pesticide sprays on the other hand temporarily suppressed the pests but with the passage of time gain resurgence after a few weeks indicating poor sustainability of chemical dependency. There has been a long term usefulness of the biological and integrated methods as compared to the

conventional spraying using these trends as given in figure 6.

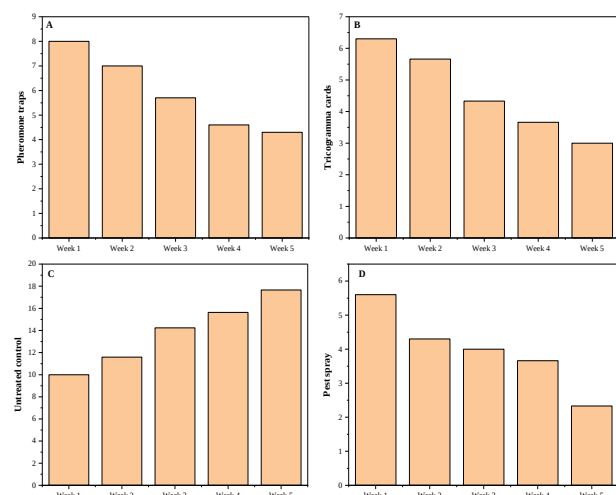


Figure 6. indicates weekly pest scouting data where A) Pheromone traps B) Trichogramma cards C) Untreated control & D) Pest spray

Non-target insect survey

The strategies used in controlling pests also affects the non-target insect groups. The non-target impact measures of Ahmad Nagar was 23%, Lalian 20%, and Sangra 24%. These findings suggest that there are some side effects but biological techniques like pheromone traps and trichogramma have the least ecological impact. Large quantity of affected on-targets in all locations is due to widespread pesticide application as given in table 1.

Table 1. indicates non-target insects affected by applying various pest control techniques in sugarcane field

Location	Non-target insect (%)
Ahmad Nagar	23%
Lalian	20%
Sangra	24%

Sugarcane yield estimation

It was observed (Table 2) that pest control yielded a positive association with output. Sugarcane production was 28 ton/acre at Ahmad Nagar, 29 ton/acre at both Lalian and Sangra. Results can interpret that biological control strategies yielded as much as only pesticide applied methods but without large environmental impacts.

Table 2. indicates sugarcane yield after applying various pest control techniques in sugarcane field

Location	Sugarcane yield (ton/acre)
Ahmad Nagar	28
Lalian	29
Sangra	29

Person correlation among untreated control, bio-control and pesticide spray

A strong positive correlation between stem borer traps and top borer traps indicating similarities in the pest populations captured in traps. However, negatively correlated with cane yield meaning that the higher their use or efficiency is, the cane yield reduces which might be due to capturing of non-target beneficial insects important for cane yield. Trichogramma card also indicates similar pattern. A negative correlation between cane yield and untreated control was also observed in comparison to pest spray. This is not surprising because when dry planting is not done the control group should have a higher pest presence that would result in lower yields as indicated in figure 7.

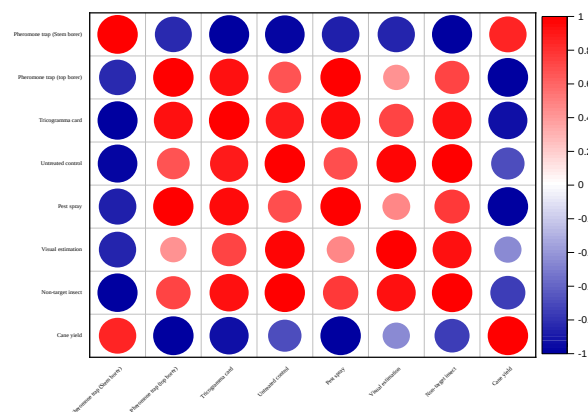


Figure 7. Person correlation among different measured parameters

Discussion

Current work exhibit the use of complementary pest control strategies by adapting integrated pest management (IPM), with a combination of monitoring using pheromones and augmentative biological control with *Trichogramma chilonis*. Both techniques efficiently suppress the most harmful sugarcane infesting species without implications on yield, which complies with Bonsucro-congruent pest management objectives. Pheromone trapping was effective in monitoring changes in pest population on a weekly basis such that pest management was possible. This goes with the previously observed results where pheromone traps offer species specific and nontoxic early warning systems and can be used to intervene with timely measures, avoiding excessive application of insecticides (Mukunthan et al., 2003). Proper treatment of *T. chilonis* with egg parasitoid cards on sugarcane upturned significant decreases in borer incidences as it previously reported by others that inundate releases of *Trichogramma* have a very strong ability of reducing sugarcane borer infestations and increase yields (Mannan et al., 2024). Further, extensive field trials in South Asian countries to compare 6-release regimes with 10-release regimes and combinations with mass trapping showed far lower infestation rates and greater yields when the two methods were combined (Sithanantham et al., 2013). The test of non-target insect is consistent with the environmental viability of IPM techniques; the biological methods were lower in the collateral effect than chemical

methods. It is true indeed that extensive use of pesticides can interfere with natural enemies and end up creating occupational risks-shields that are directly covered by Bonsucro standards (Sharma et al., 2020). All in all, pheromone trap placement and releases of *T. chilonis* are in line with Bonsucro focus of minimizing the use of hazardous chemicals in the course of IPM. Such coordinated dualism of control methods, both the monitor and suppress aspects, do not only offer efficient control of borers but also the sustainability of cost effective environmentally benign yield maintenance. The combination solution possesses great potential in terms of popularization in a sugarcane planting environment with parameters like those of Chiniot, Pakistan.

Conclusion

Combination of pheromone trapping and biological control (*Trichogramma chilonis*) is a sustainable and Bonsucro compatible system of pests control in sugarcane. The results have shown that pheromone traps can be a useful, residue free method of monitoring the population of stem and top borers thereby, facilitating rational and appropriate interventions. Synergistic releases of *T. chilonis* achieved great reductions in pest levels, where visible crop damages are minimal, and yield is not reduced. Notably, these techniques did not affect the communities of non-target insects as readily, making them ecologically friendly.

The results demonstrate that biological and semi chemical methods can substitute or significantly eliminate the use of broad based chemical pesticides thus reducing the risks to human health, soil and water pollution. Moreover, their inclusion in an IPM system works in favor of the sustainability objectives and conformance needs of Bonsucro production system. The combination of the findings thus lends great support to a scaling up of such dual measures in the sugarcane growing areas. The wider use of such practices will not only enhance pest suppression, but also resilient, environment friendly and economically sustainable sugarcane production.

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