Incidence of Major Insect Pests of Okra and Their Management

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ABSTRACT

Okra is a nutritive vegetable grow in southern Asian country. In Bangladesh okra is harvest at summer season. But production is hampered by the attacked of insect pest in flowering to harvest periods. The experiment consists of eight treatments such as T_1= Actara 25 WG @ 1g/Litre of water sprayed; T_2= Neem oil @3ml/Litre of water mixed with 10ml of trix liquid sprayed; T_3= Water based neem seed kernel extract @ 5g/Litre of water sprayed; T_4= Bioneem plus 1.0EC @ 1ml/Litre of water sprayed; T_5= Ostad 10 EC @ 2ml/Litre of water sprayed; T_6= Sevin 85 WP @ 1.2g/ Litre of water sprayed; T_7= Marshal 100EC @ 1.5ml/ Litre of water sprayed; T_8=Untreated control. The result indicates that Actara 25 WG (T_1) treatment decreased the incidence of insect pests of okra compared to other treatments.In T_1 treatment. In case of leaf infestation, the lowest percent leaf infestation was caused by whitefly (47.92%), jassid (47.35%) in T_1 treatment. Beside this, natural enemies also observed in the research field such as, the highest lady bird beetle (5.33), staphylinid beetle (5.00), spider (4.67), ant (3.67), ground beetle (3.00) were recorded in T_8 treatment and the lowest lady bird beetle (1.00), staphylinid beetle (1.00), spider (1.00), ant (1.00), ground beetle (1.33) were recorded in T_1 treatment during the study period . The highest okra yield (3.86 ton/ha) was produced in T_1 treatment. These findings illustrated that, the actara 25 WG (T_1) treatment was more effective for the reduction of incidence of major insect pests of okra.

Key words: Infestation, Okra, Mealy bug, White fly and Aphid.

INTRODUCTION

Okra is also known as lady's finger and locally called "*Dharos*" or "*Vendi*" which belongs to the family Malvaceae. It is an economically important vegetable grown in tropical and sub-tropical parts of the world (Saifullah and Rabbani, 2009; Arapitsas, 2008).Total production of okra was about 44000 metric tons from 26000 acres of land in Bangladesh with an average yield of nearly 4.6 t/ha in the year 2012-2013 (BBS, 2013), which is much lower in compare with the yield ranges from 7-12 t/ha in the developed countries (Yamaguchi, 1998).Okra production in Bangladesh is affected by many factors, among them insect pest and diseases are the major. Okra is susceptible to the attack of various insects from seedling to fruiting stage such as okra shoot and fruit borer, okra jassid, cut worm, white fly, aphids, mealybug, red cotton bug etc. Among the insect pests, whitefly, *Bemisia tabaci*, shoot and fruit borer (SFB), *Earias vittella are very dangerous*. The nymphs and adults of Jassid suck sap usually from the under surface of the leaves and inject toxins causing curling of leaf edges and leaves turn red or brown called as 'Hopper Burn' (Patel and Patel 1996). The yield loss due to jassid desapping in okra amounts to 54 to 66% (Satpathy *et al.*, 2004). Similarly, nymphs and adults of whitefly suck the sap usually from the under surface of the leaves and excrete honeydew. Leaves appear sickly and get coated with sooty mold (Jayaraj *et al.*, 1986). Apart from their direct damage by sucking plant sap, it is also known as

the vector for deadly 'yellow vein mosaic viruses. It was estimated that if insecticidal umbrella was not provided, there would be a net yield loss of 54.04 to 76% (Hafeez and Rizvi, 1994 and Choudhary and Dadheech, 1989). It is reported that about 69% losses in marketable yield due to attack of this insect pest.In Bangladesh okra sucking pest likely aphid and mealybug severely attack the leaves of okra and reduce the yield of okra.

Management practices of aphid on okra in Bangladesh and other countries are still limited to frequent spray of toxic chemical pesticides (Rathod *et al*. 2002, Chitra et al., 1997, Patel *et al*., 1996, Iyyappa 1994, Patil *et al*., 1990 Deshmukh and Barle 1976). Beside the chemical; plant product mixed with animal product is used to reduce the aphid (Ukey *et al*. 1999). Jassid population including adult and nymph may also be reduced through use of plant materials (Natarajan *et al.*, 2000, Rosaiah (2001**a**). Whitefly and mealybug population was also reduced through chemical insecticide as well as plant materials (Tatagar 2002, Chandrashekharappa 1995, Ahmad *et al.* 1995, Gopali 1992, Nandihalli *et al.* 1990, Jayaraj *et al.* 1986). Various control strategies have been adopted against these insect pest, one common method being the use of synthetic insecticides, which can be environmentally disruptive and can result in the accumulation of residues in the harvested produce creating health hazards (Chinniah *et al*. 1998).Insecticides are the only tool for pest management which is reliable for emergency action when insect pest population approach or exceed the economic threshold level (Parkash, 1988).

Mixtures of various plant parts such as leaf, bark, seed and vegetable oils are traditionally being practiced in Asia and Africa for the management of this insect pest. Botanicals possess an array of properties including insecticidal activity and insect growth regulatory activity against many insect and mite pests (Prakash *et al*., 1990).Considering the above facts, the experiment has been undertaken with the following objectives:To know the infestation level of major insect pests in okra;To evaluate the effectiveness of some selected synthetic insecticides and botanical product against different major insect pests; To show the relationship among different infestation parameters of yields attributes and yield of okra.

MATERIALS AND METHODS

The present study regarding incidence of major insect pests of okra and required materials and methodology are described below under the following sub-headings.

Location and Climate

The experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The climate of the study site was under the subtropical climate, characterized by three distinct seasons. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from weather yard, Bangladesh Meteorological Department.

Soil

The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, CEC-25.28 22 (Haider *et al*., 1991).

Seed collection and Sowing of seeds

The seeds of okra variety BARI Dheros-1 were collected from Kustia seed store, Mirpur 11, Dhaka. Seeds were sown in the experimental plots on 5 October, 2017. The row to row and plant to plant spacing was maintained at 45 cm and 40 cm respectively.

Experimental design layout and Land preparation

The experimental field was divided into three blocks maintaining 0.75m block to block distance and each block was subdivided into 8 plots for 8 treatments each maintaining 3 m x 2 m plot size. Thus the total number of plots was 24. The plot to plot distance was 0.5 m was kept to facilitate different intercultural operations.

The experimental plot was opened in the first week of October 2017 was ploughed three times followed by laddering to obtain desirable tilth.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

Manure and fertilizer

The fertilizers N, P, K in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP) respectively and as an organic manure, Cow dung were applied.

Table 2. Doses of manures and fertilizers and their methods of application used for this experiment (Haque, 1993)

Manure/Fertilizer	Dose per ha (kg)	Basal dose (kg/ha)	Top dressing(kg/ha)	
			First*	Second**
Cow dung	5000	Entire amount	-	-
Urea	150	-	75	75
TSP	120	Entire amount	-	-
MP	110	Entire amount	-	-

*25 days after sowing, **45 days after sowing

The entire amounts of urea were applied as top dressing in two equal splits at 25, 45 days after seed sowing.

Cultural practices of Gap filling, Thinning and Irrigation: Dead, injured and weak seedlings were replaced by new vigor okra seedlings which were grown in extra area of the main field. When the seedlings were established, one healthy seedling in each pit was kept and other seedlings were removed from the pit. Light overhead irrigation was provided with a watering can to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings

Harvesting: As the seeds were sown in the field at times, the crops were harvested at different times. Green fruits were harvested at two days interval when they attained edible stage. Green fruit harvesting was started from 27 November, 2017 and pulled up to January 10, 2018.

Table.3. List of treatments used in the study

Treatment	Name	Dose
T_1	Actara 25 WG	1g use per 1L water sprayed at 7 days interval
T_2	Neem oil	3ml/Litre of water mixed with 10ml of trix liquid sprayed at 7days interval
T_3	Neem seed kernel extract	10% aquous extract of neem seed kernel
T_4	Bioneem plus 1.0EC	1ml/Litre of water at 7 days interval
T_5	Ostad 10 EC	2ml/Litre of water at 7 days interval
T_6	Sevin 85 WP	1.2g/ Litre of water at 7 days interval
T_7	Marshal 100EC	1.5ml/ Litre of water at 7 days interval
T_8	Untreated control	Only water was sprayed

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50 gm of neem seed kernel crushed and dissolved in 1 litre of water for 24 hours. The solution was filtered through fine gauze (cloth) to remove the bigger particles. The filtered water was sprayed in 3m x 2m area for proper management of the target pest.

Incidence of okra insect pests per okra plant

Data were collected on the number of jassid whitefly, aphids, mealybug per plant at vegetative as well as early, mid and late fruiting stage of okra.

Leaf infestation (%)

Number of infested leaves was counted from total leaves per plant and percent leaves infested by okra insect pests were calculated as follows:

Reduction leaf infestation over control

The number of infested okra leaves, total okra leaves and untreated control plot were recorded. Leaf infestation (%) reduction over control= % infested leaves in control − % infested leaves in the treatment

X 100 % infested leaves in control

Plate 4. Whitefly on the lower portion of the leaf

Plate 5. Leaves infected by Okra yellow vein clearing mosaic virus

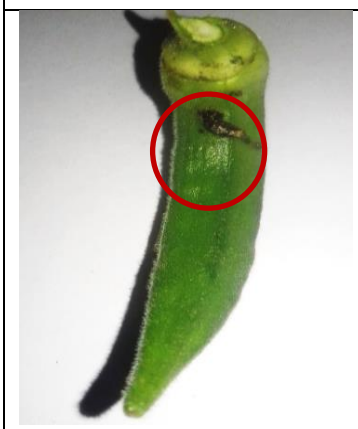

Plate 6. Larva of Okra shoot and fruit borer.

Plate 7. Pupa of Okra shoot.

Plate 8. Adult of Okra shoot and fruit borer

Incidence of beneficial arthropods per plot

Data were collected on the incidence of natural enemies like lady bird beetle, staphylinid beetle, spider, ant, ground beetle etc. per plot and the treatment through visual observation in the field.

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Plate 11. Lady bird beetle adult on the leaf	Plate 12. Lady bird beetle feeding mealybug
	
Plate 13. Staphylinid beetle on the lower side of okra leaf	Plate 14. Ground beetle on the okra plot
	
Plate 15. Ant on the lower portion of okra leaf	Plate 16. Predatory field spider on the lower portion of

Diversity of arthropods community per plot Pitfall trap method

This method was used for the species that roam on the soil surface such as ground beetles, spiders, staphylinid beetle etc. Small plastic pots having 6 cm diameter and 8 cm depth were used as pitfall traps each of which was half filled with water. Two traps were placed in soil in each of the plots at early, mid and late fruiting stages of okra to trap the insects. The trap mouth of the pot was kept at the ground level so as not to obstruct insect movement. After 48 hours of setting traps, insects were collected from each plot/treatment and kept separately. On the basis of phenotypic similarity, trapped insects were identified to family in which they belong and data were recorded against each treatment.

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Measurement of diversity index and equitability

To assess both the abundance pattern and the species richness, Simpson's diversity index was used (Simpson, 1949).

Where, Pi is the proportion of individual for the ith insect family and S is the total number of insect family in the community (i.e., the richness). The value of index depends on both the richness and the evenness (equitability) with which individuals were distributed among the families. Equitability was quantified by.

Simpson's Index, $$D = \frac{1}{\sum_{i=1}^{s} Pi^2}$$

Statistical analysis of data

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT program (Gomez and Gomez, 1976). The treatment means were separated by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The results on incidence of major insect pests have been presented by using different tables and graphs and discussed with possible interpretations have been given under the following sub-headings:

Occurrence of insect pests in the okra field

A number of insect pests were recorded in the field of okra, of when they are occurred. The jassid and whitefly occurred in the vegetative stage when 6-8 leaves are form and continued upto late fruiting stage. In case of okra shoot and fruit borer, it occurred in the early to late fruiting stage. Aphids occurred in the early flowering, and mid flowering stage. Mealy bug occur in the early to late fruiting stage.

Incidence of major insect pests of okra as a Incidence of jassid

Number of jassid per plant was recorded at vegetative as well as early, mid and late fruiting stage and statistically significant variation was observed among the treatments applied for controlling major insect pests of okra (Table 5).At the vegetative stage of okra, significant variations were observed in different treatments in case of number of jassid per plant. Results showed that, the lowest number of jassid (0.87) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of jassid (25.89) was recorded in T_8 treated plot, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against jassid per plant at the vegetative stage including untreated okra in terms of reducing number was $T_8 > T_3 > T_7 > T_2 > T_5 > T_4 > T_6 > T_1$. Later all the stage repeated.

Table 5: Effect of different management practices on the incidence of jassid infestation on leaf at different growth stages of okra

Treatment	Incidence of Jassid (No./plant)					
	Vegetative stage	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	0.87 g	5.57 c	2.17 e	0.53 e	2.79 e	78.34
T_2	8.27 d	8.20 b	7.07 cd	5.10 cd	6.79 c	47.28
T_3	16.22 b	8.00 b	6.37 d	6.63 bc	7.00 c	45.65
T_4	5.00 e	8.87 b	4.63 d	3.07 d	5.42 d	57.92
T_5	6.67 de	9.70 b	9.70 b	8.20 b	9.20 b	28.57

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

T_6	3.01 f	8.53 b	5.37 d	3.30 d	5.73 d	55.51
T_7	11.67 c	9.93 b	9.07 bc	8.43 b	9.14 b	29.04
T_8	25.89 a	12.93 a	12.57 a	13.13 a	12.88 a	-
LSD (0.01)	1.92	1.91	2.32	2.21	0.31	-
CV (%)	8.12	8.78	13.39	15.00	2.21	-

Percent reduction of leaf infestation over control was the highest (78.34 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 5) followed by T_4 (57.92 %) and T_6 (55.51 %). On the other hand, the lowest reduction of leaf infestation (28.57 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (29.04 %), T_3 (45.65 %) and T_2 (47.28 %).

Incidence of whitefly

Number of whitefly per plant was recorded at vegetative as well as early, mid and late fruiting stage and statistically significant variation was observed among the treatments applied for controlling major insect pests of okra (Table 6). At the vegetative stage of okra, significant variations were observed in different treatments in case of number of whitefly per plant. Results showed that, the lowest number of whitefly (1.60) was recorded in T_1 treated plot which was statistically different from other treatments. As a result, the trend of rank of efficacy of the treatments applied against jassid per plant at the vegetative stage including untreated okra in terms of reducing number was $T_1 > T_6 > T_4 > T_7 > T_5 > T_3 > T_2 > T_8$. Later all the stage repeated. Percent reduction of leaf infestation over control was the highest (86.73 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 6) followed by T_4 (72.03 %) and T_6 (70.04 %). On the other hand, the lowest reduction of leaf infestation (39.53 %) was recorded in T_5 treatment comprised of spraying Ostad 10 EC @ 2ml/Litre of water at 7 days interval of followed by T_7 (42.13 %), T_3 (56.09 %) and T_2 (58.14 %).

Table 6: Effect of different management practices on the incidence of whitefly infestation on leaf at different growth stages of okra.

Treatment	**Incidence of whitefly (No./plant)**					
	Vegetative stage	**Early fruiting stage**	**Mid fruiting stage**	**Late fruiting stage**	**Mean**	**% reduction over control**
T_1	1.60 h	1.40 e	0.50 e	0.27 e	0.97 e	86.73
T_2	3.97 b	3.59 cd	3.40 c	2.20 cd	3.06 c	58.14
T_3	3.80 d	3.86 bcd	3.20 c	2.57 c	3.21 c	56.09
T_4	2.38 f	2.96 d	1.67 d	1.50 d	2.04 d	72.03
T_5	3.74 c	4.69 b	4.73 b	3.83 b	4.42 b	39.53
T_6	2.02 g	3.22 d	1.87 d	1.47 d	2.19 d	70.04
T_7	2.85 e	4.36 bc	4.70 b	3.63 b	4.23 b	42.13
T_8	4.98 a	7.50 a	7.57 a	6.87 a	7.31 a	-
LSD (0.01)	0.35	0.91	0.84	0.74	0.36	-
CV (%)	4.75	10.42	10.02	10.93	4.37	-

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Incidence of aphid

Number of aphids per plant was recorded at early, mid and late fruiting stage and statistically significant variation was observed for different types of treatments applied for controlling major insect pests of okra (Table 7). At the early fruiting stage of okra, significant variations were observed in different treatments in case of number of aphids per plant. Results showed that, the lowest number of aphid (0.37) was recorded in T_1 treated plot which was statistically different from other treatments. On the other hand, the highest number of aphid (4.43) was recorded in okra (T_8) treatment, which was significantly different from all other treatments. As a result, the trend of rank of efficacy of the reducing number was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.

Table 7: Effect of different management practices on the incidence of aphid infestation on leaf at growth stages of okra.

Treatment	Incidence of aphid (No./plant)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	0.37 h	0.33 f	0	0.35 g	91.92
T_2	2.46 e	2.05 cd	0	2.26 d	47.81
T_3	2.88 d	2.28 bc	0	2.58 cd	40.42
T_4	1.15 g	1.14 e	0	1.15 f	73.44
T_5	3.63 b	2.65 b	0	3.14 b	27.48
T_6	2.01 f	1.64 de	0	1.83 e	57.74
T_7	3.25 c	2.27 bc	0	2.76 c	36.26
T_8	4.43 a	4.23 a	0	4.33 a	-
LSD (0.01)	**0.25**	**0.51**	**NS**	**0.36**	**-**
CV (%)	**4.13**	**10.16**	**NS**	**6.40**	**-**

Incidence of mealy bug

Number of mealybugs per plant was recorded at early, mid and late fruiting stage and statistically significant variation was observed among the treatments applied for controlling major insect pests of okra (Table 8). At the early fruiting stage of okra, significant variations were observed in different treatments in case of number of mealybugs per plant. Results showed that, the lowest number of mealybug (0.67) was recorded in T_4 treated plot which was statistically different from other treatments. On the other hand, the highest number of mealybug (1.41) was recorded in okra (T_8) treatment, which was significantly different from all other treatments.

Table 8: Effect of different management practices on the incidence of mealybug infestation on leaf at different growth stages of okra.

Treatment	Incidence of mealybug (No./plant)				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean	% reduction over control
T_1	0.67 e	0.17 e	0.12 e	0.12 e	92.72

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T_2	0.45 d	0.43 d	0.42 d	0.42 d	74.55
T_3	0.46 d	0.45 d	0.43 d	0.43 d	73.94
T_4	0.41 d	0.39 d	0.38 d	0.38 d	76.97
T_5	0.67 b	0.65 b	0.63 b	0.63 b	61.82
T_6	0.43 d	0.41 d	0.31 d	0.31 d	81.21
T_7	0.57 c	0.55 c	0.54 c	0.54 c	67.27
T_8	1.41 a	1.55 a	1.65 a	1.65 a	-
LSD (0.01)	0.08	0.08	0.08	0.08	-
CV (%)	4.28	4.19	4.21	4.21	-

At the late fruiting stage of cabbage, number of mealybug per plant was also varied significantly due to different types of treatments. Results showed that, the lowest number of mealybug (0.12) was recorded in T_1 treatment, which was significantly different from all other treatments. On the other hand, the highest number of mealybug (1.65) was recorded in (T_8) which was statistically different from all other treatments. As a result, the trend of rank of efficacy of the treatments applied against mealybug per plant at the late fruiting stage including untreated okra.The results agree with the findings of Jat *et al*. (2014) who found maximum population of mealy bug, *P. solenopsis* on tobacco from 4th week of November (47th standard week) and continued up to 3rd week of January (3rd standard week).

Leaf infestation of okra

Leaf infestation caused by whitefly

The significant variations were observed among the different treatments used for the management practices in terms of percent leaf infestation by number due to attack of whitefly during the study period, which is shown in Table 9. The highest number of leaf per plant (6.88) was recorded in T_1 treatment, which was statistically different from all other treatments. Accordingly, the lowest number of leaves (5.51) was recorded in T_8 treatment, which was statistically similar to T_5 (5.94) treatment.

Table 9: Effect of treatment on leaf infestation of okra caused by whitefly during the study period.

Treatment	Leaf infestation by whitefly during the study period of okra			
	Total number of healthy leaves per plant	No. of infested leaves per plant	% leaf infestation	(%) increase over control
T_1	6.88 a	3.00 g	47.92 g	48.97
T_2	6.35 b	4.18 de	54.33 f	42.15
T_3	6.20 b	4.31 cd	60.25 e	35.84
T_4	6.40 b	3.70 f	64.74 d	31.06
T_5	5.94 bc	4.61 b	72.55 c	22.75
T_6	6.29 b	3.94 e	75.98 c	19.09

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ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

T_7	6.33 b	4.44 bc	80.75 b	14.01
T_8	5.51 c	5.01 a	93.91 a	-
LSD (0.01)	0.47	0.24	3.48	-
CV (%)	3.07	2.39	2.08	-

Leaf infestation caused by jassid

The significant variations were observed among the different treatments used for the management practices in terms of percent leaf infestation by number due to attack of jassid during the study period, which is shown in (Table 10). The highest number of leaf per plant (6.88) was recorded in T_1 treatment, which was statistically different from all other treatments. Accordingly, the lowest number of leaves (5.51) was recorded in T_8 treatment.

Table 10: Effect of treatments on leaf infestation of okra caused by jassid during the study.

Treatment	Leaf infestation by jassid during the study period of okra			
	Number of healthy leaves per plant	No. of infested leaves per plant	% leaf infestation	(%) increase over control
T_1	6.88 a	3.26 f	47.35 f	50.46
T_2	6.35 b	4.19 cd	66.00 cd	30.94
T_3	6.20 b	4.37 bc	70.46 c	26.27
T_4	6.40 b	3.77 e	58.88 e	38.39
T_5	5.94 bc	4.67 b	78.57 b	17.79
T_6	6.29 b	4.00 de	63.76 de	33.28
T_7	6.33 b	4.57 b	72.22 c	24.43
T_8	5.51 c	5.27 a	95.57 a	-
LSD (0.01)	0.47	0.33	6.29	-
CV (%)	3.07	3.13	3.75	-

Okra shoot and fruit borer infestation

Number of infested shoot per plant was recorded at early, mid and late fruiting stage and statistically significant variation was observed among the treatments.At the mid fruiting stage, significant variations were observed among the treatments in case of percent of shoot infestation per plant.Lowest percent of shoot infestation (0.00) was recorded in T_1 treated plot which was statistically similar.

Table 11: Effect of different management practices on the incidence of okra shoot and fruit borer (OSFB) infestation on shoot at different growth stages of okra.

Treatment	% Shoot infestation				
	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Mean Infestation	% reduction over control
T_1	0	0.00 d	0.00 d	0.00 e	100

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ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

T_2	0	0.05 d	0.07 cd	0.07 cde	76.67
T_3	0	0.09 cd	0.08 cd	0.09 cd	70
T_4	0	0.04 d	0.04 cd	0.04 de	86.67
T_5	0	0.33 b	0.27 b	0.30 b	0
T_6	0	0.05 d	0.05 cd	0.05 cde	83.33
T_7	0	0.16 c	0.09 c	0.13 c	56.67
T_8	0	0.60 a	0.53 a	0.30 b	-
LSD (0.01)	NS	0.08	0.08	0.08	-
CV (%)	NS	18.65	19.24	15.55	-

From the results it was revealed that, the lowest number of aphid (0.00) was recorded in T_1 treated plot which was statistically similar to T_4 (0.04), T_6 (0.05), T_2 (0.07), T_3 (0.08) treatments respectively. The highest percent of shoot infestation (0.53) was recorded in T_8 which was significantly different from all other treatments. As a result, the order of rank of efficacy of the treatments applied against aphid per plant at the mid fruiting stage including untreated okra was $T_1 > T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_8$.From the above mentioned finding it was revealed that the T_1 performed as the best treatment in reducing shoot infestation (100 %) caused by okra shoot and fruit borer due to application of different management practices followed by T_4 (86.67 %) and T_6 (83.33 %) and the lowest reduction of leaf infestation was recorded in T_5 (0 %) followed by T_7 (56.67 %), T_3 (70 %). It was also revealed that shoot infestation was increased in the mid fruiting stage of okra and declined in the late fruiting stage (Table 11). Shukla et al. (1997) reported that before fruiting stage shoot infestation reached at a peak of 8.5%.

Fruit infestation

At the early fruiting stage of okra, no fruit infestation was occurred.

At the mid fruiting stage of okra, significant variations were observed in different treatments in case of percent of fruit infestation per plant. Results showed that, the lowest percent of shoot infestation (0.00) was recorded in T_1 treated plot which was statistically similar to T_4 (0.04), T_6 (0.05), T_2 (0.07), T_3 (0.08) treatments respectively.

Table 12: Effect of different management practices on the incidence of okra shoot and fruit borer (OSFB) infestation on fruit at different growth stages of okra.

Treatment	**% Fruit infestation (No./plant)**				
	Early fruiting stage	**Mid fruiting stage**	**Late fruiting stage**	**Mean infestation**	**% reduction over control**
T_1	0	0.00 d	0	0.00 c	100
T_2	0	0.07 cd	0	0.02 bc	98
T_3	0	0.08 cd	0	0.03 bc	97
T_4	0	0.04 cd	0	0.01 bc	99
T_5	0	0.27 b	0	0.09 b	91
T_6	0	0.05 cd	0	0.02 bc	98

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ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

T_7	0	0.09 c	0	0.03 bc	97
T_8	0	0.53 a	0	0.18 a	-
LSD (0.01)	NS	0.08	NS	0.08	-
CV (%)	NS	19.24	NS	14.47	-

Percent reduction of fruit infestation over control was the highest (100 %) in T_1 comprised of spraying of Actara 25 WG @ 1g/Litre of water sprayed at 7 days interval (Table 12) followed by T_4 (99 %) and T_6 (98 %). On the other hand, the lowest reduction of shoot infestation (91 %) was recorded in T_5 treatment comprised of spraying Ostad 20 EC @ 1ml/Litre of water at 7 days interval of followed by T_7 (97 %), T_3 (97 %) and T_2 (98 %).

Pareek *et al*. (2001) reported that the incidence of okra shoot and fruit borer started in first week of September and maximum fruit infestation recorded in the third week of October.

Incidence of natural enemies

In terms of number of natural enemies per plot in okra field, the significant variations were observed among the different treatments used for the management practices which have been shown in Table 13. In case of lady bird beetle, ant, predatory field spider, staphylinid beetle and ground beetle the highest number per plot such as 5.33, 3.67, 4.67, 5.00, and 3.00 respectively were obtained from T_8 treatment.While the lowest numbers of lady bird beetle (1.00), ant (1.00), predatory field spider (1.00), staphylinid beetle (1.00) and ground -beetle (1.33) per plot were recorded in T_1 treatment.

Table 13: Effect of treatment on the incidence of natural enemies in okra field during the study period

Treatment	**Number of natural enemies per plot**				
	Lady bird beetle	**Ant**	**Predatory field spider**	**Staphylinid beetle**	**Ground beetle**
T_1	1.00 e	1.00 d	1.00 d	1.00 f	1.33 bc
T_2	3.33 bc	2.33 b	2.67 c	3.67 b	2.00 b
T_3	3.00 bc	2.00 bc	2.00 c	2.67 cd	1.67 bc
T_4	3.67 b	2.67 b	3.67 b	4.00 b	2.00 b
T_5	2.00 d	1.33 cd	2.00 c	2.00 e	1.00 c
T_6	2.67 cd	2.00 bc	2.00 c	3.00 c	1.67 bc
T_7	2.00 d	1.33 cd	2.33 c	2.00 de	1.00 c
T_8	5.33 a	3.67 a	4.67 a	5.00 a	3.00 a
LSD (0.01)	0.84	0.86	0.82	0.65	0.77
CV (%)	12.00	17.32	13.23	9.16	18.62

Diversity of insect community

Trends in diversity pattern of insects under different treatments using relative methods viz. pitfall trap at the early, mid and late fruiting stages of okra.At the early fruiting stage, the highest number of insect species (18) and also the highest diversity index (5.34) per plot were observed in T_1 treatment, whereas the lowest number

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ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

of insect species (7) was observed in T_8 treatment and the lowest diversity index (1.92) per plot was recorded from T_5 treatment. On the other hand, the highest equitability (0.91) per plot was observed in T_7 treatment and the lowest equitability (0.38) per plot was recorded from T_5 treatments. At the mid fruiting stage, the highest number of insect species (20) and also the highest diversity index (5.41) per plot were observed in T_1 treatment, while the lowest number of insect species (9) and lowest diversity index (3.59) per plot was recorded from the T_8 treatment. Again, the highest equitability (0.95) per plot was observed in T_2 treatment and the lowest equitability (0.81) per plot was recorded from T_8 treatment.

Girth of fruit

The maximum length of fruit (3.97 cm), which are statistically different from all other treatments. On the other hand, the minimum length of fruit (3.14 cm) was observed in T_5 and T_4 treatment, which was significantly similar to T_7 (3.25 cm), T_8 (3.44 cm), T_3 (3.45 cm) treatments respectively. More or less similar works were done by Butani and Jotwani (1984) and Thakur *et al*. (1986) reported that the girth of the okra fruit affected by the Okra shoot and fruit borer.

Table 15: Effect of different management practices on yield contributing characters of okra.

Treatment	Height per plant	Number of fruits per plant	Length of fruit per plant	Girth of fruit per plant	Weight of fruit per Plant
T_1	37.83 a	3.85 a	5.63 c	3.41 b	10.44 a
T_2	31.97 b	2.62 cd	6.66 a	3.97 a	6.52 bc
T_3	31.05 b	2.46 de	5.62 c	3.45 bc	6.43 bc
T_4	32.86 ab	3.13 b	5.65 c	3.14 c	7.51 b
T_5	29.57 bc	2.16 e	5.97 bc	3.14 c	6.10 bc
T_6	31.87 b	2.93 bc	6.04 bc	3.56 b	7.56 b
T_7	32.82 ab	2.67 cd	6.31 ab	3.25 bc	5.77 c
T_8	25.10 c	2.04 e	6.02 bc	3.44 bc	3.17 d
LSD (0.01)	5.01	0.40	0.58	0.32	1.34
CV (%)	6.63	6.15	3.93	3.79	8.25

Weight of fruit

The maximum length of fruit (10.44 cm), was observed in T_1 treatment which are statistically different from all other treatments. On the other hand, the minimum length of fruit (3.17 cm) was observed in T_8 treatment, which was significantly different from all other treatment.

Yield

Effect of different treatments on the yield of okra Significant differences were observed among the treatments in terms of total fruit yield per plot in kg,

Table16: Effect of different management practices on the yield of Okra October 5 to January 5.

Treatment	Yield (kg/plot)	Yield (ton/ha)	(%) increase over control
T_1	2.31 a	3.86 a	229.91

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ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

T_2	1.18 bcd	1.97 bcd	68.38
T_3	0.95 bcd	1.58 bcd	35.04
T_4	1.43 b	2.38 b	103.42
T_5	0.85 cd	1.41 cd	20.51
T_6	1.43 b	2.38 b	103.42
T_7	1.34 bc	2.23 bc	90.50
T_8	0.70 d	1.17 d	-
LSD (0.01)	0.50	0.83	-
CV (%)	16.18	16.19	-

From the above mentioned finding it was revealed that the T_1 performed as the best treatment in terms of increasing the yield of okra over control (229.91 %) due to application of different management practices. On other hand, the minimum increase of fruit yield over control was recorded in T_5 (20.51 %). Different management practices ensure the optimum vegetative growth and other yield contributing characters as well as maximum yield per hectare. Choi In Hu *et al*. (2004) observed that proclaim exhibit the highest fruit yield of okra.

Relationship between leaf infestation, yield that Leaf infestation caused by whitefly

Correlation study was done to establish the relationship between the percent leaf infestation caused by whitefly at harvesting stage and yield (ton/ha) of okra. From the study it was revealed that, significant correlation was observed between the percent leaf infestation caused by whitefly and yield of okra. It was evident from the Figure 2 that the regression equation y = - 0.0343x + 4.4803 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.3775) showed that, fitted regression line had a significant regression co-efficient.

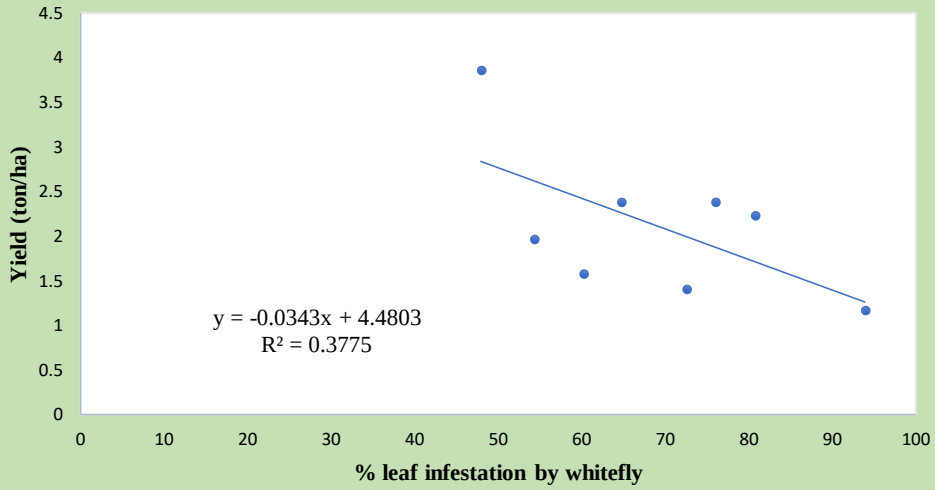

Figure 2: Relationship between percent leaf infestation by whitefly and okra yield during the study period

Relationship between leaf infestation caused by jassid and yield of okra

From the study it was revealed that, significant correlation was observed between the percent leaf infestation caused by jassid and yield of okra. It was evident from the Figure 3 that the regression equation y = - 0.052x + 5.7145 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.7824) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there a

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

was a strongly negative relationship between percent leaf infestation caused by jassid and yield of okra, i.e., the yield decreased with the increase of the infestation of leaf caused by jassid during the study period of okra.

Linkage between shoot infestation by shoot and fruit borer and yield of okra

From the study it was revealed that, significant correlation was observed between the % shoot

Infestation caused by okra shoot and fruit borer and yield of okra. It was evident from the Figure 4 that the regression equation y = -5.5546x + 2.8029 gave a good fit to the data, and the co-efficient of determination (R2 = 0.5921) showed that, fitted regression line had a significant regression co-efficient. From this regression analysis, it was evident that there was a negative relationship between percent shoot infestation caused by okra shoot and fruit borer and yield of okra, i.e., the yield decreased with the increase of the infestation of shoot caused by okra shoot and fruit borer at different stage.

SUMMARY AND CONCLUSION

The eight treatments were T_1: Actara 25 WG; T_2: Neem oil; T_3: Neem seed kernel extract; T_4: Bioneem plus 1.0EC; T_5: Ostad 10 EC; T_6: Sevin 85 WP; T_7: Marshal 100EC; T_8: Untreated control.Data was collected on insect incidence, leaf infestation, shoot infestation, fruit infestation, incidence of natural enemy, diversity index and equitability of insect community through pit fall trap methods, yield contributing characters. Statistically significant variation was recorded at vegetative as well as early, mid and late fruiting stages for the incidence of insect pest. At vegetative stage, the lowest number of jassid (0.87), whitefly (1.60), per plant were recorded from T_1 (Actara 25 WG) treatment, whereas the highest numbers were recorded in T_8 treatment (25.89 and 4.98 respectively). At early fruiting stage, the lowest number of jassid (5.57), whitefly (1.40), aphids (0.37), mealybug (0.67) per plant were recorded from T_1 treatment, whereas the highest numbers were recorded in T_8 treatment (12.93, 7.50, 4.43, 1.41 respectively). At the mid fruiting stage, the lowest number of jassid (2.17), whitefly (0.50), aphids (0.33), and mealybug (0.17) per plant were recorded from T_1 treatment, whereas the highest numbers were recorded in T_8 treatment (12.57, 7.56, 4.23 and 1.55 respectively). In case of okra shoot and fruit borer infestation, the reduced highest shoot infestation (100%) was recorded from T_1 treatment, as well as the reduced highest fruit infestation (100%) was recorded from T_1 treatment. In case of beneficial arthropods, the highest number of natural enemies like as lady bird beetle (5.33), staphylinid beetle (5.00), spider (4.67), ant (3.67) and ground beetle (3.00) were recorded from T_8 treatment, while the lowest number of lady bird beetle (1.00), staphylinid beetle (1.00), spider (1.00), ant (1.00), and ground beetle (1.33) per plot were recorded in T_1 treatment by visual observation. For pit fall trap method, the highest number of insect species and the highest diversity index were observed in T_1 treatment (5.34, 5.41 and 8.28) in early, mid and late fruiting stages respectively, whereas the lowest number of insect species was observed in T_8 treatment and the lowest diversity index were recorded from T_5 treatment (1.92) in early fruiting stage, T_8 treatment (3.59) in mid fruiting stage and T_2 treatment (3.03) in late fruiting stage. In term of okra yield (ton/ha), the highest yield was recorded from T_1 treatment (3.86 ton/ha), where the lowest yield was recorded in case of T_8 treatment (1.17 ton/ha).

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