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Assessment of Different Modules for the Control of Whitefly *Bemisiatabaci*, (GENN) and Its Effect on Associated Natural Enemies in Okra

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ABSTRACT

The experiment was carried out to evaluate mechanical control and insecticides alone and in combination against whitefly *Bemisia tabaci*, (Genn) in okra *Abelmoschus esculentus* (L.) at farmer field, District Mardan Khyber Pakhtunkhwa during summer 2020.Randomize Complete Block Design (RCBD) was used with8 treatments including control (Yellow sticky traps, Yellow sticky traps + Ulala 50 WG, Yellow sticky traps + Pyriproxyfen 10.8% EC, Yellow sticky traps + Imidacloprid 25% WP, Yellow sticky traps + Ulala 50 WG+ Pyriproxyfen 10.8% EC, Yellow sticky traps + Ulala 50 WG+ Imidacloprid 25% WP, Yellow sticky traps + Pyriproxyfen 10.8% EC+ Imidacloprid 25% WP)replicated 3 times. The treatments were applied twice at 21 days interval except Yellow sticky trap which was applied weekly. All the tested treatments were found better than control in reducing whitefly population. Yellow sticky trap+ ulala+ imidacloprid was found the most effective treatment with lowest whitefly population (0.52 and 0.61 whitefly leaf^{-1}) and maximum percent reduction (87.4 and 68.4 %) after 1st and 2nd treatment application respectively, resulting in highest yield of okra (3762.3 kgha^{-1}) with cost benefit ratio (20.9). Results revealed that all the tested treatments where yellow sticky trap was used in combination with insecticides was comparatively more hazardous and had lowest ladybird beetle and green lacewing population than the treatment where yellow sticky trap was used alone. From the results it was concluded that yellow sticky trap used alone wasfavorable for natural enemies. Hence the use of yellow sticky trap in combination with ulala and alternate spray of imidacloprid at 21 days interval was found better at District Mardan and is recommended for sustainable management of whitefly in okra.
Key words. Mechanical, Chemical, Ulala, Okra, Mardan

INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) Moench, is an important and short duration crop vegetable of Pakistanpropagated through seeds (Neeraja *et al.*, 2004). It is the kharif season vegetable but it can be grown throughout the year (Dash *et al*, 2013). Okra is a nutritive vegetable, contain both soluble and insoluble fiber which helps to lower blood cholesterol, reduce the risk of heart disease, keeps the intestinal tract healthy and decrease colorectal cancer (Broek *et al.*,2007). Okra is a best source of minerals, vitamins, salts and has 175 calories per pound (Lanjar and Sahito, 2007).

The total production of okra in Pakistan during 2018-19 was 120.639 thousand tones cultivated on an area of 15.713 thousand hectares. In Punjab the total production was 70.438 thousand tonesgrown on an area of 5.922-thousand-hectare, Sindh production was 19.731 thousand tones cultivated on an area of 4.969 thousand hectare, Baluchistan production was 15.223 thousand tones cultivated on an area

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of 2.459 thousand hectare while in Khyber Pakhtunkhwa the total production was 15.245 thousand tones cultivated on an area of 2.363 thousand hectares (Anonymous, 2019).

Whitefly give indirect damage by producing honeydew. The honeydew serves as a substrate for the growth of black sooty mold on leaves and fruit. Photosynthesis process slow down due to honeydew (Berlinger, 2002) and hence the fruit quality and quantity reduce and no market value (Oliveria *et al.*, 2001). Whitefly act as a vector of several plant viruses resulting in significant losses. In some cases, whiteflies cause complete failure of crop (Berlinger, 2002). The repeated application of synthetic insecticides has resulted in development of insecticide resistance in pest populations. (Mahrotra and Phokela, 1992). Due to the development of resistance toward the commonly used insecticides, whitefly has become a serious threat to the agricultural in the recent years. In this scenario it is necessary to develop an effective and ecologically sound and environmentally safe IPM strategy to manage whitefly infestation (Zhu *et al*., 2016).Use of yellow sticky trap and application of selective insecticides are considered as an important component of IPM strategies due to their efficacy to pests and safety to natural enemies (Delia *et al.*, 2013). The combination of yellow sticky traps and selective insecticides has proven to be an effective management for *B. tabaci* in green house (Lu *et al.*, 2012). In recent years, yellow sticky traps used for management of whitefly. The combination of yellow sticky traps and parasitoids showed best control against whitefly in a screen house (Shen and Ren, 2003).The natural enemies of okra are syrphid fly, green lacewing and ladybird beetle (Saljoqi *et al.*, 2013) ants, *Chrysoperla spp*. Coccinellidae and *Encarsia spp.* were also used for the reduction of insect pest of okra (Leite *et al.*, 2005).

Keeping in view the above facts, the present study was designed with the objective to develop an effective and environment friendly IPM strategy to control whitefly by using yellow sticky traps and selective insecticides alone and in combination to manage indiscriminate use of insecticides as low as possible.

MATERIALS AND METHODS

The present research on “Appraisal of different mechanical and chemical control against whitefly *Bemisia tabaci*, (Genn) and its effect on associated natural enemies in okra was conducted at farmer field Shergarh, District Mardan Khyber Pakhtunkhwa” during summer 2020.

Okra seed (Viraj F1 Hybrid) was sown in the field on ridges in 3rd week of March, following Randomized Complete Block Design (RCBD) with three replicates. Plot size was 5 x 4m^2. Row to row and plant to plant distances was 30 cm and 10 cm respectively. Standard agronomic practices (irrigation, fertilizer, weeding etc.) were applied uniformly to all experimental plots.

Treatments

T1. Yellow Sticky Traps (YST) (Replace after every 7 days), T2. YST + Ulala 50 WG (applied twice at 21 days interval), T3. YST+ Pyriproxyfen 10.8% EC (applied twice at 21 days interval), T4. YST + Imidacloprid 25% WP (applied twice at 21 days interval), T5. YST+ Ulala 50 WG+ 2nd spray of Pyriproxyfen 10.8% EC after 21 days of 1st application, T6. YST+ Ulala 50 WG+ 2nd spray of Imidacloprid 25% WP after 21 days of 1st application, T7. YST+ Pyriproxyfen 10.8% EC+ 2nd spray of Imidacloprid 25% WP after 21days of 1st application, T8. Control

Parameters recorded

Whitefly population leaf^{-1}and Percent Whitefly mortality

Whitefly population was recorded on 5 randomly selected plants. Each plant was divided in 3 parts top, middle and bottom portion. From each part 3 leaves were selected randomly. Data were recorded 1 day before treatment application and then 1, 2, 3, 7 and 14 days interval after treatment application. The data were converted to per leaf. Data was recorded early in the morning because of the reduced activity of whitefly (Zeeshan *et al.*, 2017).Percent mortality for each treatment was calculated after 1, 2, 3, 7 and 14 days interval. Percent reduction in whitefly *Bemisia tabaci* population was calculated using modified Abbot's formula (1925).

$$\%Reduction= \{1- \frac{\text{Post treatment pop. in treated plots}}{\text{Pre-treatment pop. in treated plots}} \times \frac{\text{Post treatment pop. in control}}{\text{Pre-treatment pop. in control}}\} \times 100$$

Natural enemies of whitefly

Natural enemies were recorded on 5 randomly selected plants. Data on natural enemies of whitefly was recorded 1 day before pesticide application and then 1, 2, 3, 7 and 14 days interval after treatments application.

CBR and Yield (kg/ha^{-1})

Cost benefit ratio was calculated according to the method used by (Hussain *et al*,. 2022) to find out the most effective treatment that gave maximum net return.Okra yield was recorded for each plot separately after every picking. The total okra yield was determined by adding yield of all pickings. The yield was converted into yield kg/ha^{-1} by using formula:

$$\text{Yield (kg/ha}^{-1}\text{) = yield plot}^{-1}\text{/ plot area (m}^{2}\text{) x10, 000}$$

Statistical Analysis

Data on the above parameters (a,b,c,d) were subjected to analysis of variance by using statistical software STATISTIX 8.1 and means were separated by using LSD test at P=0.05%.

RESULTS

Table 1. Mean number of whitefly leaf^{-1} and means percent reduction recorded after 1st application during 2020.

Treatments	Whitefly population density leaf^{-1}and means percent reduction						
	24 hrs. before spray	After treatment application (Days)					
		1	2	3	7	14	Mean
Yellow sticky traps	3.53a	2.80a (33)	2.13b (44)	1.80b (49)	1.77b (49)	2.11b (38)	2.12b (42.6)
YST + Ulala	3.62a	1.53cd (64)	0.86ce (78)	0.53de (86)	0.49d (87)	0.45d (87)	0.77e (80.4)
YST + Pyriproxyfen	3.64 a	1.60 c (63)	1.00cd (75)	0.80cd (78)	0.78c (79)	0.72c (80)	0.98d (77)

YST + Imidacloprid	3.64 a	2.20b (49)	1.13 c (71)	0.93c (75)	0.79c (78)	0.86c (76)	1.18c (69.8)
YST + Ulala+ Pyriproxyfen	3.56a	1.60c (62)	0.60ef (85)	0.46de (87)	0.44d (88)	0.43d (88)	0.70e (82)
YST + Ulala + Imidacloprid	3.69a	1.20d (73)	0.53f (87)	0.30e (92)	0.29e (92)	0.28d (93)	0.52f (87.4)
YST + Pyriproxyfen +Imidacloprid	3.66 a	1.40cd (62)	0.80def (80)	0.53de (86)	0.46d (88)	0.45d (88)	0.73e (80.8)
Control	3.60a	3.13a	3.40a	3.66a	3.70a	3.81a	3.54a
$LSD_{(0.05)}$	0.461^{ns}	0.362	0.318	0.372	0.139	0.189	0.166

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

After 1st spray application means density of whitefly and means percent reduction

Table 1 shows that the treatment yellow sticky trap+ ulala+ imidacloprid was found the most effective in managing whitefly population (0.52 $leaf^{-1}$)followed by yellow sticky trap+ulala+pyriproxyfen(0.70 $leaf^{-1}$) which was statistically non-significant to yellow sticky trap+ pyriproxyfen+ imidacloprid (0.73 $leaf^{-1}$) and yellow sticky trap+ ulala (0.77 $leaf^{-1}$) respectively. The highest mean density of whitefly was recorded in control (3.54 $leaf^{-1}$).

Table 1 also showed thatthe highest mean percent reduction of whitefly (87.4%) was recorded in yellow sticky trap+ ulala+ imidacloprid followed by yellow sticky trap+ ulala+ pyriproxyfen (82%) while the lowest reduction (42.6%) was recorded in plot treated with yellow sticky trap.

Table 2. Mean number of whitefly $leaf^{-1}$ and means percent reduction recorded after 2nd application during 2020.

Treatments	Whitefly population density $leaf^{-1}$ and means percent reduction						
	24 hrs. before spray	After treatment application (Days)					
		1	2	3	7	14	Mean
Yellow sticky traps	2.42b	2.22b (10)	2.15b (11)	1.81b (24)	1.76b (40)	1.88b (44)	1.96b (25.8)
YST + Ulala	1.70c	0.95c (45)	0.83cd (51)	0.70c (58)	0.40d (81)	0.36d (85)	0.65de (64)
YST + Pyriproxyfen	1.36f	0.95c (31)	0.85cd (37)	0.68c (49)	0.59c (64)	0.45c (76)	0.70cd (51.4)
YST + Imidacloprid	1.37f	0.99 c (28)	0.93c (32)	0.68c (50)	0.65c (61)	0.41cd (79)	0.73c (50)
YST + Ulala + Pyriproxyfen	1.74de	0.92c (48)	0.82d (53)	0.72c (58)	0.55c (74)	0.39cd (84)	0.68cd (63.4)
YST + Ulala + Imidacloprid	1.83e	0.91c	0.84cd	0.60c	0.38d	0.33d	0.61e

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		(51)	(54)	(67)	(83)	(87)	(68.4)
YST + Pyriproxyfen +Imidacloprid	1.79cd	0.94c (48)	0.84cd (53)	0.69c (61)	0.41d (81)	0.37cd (85)	0.65de (65.6)
Control	3.89a	3.89a	3.93a	3.98a	3.24a	2.85a	3.58a
LSD $_{(0.05)}$	0.0770	0.101	0.1079	0.1323	0.114	0.083	0.053

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

After 2nd spray application means density of whitefly and means percent reduction

Table 2 showed that yellow sticky trap used in integration with ulala+ imidacloprid (0.61 leaf^{-1}) was found the most effective in managing whitefly population which was statistically non-significant toYST + Ulala (0.65 leaf^{-1}) and YST + Pyriproxyfen +Imidacloprid (0.65 leaf^{-1}) followed by YST + Ulala + Pyriproxyfen (0.68leaf^{-1}) which was statistically similar to YST + Pyriproxyfen (0.70 leaf^{-1}) and YST + Imidacloprid (0.73 leaf^{-1}) respectively. The mean density of whitefly per leaf was observed maximum in untreated plot (3.58).

Mean percent reduction of whitefly was recorded highest (68.4%) in plot treated with YST + ulala+ imidacloprid followed by YST + pyriproxyfen+ imidacloprid (65.6%) while the lowest percent reduction was recorded in yellow sticky trap (25.8%) when used alone.

Table 3. Mean number of Ladybird beetle plant^{-1} recorded before and after 1st application during 2020.

Treatments	Ladybird beetle population plant^{-1}						
	24 hrs. before spray	After treatment application (Days)					
		1	2	3	7	14	Mean
Yellow sticky traps	2.80a	2.66a	2.00b	1.86b	0.86b	0.83b	1.64b
YST + Ulala	2.76a	1.73b	0.83cd	0.66d	0.41e	0.24e	0.77e
YST + Pyriproxyfen	2.70a	1.76b	0.90c	0.79c	0.64d	0.62c	0.94c
YST + Imidacloprid	2.83a	1.80b	0.90c	0.83c	0.74c	0.63c	0.98c
YST + Ulala + Pyriproxyfen	2.83a	1.66b	0.80d	0.64d	0.42e	0.29e	0.76e
YST + Ulala + Imidacloprid	2.76a	1.70b	0.80d	0.62d	0.41e	0.23e	0.75e
YST + Pyriproxyfen +Imidacloprid	2.76a	1.70b	0.80d	0.75c	0.60d	0.56d	0.88d
Control	2.80a	2.83a	2.86a	2.96a	3.13a	3.16a	2.99a
LSD $_{(0.05)}$	0.197^{ns}	0.193	0.094	0.088	0.0689	0.0593	0.055

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

Number of Ladybird Beetleplant^{-1}after 1st pray application

Mean population of Ladybird beetle was non-significant before spray application in all treatments. Table 3 showed that mean ladybird beetle population after 1st spray application was observed maximum in Yellow Sticky Trap (1.64 plant^{-1})followed by YST + Imidacloprid (0.98plant^{-1}) which was statistically similar to YST + Pyriproxyfen(0.94 plant^{-1}) respectively. The lowest ladybird beetle

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population was recorded in YST + Ulala + Imidacloprid (0.75plant^{-1}) which was non-significant to YST + Ulala + Pyriproxyfen (0.76 plant^{-1}) and YST + Ulala (0.77 plant^{-1}) respectively.

Table 4. Mean number of ladybird beetle plant^{-1} recorded before and after 2nd application during 2020.

Treatments	Ladybird beetle population plant^{-1}						
	24 hrs. before spray	After treatment application (Days)					
		1	2	3	7	14	Mean
Yellow sticky traps	1.70b	1.63b	1.43b	1.36b	1.00b	0.83b	1.25b
YST + Ulala	0.96cd	0.66e	0.56c	0.44ef	0.39cd	0.30cde	0.47de
YST + Pyriproxyfen	1.06c	0.83cd	0.63c	0.59c	0.44c	0.37c	0.57c
YST + Imidacloprid	0.93cd	0.86c	0.61c	0.58c	0.40cd	0.30cde	0.55c
YST + Ulala + Pyriproxyfen	0.80d	0.73de	0.59c	0.52d	0.42cd	0.34cd	0.52cd
YST + Ulala + Imidacloprid	0.85d	0.66e	0.56c	0.41f	0.34d	0.22e	0.44e
YST + Pyriproxyfen +Imidacloprid	0.93cd	0.66e	0.62c	0.49de	0.36cd	0.25de	0.48de
Control	3.26a	3.30a	3.33a	3.36a	3.00a	2.73a	3.14a
LSD $_{(0.05)}$	0.210	0.115	0.108	0.065	0.086	0.106	0.067

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

Number of Ladybird Beetleplant^{-1}after 2nd pray application

Mean number of ladybird beetle population per plant after 2nd spray application (Table 4) was observed maximum in Yellow sticky traps (1.25plant^{-1}) followed by YST + Pyriproxyfen (0.57plant^{-1}) which was similar to YST + Imidacloprid (0.55plant^{-1}) and YST + Ulala + Pyriproxyfen (0.52plant^{-1}) statistically. The lowest number of ladybird population was observed in plot treated with YST + Ulala + Imidacloprid (0.44plant^{-1}) which was non-significant to YST + Ulala (0.47plant^{-1}) and YST + Pyriproxyfen +Imidacloprid (0.48plant^{-1}).

Table 5. Mean number of Green lacewing plant^{-1} recorded before and after 1st application during 2020.

Treatments	Green lacewing population plant^{-1}						
	24 hrs. before spray	After treatment application (Days)					
		1	2	3	7	14	Mean
Yellow sticky traps	2.00a	1.86a	1.80b	1.73b	1.66b	1.60b	1.77b
YST + Ulala	1.96a	1.40b	0.85cde	0.50ee	0.38de	0.29e	0.68de
YST + Pyriproxyfen	2.00a	1.83a	0.93c	0.59cd	0.42d	0.39cd	0.83c
YST + Imidacloprid	2.03a	1.83a	0.86cd	0.64c	0.48c	0.43c	0.85c
YST + Ulala + Pyriproxyfen	2.00a	1.40b	0.76e	0.49ef	0.36ef	0.32de	0.66de
YST + Ulala + Imidacloprid	2.00a	1.46b	0.63f	0.44f	0.31f	0.27e	0.62e
YST + Pyriproxyfen +Imidacloprid	1.96a	1.50b	0.83de	0.52de	0.39de	0.29e	0.70d

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Control	1.96a	1.96a	2.03a	2.10a	2.16a	2.23a	2.10a
LSD $_{(0.05)}$	0.181^{ns}	0.194	0.0930	0.075	0.057	0.0760	0.060

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

Number of Green lacewings plant^{-1}after 1st pray application

Mean population of green lacewing before treatment application (Table 5) was statistically similar. After the application of treatments, the highest population was recorded in Yellow Sticky Trap (1.77plant^{-1}) followed by YST + Imidacloprid (0.85 plant^{-1}) which was non-significant to YST + Pyriproxyfen (0.83plant^{-1}). Minimum number of green lacewings was observed in plot treated withYST + Ulala + Imidacloprid (0.63plant^{-1}), statistically similar to YST + Ulala + Pyriproxyfen (0.66plant^{-1}) and YST + Ulala (0.68plant^{-1}) respectively.

Table 6. Mean number of Green lacewing plant^{-1} recorded before and after 2nd application during 2020.

Treatments	Green lacewing population plant^{-1}						
	24hrs before spray	After treatment application (Days)					
		1	2	3	7	14	Mean
Yellow sticky traps	1.80b	1.76b	1.70b	1.66b	1.00b	0.89b	1.40b
YST + Ulala	1.03c	0.76c	0.60d	0.49de	0.38de	0.31d	0.51de
YST + Pyriproxyfen	1.00c	0.80c	0.73c	0.54cd	0.40cd	0.38c	0.57c
YST + Imidacloprid	0.96c	0.83c	0.66cd	0.54c	0.41c	0.33d	0.55c
YST + Ulala + Pyriproxyfen	1.60c	0.80c	0.70cd	0.50cde	0.38de	0.33d	0.54cd
YST + Ulala + Imidacloprid	0.96c	0.73c	0.70cd	0.40f	0.33f	0.24e	0.48e
YST + Pyriproxyfen +Imidacloprid	1.03c	0.73c	0.63cd	0.48e	0.36e	0.30d	0.50e
Control	2.26a	2.33a	2.36a	2.43a	2.50a	2.56a	2.44a
LSD $_{(0.05)}$	0.147	0.131	0.120	0.053	0.020	0.040	0.035

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

Number of Green lacewings plant^{-1}after 2nd pray application

Table 6 showed that the highest population of green lacewing was observed maximum in control (2.44 plant^{-1}). Among the treatments the highest number of green lacewing was recorded in Yellow Sticky Trap (1.40plant^{-1}) followed by YST + Pyriproxyfen(0.57plant^{-1}) which was non-significant to YST + Imidacloprid (0.55plant^{-1}) and YST + Ulala + Pyriproxyfen (0.54plant^{-1}). The lowest number of green lacewings was observed in plot treated with YST + Ulala + Imidacloprid (0.48plant^{-1}), statistically similar to YST + Pyriproxyfen +Imidacloprid (0.50plant^{-1}) and YST + Ulala (0.51plant^{-1}) respectively.

Table 7. Effect of treatments on the yield of okra

Treatments	Total Yield (kgha^{-1})
Yellow Sticky Trap (YST)	2316.6d
YST + Ulala	3510.0b
YST + Pyriproxyfen	2426.6d
YST + Imidacloprid	2596.6c
YST + Ulala+ Pyriproxyfen	3539.6b
YST + Ulala+ Imidacloprid	3762.3a
YST + Pyriproxyfen+ Imidacloprid	3553.3b
Control	1066.6e
LSD (0.05)	113.2

Means followed by different letters are significantly different at P 0.05 level of significance followed by LSD Test.

Effect of treatments on the yield of okra

Table 7 showed that the maximum yield (3762.3) was observed in plot treated with YST + Ulala + Imidacloprid followed by YST + Ulala+ Pyriproxyfen (3539.6) which was statistically similar to YST + Ulala (3510.0). The lowest yield was recorded in untreated plot (1066.6).

Table 8. Cost Benefit Ratio of different treatmentsagainst whitefly on okra crop

Treatments	Yield (kg/ha^{-1}) A	Gross income (Rs.) B	Cost of control ha^{-1} (Rs.) C	Return over control (Rs.) ha^{-1} D	Estimated net benefit (Rs. ha^{-1}) E (D-C)	C:B F(D/C)
Yellow Sticky Traps (Y.S.T)	2316.6	127416.7	5600	68750	63150	12.2
Y.S.T + Ulala	3510	193050	10165.9	134383.3	124217.4	13.2
Y.S.T + Pyriproxyfen	2426.6	133466.7	6218.9	74800	68581.1	12.0
Y.S.T + Imidacloprid	2596.6	142816.7	3971.2	84150	80178.8	21.1
Y.S.T + Ulala +Pyriproxyfen	3539.6	194681.7	8192.3	136015	127822.7	16.6
Y.S.T + Ulala +Imidacloprid	3762.3	206928.3	7068.5	148261.7	141193.2	20.9
Y.S.T +Pyriproxyfen +Imidacloprid	3553.3	195433.3	5095	136766.7	131671.7	26.8
Control	1066.6	58666.67				

Yield kg/ha^{-1} and CBR

Data presented in Table 8 shows the cost benefit ratio of the tested treatments used to manage whitefly infestation. It was found that all the tested treatment were found profitable having positive cost benefit ratio. However, the yellow sticky trap+ pyriproxyfen + imidacloprid was found the most profitable with CBR value (26.8) followed by yellow sticky trap+ imidacloprid (21.1). The treatment YST + Pyriproxyfen was found least profitable with CBR valve (12.0).

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DISCUSSION

The study was conducted on appraisal of different mechanical and chemical control against whitefly *Bemisia tabaci,* (Genn) in okra at District Mardan, Khyber Pakhtunkhwa.The present finding showed that ulala (flonicamid) remain effective for 3 weeks. Morita *et al*. (2014) also reported that flonicamid had a long-lasting efficacy. Similarly,Hussain*et al*. (2022) also found that flonicamid gave best result in first and second spray against sucking insects.In the present study ulala showed 80.4% reduction in the population of whitefly. The present finding is in agreement with Kodandaram *et al.* (2017). They reported >85% reduction in whitefly population compared to control.

In present study, yellow sticky trap was not as effective as insecticide in reducing population of whitefly. Our finding was in line with the finding of Lu *et al*. (2012). They reported that yellow sticky trap did not have best effect on immature or adult whitefly. It could be due the presence of both nymph and adult whitefly in the same time.

Pyriproxyfen showed better results in controlling whitefly population and was very good against sucking insects. Our finding was in line with the finding of Qureshi *et al*. (2009), reported that pyriproxyfen was very effective against whitefly and other sucking insects and gave more yield.In second spray application pyriproxyfen show best result against whitefly and increases the mortality of whitefly population as the number of day's increases. Our finding was slightly in agreement with Hanif *et al*. (2019), revealed that percent mortality of pyriproxyfen was 80%. This trend showed that maximum mortality of whitefly population occurs when increase in dose of the insecticide.Qureshi *et al*. (2009) also observed that pyriproxyfen was best control against whitefly eggs and adults.

The maximum mortality of whitefly was recorded in yellow sticky trap+ ulala+ imidacloprid during second spray application. Theses finding were similar with Chaitanya *et al.* (2018). They observed that imidacloprid (1.52 whiteflies/3leaves) was the most effective and recorded the lowest whitefly population 1.52 per 3 leaves. Similarly, Pawar *et al*. (2016) reported that mean population of whiteflies, aphids and Jassids after three sprays revealed that imidacloprid was effective and superior. Imidacloprid found to be toxic to beneficial insects. Similar finding has also been reported by Rondeau *et al.* (2014) that imidacloprid is more toxic to bees and other beneficial insects. In the present study two insect predators' ladybird beetle and green lacewingwere recorded. The highest predator's population was found in plots where only yellow sticky trap was installed but the predator's population was significantly lower than control. It might be because less whitefly population.

The variation in okra yield was observed ranging from (1066.6 kg/ha^{-1} to 3762.3 kg/ha^{-1}) in different treatment. The present finding is in contractions to the finding of Rehman *et al.* (2015), khan *et al.* (2019) and Adhikary (2009). They reported (2255.5kg/ha^{-1}), (4530.3 kg/ha^{-1}) and (5001.4 kg/ha^{-1}) yield respectively at different treatment. Yield variation might be due to difference in the okra genotype and variation in biotic and abiotic factors.

In the present study treatment supported high whitefly population gave low yield and vice versa. Present findings are in agreement with the findings of Shannag *et al.* (2007) and Mehra *et al.* (2018).In the present study the yellow sticky trap+ pyriproxyfen + imidacloprid was found the most profitable with cost benefit ratio (26.8) followed by yellow sticky trap+ imidacloprid (21.1), while the least was found in yellow sticky trap+ pyriproxyfen (12). The present finding cannot be compared with the findings of earlier researcher. As the cost of control value of the commodity is fluctuating and vary from region to region.

CONCLUSION AND RECOMMENDATIONS

All treatments found better in managing whitefly as compared to control.Treatment where yellow sticky trap was integrated with ulala and 2nd spray of imidacloprid at 21 days interval was found the most effective treatment in reducing whitefly population and also gave better yield with CBR value (1:20.9).Yellow sticky trap used alone was found the friendliest for insect predator of whitefly but least effective against whitefly. Moreover, it was least profitable treatment with CBR value of (1:12.2).To get the more desirable control, it is recommended to integrate yellow sticky trap with some novel and selective insecticide. Moreover, use of yellow sticky trap alone is not recommended to manage whitefly infestation in fields.Further work should be carried out to study the behavior of other natural enemies of okra in the presence of yellow sticky trap in screen houses / lab conditions.

Authors' Contributions

Ahmad Said Zia: Conducted research work
Amjad Usman: Main Supervisor
Adnan Ihsan and Riaz Hussain: Wrote the Article.
Azaz Ali Shah and Najeeb Ullah: Proof reading
Muhammad Usman: Co-Supervisor

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