Pakistan J. Zool., vol. 44(5), pp. 1203-1208, 2012.

Comparative Efficacy of Different Strategies for Management of Spotted Bollworms, *Earias* spp. on Okra, *Abelmoschus esculentus* (L). Moench

Muhammad Asif Aziz, [1]* Mansoor Ul Hasan,[2] Amjad Ali[3] and Jamshaid Iqbal[4]
[1]*PMAS Arid Agriculture University, Rawalpindi*
[2] *University of Agriculture, Faisalabad*
[3] *Entomological Research Institute, Faisalabad*
[4]*Pest Warning and Quality Control of Pesticides, Attock*

Abstract.- Integrated control measures were tested for efficacy against *Earias* spp. on okra in Pakistan with the over-riding goal of finding the most cost-effective control. Five control methods: (i) biological control with *Trichogramma chilonis* Ishii., (ii) cultural control of alternate host plants by hand weeding and hoeing, (iii) botanical control by spraying the plants with 5% neem seed kernel extract, (iv) mechanical control by hand-clipping injured plant parts and (v) chemical control with by spraying the plants with a commercial insecticide (Tracer®, Dow AgroSciences). These treatments were tested alone and as seven combinations of two methods and three combinations of three methods. All treatments were applied each week for six weeks and compared by measuring damaged fruits and shoots, yield and cost-benefit ratio in a controlled, replicated field experiment on Diksha cultivar of okra. Fruit and shoot damage was significantly lowest at 7% and 14%, respectively, in the plots treated with only chemical control and fruit yield was highest, at 63 kg/plot, in plots treated with the combination of mechanical and chemical control. Plots treated with only mechanical control had the highest cost: benefit ratio at 1:2.61, followed by plots treated with mechanical control and chemical control, at 1:2.39 and plots treated with chemcial plus botanical plus mechanical control at 1:2.38.

Key words: Okra, *Earias* spp., pest management, neem, spinosad, *Trichogramma*.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the most common and widely grown vegetables all over Pakistan (Javed *et al.*, 2009). It is attacked by a number of phytophagous insects, diseases and mites during different growth stages (Kumar *et al*., 2002; Gulati, 2004) but the spotted bollworms (*Earias vittella* Fab. and *Earias insulana* Boisd.) are the most important ones (Aziz *et al.*, 2011). *Earias* spp. attacks rigorously on okra both at the vegetative and fruiting stages, resulting in a serious decline in terms of quality and quantity of the produce. Due to high reproductive as well as damage potential and internal feeding habits of spotted bollworms, their management on okra has become increasingly difficult. Farmers heavily rely on the use of synthetic insecticides for the control of this pest. As vegetables like okra are consumed fresh in Pakistan, use of highly toxic substances on okra is not desirable (Memon *et al*., 2002).

Earias spp. can be controlled by the synthetic chemicals to some extent (Krishnajah *et al.*, 1976) but an indiscriminate use of chemical insecticides for the suppression of this pest has generated many problems like development of insecticide resistance (Saini and Chopra, 1988), human health hazards, destruction of the beneficial fauna, resurgence of minor pests, and environmental pollution (Mahapatro and Gupta, 1998).

There is a need to explore alternatives, encompassing available pest control methods and techniques in order to reduce the sole dependence to insecticides. For this purpose, integrated pest management seems to be the most appropriate approach to achieve sustainability in okra production. *Trichogramma* spp. is more or less universal parasites of eggs of the Lepidoptera and is recommended as an important component of IPM programme of okra against *Earias* spp. (Anonymous, 2001). Neem-based formulations can also be integrated with other control tactics (Gupta

* Corresponding author: aisfaziz@uaar.edu.pk
0030-9923/2012/0005-1203 $ 8.00/0

and Sharma, 1997). They offer economically compatible and ecologically viable alternatives in managing the insects below economic injury levels (Govindachari, 1992). Similarly, destruction of infested fruits and shoots as well as hoeing/ hand weeding as mechanical control operations occupy an important place in the IPM of okra (Anonymous, 2001).

Though there have been several studies on the management aspects of the spotted bollworms on okra especially in India, but in Pakistan such type of studies are mostly dealt in isolation. So, keeping in view the importance of low input based crop production and reduction of pesticide load on the okra crop; the present investigations were carried out under to integrate biological, cultural, botanical, mechanical, and chemical control practices in suppressing the population/damage of spotted bollworms on okra and findout the most effective and economical combination of these practices.

MATERIALS AND METHODS

Integrated pest management was conducted at the research area of the Entomological Research Institute (ERI), Faisalabad, Pakistan. Okra, genotype Diksha, seed was planted on 14 July 2007 at the ERI. The size of each experimental plot was 8.5 x 8.5 cm. Plant to plant distance was 30 cm. Row to row spacing was 60 cm. All the recommended agronomic practices (irrigation, fertilizer etc.) were strictly followed in case of all treatments while conducting the trial. The following treatments were applied on the crop in a randomized complete block design with three replications (blocking was used to minimize the effect of difference insect density and soil) to investigate their effectiveness: biological control, release of *Trichogramma chilonis* @ 60 cards per hectare (1000 eggs/ card); cultural control, weeding and hoeing; botanical control, spraying of 5% neem seed kernel extract (5% NSKE); mechanical control, hand clipping of infested shoots and fruits; chemical control, spray of Tracer @ 90 ml/ ha; biological control plus cultural control, *T. chilonis* + weeding and hoeing; biological control plus botanical control, *T. chilonis* + NSKE 5%; biological control plus mechanical control, *T. chilonis* + hand clipping; cultural control plus botanical control, weeding and hoeing + NSKE 5%; cultural control plus mechanical control, weeding and hoeing + hand clipping; mechanical control plus chemical control, hand clipping + tracer; mechanical control plus botanical control, hand clipping + NSKE 5%; cultural control plus botanical control plus biological control, weeding and hoeing + NSKE 5% + *T. chilonis*; mechanical control plus botanical control plus biological control, hand clipping + NSKE 5% + *T. chilonis*; chemical control plus botanical control plus mechanical control, tracer + NSKE 5% + hand clipping; control, non treated plots.

The plants were inspected regularly for the appearance of the pest on visual basis. The adults appeared first, laid eggs and the damage started with egg hatching. The treatments were applied six times to the crop with the start of damage on shoots and fruits (at weekly interval. Fruit damage (%), shoot damage (%), yield (kg/plot) and cost benefit ratio were the paratmenters to assess the effect of various treatments. Damaged and undamaged fruits from five randomly selected plants were counted from each plot at weekly interval and percent fruit damage was calculated. Similarly, damaged and undamaged shoots from the 25 randomly selected plants in each experimental plot were counted and percent shoot damage was calculated. The data regarding the fruit yield from each picking of each plot were recorded carefully and added to get the total yield of each plot. Cost benefit ratio (CBR) was calculated to fine out the best treatment, showing maximum control of the pest and resulting in maximum yield with a minimum cost. The data were analyzed using an MSTATC package (Bricker, 1991) and the means were separated by the Duncan's Multiple Range Test at 0.05% probability (Steel *et al.,* 1990).

RESULTS

Fruit damage

Means comparison of the data regarding fruit damage in okra (Diksha) caused by *Earias* spp. revealed highly significant differences between treatments (Table I). The application of chemical control proved compartatively most effective (7%)

Table I.- Means comparison of fruit and shoot damage (%) caused by *Earias* spp. and yield (kg/plot) of okra (Diksha) in different treatments at ERI, Faisalabad.

Treatment	Fruit damage (%)	Shoot damage (%)	Yield (Kg/plot)
Biological control	17^{e}	27cd	41^{h}
Cultural control	22^{b}	30^{b}	34^{l}
Botanical control	15^{f}	23^{g}	38^{j}
Mechanical control	10^{j}	18^{i}	48^{e}
Chemical control	7^{k}	14^{k}	52^{c}
Cultural plus biological control	20^{c}	28^{c}	36^{k}
Botanical plus biological control	17^{e}	25^{f}	38^{j}
Mechanical plus biological control	14^{g}	23^{fg}	43^{f}
Cultural plus botanical control	19^{d}	26^{de}	39^{i}
Cultural plus mechanical control	17^{e}	23^{fg}	40^{h}
Mechanical plus chemical control	9^{j}	16^{j}	63^{a}
Mechanical plus botanical control	13^{h}	20^{h}	50^{d}
Cultural plus botanical plus biological control	18^{e}	24^{fg}	39^{i}
Mechanical plus botanical plus biological control	17^{e}	23^{g}	42^{g}
Mechanical plus botanical plus chemical control	11^{i}	17^{ij}	61^{b}
Untreated plots (control)	27^{a}	39^{a}	24^{m}
DMR value	0.99	1.66	0.64

Means sharing similar letters are not significantly different (DMR tes t= 0.05%).

in controllong fruit damage by *Earias* spp. followed by mechanical plus chemical control and mechanical control alone. Maximum fruit damage was recorded as 27% in untreated plots (control), which differed significantly from those recorded from all other treatments. Furthermore it was observed that the releases of biological control alone resulted in 34% reduction of fruit damage. Application of botanical control alone showed 44.92% reduction where as when used in combination with biological control, it resulted in 37.62% reduction in fruit damage.

Shoot damage

The results regarding the shoot damage in okra caused by *Earias* spp. in different treatments after six applications showed a highly significant difference among treatments (Table I). Chemical control was found to be the most effective and resulted in a minimum shoot damage, *i.e.*, 14%, where as the highest shoot damage (30%) among different control options was recorded in case of cultural control alone. In comparison, untreated plots (control) produced 39% shoot damage. The application of mechanical control hand and botanical control alone resulted in 18% and 23% shoot damage, respectively, but these treatments proved more effective when integrated with spray of tracer (mechanical plus chemical control) resulted in 16% shoot damage and mechanical plus botanical plus chemical control resulted in 17%. These treatments resulted in satisfactory reduction in shoot damage of okra due to *Earias* spp.

Fruit yield

Analysis of the data revealed that all the treatments were associated with significant increase in the fruit yield of okra as compared to the control (Table I). The highest fruit yield was observed in mechanical plus chemical control followed by mechanical plus botanical plus chemical control and chemical control with 61 and 52 Kg/plot fruit yield, respectively. Those plots, where mechanical control alone and in combination with botanical control also generated better yields (48 and 50 kg/plot), whereas all other combinations did not perform well as compared to the control (24 kg/plot).

Cost benefit ratio

The cost benefit ratio (calculated) of different control methods against *Eaias* spp. on Diksha was calculated to determine the most effective and economical method (Table II). The highest CBR was found in mechanical control (1:2.61) followed

Table II.- Cumulative Cost-benefit ratio (calculated) of okra (Diksha) for different control methods of *Earias* spp. at ERI, Faisalabad during 2007.

Treatment	Yield (q/ha)	Increased yield over control (q/ha)	Benefit/ha (Rs)	Expenses/ha (Rs)	Cost benefit ratio
Biological control	33.2	1.54	3850	4200	1: 0.92
Cultural control	31.5	-0.16	-400	12000	1: -0.03
Botanical control	34.3	2.57	6425	6050	1: 1.06
Mechanical control	36.4	4.70	11750	4500	1: 2.61
Chemical control	37.5	5.81	14525	6110	1: 2.38
Cultural plus biological control	32.2	0.40	1225	8100	1: 0.15
Botanical plus biological control	33.5	1.78	4450	5125	1:0.87
Mechanical plus biological control	34.8	3.10	7750	4350	1:1.78
Cultural plus botanical control	32.7	1.02	2550	9025	1: 0.28
Cultural plus mechanical control	33.2	1.56	3887.5	8250	1: 0.47
Mechanical plus chemical control	36.8	5.08	12707.5	5305	1: 2.39
Mechanical plus botanical control	35.2	3.52	8800	5275	1:1.67
Cultural plus botanical plus biological control	33.2	1.47	3675	7416.7	1:0.50
Mechanical plus botanical plus biological control	33.4	1.76	4400	4916.7	1: 0.9
Mechanical plus botanical plus chemical control	36.0	4.28	10700	5553	1: 1.9
Untreated plots (control)	31.7	-	-	-	-

Rate of Okra fresh fruit, Rs. 25 /kg; q, quantals; ha, Hactare.

by mechanical plus chemical control, chemical control and mechanical plus botanical plus chemical control with CBR values of 1:2.39, 1:2.38 and 1:1.93, respectively. The lowest CBR (1:-0.03) was recorded in cultural control, where weeding and hoeing was practiced due to heavy labour charges and low increase in yield. However, other treatments performed better and gave higher yields over the control and benefits per hactare ranged from Rs. 1225 to 14525. The expenditure of the treatments is a driving force of CBR values. Comparatively low labour charges of hand clipping proved advantageous to give the higest CBR. However chemical control in combination with mechanical control also proved good, although CBR decreased as compared to those plots where mechanical control was practiced alone. CBR in mechanical plus chemical control is almost comparable with chemical control, which indicates that this combination may be used atlternatively to minimize the sole reliance on chemical insecticides. Although mechanical plus botanical plus chemical control, also gave comparatively better CBR than the rest (1:1.93), which comprised the addition of NSKE 5% to hand clipping with tracer, but high cost of production of botanical insecticide and relatively less increase in the CBR may be the limiting factor. But if the neem products are made available to the farmer as a commercial product in the refined form, there are bright chances for effectiveness of this combination.

DISCUSSION

Present studies were aimed to evaluate the effectiveness of different management options of okra shoot and fruit borer alone, and in different combinations. When applied alone, chemical control proved comparatively most effective than others and resulted in minimum fruit and shoot damage. Mechanical control of damaged shoots and fruits also remained better than other non chemical treatments suggesting usefulness of this practice. Application of botanical control produced encouraging results with 44.93% reduction in fruit and 41.83% in shoot damage, respectively. In case of different combinations, mechanical control along application of chemical plus botanical control proved effective in controlling the pest and provided better yield and higher CBR values as compared to other combinations.

It is evident from the results that although

different non chemical measures provided control to varying degrees against the pest, but no one seem to be effective alone. However, using in combination with comparatively safer pesticides may be a better option. In the present studies, in spite of using convententional insecticides like endosulfan (Shukla *et al.,* 1997, Gupta and Misra, 2006), carbaryl (Kumar and Singh, 2006) fenvalerate (Sing *et al.,* 2005) and cypermethrin (Bagade *et al.,* 2005); Tracer was used which is a biological insecticide derived from naturally occurring bacteria with novel mode of action and is comparatively safer to parasitoids, predators and non target organisms as compared to the previous ones (Bret *et al*., 1997; Salgado *et al*., 1997).

Effectiveness of combination of hand clipping along with chemical and botanical control in the current studies is encouraging. Effectiveness of different neem products against okra fruit and shoor borer is advocated by different workers as Raja *et al.* (1998) reported 49.73% decrease in pest the damage by determining the effect of *T. chilonis*, endosulfan and neem oil for the control of *E. vittella* on okra. According to Sarode and Gabhane (1994), the application of neem seed kernel extract and chemicals application alone and in combination showed a significant control of *E. vittella* than the untreated control. Patel and Sojitra (1993) 73.26% reduction in shoot infestaion by *Earias vittella* on okra with three sprays of neem based Repelon. Ramesh and Gupta (2005) found that spray combination of endosulfan- neem azal-biolep-neem azal were the most effective in getting higher seed yields of okra. The effectiveness of mechanical control in combination with chemical control was reported by Gupta *et al*. (2000) who found that combination of carbofuran (soil application)+ endosulfan+mechanical control was the most effective on okra resulting in lowest incidence of *Earias* spp. and maximum fruit yield. Okra yield was more in plots treated with NSKE in integration with tracer and hand clipping than that on KSKE alone. Singh *et al.* (2005) reported maximum reduction in pest incidence and increase in yield (76.95 q/ha) in the plots treated with fenvalerate (0.15%) followed by NSKE (1.5%) (58.27q/ha) but they observed that maximum control over fruit and shoot damage and yield of okra in those plots where chemical control was applied alone or in combination with other control tactics.

Use of botanicals and mechanical control in pest management programme of okra fruit and shoot borer can help the farmers to reduce the sole reliance on synthetic insecticides. Hand clipping alone may be useful tactic against this pest especially where okra is cultivated on small plots. Moreover, these are both eco-friendly approaches of pest control with minimum disturbance to natural beneficial insects and non target organisms.

ACKNOWLEDGEMENTS

The authors are grateful to Higher Education Commision, Islamabad for financial support to complete this research work.

REFERENCES

ANNONYMOUS, 2001. *Integrated pest management for okra.* Directorate of Plant Protection, Quarantine and Storage. Faridabad. India, pp. 4.

AZIZ, M.A., HASAN, M. AND ALI, A., 2011. Impact of abiotic factors on incidence of fruit and shoot damage of spotted bollworms *Earias* spp. on okra (*Abelmoschus esculentus* L.). *Pakistan J. Zool.,* **43**: 863-868.

BAGADE, A.S., AMBEKAR, J.S., BHAGAVATI, V.Y. AND BADE, B.A., 2005. Field efficacy of neem formulations in alternation with synthetic insecticides against okra fruit borer (*Earias vittella* Fab.). *J. Maharashtra Agric. Univ.,* **30**: 210-212.

BRET, B.L., LARSON, L.L., SCHOONOVER, J.R., SPARKS, T.C. AND THOMPSON, G.D., 1997. Biological properties of spinosd. *Down to Earth,* **52:** 6-13.

BRICKER, B., 1991. *M STATC: A micro computer program from the design management and analysis of agronomic research experiments.* Michigan State University.

GOVINDACHARI, T.R., 1992. Chemical and biological investigations on *Azadirachta indica* (the neem tree). *Curr. Sci.,* **63**: 117-122.

GULATI, R., 2004. Incidence of *Tetranychus cinnabarinus* infestation in different varieties of *Abelmoschus esculentus*. *Ann. Pl. Protect. Sci.,* **10**: 239-242.

GUPTA, G.P. AND SHARMA, K., 1997. Neem based pest management strategy in cotton system. *Pestic. Res. J.,* **9**: 190-197.

GUPTA, S.C. AND MISRA, A.K., 2006. Management of okra shoot and fruit borer, *Earias vittella* Fabr. through bio-rational insecticides. *Pestic. Res. J.,* **18**: 33-34.

GUPTA, S.C., PRASAD, G.S. AND SINGH, P.P., 2000. Evaluation of safer formulations of insecticides,

mechanical measures and their combinations against *Earias vittella* Fabr. on okra. *Shashpa*, **7**: 77-80.

JAVED, H., AZIZ, M. A. AND LEGHARI, R. A. K., 2009. Resistance in different okra (*Abelmoschus esculentus* L.) cultivars against American bollworm (*Helicoverpa armigera* Hub.). *J. agric. Res.*, **47**: 433-438.

KRISHNAJAH, K., TANDON, P. L., MATHER, A.L. AND JAGON MOHAN, N., 1976. Evaluation of insecticides for the control of major insect pests of okra. *J. agric. Sci.*, **48**: 178-186.

KUMAR, M. AND SINGH, A.K., 2006. Determination of economic threshold level of *Earias vittella* in okra. *Annls. Pl. Protect. Sci.*, **14**: 226-227.

KUMAR, S., PRASAD, S. AND SINGH, R.N., 2002. Resurgenco of two spotted mite due to acaricides and botanicals on okra. *Ann. Pl. Protect. Sci*., **10**: 51-54.

MAHAPATRO, G.K. AND GUPTA, G.P., 1998. Pesticide induced resurgence. *Pestology*, **22**:14-20.

MEMON, A.J., ABRO, G.H. AND SYED, T.S., 2002. Varietal resistance of okra against *Earias* spp. *J. Ent.*, **1**:1-5.

PATEL, J.R. AND SOJITRA, I.R., 1993. *World Neem Conference*, Bangalore, India, pp. 27.

RAJA, J., RAJENDRAN, B. AND PAPPIAH, C.M., 1998. *Management of bhendi fruit borer*, Earias vittella *(F.). Advances in IPM for horticultural crops.* Proceedings of the First National Symposium on Pest Management in Horticultural Crops: Environmental Implications and Thrusts, Bangalore, India, 15-17 October 1997, pp. 118-120.

RAMESH, K. AND GUPTA, G.P., 2005. Effect of different spray combinations for okra crop. *Ann. Pl. Protect. Sci.*, **13**: 41-43.

SAINI, R. K. AND CHOPRA, N.P., 1988. Relative toxicity of different insecticides to field collected larvae of *Earias vittella. J. Ent. Res.*, **12**: 169-170.

SALGADO, V.L., 1997. The modes of action of spinosad and other control products. *Down to Earth*, **52**: 35-43.

SARODE, S.V. AND GABHANE, A.T., 1994. Performance of neem seed kernel extract with reduced insecticidal dosage on the infestation of okra fruit borer, *Earias vittella* Fab. *J. Ent. Res.*, **18**: 327-330.

SHUKLA, A., PATHAK, S.C. AND AGARWAL, R.K., 1997. Effect of some plant odours in the breeding environment on fecundity and hatching of okra shoot and fruit borer, *Earias vittella* Fab. under laboratory conditions. *Crop Res.*, **13**: 157-161.

SINGH, B.K., SINGH, A.K. AND SINGH, H.M., 2005. Efficacy of certain synthetic insecticides and two botanicals against the okra fruit and shoot borer, *Earias vittella* (Fabr.). *Pest Managem. Econ. Zool.*, **13**: 99-103.

STEEL, R.G.D., TORRIE, J.H. AND DICKEY, D.A., 1990. *Principles and procedure of Statistics: A biometrical approach*, 3rd edition, WCB McGraw Hill Companies, Inc., USA.

(Received 9 September 2011, revised 16 May 2012)