Pakistan J. Zool., vol. 43(5), pp. 869-878, 2011.

Economic Appraisal of Pest Management Options in Okra

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Abstract.- Field studies were conducted to determine the comparative effect of neem and tobacco based synthetic insecticides and use of natural enemies on insect pests of okra (*Abelmoschus esculentus*). Maximum mean population of insect pests was recorded in control, while it was minimum on okra fields treated with synthetic insecticides as compared to botanical treated fields. Population of natural enemies *viz*. lady bird beetles, *Chrysoperla* spp. spiders and predatory bugs was minimum in synthetic insecticides treated fields compared to botanical treated fields. There was negative a correlation between insect pests and natural enemies population. It was concluded that biopesticides are safe to natural enemies and integration of biopesticides with natural enemies have a good impact on crop yield parameters. The cost benefit ratio was maximum in case of biosal followed by natural enemies as compared to the application of synthetic insecticides.

Key Words: Okra, insect pests, management, botanicals, natural enemies

INTRODUCTION

The okra, *Abelmoschus esculentus* L. (Malvaceae) is an important vegetable of Pakistan and eaten by people with a great interest. The okra crop is infested by a number of insect pests like *Amrasca devastans, Earias vittella, Bemisia tabaci, Helicoverpa armigera, Acrocercops bifasciata, Thrips tabaci, Aphis gossypii, Podagrica, Anomisflava, Sylepta derogata, Haritalodes derogata*, *Dysdercus koengii* and *Nezara viridula.* But *Amrasca devastans*, *E. vittela*, *H. armigera* and *B. tabaci*, are the notorious and major insect pests of okra (Dubey *et al*., 1999; Basu, 1995; Lohar, 2001). Insect pest infestation not only reduce the growth but also transmit pathogenic diseases (Sheedi, 1980; Dhaliwal *et al*., 1981).This challenging situation invites attention of entomologists to concentrate energies on integrated pest management (IPM) of okra and other crops (Huffaker and Carl, 1980; Dhaliwal *et al.*, 1981; Mahadevan and Chelliah, 1986; Dubey *et al*., 1999; Kumawat *et al*., 2000).

Natural enemies, parasitoids and predators are the main sources of reduction in the populations of noxious insect pests (Pfadt, 1980). Biocontrol agents and neem extracts have been reported ecofriendly options for management of insect pests of okra (Al-Eryan *et al.*, 2001; Bindu *et al.*, 2003; Singh and Brar, 2004; Paulraj and Ignacimuthu, 2005). Neem oil produced non-toxic effects after spray and acted as antifeedant, growth inhibitor and oviposition deterrent against insects pests of okra and cotton (Ahmed *et al.*, 1995). Indiscriminate use of insecticides has resulted in killing of natural enemies and environmental pollution problem on the large scale. Adoptions of IPM strategies ensure safety of environment. In this regard encouragement of natural enemies occupies a central position in integrated pest management because biological control of pests and weeds through natural enemies is eco-friendly (Kapadia and Puri, 1991; Stelzel and Devetak, 1999; Biesinger and Haefner, 2005; Sardana *et al., 2005a;* Shivalingaswamy *et al.*, 2002; Telang *et al.*, 2004)

Botanical insecticides (Neem oil or biosal and tobacco extracts), microbial control (*Bacillus thuringiensis*) and biological control agents (spider, ant, lady bird beetle, *Orius*, myrid bug, *Laius*, *Chrysoperla*, *Trichogramma* etc.) should be integrated for economic management of insect pests (Arora, *et al*., 1996; Abro *et al.*, 2004; Memon *et al.*, 2004).

The present study was undertaken to determine the comparative effect of different management tatics *e.g.* use of botanicals (biosal and tobacco extract), synthetic insecticides and natural enemies (*Chrysoperla carnea* and *Trichogramma chilonis*) on insect pest population of okra crop.

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0030-9923/2011/0005-0869 $ 8.00/0

MATERIALS AND METHODS

The present research was carried out at Jiskani Goth with the participation of Pakistan Agriculture Research Council (PARC) National Integrated Pest Management (NIPM) programme for the Training of Trainers (TOT) at Farmers Field School (FFS) Tandojam, district Hyderabad during spring season, 2008.

The crop was sown on an area of one acre on 12-2-2008 in a Randomized Complete Block Design (RCBD) with four replications. The okra (cv. Rama Krishna) was sown in well prepared soil on ridges. The distance between row to row was 60 cm, and plant to plant 30cm. The seed rate was 8 kg per acre. The treatment size was 1500 square feet. There were five treatments including a control.

Treatment I (T1): Biosal was obtained from HEJ Research Institute, University of Karachi. Biosal was used at the recommended concentration of 1 percent spray solution on weekly basis

Treatment II (T2): the cured tobacco leaves/stems (Desi variety) were grinded in distilled water using juicer/blender and kept for 24 hours as such. This pulp was sieved through muslin cloth to get tobacco extract. The tobacco extract was sprayed at the rate of 2% (2 gm of tobacco leaves / stems in 100 ml water) on weekly basis.

Treatment III (T3): the natural enemies (*C. carnea* and *T. chilonis*) cards were released as pest management tactics on weekly basis. The cards were obtained from Nuclear Institute of Agriculture, Tandojam.

Treatments IV (T4): The conventional farmer practices (FP) in which farmer used chemical insecticides "Thiodan" as crop protection tactics at different doses and time intervals.

Treatment V (T5): kept as untreated control so as to compare the results with other pest management tactics.

Data recording

The data of the treatments were recorded at weekly intervals. While recording the data, it was noted that the observations on insect pests and predators should be recorded early in the morning because of flying and moving of these creatures. The observations were recorded through tagging 5 plants selected at random in each treatment. The populations of sucking insect complex were recorded as per leaf, from five leaves by selecting one from top, 2 from middle and 2 from bottom portion of plant, while the population of chewing insect pests and predators were recorded as per plant.

For counting the population of *Trichogramma*, cards containing 100 fresh eggs per card of *Sitotroga cerealella* were placed in all five treatments at the rate of 10 cards per acre. The *S. cerealella* egg cards were collected from the field after 24 hours and kept in Petridish at $27\pm2^{\circ}C$ in lab. The *S. cerealella* egg cards were examined under microscope after 4 days. The black coloured eggs were counted and considered to be parasitized by *Trichogramma* and parasitization percentage was calculated.

The pre-treatment observations were recorded before employing plant protection tactics, while post-treatment observations were recorded 48 hours after application of the respective IPM tactic.

Yield parameters record

Okra crop yield parameters were observed from germination of seed till harvesting of the crop. When the crop started fruiting, it was recorded as per plant in each treatment. The yield parameters were recorded on pre- and post-treatment basis at weekly interval.

Cost: benefit analysis

As per recommended spacing (Khoso, 1992) a total population of 22000 plants per acre was maintained. The total yield of okra crop per acre was calculated by multiplying the yield of okra per plant in different treatments with the total number of plants per acre.

Due to fluctuation in prices throughout the season, the average price per kilogram of the produce was fixed at Rs.10.00 per kg for the calculation of cost benefit ratio. Total income per acre was calculated by multiplying the total yield of okra crop with per kg price. For calculating crop protection expenses, the recommended doses of treatments per acre were recorded and cost per spray was worked out. The total seasonal crop protection expenses were calculated by multiplying per spray expenses with total number of sprays throughout the season. The benefit per acre was calculated by subtracting plant protection expenses from per acre total income. Finally the cost: benefit ratio was calculated by subtracting the income of control plot from the total income. The products were divided by per acre expenses. The remaining values were said as cost benefit ratio.

Analysis of data

Observations were recorded before application of treatments (pretreatment) and post-treatment after 48 hours of application of IPM tactics per week. The data were compiled and presented at fortnight interval. All the data recorded were statistically analyzed and means were compared through LSD. A correlation between population growth of pests and predators was also worked out to ascertain the effect of predators on population of pests.

RESULTS

Pest population development

Aphid, Aphis gossypii *(Glov.).*

The mean population of aphid (Table I) indicated that the minimum aphid population was recorded in farmer practices plot who was applying Thiodan after every third day in his crop, whereas maximum pest population was found in control treatment. The analysis of data showed that there was a highly significant ($F= 18.48$, $DF=4, 87$, $P < 0.001$) difference in population development of aphid in different treatments. Correlation studies carried out between aphid population and different predators' population development indicated that there was negative correlation between aphid population growth and different predators in okra crop. The correlation between aphid and lady bird beetle was significant ($r = -0.63$, $df = 12$, $P<0.05$).

Thrips, Thrips tabaci *(Lind.)*

Thrips appeared in the crop in the second fortnight of March, their infestation was observed till first week of April. Thrips population remained comparatively low throughout the season. The maximum population of thrips (0.46 per leaf) was recorded in control treatment, while the minimum population (0.05 thrips per leaf) was recorded in farmer practices treatment during first fortnight of April. The seasonal mean population (Table I) indicated that pest population remained low in different treatments. Moreover, pest population development in different treatments was not significantly different from each other. There was negative correlation between thrips population growth and almost all predators, however it was insignificant.

Jassids, Amrasca devastans *(Dist.)*

Jassid population started on okra crop in the second fortnight of March and continued till the second fortnight of May when the crop was harvested. The minimum mean population of jassid (1.65/leaf) was recorded in Biosal , whereas the maximum pest population (2.39/leaf) was found in control(Table I). The analysis of data showed that there was a highly significant ($F = 58.05$, $DF= 4, 298$, $P<0.001$) difference in population development of jassid in different treatments. There was a negative correlation between jassid population growth and different predators in okra crop; however, it was not significant.

Whitefly, Bemisia tabaci *(Genn.)*

Whitefly appeared on okra crop from 3rd week of March and remained in the crop till 3rd week of April. The minimum mean population of whitefly was recorded (0.10/leaf) in FP treatment, whereas the maximum mean population of whitefly (0.18/leaf) was recorded in untreated control as shown in (Table I). The analysis of data showed that there was no significant difference ($F= 1.59$, $DF= 4, 102$, $P<0.18$) in population development of pest in different treatments. There was negative correlation between whitefly and different predators population, however, it was non-significant.

Spotted bollworm, Earias vittella *(Fab.)*

Spotted bollworm started to appear from 2nd fortnight of March and continued till the 2nd fortnight of May when crop was harvested. The mean population of spotted bollworm (Table I) indicated that the minimum spotted bollworm population was recorded (2.10/plant) in Biosal treated plot, whereas the maximum pest population was recorded (3.19/plant) in control treatment. The analysis of data showed that there was significant (F=80.4, DF= 4, 94, P< 0.001) difference in population development of spotted bollworm in different treatments.

Bollworm, Helicoverpa armigera *(Hb.)*

Helicoverpa started its activities in 2nd fortnight of March, and peak population (10.32 larvae per plant) was recorded in control plot in the second fortnight of May, while the minimum population was recorded as (0.16/plant) in 2nd fortnight of March in Biosal and tobacco treated plots, respectively.

The seasonal mean population (Table I) indicated that pest population remained lower in different treatments. The minimum pest population was 1.04/plant in tobacco extract plot, whereas the maximum mean population of pest was (3.36 larvae/plant) found in untreated control plot. The analysis of data showed that there was significant (F= 60.2, DF= 4, 86, P<0.001) difference in population development of *Helicoverpa* in different treatments.

Predators population development

Spiders

Spider population started to appear 29 days after sowing of the okra crop in the first fortnight of March and continued its predatory activity till the harvesting of the crop. The population increased with the increase in pest population and plant growth. The mean population of spiders (Table II) indicated that minimum predator population was recorded in farmer practiced plot, where as the maximum predators population was found in control treatment. The analysis of data showed that there was a significant (F=7.38, DF= 4,342, P < 0.001) difference in population development of spider in different treatments.

Ant, Solenopsis geminata *(F.)*

Ants appeared in okra crop in the first fortnight of March. Their predatory activity was observed till the end of the crop. The seasonal mean population (Table II) indicated that the maximum ant population was observed (0.68/plant) in tobacco extract applied plot, whereas the minimum population (0.51/plant) was recoded in Biosal and Farmer practiced plots. The predator population development in different treatments was significantly (F= 10.98, DF=4,342, P<0.001) different.

Lady bird beetles

Lady bird beetles played a vital role in minimizing the population of sucking pests, especially aphids. Their population was at peak in the second fortnight of May which was 1.41/plant in untreated control plot. The mean population (Table II) indicated that the maximum lady bird beetle population (0.62/plant) was observed in control, whereas the minimum seasonal population was observed in FP which was treated with Thiodan. It indicated that the chemical applied discouraged the activities and population development of lady bird beetles. The predator population development in different treatments was significantly (F=43.24, DF=4,342, P<0.001) different in different treatments. Different species of lady bird beetles, *Coccinella septempunctata* (L.), *C. undecimpunctata* (Linn.), *C. repanda* (Thumb.), *Brumus suturalis* (F.), and *Cheilomenes sexmaculata* (Fabr.) were found in the okra crop field.

Green lacewing, Chrysoperla carnea *(Stephens)*

Chrysoperla is an important predator of aphid, whitefly and jassid. The *Chrysoperla* was recorded from the second fortnight of March till the 2nd fortnight of May when crop was harvested, its maximum activities were recoded during second fortnight of May. The mean population of *chrysoperla* shown in Table II indicated that the maximum *Chrysoperla* population was 0.20/plant in natural enemies plot, where as the minimum population (0.08/plant) was recorded in farmer practices plot treated with Thiodan. The analysis of data showed that there was a highly significant (F=9.17, DF=4,327, P<0.001) difference in population development of *chrysoperla* in different treatments.

Trichogramma, Trichogramma chilonis *(Ishii)*

The parasitoid showed a very active parasitism throughout the season because of releasing the *Trichogramma* cards in natural enemies plot. The seasonal maximum mean parasitism (21.50%) was recorded in natural enemies plot in which *Chrysoperla* + *Trichogramma* cards were released, whereas the minimum seasonal mean prarasitism was recorded (7.63 percent) in farmer practiced plot (Table II). The analysis of data showed that there was a highly significant (F=108.81, DF=4,342, P<0.001) difference in parasitism of *Trichogramma* in different treatments.

Orius bug

In okra crop field, the *Orious* bug was active against aphids and jassids. Its co-occurrence was recorded with these insect pests. However, the maximum activity of this bug was record in the end of May. The seasonal maximum mean population was recorded (0.75 bugs/plant) in control plot, whereas the minimum seasonal population (0.34/plant) was recoded in farmer practiced, Thiodon applied plot (Table II). It showed that the Thiodon was not a safe insecticide for *Orious* bug. The analysis of data showed that there was a significant (F=38.46 DF=4,207; P < 0.001) difference in different treatment.

Formicomus, Formicomus antiqumus *(DeGear.)*

Formicomus was one of the important predators against sucking insect pests. It played an important role in suppressing the sucking pests population. The population of the *Formicomus* appeared in field from the first fortnight of April and continued its predatory activity till the end of the crop. The maximum mean population (0.34/plant) was observed in control plot, while the minimum mean population (0.13/plant) was observed in FP (Thiodan treated) plot (Table II). The statistical analysis of data showed that there was a highly significant (F=9.99, DF=4, 207; P < 0.001) difference in different treatments.

Laius malleifer *(Thom.)*

Among predators, the *Laius* appeared late in the field compared with other predators. The *Laius* was active from 3rd week of April till the last week of May. The maximum mean population of *Laius* spp. was recorded in control plot, where as the minimum predator population was found in farmer practiced plot treated with Thiodan (Table II). The predator population development in different treatments was highly significant, (F= 15.30, DF= 4, 177, P<0.00).

Myrid Bug

Myrid bug started their predatory activity comparatively later among the predators in the okra crop field. It appeared on okra crop in the second fortnight of April and continued till the end of the crop. The mean population of myrid bug shown in table-II indicated that the maximum myrid bug population was recorded in Biosal treated plot. It showed that the bio-pesticide “Biosal” was safe for Myrid. The minimum mean population of myrid bug was observed as 0.23 bug per plant in farmer practiced plot treated with Thiodan. The analysis of data showed that there was a significant (F=1.57, DF=4, P<0.001) difference in population of myrid bug in different treatments.

Okra crop yield parameters

Leaves

The overall mean number of leaves shown in table III indicated that the minimum number of leaves (20.61/plant) were recorded in controlled plot, where as the maximum number of leaves were noted in tobacco extract treated fields. The difference in the number of leaves was significant (F=18.40, DF=4, 342 P<0.001) in different treatments.

Branches

The over all mean of branches indicated that the minimum numbers of branches were recorded (3.70/plant) in tobacco treated plot (Table III) and maximum number of branches was recorded (4.22/plant) in farmer practices plot which was sprayed with Thiodan. The data were analyzed and showed that there was a highly significant (F=34.32, DF=4,282, P<0.001) difference in number of branches in different treatments.

Height

The okra plant attained maximum height of 41.41 inches in Biosal treated plot, whereas the minimum height (36.02 inches/plant) was recorded in control (Table III). The height of okra plants in

Table I.- Overall mean population of pests in different treatments on okra crop under field conditions.

Treatment	Per leaf			Per plant		
	Aphid	Thrips	Jassid	Whitefly	Spotted bollworm	Helicoverpa
T1	2.27c	0.12	1.65d	0.13ab	2.10b	1.14c
T2	2.41c	0.21	2.10b	0.16ab	2.22b	1.04c
T3	2.83b	0.14	1.98c	0.11b	2.43b	1.06c
T4	2.20 d	0.14	2.00c	0.10b	2.62b	2.00b
T5	3.28a	0.28	2.39a	0.18a	3.19a	3.36a

*Means followed by the same letters in a column are not significantly (P<0.05) different from each other by LSD

Table II.- Overall mean population of predators (per plant) in different treatments on Okra crop under field conditions.

Treatments	Spiders	Ants	Lady bird beetles	*C. carnea*	*Trichog-ramma*	*Orius* bug	*Formicomus* sp.	*Laius* sp.	Myrid bug
T1	0.45cd	0.51c	0.44b	0.13c	16.86b	0.67b	0.20bc	0.17b	0.74
T2	0.59bc	0.68a	0.46b	0.13bc	15.02c	0.62b	0.17bc	0.16b	0.57
T3	0.65ab	0.66ab	0.46b	0.20a	21.50a	0.65b	0.21b	0.19b	0.40
T4	0.33d	0.51c	0.27c	0.08d	7.63e	0.34c	0.13c	0.08c	0.23
T5	0.79a	0.60b	0.62a	0.17ab	11.78d	0.75a	0.34a	0.29a	0.60

* Means followed by same letters in a column are not significantly (P<0.05) different from each other by LSD.

Table III.- Overall mean (per plant) of okra plant parameters in different treatments under field conditions.

Treatments	Leaves	Branches	Height	Squares	Flowers	Fruits
T1	20.78a	3.90b	41.41	18.00b	8.54a	19.36a
T2	21.90a	3.70d	39.04	19.46a	8.18ab	19.24a
T3	22.18a	3.80c	36.22	16.68c	8.16ab	19.22a
T4	21.85a	4.22a	36.64	17.47c	8.24ab	19.02a
T5	20.61b	3.83c	36.02	12.76d	7.42b	19.05b

* Means followed by the same letters in a column are not significantly (P<0.05) different from each other by LSD.

Table IV.- Cost-benefit analysis of okra production employing different IPM tactics.

Treatments	Yield/ plant (g)	Yield / acre (kg)	Total income / acre	Total cost	Benefit	Cost: benefit ratio
T1 = Biosal	327.17	8187.74	Rs. 81877	Rs. 3600	Rs. 78277	1:4.13
T2 = Tobacco Extract	317.65	6988.30	Rs. 69883	Rs. 2400	Rs. 67483	1:1.19
T3 = *Chrysoperla* + *Trichogramma*	310.85	6838.70	Rs. 68387	Rs. 480 + 400 = 880	Rs. 67507	1:1.55
T4 = Farmer Practices	311.55	6854.10	Rs. 68541	Rs. 1250	Rs. 67291	1:1.21
T5 = Control	304.20	6702.30	Rs. 67023		Rs. 67023	

different treatments was not significantly (P<0.05) different from each other.

Squares

The maximum numbers of squares (26.60/plant) were recorded in tobacco extract treated plot during the 2nd fortnight of April; where as the minimum number of squares (5.00/plant) was recorded in unprotected control plot during the 2nd fortnight of March. The overall maximum number of squares (19.46/plant) was recorded in Biosal treated plot whereas the minimum number of squares was recorded (12.76/plant) in untreated control plot (Table III). The analysis of data showed that the number of squares per plant was highly significant (F=186.84, DF=4,312 P<0.001) in different treatments.

Flowers

The flowering on okra plant started in the last week of the March. The maximum number of flowers (13.40/plant) was observed in Biosal treated plot in the second fortnight of April. The overall maximum means (8.54 flowers/plant) was recorded in Biosal plot, whereas the minimum number (7.42 flowers/plant) was observed in unprotected control plot (Table III). The analysis of data showed that there was a significant (F=1.50, DF=4,267, P<0.001) difference of flower number in different treatments.

Fruits

Data showed that fruits started to appear from 1st fortnight of April. The maximum fruit number was 10.86 fruits per plant in natural enemies plot in the 2nd fortnight of May. The maximum total number of fruits (19.36 fruits/plant) was observed in Biosal, whereas the minimum (18.05 fruits/plant) was recorded in untreated control plot (Table-III). The analysis of data showed a significant (F=11.18, DF=4,237, P<0.001) difference in different treatments.

Yield

The highest okra yield (327.17 gram/plant) was recorded in Biosal treated plot, whereas the minimum okra yield (304.65 grams/plant) was recorded in untreated control plot. The analysis of data showed that there was a significant (F=5.45, DF=4, 15, P<0.001) difference in yield of different treatments.

Cost benefit analysis

Income per acre

The highest income of okra crop (Rs.81877.00 /acre) was recorded in Biosal, while the minimum income of okra crop (Rs.67023 .00/acre) was recorded in untreated control (Table IV).

Plant protection expenses per acre

The highest plant protection expenses per spray was Rs. 500 in farmer practices , whereas the lowest plant protection expenses per release was recorded in natural enemies treatment (Rs.88.00 /release). The highest cost of plant protection expenses per acre were Rs.3600.00 in Biosal treated plot, whereas, the lowest total cost of plant protection expenses (Rs.280.00) were recorded in natural enemies.

Benefit per acre and Cost: Benefit ratio

The highest benefit of okra crop per acre was recorded as (Rs.78277.00) in Biosal treated plot, whereas, the lowest benefit per acre (Rs.67023.00) was recorded in untreated control (Table IV).

The maximum and minimum cost: benefit ratio of okra was (1:4.13/) and (1:1.19) calculated for Biosal and natural enemies treatments, respectively.

DISCUSSION

Pest population was significantly lower in different IPM options tested compared with farmers who used conventional pesticides for the control of insect pest. Pest population was comparatively low in neem based treatment compared with farmer's practices. Mudathir and Basedow (2004) found that different preparations of neem significantly reduced insect pest infestation in okra. Similarly, predators population was significantly higher in biosal treated okra compared with thiodan indicating that neem insecticide was comparatively less harmful to predators. Gowri *et al.* (2002) evaluated a formulation of neem against two coccinelid predators *M. sexmaculta* and *V. vincta* on okra, found all formulations relatively safer than thiodan. Predatory coccinelids were active in biopesticide (neem) treated fields (Mishra and Mishra, 2002). Similarly, different preparations of neem were found relatively safe against *C. carnea* and *T. chilonis* compared with chemical pesticides and could contribute to preserve the natural enemy biodiversity in crop ecosysytem (Rao and Raguraman, 2003). Praveen and Dhandapani (2001) evaluated effectiveness of *C. carnea* and a neem product Econeem against insect pests of okra and found that both products were effective in reducing the population of sucking pests as well as fruit borer. Rajaram *et al.* (2006) evaluated IPM strategy for cotton and found that leaf hopper (*Amrasca spp.)* incidence was 1.4 / plant in IPM plots and 2.2 / plant in non-IPM plots. Bollworm (*Helicoverpa* spp.) incidence caused lower (11-14%) damage in IPM plots, compared to (25-29%) damage in non-IPM plots. The IPM plot yielded 1450Kg / hectare, while the non-IPM plot yielded 1000Kg/ hectare.

Natural enemies play important role in the population regulation of phytophagous insects. In the present study, application of insecticide, Thiodan by farmer significantly reduced the activity of predators in okra plot as compared with untreated control plot. Sardana *et al.* (2005b) evaluated impact of IPM programmes to reduce pest infestation on okra and tested different IPM modules. Module including bio-intensive, cultural and chemical treatments provided optimum control of pests. Tanwar *et al.* (2007) conducted trails to evaluate the impact of IPM on conservation of natural enemies and found that *T. chilonis* helped to reduce *H. armigera* population.

There were many species of spiders present in okra crop. Spiders are general predators present in agroecosystem feeding on phytophagous insects. Predatory spiders and coccinelids are the main defenders against insect pests in okra fields (Mishra and Mishra, 2002). Kumar *et al*. (2004) determined the predatory potential of spider against insect pest and recorded 13 species of spiders in okra crop. Kubar *et al*. (2006) observed many spider species in okra crop feeding on phytophagous insects.

In present study, highestcost benefit ratio (1:4.13) was obtained with the application of neem based insecticide. Praveen and Dhandapani (2001) recorded cost benefit ratio of 1:2.60 when *C. Carnea*+Econeem was applied on okra against major insect pests. Das *et al.* (2000) recorded the highest cost benefit ratio from application of acephate (1:58) followed by imidacloprid (1:4.63) in okra. Shukla *et al.* (1996) found fenvalerate highly cost effective with a cost:benefit ratio of 1:10.3. Release of *C. carnea* (at predator: aphids ratio of 1:50) in plots grown with okra achieved 100% reduction in *A. gossypii* after 12 days (Zaki *et al.*, 1999). Singh and Kumar (2003) found neem products effective against jassid on okra and on the basis of cost:benefit ratio, neem seed kernel extract (3%) ranked first (1:10.7) followed by endosulfan (1:10.1)**.**

CONCLUSIONS

It is concluded that proper application of bio-insecticide and natural enemies have good impact on plant yield parameter. The Biosal and tobacco extract were safe to predators. The natural enemies suppressed the insect pests and have good impact on agro-ecosystem. The crop protection expenses of bio-insecticides and natural enemies were less compared to chemical insecticide. The bio-insecticide plots yielded more compared to chemical insecticides plot.

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(Received 15 February 2010, revised 28 October 2010)