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Integrated control of white fly (*Aleurolobus barodensis*) of sugarcane at its grand growth stage: A sustainable approach

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White fly and other sucking insect pests are considered the minor pests of sugarcane in Punjab-Pakistan. But in the last few years, the white fly of sugarcane has become a major trouble for the sugarcane growers to handle and for sugar industries to extract proper sugar. A field trial was conducted at the seed farm of Kashmir Sugar Mills (Lat. 30.9370, Long. 72.1105). Treatments were comprised of crysopera eggs cards and insecticide(s). The insecticide(s) was sprayed with tractor mounted Jecto sprayer at the grand growth stage of autumn planted sugarcane (8th-month-old crop). Pre and post-spray population counts of whitefly were recorded. The results were compared with the control with a curved polar bar chart in R using the 'ggplot2' package. It was observed that drenching of chlorantraniloprole @ 250 ml/ha made an excellent control (~88%) and 24.2% over the control treatment. The 2nd most efficient control (86%) (22.7% over control) was recorded in a blend of pyriproxyfen + bifenthrin @ 1250 ml + 1000 ml/ha, respectively than the individual use of said insecticide (61% and 69%, respectively). Very hot and dry weather in the month of May in plains of Punjab Province-Pakistan did not support the Lab. reared crysoperla eggs cards @ 15000/ha in the field. But a large number of natural bio control agents worked well and surpassed some treatments in % mortality of whitefly.

Keywords: Sugarcane white fly, bio control agents, insecticides, sustainable.

INTRODUCTION

More than 85% of the world sugar is produced from sugarcane. Pakistan, ranks at 4th and 6th in sugarcane area, production and cane sugar production in the world, respectively. Sugarcane is providing the raw material to the 2nd largest industry, the sugar industry, and side by side the cottage industry of Jaggery (*Gur)* to fulfill the dietary demand for sugar for the national ever-increasing population. The contribution of the province of Punjab in Pakistan is around 70% in terms of area and sugarcane production. On being the long duration, sugarcane is attacked by many sucking pests, borers, and subterranean pests during different growth stages (Srikanth, 2019). As sugarcane remains standing in the field even for more than a year followed by ratoons exhibit a type of monoculture and stable agro-ecosystem to build up the insect pressure. Limited use of insecticides, especially in grown-up crop maintains an equilibrium of harmful and beneficial insects (Geetha *et al*., 2018). The grand growth and ripening stages of sugarcane are presumed to be a vital part of insect pest management because it is difficult to control in heighted crop. In the list of over 200 insects of sugarcane, more than ten insect pests are more important which makes heavy losses to the quality as well as quantity of the crop (Srikanth, 2019). The whitefly is one of the widespread pests of sugarcane (Arti and Singh, 2016). Among various sugarcane pests, the whitefly of sugarcane *Aleurolobus barodensis* (Maskell). *A. barodensis*) is now a very serious threat for sugarcane in Pakistan and Iran (Koohzad-Mohammadi *et al.*). It is small-sized winged adults of the

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whitefly yellowish white around 2 mm long, just like the whitefly of cotton but bigger in size. The female lays white coloured eggs underneath the sugarcane leaves in line stuck together. Near to hatching the eggs become dark brown in colour. The emerging nymphs suck cell sap and excrete honeydews over which black sooty mold develops (Nikpay and Goebel, 2016) which hinders the photosynthesis, get pale and dried up making the crop unfit for fodder (Ansari and Lin, 2011, Mann and Singh, 2003). And more than 50% yield reduction is observed in severe cases (Bhavani and Rao, 2013). The management of sugarcane whitefly can be approached through various methods. These include biological control, cultural control, resistant varieties, and chemical control. By implementing these strategies, it is possible to effectively manage and minimize the damage caused by the sugarcane whitefly (Ebrahimifar *et al.*, 2016, Goebel and Nikpay, 2017, Koohzad-Mohammadi *et al.*, 2017). The reckless and indiscriminate use of pesticides has led to the development of resistance in insects, as well as the emergence of new pests. It is imperative to adopt more responsible and sustainable approaches to pest management to mitigate these problems by integrated pest management (IPM) with prioritizing the use of biological control, cultural practices, and selective pesticide application. Traditionally, chemical control methods have been widely employed to combat insect pests. However, in recent times, there has been a growing trend towards the use of biocontrol methods. This approach relies on the natural enemies of the pests to reduce their populations, ultimately minimizing the need for chemical interventions. The adoption of biocontrol strategies marks a positive shift towards more environmentally friendly and ecologically sound pest control practices in modern agriculture (Barratt *et al.*, 2018, Hajek and Eilenberg, 2018, Sajid *et al.*, 2023). The aim of this study was to identify the most effective insecticides and biological agents for controlling sugarcane whitefly infestations in Punjab, Pakistan, under semi-arid conditions during the grand growth stage of sugarcane.

MATERIALS AND METHODS

The study was conducted at the sugarcane seed farm of Kashmir Sugar Mills (Lat. 30.9370, Long. 72.1105) (Pvt.), Limited Punjab, Pakistan, in the month of May, 2022. The efficacy of the following insecticides was evaluated along with crysoperla eggs card and crop natural conditions (control) (table 2). The insecticides were foliar sprayed in autumn-planted (8^{th} month old) sugarcane fields on its grand growth stage of around the height of 10 feet with tractor mounted Jeeto sprayer machine, except chlorantraniliprole which was drenched in the base of plants followed by irrigation (flooding). Each experimental unit was comprised of 2000 m^2 and treatments were applied under randomized complete block design (RCBD).

Table 2. Use of different insecticide(s) and *Crysoperla* egg cards against sugarcane white fly.

Treatment	Dose/ha	Notes
Crysoperla eggs	150000	Chrysoperla are predatory insects that feed on sugarcane whitefly. They are a biological control agent that can be used to control the pest.
Pyriproxyfen	1250 ml	Pyriproxyfen is an insect growth regulator that can be used to control sugarcane whitefly. It works by interfering with the development of the pest, preventing them from maturing into adults.
Acetamiprid	312 g	Acetamiprid is a neonicotinoid insecticide that can be used to control sugarcane whitefly. It works by disrupting the nervous system of the pest, killing them.
Spirotetramat	312 ml + 625 ml	Spirotetramat is a new insecticide that can be used to control sugarcane whitefly. It works by blocking the production of a protein that is essential for the development of the pest, killing them.
Bifenthrin	1000 ml	Bifenthrin is a pyrethroid insecticide that can be used to control sugarcane whitefly. It works by disrupting the nervous system of the pest, killing them.
Flonicamid	200 g	Flonicamid is a new insecticide that can be used to control sugarcane whitefly. It works by blocking the production of a protein that is essential for the development of the pest, killing them.
Carbosulfan	1250 ml	Carbosulfan is an organophosphate insecticide that can be used to control sugarcane whitefly. It works by disrupting the nervous system of the pest, killing them.
Lambda + pyryproxyfen	750 ml + 1250 ml	Lambda-cyhalothrin is a pyrethroid insecticide that works by disrupting the nervous system of the pest, killing them. Pyriproxyfen is an insect growth regulator that works by interfering with the development of the pest, preventing them from maturing into adults.
Pyriproxyfen + bifenthrin	1250 ml + 1000 ml	Pyriproxyfen is an insect growth regulator that works by interfering with the development of the pest, preventing them from maturing into adults. Bifenthrin is a pyrethroid insecticide that works by disrupting the nervous system of the pest, killing them.
Chlorantraniliprole	250 ml	Chlorantraniliprole is a new insecticide that can be used to control sugarcane whitefly. It works by blocking the production of a protein that is essential for the development of the pest, killing them.
Control	-	This is the control treatment, which is used as a baseline to compare the effectiveness of the other treatments.

Before spraying the field, three sugarcane plants were tagged from each experimental unit at different places. Three infested leaves from each plant was selected and further marked with horizontal lines with a permanent markers from the base to the tip of leave blade, portioning a leave in three rectangular compartment each of around 8 $inches^2$ area. Thereafter, the population of whitefly nymphs was counted. After seven days

of spray, the population of whitefly nymphs was again counted and the ± difference was calculated. While counting after the spray the T-shaped exit holes which appear when the adult sugarcane whitefly emerges from its pupa were considered as live population.

The mortality percentage (table 1) of whitefly for individual treatment was calculated by the following formula:

$$Mortality\% = \left(\frac{Initial\ poupulation - Final\ population}{Initial\ population}\right) \times 100$$

The data recorded were used to create a curved polar bar chart (figure 1) in R using the 'ggplot2' package [30].

RESULTS

The figure1 shows the results of the effectiveness of different treatments over the control, while the table 1 shows the percentage mortality of sugarcane whitefly. Chlorantraniliprole was found the most effective in reducing the population of sugarcane whitefly over control by 24.2% (Fig. 1) and 87.93% mortality (Table 1). Followed by combined use of pyriproxyfen + bifenthrin (22.7%) over control (Fig. 1) and overall 86.36% mortality. The Carbosulfan and Flonicamid have about similar results (16.3% and 16.1%, respectively). Lamda + pyriproxyfen, Acetamiprid and bifenthrin were found least effective over the control treatments (10.8%, 8.2%, and 5.5%, respectively) and mortality of 74.48%, 71.88% and 69.23, respectively. Even alone the highly efficient report insecticide against white fly i.e., pyriproxyfen and spirotetramate were having lower results (-4.4% and -2.3%, respectively) over the control both having around 60 mortality% of white fly. Surprisingly, the results of crysoperla eggs were found even much lesser (-11.5% and 52.23% mortality) than the control treatment with white fly mortality of 63.72%.

Table 1. The mortality% of the whitefly for individual treatments

Sr.	Treatment	Mortality%
1	*Crysoperla* eggs	52.23
2	Pyriproxyfen	61.43
3	Acetamiprid	71.88
4	Spriotetramat	59.36
5	Bifenthrin	69.23
6	Flonicamid	79.76
7	Carbosulfan	80.00
8	Lamda + pyryproxyfen	74.48
9	Pyriproxyfen + bifenthrin	86.36
10	Chlorantraniliprole	87.93
11	Control	63.72

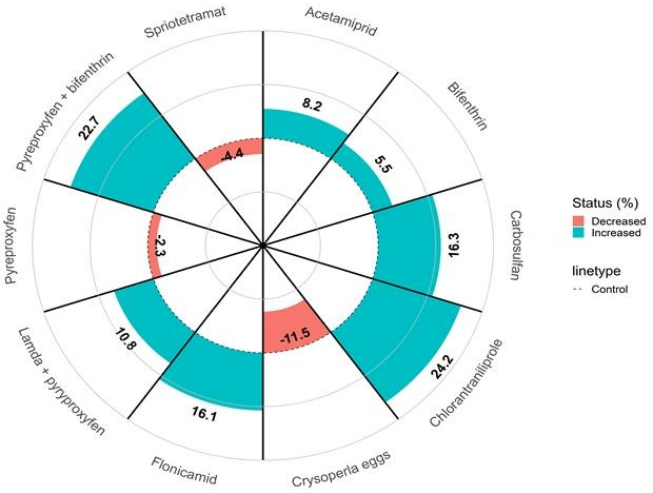

Figure 1. Percentage decrese in whitefly of over the control tretment.

(a) (b)

Figure 2. Adult and Sugarcane white fly (a) Yellowish white female adult with freshly (whitish) laid and near to hatch (dark brown) eggs, (b) whitefly adult predation by natural beneficial arachind present in the sugarcane field, a tiny brown (in centre) web spider and a pinkish brown coloured (top left) active spider.

(a) (b)

Figure 3. Sugarcane white fly eggs mass predation under natural conditions. Different types of Coccinellidae beetles feeding on the feeding on the egg mass of the sugarcane white fly.

(c) (d)

Figure 4. Sugarcane white fly eggs mass predation under natural conditions. (a) mite destroyed lady beetle (b) Rove beetle.

(a) (b)

Figure 5. Crysoperla under conditions of a sugarcane fied. (a) stalked bunch of egg mass, (b) larva of crysoperla feeding on white fly nymph.

DISCUSSION

Relatively a long-term (for two weeks) white fly control was where chlorantraniliprole was drenched with a limited negative impact on the natural predation. Similar results were observed by Saeedi and Ziaee (Saeedi and Ziaee, 2020) who found that flupyradifurone significantly affected all life stages of white flies (mortality 90%) for at least four weeks after its application. It did not adversely influence the nymphatic parasitism by Encarcia.

As shown in the figures (2-5) the control treatment of the experimental unit was having a number of natural predators. These were effectively controlling the white fly at its different life stages. Even the mortality% of sugarcane white flies was more in control treatment than where the chemicals i.e. insecticides pyriproxyfen and spirotetramate and Lab. reared crysoperla eggs card were used. It was observed that crsoperla (developed from Lab. reared eggs) role under field conditions was very shy. But the naturally occurring bio control agents (figures 2-5) were working very efficiently under the harsh environmental field conditions. The results are in accordance with the findings of (Bhargava *et al.*, 2020), who reported that biological control of whiteflies with Encarsia spp. is more feasible in a crop like sugarcane where chemical control is uneconomical. Similarly (Koohzad-Mohammadi *et al*., 2017) forced the conservation of biological control parasitic wasps and native predators such as spiders and lacewings for the effective control of sugarcane whitefly. In contrary, (Barratt *et al*.,, 2018) found the crysoperla carnea, or green lacewing, egg cards much efficient in controlling sugarcane whitefly, mites, thrips, mealybugs, and eggs of sugarcane borers, under IPM approach. Whereas, in his another study (Bhatti *et al.*, 2019) found that highest % mortality of whitefly (80%) was recorded where de-trash the infested leaves followed by the release of *Crysoperlla carnea* and application of pesticide (fipronil 5SC) at 1800 ml ha^{-1} through irrigation. (Behnam-Oskuyee *et al.*, 2020) found that among the thiacloprid + deltamethrin, pyriproxyfen, and spirotetramat the combination of thiacloprid + deltamethrin was found to be the most effective in controlling different life stages of sugarcane whitefly in different sugarcane varieties but having negative impact on parasitism. While (Askarianzadeh and Minaeimoghadam, 2018) observed that whitefly damage differed among cultivars. The destruction in quality of early maturing cultivars was more than others. (Muhammad *et al.*, 2021), conducted a study to check the efficacy of three insecticides, Pyrifluquinazon, Spirotetramate, and Dinotefuron, against sugarcane whitefly (*Aleurolobus barodensis*) in ratoon CPF 251 sugarcane variety. Pyrifluquinazon was found the most effective insecticide, used @ 500g/ha, with a corrected mortality of 84.4%. Spirotetramate had corrected mortality of 80% and Dinotefuran of 64%.

The plain areas of Punjab-Pakistan are hit by server heat with desiccating winds the month of May-June. And perhaps the less effectiveness of some well-reported insecticides and chrysoperla was due to the harsh weather. It is claimed by many studies that predation of chrysocolla under Labs is not accurate because the lab doesn't show how predators behave differently under field conditions due to varying host and predator ecology, environment, weather, other beneficial or host species etc. (De Clercq *et al.*, 2000, Madadi *et al.*, 2007). However, a large number of naturally occurring biocontrol agents (against white fly adults and eggs mass) were present and working very efficiently in the scorching heat in the sugarcane field (control), like web and active hunting spiders (Fig. 2), Coccinellidae beetles (Fig. 3), mite destroyer lady beetle and rove beetles (figure 4) and chrysoperla (Fig. 5). These bio agents make the control treatment, no insecticide was used, even better than chrysoperla eggs, pyriproxyfen, and spirotatramte. Perhaps, the feasible and executable practice to control white flies in sugarcane is the

chemigation/drenching of new chemistry insecticides with minimal negative impacts on predation and parasitism of naturally occurring beneficial insects.

***Conclusion*:** Chlorantraniliprole at 250 ml/ha demonstrated exceptional whitefly control (~88%), surpassing other treatments, while a combination of pyriproxyfen + bifenthrin @ 1250 ml + 1000 ml/ha showed the second most effective control (86%). Despite unfavorable weather for lab-reared crysoperla eggs cards, natural biocontrol agents played a significant role, exceeding the efficacy of certain treatments in achieving whitefly mortality.

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