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Research Article

Management of *Helicoverpa armigera* by Using Various Techniques

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ABSTRACT

The study was conducted to find out the best management practices against American bollworm on Okra variety Arka Anamika during 2016. The three different management practices viz. Release of *Trichogramma chilonis,* hoeing and weeding, clipping and lufenuron insect growth regulator (IGR) which were tested individually and with all possible combinations for the controlling of American bollworm at 3 diverse areas viz. University Research Farm Koont, NARC and Farmer Field Taxila. All the treatment combinations regarding damage of fruit showed significant results. The minimum fruit infestation i.e. 3.20% and 3.58% was recorded with combined treatment (i.e. *T. chilonis* + hoeing + weeding + lufenuron) in two different localities. This combined treatment also resulted in maximum yield at NARC and Taxila i.e. 57.67 and 62.66 q/ha respectively. This treatment gave the best results to manage *H. armigera.* On the basis of different integrated pest management techniques, Arka Anamika variety proved to be comparatively resistant against *H. armigera* in different localities. So, this variety is recommended for the cultivation in Pothwar region to get maximum yield.

Keywords: Management, American Bollworm, Okra, Treatments, Pothwar.

INTRODUCTION

Okra which is also called Lady Finger is an important vegetable in Pakistan. Okra belongs to Malvaceae family scientifically called (*Abelmoschus esculentus* L. Moench), is originally included in the genus Hibiscus; however, section *Abelmoschus* is now accepted as distinct genus on the basis of its caducous nature of the calyx (Patel et al., 2019). Lady finger is an extensively cultivated vegetable. Okra is well-known vegetable crop in tropical countries has its origin in Africa or Asia, specifically from the Ethiopian Highlands and West Africa (Dantas et al. 2021). Okra is a dynamic vegetable broadly developed everywhere throughout the Pakistan (Javed *et al*., 2009). It is predominantly cultivated as a summer and fall crop mostly in the tropics and subtrop-ics (Elkhalifa et al. 2021; Manju et al. 2021). Insect pests are one of the key limiting factors contributing towards the low yield of okra globally (Tamta et al. 2022; Chakraborty et al. 2021, 2022; Samanta et al. 2023, 2021)

There are different insects and diseases damaging the okra plants but the fruit borer *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) is a major pest of wide range of economically important plant okra and including field and horticultural crops (Farid, 1986) all over the world (Yu *et al*., 2008; Jallow *et al*., 2004; Mironidis and Savopoulou-Soultani, 2008 and Reddy *et al*., 2004) are the most feared ones. Generalist feeders like *H. armigera* oviposit on a wide range of hosts and thus cause significant yield losses in crop plants and huge monetary erosion each year (Sarate et al., 2012; Saraf et al., 2015).

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The Okra is prone to various phytophagous pests, parasites, microscopic organisms, infections, nematodes, mycoplasma and insects which cause enormous lessening in yield and quality at various development stages (Kumar *et al*., 2002 and Gulati, 2004). Ewete in 1983 detailed 72 and Hill in 1983 reported 48 insect species, for the most part insect species are sapsuckers, leaf eaters, fruit borers, leaf rollers, flower feeders and leaf miners.

Okra is one of those plants for which insect female has an oviposition preference over other hosts (Jallow *et al*., 2001). The hatchlings of this insect additionally assault many vegetables. The nuisance rank of this species is inferred, to a limited extent, from its four life history attributes (to be specific, high versatility, polyphagy and high fruitfulness) which empower the insect to make survive in unstable natural surroundings (Fitt, 1989). Pest existence, multiplication and life cycle factors of pest are affected by plant sort (Lee, 2002; Tsai and Wang, 2001 and Kim and Li *et al*., 2002). In Pakistan, manufactured pest sprays are widely utilized for the control of pests yet then use causes some undesirable impacts, including pesticide contamination, resurgence of secondary pests, pest resistance to particular pest spray, end of helpful fauna and distinctive human medical issues.

Excessive utilization of insecticidal sprays has made issues with wellbeing risk, ecological contamination and increase in resistance against the harms of insecticides (Ahmad *et al.*, 1997). The variation in growth is even more remarkable when different food materials are involved. Hereditary assorted qualities in thickness of pubescence in both wild and cultivated plants bring about shifting impacts upon the science of insect pest.

There is serious action required to search alternate pest control technique. The integrated pest management (IPM) technique is very effective tool for sustainability in the production of okra. The egg parasitoid *Trichogramma* spp is pretty much a general egg parasite for Lepidoptera. It is suggested as an essential part of integrated pest management program. They offer cost-effectively friendly and naturally feasible ways for suppressing pest population between the Economic Injury Level (EIL) (Govindachari, 1992). Correspondingly, removal of damaged fruits and shoots, hoeing/weeding and mechanical control are important for integrated pest management of okra (Anonymous, 2001). The several researches were conducted to management American Bollworm. The main aim of this research is to minimize the use of pesticides and increase the production of okra crop.

MATERIALS AND METHODS

Management of *H. armigera* by using various techniques

Studies on integration and evaluation of various pest management techniques were carried out at University Research Farm Koont, Farmer Field Taxila and National Agriculture Research Center (NARC). The Arka Anamika variety of okra showed comparatively resistant response and high yielding against *H. armigera* on the basis of less fruit infestation was observed in different researches from the screening trials. Various treatments alone and with different combinations were applied for the management of *H. armigera*. These were weeding/hoeing, spray, removal of damaged part of the plant, by using hand picking removal of larvae, installation of *T. chilonis* eggs @ 1000/card and spraying of IGR (Lufenuron @ 800 ml/acre). On appearance of the pest the possible combination of treatment should be applied three times with a 10 days interval. Arka Anamika variety was sown in the month of April, 2016 at University Research Farm Koont, NARC and Farmer field Taxila respectively. The Randomized Complete Block Design (RCBD) was done with 3 replications. Plot size was 2 kanal with plant to plant 60cm and row to row 75cm spacing. The thirteen alone and with all combination treatments were selected for testing to investigate the best effective and economical. The followings four management techniques were used:

Cultural control

(Hoeing /Weeding)

Mechanical control

(Clipping)

Biological control

(*Trichogramma chilonis)*

Chemical control

IGR (Lufenuron)

T1 = *Trichogramma chilonis* at the rate of 25-35 cards/acre at weekly interval (1000 eggs per card).

T2 = Hoeing and Weeding at weekly interval.

T3 = Clipping of damaged shoots and fruits at weekly interval.

T4 = Lufenuron at weekly interval.

T5 = *Trichogramma chilonis* at the rate of 25-35 cards/acre at weekly intervals + Hoeing and Weeding at weekly interval.

T6 = *Trichogramma chilonis* at the rate of 25-35 cards/acre at weekly intervals + Clipping of damaged shoots and fruits at weekly interval.
T7 = *Trichogramma chilonis* at the rate of 25-35 cards/acre at weekly intervals + Lufenuron at weekly interval.
T8 = Hoeing and Weeding at weekly interval + Clipping of damaged shoots and fruits at weekly interval.
T9 = Hoeing and Weeding at weekly interval + Lufenuron at weekly interval.
T10 = Clipping of damaged shoots and fruits at weekly interval + Lufenuron at weekly interval.
T11 = *Trichogramma chilonis* at the rate of 25-35 cards/acre at weekly intervals + Hoeing and Weeding at weekly interval + Clipping of damaged shoots and fruits at weekly interval.
T12 = *Trichogramma chilonis* at the rate of 25-35 cards/acre at weekly intervals + Hoeing and Weeding at weekly interval + Lufenuron at weekly interval.
T13 = Hoeing and Weeding at weekly interval + Clipping of damaged shoots and fruits at weekly interval + Lufenuron at weekly interval.
T14 = Control.

Data collection

Five different plants were randomly selected from each variety. At 7±1 days interval the damaged fruits and healthy fruits, were counted. According to the following formula the fruit infestation percent was calculated:

$$\text{Infestation percentage} = \frac{B}{A} \times 100$$

Where: A= Total number of fruits
B=Damaged fruits

Statistical analysis

The data on fruit infestation percentage were analyzed statistically by COSTATC package. Treatments were analyzed by DMR Test at P=0.05 (Steel and Torrie, 1997).

RESULTS

The research was conducted to incorporate different integrated pest management methods *viz*., Cultural control (Hoeing /Weeding), Mechanical Control (Clipping), Biological Control (*T. chilonis*) and Chemical: IGR (Lufenuron) individually and with all possible combinations were applied 3 times on resistant variety Arka Anamika during 2016 for the management of *H. armigera*. The aim of this study to expose competitively actual and inexpensive management practices and recommend to the farmers community. The results are as under.

Fruit infestation caused by *H. armigera* on okra variety

Effect of treatments at research farm Koont

The fruit infestation means comparison data of okra which caused by *Helicoverpa armigera* in different treatments, revealed highly significant differences (Table 1). It is evident from the result that the minimum fruit infestation (3.20 %) was observed with the T_{12} treatment *Trichogramma chilonis* + Hoeing and Weeding + Lufenuron. This was statistically similar to (T_9) Hoeing and Weeding + Lufenuron with 3.94 percent fruit infestation. The release of *Trichogramma* individually did not show best control of pest resulting in 5.03 percent fruit infestation. Highest fruit infestation of *Helicoverpa armigera* (6.47%) was recorded, in the control because no treatment was applied on control.

Effect of treatments at NARC

The fruit infestation of okra variety in different treatments against *H. armigera* revealed significant differences (Table 1). It is evident from the result that the minimum fruit infestation (3.58%) was observed with the treatment (T_{12} and T_{10}) *Trichogramma chilonis* + Hoeing and Weeding + Lufenuron and Clipping + Lufenuron. This was statistically similar to (T_{10}) Clipping + Lufenuron. The release of *Trichogramma* alone (T1) and treatment with Hoeing and Weeding (T2) did not show the best control of pest resulting in 5.33 and 5.19 percent fruit infestation. Highest fruit damage of *Helicoverpa armigera* was noticed 5.43 and 5.33 percent, in the (T1) *Trichogramma* and (T14) control. The fruit infestation on okra in the other was not significantly different except for (T_{14}) control

Effect of treatments at farmer field, Taxila

The fruit infestation of okra variety in different treatments against *H. armigera* revealed significant differences (Table 1). It is evident from these results that the minimum fruit infestation was observed 2.14 percent from the (T_{11}) treatment *Trichogramma chilonis* + Hoeing and Weeding + clipping but there was no significant difference with (T_{13} and T_{12}) Hoeing and Weeding + clipping + Lufenuron and *Trichogramma chilonis* + Hoeing and Weeding + Lufenuron. All the other treatment showed no significant differences with each other except (T14) control with 4.19 percent fruit infestation.

Table 1. Mean comparison data of fruit infestation (%) caused by *Helicoverpa armigera* on okra variety (Arka Anamika) in different Treatment and localities during 2016.

Treatment	KOONT	NARC	TAXILA
T1=*Trichogramma chilonis*	5.03 bc	5.33 a	2.54 b
T2= Hoeing and Weeding	4.63 bcd	5.19 ab	2.44 b
T3= Clipping	4.58 bcd	4.65 bcd	2.29 b
T4= Lufenuron	4.58 bcd	4.49 bcd	2.73 b
T5=T1+T2	4.39 cd	4.98 abc	3.26 b
T6=T1+T3	5.24 b	4.27 cd	3.24 b
T7=T1+T4	4.71 bcd	4.35 cd	2.44 b
T8=T2+T3	5.19 b	4.52 bcd	3.07 b
T9=T2+T4	3.94 d	4.46 bcd	3.05 b
T10=T3+T4	4.34 cd	3.58 e	3.03 b
T11=T1+T2+T3	4.33 cd	4.34 cd	2.14 b
T12= T1+T2+T4	3.20 e	3.58 e	2.58 b
T13=T2+T3+T4	4.08 d	4.06 de	2.32 b
T14=Control	6.47 a	5.43 a	4.19 a
LSD at 0.05%	0.49	0.51	0.68

Mean sharing common letter in columns and rows for interaction, in column for treatment and rows for location mean are not significantly different by DMR test at P=0.05 (KOONT = Research farm Koont Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi; NARC =National Agriculture Research Center, Islamabad; TAXILA = Farmer field).

Impact of Control Methods in Relation to Yield (q/ha)

Okra yield at research farm, Koont

The yield of various treatments at University research farm Koont as shown in (Appendix 33) (Table 2). The results showed that maximum yield (50.33 q/ha) of Arka Anamika was recorded from (T8) Hoeing and Weeding + clipping. The minimum yield 34.33 q/ha was recorded (T14) control that was statistically at par with those recorded from *Trichogramma chilonis* (T1) and (T9) with yield 46 and 48.33 q/ha. The yield from T2, T4, T11, T12 and T10 were statistically non-significant with each other's 41, 41, 41 41 and 42.67 q/ha yield, respectively.

Table 2. Mean comparison data of yield (q/ha) of okra variety (Arka Anamika) in different treatment and localities during 2016.

Treatment	KOONT	NARC	TAXILA
T1=*Trichogramma chilonis*	46 bcde	52.33 bcd	53.33 bc
T2= Hoeing and Weeding	41 fg	45.33 e	47 de
T3= Clipping	39.67 g	45 e	48.33 d
T4= Lufenuron	41 fg	48.67 d	49.33 d
T5=T1+T2	45.33 cde	50.33 bcd	57.66 abc
T6=T1+T3	45 cdef	51.33 bcd	52.66 c
T7=T1+T4	47.67 abcd	53 bc	57.66 abc
T8=T2+T3	50.33 a	54 b	57.66 abc
T9=T2+T4	48.33 abc	50.67 bcd	57.66 abc
T10=T3+T4	42.67 efg	49.67 cd	57.66 abc
T11=T1+T2+T3	41 defg	52.33 bcd	58.33 ab
T12= T1+T2+T4	41 abc	57.67 a	62.66 a
T13=T2+T3+T4	39.66 ab	53 bc	62.66 a
T14=Control	34.33 h	41.67 f	44.33 e
LSD at 0.05%	2.82	2.38	3.30

Mean sharing common letter in columns and rows for interaction, in column for treatment and rows for location mean are not significantly different by DMR test at P=0.05 (KOONT= Research farm Koont Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi; NARC = National Agriculture Research Center, Islamabad; TAXILA**=** Farmer field).

Okra yield at NARC

The yield of in various treatments at National Agriculture Research Center are shown in (Appendix 33) and

means in (Table 2). The results showed that maximum yield (57.67 q/ha) of Arka Anamika was recorded from (T12) *Trichogramma chilonis* + Hoeing and Weeding + Lufenuron. The minimum yield 41.67 q/ha was recorded on (T14) control that was statistically at par with those recorded from *Trichogramma chilonis* (T12) with yield 57.67 q/ha. The yield from T1, T5, T6, T7, T8, T9, T10, T11 and T13 were statistically non-significant with each other's 52.33, 50.33, 51.33, 53, 54, 50.67, 49.67, 52.33 and 53 q/ha yield, respectively.

Okra yield at farmer field, Taxila

The okra variety Arka Anamika yield showed in various treatments at Taxila Farmer Field, (Appendix 33) (Table 2). The results showed that maximum yield (62.66 q/ha) of Arka Anamika were recorded from (T12 and T13) *Trichogramma chilonis* + Hoeing and Weeding + Lufenuron and Hoeing and Weeding + clipping + Lufenuron. Minimum yield 44.33q/ha recorded on (T14) control that was statistically at par with others treatments. The yield from T1, T5, T7, T8, T9, T10 and T11 were statistically non-significant with each other's 53.33, 57.66, 57.66, 57.66, 57.66, 57.66 and 58.33q/ha yield, respectively.

DISCUSSION

Various management practices like release of *T. chilonis*, hoeing and weeding, clipping and Lufenuron etc, were applied for best effective results on Arka Anamika variety during the year 2016 at Research Farm Koont, National Agriculture Research Center (NARC) and farmer field, Taxila. A combined treatment or spray of Lufenuron, *Trichogramma chilonis* and hoeing/weeding was the most effective treatment with least fruit damaged (3.20%). Release of *Trichogramma* only showed fruit infestation 5.03 percent whereas in combination with the Application of hoeing/weeding and lufenuron, it minimized the fruit damaged to 3.20 %. The current results are similar to Sardana *et al*. (2005) use of mechanical + cultural + chemical and biological results best. The results are not similar with Bagade *et al.* (2005) treatments results (8.05-14.38%) minimum fruit infestation. The release of *Trichogramma chilonis*, Hoeing/weeding, clipping and spray of IGR Lufenuron were used to manage *H. armigera* pest. Maximum infestation of *Helicoverpa armigera* larvae was found in untreated plots which were statistically different from all the other treatments. These findings are similar with Ahmad *et al.,* 1999, Abdul *et al.,* 2003, David *et al.,* 2005, Noorani *et al.,* 1994, Satyavani *et al.,* 1991 and Jadhav *et al.,* 1996 who got effective control of *Helicoverpa armigera* after adopting different techniques. The results showed that maximum yield of Arka Anamika was recorded 50.33, 57.67 and 62.66 q/ha from three different localities and the most effective integrated combination for high yield was (T12) *Trichogramma chilonis*, Hoeing/weeding and Lufenuron. The result was similar to Noorani *et al.* (1994) who used Match (trade name of Lufenuron) and got maximum yield. All IPM practices alone and with all combinations result showed reduction the number of sprays increase Okra fruit yields up to 50.33 to 62.66 q/ha in IPM and 34.33 to 44.33 q/ha in non-IPM field the result were similar to the findings of (Sardana, 2005) who reported that adaptation of IPM technology the minimum spray used and got maximum yield. The variety Arka Anamika was selected for final management trial because this variety proved as comparatively resistant and this finding was also reported by Tripathy (2008) that the Arka Anamika was comparatively resistant variety against fruit borer (5.93%).

CONCLUSION

Nine local and exotic varieties of Okra (*Abelmoschus esculentus* L)*,* were screened against the damage of *Helicoverpa armigera*, under organic farming system at University Research Farm Koont. Comparative resistance could be attributed to different physico-morphic characters, abiotic factors like temperature, relative humidity and rainfall also contributed in comparative resistance/susceptibility in Okra varieties. Promising results were achieved with variety Arka Anamika. It was least affected by *H. armigera*, and gave the highest yield (q/ha) and performed very well under field conditions. In combination with other organic farming treatments as *Trichogramma chilonis,* Hoeing/Weeding and Lufenuron (IGR), same effective level of pest management attained and it gave the highest yield (q/ha).

AUTHOR CONTRIBUTIONS

All authors contributed equally.

COMPETING OF INTEREST

The authors declare no competing interests.

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