EFFECTIVENESS OF SOME INSECTICIDES AGAINST MAJOR SUCKING PESTS OF OKRA (*Abelmoschus esculentus* L.)

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EFFECTIVENESS OF SOME INSECTICIDES AGAINST MAJOR SUCKING PESTS OF OKRA (*Abelmoschus esculentus* L.)

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This is to certify that thesis entitled, **“Effectiveness of Some Insecticides against Major Sucking Pests of Okra”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY,** embodies the result of a piece of bona fide research work carried out by **Nipu Dey**, **Registration No. 03-01154** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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EFFECTIVENESS OF SOME INSECTICIDES AGAINST MAJOR SUCKING PESTS OF OKRA (*Abelmoschus esculentus* L.)

ABSTRACT

The experiment was conducted to study the effectiveness of some insecticides against major sucking pests of okra. The experiment consisted of 8 management practices. Incidence of major sucking insect pests of okra was recorded for the entire cropping season; and the insect pests were Jassid, white fly and aphid, respectively was observed. At total fruiting stage, in number basis, considering the % fruit infestation, the lowest infested fruits per plant in number were recorded from Admire 200 SL @ 0.5 ml/L of water (2.66%), while the highest infested fruits were recorded in control (18.99%). In weight basis % fruit infestation was found from Admire 200 SL @ 0.5 ml/L of water (2.46%), whereas the highest infested fruits were recorded in control (16.88%). The tallest plant was recorded from Admire 200 SL @ 0.5 ml/L of water (227.62 cm), while the shortest plant was found from control (190.96 cm). The longest fruit was observed from Admire 200 SL @ 0.5 ml/L of water (18.69 cm) again the shortest fruit was recorded from control (15.45 cm). The maximum number of fruits per plant was obtained from Admire 200 SL @ 0.5 ml/L of water (32.60) and the minimum number of fruits per plant was found from control (28.20). The highest yield of fruits was observed from Admire 200 SL @ 0.5 ml/L of water (15.94 ton/ha), while the lowest yield per hectare was found from control (11.64 ton). Considering the controlling of okra sucking pest highest benefit cost ratio (2.91) was recorded in the treatment Admire 200 SL @ 0.5 ml/L of water and the lowest benefit cost ratio was recorded from Shobicron 425 EC@ 2 ml/L of water (1.15).

CHAPTER 1

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is a popular summer vegetable in Bangladesh belongs to the family Malvaceae and locally known as "Dherosh" or "Bhindi". It plays an important role in vegetable market during summer season when the supply of vegetable is acute. It is an annual vegetable crop in tropical and sub-tropical parts of the world (Tahkur and Arora, 1986). It is well distributed throughout the Indian sub continent and East Asia (Rashid, 1990). Its tender green fruits are popular as vegetable among all classes of people in Bangladesh and elsewhere in the world.

The present consumption of vegetables in Bangladesh only about 50g/day/person; with potato and sweet potato, while it is 70g/day/person among the countries of South Asia and South-East Asia. But many dietitians prescribed daily requirements 285 g of vegetables for an adult person (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and supply of vegetable in Bangladesh. As a result, malnutrition is very much evident in the country. On the other hand, vegetable production in Bangladesh is not found uniform round the year. Vegetables are plenty in winter but are insufficient in summer. Out of total vegetable production, around 30% is produced during Kharif season and around 70% is produced in Rabi season. So, okra can get an importance in summer season vegetables production (Anon., 1993).

The tender fruit of okra generally marketed as fresh condition that contains approximately 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 01.0% fibre and 0.8% ash (Purseglove, 1987). Tender pods contain high mucilage and are used in soups and graves; seeds are also a good source of protein. The pods also have some medicinal value and a mucilaginous preparation from the pod can be used as a plasma replacement or blood volume expander (Savello *et al.,* 1980). Successful okra production may contribute partially in solving vegetable scarcity of summer season for the increasing population. Total production of okra in Bangladesh was about 32.36 thousand tons, produced from 7321 hectare of land in the year 2008-2009 and the average yield was about 4.42 t/ha which is very low (BBS, 2009).

In spite of being a prospective crop, high incidences of insect pests have limited the crop into its low yield and poor quality. Farmers in our country face various problems including the availability of quality seeds, fertilizer and manures, irrigation facilities, modern information in the fields of technical and instrumental inputs, pests and diseases in cultivation of the crop (Rashid, 1993). Among these, insect pests are the most important and cause enormous quantity of yield losses in every season and every year. A survey on pesticide use in vegetables conducted in 1988 revealed that only about 15% and 16% of the farmers received information from the pesticide dealers and extension agents, respectively (Islam, 1999). In most of the cases, the farmers either forgot the instructions or did not care to follow those instructions and using insecticides at their own choice or experience. Some farmers believed that excess use of insecticide could solve the insect pests' problem. As a result, harmful impact of insecticides on man, animal, wild life, beneficial insects and environment is imposing a serious threat. Indiscriminate uses of insecticides are reported to cause insecticide resistance in insect pests, resurgence and secondary pests out break (Rashid, 1993). The accumulation of insecticide residues in food is increasing at an alarming rate. So there is every reason of human health hazards due to these detrimental toxicants.

There are several pest control methods for controlling sucking pests of Okra as cultural (Sharma, 1998), natural and applied biological (Karim, 1995) and chemical control measures (Rahman and Rahman, 1988). Okra sucking pests frequently feed internally on infested plant parts or pods. Insecticide applications, particularly a single application, may often fail to provide successful control of the pest (Begum, 1993; Rahman, 1989). As a result, multiple applications of control measure are required for controlling this insect pest. Use of botanicals against insect pest control is however a recent approach and it has drawn the special attention of the Entomologist all over the world. Neem oil is a promising and less exploited approach in this context. Considering the present situation it is necessary to identify suitable management of insect pests of okra. Therefore, the present study was designed with the following objectives:

1. To determine the effectiveness of some insecticides against major okra sucking pests;
2. Screening a suitable insecticides for controlling the pests;
3. To analyze the benefit cost ratio of various insecticides used against the pests.

CHAPTER 2

REVIEW OF LITERATURE

Okra is one of the important summer vegetable in Bangladesh as well as many countries of the world. There are many sucking pests of okra. Among them jassid, aphid and white fly are of serious is considered as the damaging and has profound yield loss in okra production in Bangladesh. Farmers mainly control the insect pests of okra through use of different chemicals. The concept of management of pest employing eco-friendly materials gained momentum as mankind became more safely about environment. Use of botanicals is the recent approaches for pest control that was commonly practiced. Nevertheless, some of the important and informative works and research findings related to the control through chemicals and botanicals so far been done at home and abroad have been reviewed in this chapter.

2.1 Insect pests in okra and their control measures

Dandale *et al.* (1984) reported the superiority of cypermethrin, fenvalerate and endosalfan in reducing pod borer infestation in red gram. Four sprays of 0.08% cypermethrin (at flowering, at 50 and 100% flowering and at 100% pod setting) afforded complete protection against *Maruca testulalis* on pigeon pea in

Bangladesh in winter season of 1987-88. But Rahman and Rahman, 1988 reported that dimethoate was not as effective as cypermethrin. But no such trial has so far been conducted on bean in Bangladesh. Several commonly used insecticides such as endosulfan, carbaryl, methomyl, monocrotophos have been found effective against *Maruca testulalis* G. on cowpea (Lalasangi, 1988).

The biology of *Aphis gossypii* was studied by Kandoria and Jamwal (1988) on okra, aubergine and chilli [*Capsicum annuum*] in screenhouse cages in the Punjab, India, during August-October 1986. Nymphal development lasted for 8.38, 8.30 and 8.25 days, on okra, aubergines and *C. annuum*, resp. Nymphal survival was highest on okra (96%), followed by aubergine (95%) and *C. annuum* (92%). Adult longevity was 11.66, 11.48 and 10.95 days on aubergines, *C. annuum* and okra, respectively, and the generation time was 19.35, 19.94 and 19.22 days on these crops.

Kumar and Urs (1988) were evaluate the seasonal incidence of *Earias vittella* on okra in Karnataka, India, in 1983-85 showed that infestation of shoots and fruits started in the 2nd and 6th weeks after germination, respectively. Crops sown in any month had infested shoots from the 3rd to 5th weeks in both years of the study. The infestation level on fruits varied from 8.4 to 53.8 and 9.2 to 73.2% in different weeks during 1983-84 and 1984-85, respectively. The pooled data revealed an infestation level varying from 12.6 to 32.6 and 13.6 to 46.7% in crops sown in different months in 1983-84 and 1984-85, respectively. The crop suffered heavily in the 10th week after sowing in 1983-84 and in the 11th week after sowing in 1984-85. Infestation was more severe in crops sown in warmer months than in those sown in rainy or cooler months.

The optimum time and spray interval for application of 0.05% monocrotophos (Nuvacron 40 EC) for the control of the cicadellid *Amrasca biguttula* biguttula on okra were determined by Srinivasan and Krishnakumar (1988) in Karnataka, India. Two applications of monocrotophos, 21 and 35 days after germination, gave the most effective and economical control. Application of carbofuran (Furadan 3G) at 1 kg a.i./ha at sowing did not control cicadellids in later stages of crop growth and yield was reduced by 37.9% in comparison with the most effective treatment.

Hibiscus yellow vein mosaic virus was controlled by 3 sprays of phosphamidon (0.02%) or methyl demeton [demeton-S-methyl] (0.025%), a single soil application of Foratox [phorate] (15 kg/ha) or by early sowing (1 Mar.) or intercropping okra with cowpea [*Vigna unguiculata*] or mungbean [*V. radiata*] by Singh *et al*. (1989). The insecticides reduced numbers of *Bemisia tabaci*/plant and increased yields more effectively than the other treatments.

Verma (1989) tested Lindane, endosulfan, fenitrothion, methyl-O-demeton [demeton-O-methyl], phosalone, monocrotophos, dimethoate, Sevimol [carbaryl], Sevisulf [carbaryl plus sulfur], permethrin and deltamethrin were tested by against control of the cicadellid *Amrasca biguttula* biguttula on okra in the field in India. Deltamethrin at 0.01 and 0.02% resulted in a 100% reduction of the cicadellid population, 15 days after spraying. Lindane was the least effective treatment, resulting in 44-46% mortality, 15 days after the 1st spray. In the laboratory, the time for 50% mortality (LT50) for permethrin, monocrotophos, endosulfan, fenitrothion, phosalone, malathion and lindane at the recommended concentration was 9.8, 8.0, 5.1, 4.0, 3.3, 3.2 and 0.6 days, respectively.

Kumar *et al*. (1989) evaluated the critical time of insecticidal application for control of *Aphis gossypii* and *Amrasca biguttula* biguttula on okra was investigated in Karnataka, India. Application of insecticide (monocrotophos 36 EC at 500 g a.i./ha) 21-42 days after germination resulted in the lowest infestation of both pests and the highest cost : benefit ratio. Application of carbofuran 3G at 1 kg a.i./ha at the time of sowing did not give effective control at the later crop stages.

A schedule of insecticide sprays using decis (Deltamethrin) and systoate (Dimethoate) on 35, 45, 55 and 65 days after planting was investigated in Benin to determine the most effective treatment against the pyralid *M. testulalis* on cow pea (Atachi and Sourokou, 1989). Application of deltamethrin, cypermethrin or fenvalerate @ 0.008% or dimethoate, fenitrothrin, malathion, quinalphos or monocrotophos @ 0.008% or endosulfan 0.10% one at flowering and then at pod setting stage would be highly effective. However, at lower infestation, insecticide application would not be economically advisable.

Cypermethrin was sprayed at 0.2 kg a.i./ha to control different densities of pyralid *M. testulalis* larvae when infestation in flowers reached 10, 20, 30, 40 and 50% in 1985 and 10; 20 and 30% in 1986 (Ogunwolu, 1990). The effect of rainfall on the numbers of *Amrasca biguttula* biguttula infesting 13 varieties of okras sown on 21 July 1986 was studied by Lal *et al*. (1990) in Ludhiana, Punjab, India. The cicadellid first appeared on crops 2 weeks after sowing. Thereafter, the population increased with the age of the crop, except during the 2nd half of the 4th and 5th weeks. Continuous heavy rainfall for 4 days (61.1 mm) during the 2nd half of the 4th week, a low mean temperature (<29^{0}C), a high RH (>78%) and less sunshine (6.4 h) drastically reduced the pest population on the different varieties of okras, irrespective of their level of susceptibility to attack. Under these weather conditions, the pest population was reduced by 72.6%.

Spraying of synthetic pyrethroid insecticides at the rate of 1 ml per liter of water has been recommended for the control of the pest of okra (Karim, 1993). The life cycle of *Tetranychus macfarlanei*, a pest of okras in South Gujarat, India, was studied by Sejalia *et al*. (1993) in the laboratory during March-April and July-August. Low temperatures and humidity during March-April prolonged the developmental period, whereas higher temperatures and humidity during July-August resulted in a decrease in developmental period. At 29.67^{0}C and 87.3% RH (during July-August), the net reproductive rate, mean generation time, innate capacity for increase and the finite rate of increase were 30.37, 12.04 days, 0.28 and 1.33 per day, respectively.

The effect of simulated exposure to natural infestation of *Amrasca biquttula* [biguttula] at different crop ages on seed yield of okra with respect to 3 sowing dates and 2 varieties was investigated by Mahal *et al*. (1994) in the Punjab, India.

The crop at the time of sowing was covered with muslin cages and the plants were periodically exposed to natural jassid infestation at 5, 15, 25 and 35 days after germination (DAG). The unexposed plants were kept as controls. After 45 DAG blanket sprays of monocrotophos (Nuvacron 36 SL) were given regularly at 10-day intervals to control further infestation. The crop kept free from natural infestation of *A. biguttula* throughout the vegetative phase of growth (up to 45 DAG) and that exposed after 35 DAG (10 days feeding exposure) exhibited longer plants and fruits, and more fruits per plant, seeds per fruit and seed yield in contrast to early exposure for up to 15 DAG. This trend was evident in both cvs, Pusa Sawani and Punjab-7, at all the sowing dates. In the late sown crop, exposures beyond 25 DAG and jassid-free plants were on a par with respect to all the parameters. Early exposure to jassid infestation up to 15 DAG, especially in the early and normal sown crops, resulted in greater losses in seed yield (37.55 and 42.18%, respectively) than in late-sown crop (20.39%). The losses were marginal (3.56 and 2.95%, respectively) when the crop was exposed to jassid infestation late in season at 35 DAG.

A number of reports revealed that a hundred of insecticides are used against pod borer. Most of the cases the farmers reduced their spray interval. A report showed that the vegetable growers of Jessore Region of Bangladesh spayed insecticides almost every day or every alternate day in their bean field (Anon., 1994). Some of the farmers spray insecticides in their vegetable field even 84 times in one season. Majority of the farmers were found to sell their produce harvested residues with bean that causes health hazards to the consumers.

Singh and Brar (1994) carried out an experiment on Okras sown on May 15 in Ludhiana, Punjab, India, harboured the highest mean population of *Amrasca biguttula* biguttula and *Earias* spp., followed by the crop sown on May 30. Maximum damage by *Earias* spp. was observed on okras sown on June 15 and lowest on okras sown on July 30. The highest fruit yield was obtained by sowing the crop on May 15. Crops protected from the insect pests gave a greater fruit yield than the control and the losses in yield varied from 32.06 to 40.84%.

Application of deltamethrin, cypermethrin or fenvalerate or cyfluthrin (Bethroid 0.50 EC) at the rate of 1.0 ml / 1 of water may be helpful for the control of the pod borer (Karim, 1995). The red spider mite, *Tetranychus macfarlanei*, so far recorded as a minor pest in South and Central Gujarat, India, is rapidly becoming a pest causing considerable damage to okra, aubergines and cotton by Rai *et al*. (1995). The rate or multiplication of *T. macfarlanei* was studied when reared on okra leaves under laboratory conditions at 29.67°C average temperature and 87.30% average relative humidity. The maximum female birth (mx = 6.18) was on day 11 of the pivotal age. Under a given set of conditions and food supply, the mite was able to multiply on okra leaves. In the stable age-distribution, a 93% contribution was made by immature stages including egg, larva, protonymph and deutonymph.

An overview is given of insect pests found in India on okras during 2 cropping seasons (spring-summer and rainy season) by Arora *et al*. (1996). Various management practices including the appropriate timing of sowing, judicious use of fertilizers, use of resistant cultivars, physical control, botanical insecticides (neem seed extracts), microbial control (*Bacillus thuringiensis*) were more effective than the control and the use of economic thresholds to take spraying decisions.

Dubey *et al*. (1998) conducted a field experiment in Madhya Pradesh with okra cv. Parbhani Kranti, 9 treatments were compared for the control of *E. vittella*. The application of 1 kg phorate a.i./ha basally + single spray of monocrotophos (0.05%) 30 DAS (days after sowing) followed by 4 sprays of cypermethrin (0.006%) (45, 55, 65 and 75 DAS) produced the lowest infestation level on fruits (12.68%) and the highest marketable fruit yield (10.42 t/ha).

Satpathy *et al*. (1998) reported that both sowing time and crop growth stage influenced the insect population significantly in okra crop sown from 15 May to 15 July during the 1996 and 1997 cropping season in Varanasi, Uttar Pradesh, India. The crop was found to be most susceptible to the jassids (*Amrasca biguttula*) at 50 DAS, where as peak population of jassids were observed in the first sown crop. With the advancement of sowing time jassid infestation decreased and borer (*Earias vittella*) damage increased. However, maximum yield was obtained from the crop sown in the first week of June. Although a considerable number of jassids were present during this period, suitable growing conditions resulted in maximum yield.

In a field experiment was conducted by Faqir and Gul (1998) in 1995 in Pakistan with okra cv. T-13, Richgreen, Perkingdwarf, Pussagreen, Climsonspinless

[*Clemson Spineless*] and Swat local. Dimethoate 40 EC, dichlorvos 100 EC, imidacloprid 200 SL, methylparathion [parathion-methyl] 50 EC and monocrotophos + alpha-cypermethrin 42 EC were tested against cicadellids (*Amrasca devastans* [*A. biguttula* biguttula]). Imidacloprid 200 SL was effective in controlling the pest over a longer time period than the other insecticides. Yield was highest in plots treated with monocrotophos + alpha-cypermethrin (11.85 t/ha), which was not significantly different from 10.31 t obtained in imidacloprid treated plots. All the cultivars were susceptible to the pest.

A field experiment was conducted by Adiroubane and Letchoumanane (1998) during 1994 to evaluate efficacy of 3 plant extracts, sacred basil (*Ocimum sanctum*), Malabar nut (*Adhatoda vesica*), Chinese chaste tree (*Vitex negundo*) and synthetic insecticides (endosulfan and carbaryl) and their combination products in controlling okra jassids, *Amrasca biguttula* biguttula and fruit-borers, Earias spp. during the rainy season in 1994 by spraying them at 10, 25 and 40 days after sowing. All the treatments suppressed both the jassid population and fruit borer incidence.

Rai and Satpathy (1999) carried out an experiment to find out the effect of sowing date and insecticides in controlling the insect pests of okra, studied in a field experiment conducted in Varanasi, Uttar Pradesh, India during 1996 and 1997, showed that there is gradual increase in jassid population with advancement of sowing date up to mid-June. Thereafter it declined substantially. However, late-sown crops suffer more from borers. Crops sown in the second week of July (S6) recorded maximum fruit damage which was lowest on 25 May (S_2)-sown crops. Monocrotophos at 500 g a.i./ha controlled the jassids more effectively than cypermethrin at 50 g a.i./ha.

Beta-cyfluthrin @ 12.5, 18.75, 25, 37.5 and 75 g a.i. ha^{-1}, lambda-cyhalothrin @ 37.5 g a.i. ha^{-1} and imidacloprid @ 40 g a.i. ha^{-1} were sprayed at the fruiting stage of the okra crop by Dikshit *et al*. (2000). In a separate experiment, okra seeds were treated with imidacloprid (Gaucho 600 FS) @ 3, 5.4, 10.8 and 21.6 g kg^{-1} seeds and were sown. Residues of the insecticides from okra declined progressively with time and became non detectable on 7th d from beta-cyfluthrin and on 10th and 15th d from imidacloprid and lambda-cyhalothrin spray treatment, respectively.

Studies were carried out by Praveen and Dhandapani (2001) during January-March 2000 at Coimbatore, Tamil Nadu, India to evaluate the effectiveness of different biological control agents against the major pests of okra, i.e. leafhopper (*Amrasca biguttula* biguttula), sweet potato whitefly (*Bemisia tabaci*), cotton aphid, and the fruit-boring insects, *Helicoverpa armigera* and *Earias vitella*. The results revealed that release/application of the predator, *Chrysoperla carnea* (25000 larvae ha^{-1} $release^{-1}$) + Econeem 0.3% (0.5 l/ha) for three times at 15-day intervals starting from 45 days after sowing was found to be effective in reducing the population of sucking pests as well as the fruit-borers. The percent fruit damage by *Heliothis armigera* (8.61%) and *E. vitella* (9.21%) was also reduced. Fruit damage in untreated control was recorded as 22.56 and 22.6%, respectively.

Field trials were conducted in by Chakraborty *et al*. (2002) West Bengal, India to determine the effect of methomyl (Lannate 40 SP; at 150, 300 and 450 g a.i./ha) and/or 60 g cypermethrin/ha or 250 g quinalphos/ha to control jassid (*Amrasca biguttula*) and fruit borer (*Earias vitella* [*E. vittella*]) on the first season of spray (March-July 1996), and leaf rollers (*Sylepta derogata* [*Haritalodes derogata*]) and fruit borers on the second spray (July-October 1996). Methomyl at 300 g a.i./ha provided sufficient reduction (75%) in pest population and its performance was similar to that of quinalphos. Methomyl at 150 g a.i./ha was chemically compatible with cypermethrin; the performance of this combination was superior to all other treatments in terms of pest control and yield. Residues declined progressively with time. All pesticidal treatments were superior to the untreated control plots in terms of pest control and yield.

2.2 Non-chemical control

Farmers believe that insecticides are the only method to control insect pest. This mental make up has been created from their practice of using insecticides to control the insect pests attacking their crops over many years (Islam, 1999). More over, the Government's policy of giving 100% subsidy on pesticides i.e., giving the pesticides free of cost to the farmers had helped encourage and develop the habit of indiscriminate use of pesticides among the farmers. This is serious basic problem in achieving success in IPM programs.

2.3 Use of botanical extracts

Botanical pesticides are becoming popular day by day and now a day these are using against many insect pests. It was found that Lepidopteran insect is possible to control by botanical substances.

Khan and Khan (1984) stated that the toxicity of the vegetable oils 1% taramira (seed oil of *Eruca sativa*) and 1% Aartemisia (oil from the distilation of leaves and shoots alone and in combination with 0.5% DDT and 0.5% lindane against *Dacus dorsalis*, *D. zonatus* were assessed in the laboratory. Direct and indirect spray techniques were used. The vegetables oils alone and in combination with the DDT and lindane were effective against the tephritids.

Ranganath *et al*. (1997) tested a number of botanical against *Bactrocera cucurbitae* on cucumber (*Cucumis sativus*) and ribbed gourd (*Luffa acutangula*) and found that neem oil at 1.2% was the most effective treatment in reducing damage to cucumber (mean percentage damage 6.2%, as compared with 39.0% in the control), while neem cake at 4.0% and DDVP (dichlorovs) at 0.2% were the most effective against the pest on ribbed gourd, reducing damage to 9.1 to 9.5% as compared with 32.9% in control.

Lopez *et al.* (1999) assayed short-term choice and no-choice feeding used to assess the antifeedant activity of *T. havanensis* fruit extracts (at 5000 ppm) against 5th-instar *Heliothis armigera* larvae. The acetonic extract gave the highest activity and was further fractionated by silica gel column chromatography. Of the 7 fractions isolated, 5 were identified as the limonoids azadirone, trichilinone acetate, 14,15-deoxyhavanensin-1,7-diacetate, 14,15-deoxyhavanensine-3,7-diacetate and a mixture of havanensin-1,7-diacetate and havanensin-3,7-diacetate. Choice and no-choice feeding assays of each fraction at 1000 ppm, showed that the mixture of havanensin-1,7-diacetate and havanensin-3,7-diacetate had the highest antifeedant activity against *H. armigera* larvae. Azadirone and trichilinone acetate were also antifeedants. No antifeedant activity was found in the remaining fractions. It is suggested that all of the limonoids with antifeedant activity have a similar mode of action, which is probably toxic.

Ju *et al*. (2000) tested six desert plants chosen to study their toxicity and effects on the growth and metamorphosis of the insect pest, *Heliothis armigera* [*Helicoverpa armigera*]. An artificial diet containing 5% aqueous extracts of *Cynanchum auriculatum* or *Peganum harmala* var. multisecta showed strong toxicity to the larvae and caused mortality of 100% and 55%, respectively. These two extracts at the same dosage also significantly affected metamorphosis of the insect. An artificial diet containing 1% aqueous extracts of *C. auriculatum* or 5% aqueous extracts of *P. harmala* resulted in mortality of 85% and 55%, respectively, and a zero emergence rate. Tests of extracts of *C. auriculatum* made at different pHs showed that the pH 3 and pH 10 portions of the extracts affected the larvae growth significantly. The other plant species tested were *Euphorbia helioscopia, Sophora alopecuroides, Peganum nigellastrum and Thermopsis lanceolata*; extracts of these species caused either much lower mortality of *H. armigera* or zero mortality (*E. helioscopia*).

Sundarajan & Kumuthakalavalli (2000) tested Petroleum ether extracts of the leaves of *Gnidia glauca* Gilg., *Leucas aspera* Link., and *Toddalia asiatica* Lam. against sixth instar larvae of *Helicoverpa armigera* (Hubner.) at 0.2, 0.4, 0.6, 0.8 and 1.0% by applying to bhendi (okra) slices. After 24 hr, percentage mortality, EC50 and EC90 were calculated. Total mortality was recorded in the treatment with 0.8% of the extract of *G. glauca.* Of the three leaf extracts used, *G. glauca* showed an EC50 of 0.31%.

Kulat *et al.* (2001) conducted an experiment on extracts of some indigenous plant materials, which are claimed important as pest control like seed kernels of neem, *Azadiracta indica*, *Pongamia glabra* [*P. pinnata*], leaves of tobacco, *Nicotiana tabacum* and indiara, a neem based herbal product, against *H. armigera* on chickpea cv. I.C.C.V.5 for its management in Rabi seasons of 1993-96 at College of Agriculture, Nagpur, Maharashtra, India. The results revealed that the crop treated with the leaf extract of *N. tabacum* and seed extract of *P. glabra* (5%) and indiara (1%) and neem seed kernel extract (5%) exhibited low level of population built up compared to control.

Sundarajan (2002) screened methanol extracts of selected plants namely *Anisomeles malabarica, Ocimum canum [O. americana], O. basilicum, Euphorbia hirta, E. heterophylla, Vitex negundo, Tagetes indica and Parthenium hysterophorus* for their insecticidal activity against the fourth instar larvae of *Heliothis armigera* by applying dipping method of the leaf extracts at various concentrations (0.25, 0.5, 1.0, 1.5 and 20) on young tomato leaves. The larval mortality of more than 50% has been recorded for all the plant extracts in 2 per cent test concentration (48 h) except *Euphorbia heterophylla* which recorded 47.3 per cent mortality in 2 per cent concentration. Among the plant extracts tested *V. negundo* is found to show higher rate of mortality (82.5%) at 2 per cent concentration.

2.4 Use of Neem oil

Experiment with botanical pesticides has also been conducted in Bangladesh on a limited scale. Islam (1983) reported that extract of leaf, seed and oil of neem, showed potential as antifeedants or feeding and oviposition deterrents for the control of brown plant hopper, green leaf hopper, rice hispa and lesser rice weevil. He also conducted experiments to asscertain the optimal doses of the extract against rice hispa, and pulse beetle. Addition of sesame or linseed oil to extract of neem resulted in higher mortality of the grubs and in greater deterrence in feeding and oviposition compared to those obtained with extract alone (Islam, 1986).

Fagoonee (1986) used neem in vegetable crop protection in Mauritius and showed neem seed kernel extract was found to be effective as deltamethrin (Decis) against the *Plutella xylostella* and *Crocidolomia binotalis.* He also found neem extract alternate with insecticides gave best protection against *Helicovarpa armigera.* Neem product have been used to control vegetable pests under field condition and good control of *Plutella xylostella* and Pyralid, *Hellula undalis* on cabbage was achieved with weekly application of 25 or 50 gm neem kernel powder/liter of water (Dreyer, 1987).

Field trail with neem products have shown, not only a decrease in damage by pest but also an increase in crop yield compared to those obtained with recommended synthetic insecticides. A methanol suspension of 2-4% of the neem leaves have been used against the caterpillar of diamondback moth, *Plutella xylostella* and it was as effective as either synthetic insecticides mevinphous (0.05%) or deltamethrin in (0.02%) in Togo (Dreyer, 1987). In Thailand, a field trail showed that piperanyl butoxide increased the efficacy of neem and the combination was as active as cypermethrin (0.025%) against *Plutella xylostella* and *Spodoptera litura,* which revealed that neem oil with synthetic insecticides may have some synergetic effect in controlling insect pests (Sombatsiri and Tigvattanont, 1987).

Saxena (1988) summarized the effectiveness of neem oil against 87 arthropods and 5 nematodes, 100 insects and mites and 198 different species of insects, respectively. Neem *(Azadicachat Indica A. Juss*) seed oil, a botanical pesticide have also been used to control different insect pests of important agricultural crops in different countries of the world. More than 2000 species of plants have been reported to posses' insecticidal properties (Grainge and Ahmed, 1988). The neem tree *(Azadirachta indica*) is one of them. The development and use of botanical pesticides become an integral part of the integrated pest management (IPM) strategies.

Entomologist of many countries including India, the Philippines, Pakistan and Bangladesh has conducted various studies of neem against different insect pests. Most of the cases the investigators have been used a particular concentration of the neem extract. Neem seed kernel extracts (3-5%) were effective against *Nilaparbata lugens, Nephotettix* spp., *Marasmia patnalis, Oxya nitidula* and Asian gall midge. Neem leaf extract, however, is less effective than neem seed kernel extract. But the same extract of 5-10% was highly effective, inclusive of *Scirpophaga incertulus* and thrips. Damage by leaf folders was reduced by 3% neem oil. Neem seed kernel extracts reduced egg deposition on rice seedling by *Nephotettix* spp. and *Nilaparvata lugens* (Jayaraj, 1991). Neem seed kernel extract was an effective antifeedent to pigeon pea pod borer. He also found that there has been no adverse effect, even though neem was systemic. According to him neem oil can be used @ 1-3% without any problem. But 5% neem oil will cause phytotoxicity in many plants. The effect of neem oil is systemic, though not persistent. It should be noted that application of neem oil beyond 5% will cause serious phytotoxicity in rice. At 3%, the initial phytotoxicity effects are minimum and the plant can recovered completely. Thus, neem oil should be applied at concentrations not beyond 3% (Jayaraj, 1991).

Most of the cases, the user of neem oil use it at different doses ranged from 0.5-50% (Krishnaiah and Kalode, 1991). They use different emulsifier to mix neem oil with the water. Detergent in water helps neem oil to emulsify in the water. In a field observation of neem oil, Krishanaiah and Kalode (1991) used soap as emulsifier with water. Another study with neem oil in rice field, Palanginan and Saxena (1991) added 1.66% Teepol (liquid detergent) to the extract solutions as an emulsifier. In a study of Bangladesh Rice Research Institute (BRRI), Gazipur, Alam (1991) added 1 ml (0.1%) of teepol detergent per liter of water and spray at 7 days interval against stem borer of rice.

Stoll (1992) summarized the potential benefits of botanical pesticides which diminish the risk of resistant development, natural enemy elimination, secondary pest out break and ensure overall safety to the environment. The seed and leaves of the neem tree contain terpenoids with potent anti-insect activity. One of the most active terpenoids in neem seeds is “azadirachtain” which acts as an antifeedant and growth disrupter against a wide range of insect pest at microgram levels. The active terpenoids in neem leaves include nimbin, deactylnimbin and thionemone (Simmonds *et al.,* 1992).

The leaf extract of neem tested against the leaf caterpillar, *Selepa docilis* at 5% concentration had a high anti-feedant activity with a feeding ratio of 28.29 followed by 3% having only medium anti-feedant properties with 23.89 as the feeding ratio (Jacob and Sheila, 1994).

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted to study the effectiveness of some insecticides against major sucking pests of okra during the period from February to August 2009. The details materials and methods of this experiment are presented below:

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in $23^0 74^/$N latitude and $90^0 35^/$E longitude (Anon., 1989).

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No. 28 and is shallow red brown terrace soil. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and has been presented in Appendix I.

3.3 Climate

The climate of experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experimental period was collected from Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and has been presented in Appendix II.

3.4 Planting material

BARI Dherosh 1 was used as the test crop of this experiment. The seeds were collected from Siddique Bazar, Dhaka, Bangladesh.

3.5 Land preparation

The land was first opened with the tractor drawn disc plough. Then the soil was ploughed and cross ploughed. Ploughed soil was then brought into desirable fine tilth by the operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The final land preparation was done on 21 and 28 February 2009, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before seed sowing and the basal dose of fertilizers was incorporated thoroughly with the soil.

3.6 Manures and Fertilizers application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, Urea, TSP and MP was applied as basal dose at the time of land preparation.

Table 1. Dose of manures and fertilizers in okra field (Anon., 2005)

Fertilizers and Manures	Dose/ha
Cowdung	10 tons
Urea	45 kg
TSP	85 kg
MP	35 kg

3.7 Treatments of the experiment

The experiment consists of the following management practices:

T_1: Admire 200 SL @ 0.5 ml/L of water

T_2: Actara 25 WG @ 1 g/L of water

T_3: Neem oil @ 5 ml/L of water

T_4: Neem seed kernel extract @ 5 g/L of water

T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water

T_6: Detergent @ 5 ml/L of water

T_7: Shobicron 425 EC@ 2 ml/L of water

T_8: Control

Application of insecticides: All the insecticides used as treatments applied 7 days interval.

3.8 Experimental layout and design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 24.50 m × 13.00 m was divided into three equal blocks. Each block was divided into 8 plots, where 8 treatment combinations were allocated at random. There were 24 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 2.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.9 Seed sowing

The okra seeds were sown at 5 March, 2009. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. Total 2 seeds were sown in each hill in the furrows having a depth of 2-3 cm. Line to line distance was 60 cm and plant to plant distance was 50 cm.

3.10 Intercultural operations

3.10.1 Thinning

Seeds were germinated five days after sowing (DAS). Thinning was done at 15 days after sowing keeping 1 seedling in every hill to obtain proper plant population in each plot.

3.10.2 Irrigation and weeding

Irrigation was done at 30 and 45 DAS. The crop field was weeded twice; first weeding was done at 25 DAS and second at 40 DAS.

3.11 Crop sampling and data collection

Five plants from each treatment were randomly marked inside the central row of each plot with the help of sample card.

3.12 Monitoring and data collection

The okra plants of different treatment were closely examined at regular intervals commencing from germination to harvest. The following data were collected during the course of the experiment.

- Incidence of insect pests
- Number of healthy fruits
- Number of infested fruits
- Fruit infestation in number (%)
- Weight (g) of healthy fruits

- Weight (g) of infested fruit
- Fruit infestation in weight (%)
- Plant height (cm) at harvest
- Plant diameter (cm) at harvest
- Days for sowing to 1st flowering
- Days for flowering to attaining marketable sized fruits
- Fruit length (cm)
- Fruit diameter (cm)
- Number of fruits per plant
- Individual fruits weight (g)
- Fruit yield per plot (kg)
- Fruit yield per hectare (ton)

3.13 Determination of fruit damage in number

All the fruits were counted from 5 randomly selected plants from middle rows of each plot and examined. The collected data were divided into early, mid and late fruiting stage. The healthy and damaged fruits were counted and the percent fruit damage was calculated using the following formula:

$$\%\ \text{Fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

3.14 Determination of fruit damage in weight

All the fruits were counted from 5 randomly selected plants from middle rows of each plot and examined. The collected data were divided into early, mid and late fruiting stage. The healthy and damaged fruits were weighted and the percent fruit damage was calculated using the following formula:

$$\% \text{ Fruit damage} = \frac{\text{Weight of damaged fruit}}{\text{Total weight of fruit}} \times 100$$

3.15 Harvest and post harvest operations

Harvesting of fruit was done when the fruits attained marketable sized**.** The optimum marketable sized fruits were collected by hand picking of each plot and yield was converted into t ha^{-1}.

3.16 Procedure of data collection

3.16.1 Plant height (cm) at harvest

The plant heights of 5 randomly selected plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in centimeter (cm). Data were recorded from the inner rows plant of each plot during harvesting period.

3.16.2 Plant diameter (cm) at harvest

The plant circumstances of 5 randomly selected plants were measured with a meter scale at base, middle and upper level and average were calculated and converted into diameter and expressed in centimeter (cm). Data were recorded from the inner rows plant of each plot during harvesting period.

3.16.3 Days for sowing to 1st flowering

Days to 1st flowering were calculated by counting the number of days required to flower initiation in each plot.

3.16.4 Days for flowering to attaining marketable sized

Days for flowering to attaining marketable sized fruit were measured by counting the number of days required to attaining marketable size of fruits.

3.16.5 Fruit length

Fruits were collected from 5 randomly selected plants and length was measured and the mean length was expressed on per fruit basis in centimeter.

3.16.6 Fruit diameter

Fruits were collected from 5 randomly selected plants and circumferences were measured and converted in diameter and the mean diameter was expressed on per fruit basis in centimeter.

3.16.7 Number of fruits per plant

Number of total fruits of 5 randomly selected plants from each plot was counted and the mean number was expressed plant^{-1} basis.

3.16.8 Individual fruit weight

Fruits were counted from the ten randomly selected plants and were weighted by a digital electronic balance. The weight was expressed plant^{-1} basis in gram (g).

3.16.9 Fruits yield plot^{-1}

The fruits were collected from 5.0 m^2 of each plot in each harvest and weighted. The weight of fruits per plot was expressed in kilogram (kg).

3.16.10 Fruits yield per hectare

Fruits per plot were converted into hectare and the weight of fruits per hectare was calculated and expressed in ton.

3.17 Statistical analyses

The data on different parameters as well as yield of okra were statistically analyzed to find out the significant differences among the effects of different management for sucking pest of okra. The mean values of all the characters were calculated and analyses of variance were performed by the ‘F’ (variance ratio) test. The significance of the differences among the mean values of treatment in respect of different parameters was estimated by the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The study was conducted to know the effectiveness of some insecticides against major sucking pests of okra. Data on the following parameters - number of pests plant^{-1}, number and weight of healthy fruit, infested fruit and percentage of fruit infestation in number and weight, yield contributing characters and yield of okra were recorded. The results have been presented and discussed, and possible explanations have been given under the following headings:

4.1 Insect pest incidence

Incidence of major sucking pests of okra was recorded for the entire cropping season while jassid, white fly and aphid were observed. Data were taken from each plant at early, mid and late fruiting stages to investigate the sucking insect's incidence.

4.1.1 Early fruiting stage

Statistically significant variation was recorded at early fruiting stage for jassid, aphid and white fly due to different management practices (Table 2). In case of jassid, the lowest number per plant (0.07) was found from T_1 (admire 200 SL @ 0.5 ml/L of water) which was statistically identical (0.13 and 0.20) with T_3 (neem oil @ 5 ml/L of water) and T_2 (Actara 25 WG @ 1 g/L of water) and closely followed (0.47 and 0.60) by T_4 (neem seed kernel extract @ 5 g/L of water) and T_7 (shobicron 424 EC @ 2 ml/L of water), whereas the highest number (2.13) was observed from T_8 (control) followed (1.33 and 1.13) by T_6 (detergent @ 5 ml/L of water) and T_5 (petroleum oil @ 2 ml/L of water). In case of aphid, the lowest number (0.07) per plant was recorded from T_1 (Admire 200 SL @ 0.5 ml/L of water) and T_3 (Neem oil @ 5 ml/L of water) which was statistically identical (0.13 and 0.27) with T_2 (Actara 25 WG @ 1 g/L of water) and T_4 (Neem seed kernel extract @ 5 g/L of water) and closely followed (0.33) by T_7 (Shobicron 425 EC@ 2 ml/L of water), while the highest number (1.47) was obtained from T_8 (control) which was followed (0.73 and 0.60) by T_6 (Detergent @ 5 ml/L of water) and T_5 (Petroleum oil (sparrow 888 plus) @ 2ml/L of water). In case of white fly, the lowest number per plant (0.13) was obtained from T_1 (Admire 200 SL @ 0.5 ml/L of water) which was statistically identical (0.27 and 0.33) with T_3 (Neem oil @ 5 ml/L of water) and T_2 (Actara 25 WG @ 1 g/L of water) and very close to (0.47) by T_4 (Neem seed kernel extract @ 5 g/L of water). On the contrary, the highest number (2.20) was recorded from T_8 (control) followed (1.40 and1.13) by T_6 (Detergent @ 5 ml/L of water) and T_5 (Petroleum oil (sparrow 888 plus) @ 2ml/L of water).

4.1.2 Mid fruiting stage

At mid fruiting stage number of jassid, aphid and white fly showed statistically significant variation due to different treatment or management practices (Table 2). For jassid, the lowest number of jassid per plant was recorded from T_1 (0.13) which was statistically identical with T_3 (0.33) and close to T_2 (0.53). On the other hand, the highest number was found from T_8 (2.80) which was followed by

T_6 (1.67). In context of aphid, the lowest number in each plant was found from T_1 (0.13) which was statistically identical with T_3 (0.27) and closely followed by

Table 2. Effect of different treatment on number of major sucking insect pests per plant of okra

Treatments	Number of sucking insect pests								
	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	Jassid	Aphid	White fly	Jassid	Aphid	White fly	Jassid	Aphid	White fly
T_1	0.07 e	0.07 d	0.13 f	0.13 f	0.13 f	0.20 f	0.27 e	0.13 e	0.20 f
T_2	0.20 e	0.13 cd	0.33 ef	0.53 e	0.40 e	0.87 e	0.67 d	0.33 cde	0.47 e
T_3	0.13 e	0.07 d	0.27 ef	0.33 ef	0.27 ef	0.80 e	0.40 e	0.27 de	0.20 f
T_4	0.47 d	0.27 cd	0.47 e	0.93 d	0.73 d	1.20 de	0.87 d	0.47 cd	0.67 d
T_5	1.13 c	0.60 b	1.13 c	1.27 c	1.27 bc	1.67 bc	1.47 b	0.60 bc	1.13 b
T_6	1.33 b	0.73 b	1.40 b	1.67 b	1.47 b	1.87 b	1.67 b	0.80 b	1.27 b
T_7	0.60 d	0.33 c	0.73 d	1.13 cd	1.07 c	1.40 cd	1.20 c	0.47 cd	0.87 c
T_8	2.13 a	1.47 a	2.20 a	2.80 a	2.53 a	3.00 a	2.40 a	2.13 a	1.87 a
$LSD_{(0.05)}$	0.175	0.200	0.241	0.271	0.215	0.422	0.235	0.254	0.175
Level of Significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	13.50	14.97	16.56	14.10	12.55	7.49	11.97	22.14	12.28

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_2 (0.40), whereas the highest number was obtained from T_8 (2.53) which was followed by T_6 (1.47) and T_5 (1.27). Considering white fly, the lowest number of white fly per plant (0.20) was observed from T_1 which was close to T_3 (0.80), T_2 (0.87) and T_4 (1.20), consequently the highest number from T_8 (3.00) which was followed by T_6 (1.87) and T_5 (1.67) treatment (Table 2).

4.1.3 Late fruiting stage

Different treatments of management practices showed significant differences at late fruiting stage for the number of jassid, aphid and white fly (Table 2). Regarding jassid, the lowest number of jassid per plant was obtained from T_1 (0.27) which was statistically identical with T_3 (0.40) and followed by and T_2 (0.67) and T_4 (0.87). Nevertheless, the highest number was found from T_8 (2.40) which was followed by T_6 (1.67) and T_5 (1.47), respectively. The lowest number of aphid per plant (0.13) was recorded from T_1 which was statistically identical with T_3 (0.27) and T_2 (0.33) and closely followed by T_7 (0.47), whereas the highest number was observed from T_8 (2.13) followed by T_6 (0.80) and T_5 (0.60). In relation to white fly, the lowest number per plant (0.20) was found from T_1 and T_3 and close to T_2 (0.47), while the highest number was obtained from T_8 (1.87) followed by T_6 (1.27) and T_5 (1.13) treatments.

Kandoria and Jamwal (1988) reported that nymphal development lasted for 8.38, 8.30 and 8.25 days, on okra, aubergines and *Capsicum annuum*, resp. Nymphal survival was highest on okra (96%) and significant fruit infestation occurred in late fruiting stage. Similar findings also reported by, Praveen and Dhandapani (2001). Fruit damage in untreated control was recorded as 22.56 and 22.6%, respectively for okra insect pests. Similar results also reported by Singh and Brar (1994), Dikshit *et al*. (2000), Ranganath *et al*. (1997) from their experiments.

4.2 Fruit bearing status

4.2.1 Fruit bearing status at early fruiting stage

Statistically significant differences were obtained in number of healthy, infested fruits, percent infestation and infestation reduction over control at early fruiting stage for different management practices in controlling major sucking pests of okra (Table 3). In the number of healthy fruits, the highest number per plant (8.27) was recorded from T_1 which was statistically similar with T_3 (7.93) and T_2 (7.47) and followed by T_4 (7.13), while the lowest number of healthy fruits was obtained from T_8 (5.40) which was statistically identical with T_6 (6.13) and close to T_7 (6.53) and T_5 (6.67) treatments. The lowest number of infested fruits per plant was observed from T_1 (0.13) which was statistically similar with T_3 (0.27) and T_2 (0.33) and closely followed by T_4 (0.40) and T_7 (0.47). On the other hand, the highest number of infested fruits was obtained from T_8 (1.07) followed by T_6 (0.80) treatment. In relation to the % fruit infestation, the lowest infested fruits per plant in number was observed from T_1 (1.63%) which was statistically similar with T_3 (3.30%) and closely followed by T_2 (4.27%) and T_4 (5.31%), again the highest infested fruits was recorded in T_8 (16.48%) followed by T_6 (11.51%) treatment. Fruit infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (90.11%) and the lowest reduction of fruit infestation over control from T_6 (30.16%) treatment.

Table 3. Effect of different pest management treatments in controlling major sucking insect pests of okra at early fruiting stage in terms of fruits per plant by number and weight

Treatments	Fruits in number				Fruits in weight (g)			
	Healthy	Infested	% Infestation	Reduction over control (%)	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	8.27 a	0.13 d	1.63 f	90.11	99.82 a	1.58 e	1.55 f	88.80
T_2	7.47 abc	0.33 cd	4.27 de	74.09	91.39 ab	3.88 cd	4.06 e	70.66
T_3	7.93 ab	0.27 cd	3.30 ef	79.98	96.82 a	3.18 de	3.19 ef	76.95
T_4	7.13 bc	0.40 c	5.31 de	67.78	87.09 bc	4.52 cd	4.94 de	64.31
T_5	6.67 cd	0.67 b	9.06 bc	45.02	80.65 cd	7.62 b	8.60 bc	37.86
T_6	6.13 de	0.80 b	11.51 b	30.16	74.87 de	8.68 ab	10.38 b	25.00
T_7	6.53 cd	0.47 c	6.73 cd	59.16	78.99 cd	5.44 c	6.52 cd	52.89
T_8	5.40 e	1.07 a	16.48 a	--	66.01 e	10.57 a	13.84 a	--
$LSD_{(0.05)}$	0.879	0.200	2.502	--	9.088	1.905	2.184	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	7.23	21.74	19.61	--	6.14	9.14	18.79	--

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Healthy and infested fruit, % infestation and infestation reduction over control in terms of weight showed statistically significant variation at early fruiting stage for different management practices in controlling major sucking insect pests of okra (Table 3). In context of healthy fruit, the highest weight per plant (99.82 g) was recorded from T_1 which was statistically similar with T_3 (96.82 g) and T_2 (91.39 g) followed by T_4 (87.09 g). On the other contrary the lowest weight of healthy fruits was obtained from T_8 (66.01 g) which was statistically similar with T_6 (74.87 g) followed by T_7 (74.87 g) and T_5 (80.65 g) treatments. Considering the infested fruits, the lowest weight of infested fruits per plant was recorded from T_1 (1.58 g) which was statistically similar with T_3 (3.18 g) and close to T_2 (3.88 g) and T_4 (4.52 g), while the highest weight of infested fruits was found in T_8 (10.57 g) which was statistically identical with T_6 (8.68 g) and closely followed by T_5 (7.62 g) treatment. In relation to the % fruit infestation in weight, the lowest infested fruits per plant was recorded from T_1 (1.55%) which was statistically similar with T_3 (3.19%) and closely followed by T_2 (4.06%) and T_4 (4.94%), whereas the highest infested fruits was observed in T_8 (13.84%) which was closely followed by T_6 (10.38%) and T_5 (8.60 g) treatment. Fruit infestation reduction over control in weight was estimated and the highest value was attained from the treatment T_1 (88.80%) and the lowest from T_6 (25.00%) treatment.

4.2.2 Fruit bearing status at mid fruiting stage

Significant differences were shown for number of healthy, infested fruit, % infestation and infestation reduction over control at mid fruiting stage among the different treatments in controlling major sucking pests of okra (Table 4). The highest (13.07) number of healthy fruits per plant was recorded from T_1 and T_3 treatment which was statistically identical with T_2 (12.53) and T_4 (12.13), while the lowest number of healthy fruits was recorded in T_8 (10.13) treatment. The lowest number of infested fruits per plant was obtained from T_1 (0.40) which was statistically similar with T_3 (0.47) and closely followed by T_2 (0.73) and T_4 (0.93). On the other hand, the highest number of infested fruits was found in T_8 (2.27) which was closely followed by T_6 (1.60) treatment. The lowest infested fruits per plant in number was observed from T_1 (2.97%) which was statistically similar with T_3 (3.46%) and close to T_2 (5.54%) and T_4 (7.14%), while the highest infested fruits was recorded in T_8 (18.25%) which was close to T_6 (12.31%) treatment. Fruit infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (83.73%) and the lowest reduction of fruit infestation over control was recorded from T_6 (32.55%) treatment.

Table 4. Effect of different pest management practices in controlling major sucking pests of okra at mid fruiting stage in terms of fruits per plant by number and weight

Treatments	Fruits in number				Fruits in weight (g)			
	Healthy	Infested	% Infestation	Reduction over control (%)	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	13.07 a	0.40 f	2.97 f	83.73	180.34 a	4.88 f	2.64 f	84.04
T_2	12.53 ab	0.73 e	5.54 e	69.64	171.62 ab	8.92 e	4.95 e	70.07
T_3	13.07 a	0.47 f	3.46 f	81.04	179.23 a	5.66 f	3.07 f	81.44
T_4	12.13 ab	0.93 de	7.14 de	60.88	165.92 abc	11.32 de	6.38 de	61.43
T_5	11.60 b	1.27 c	9.83 c	46.14	157.79 bc	15.24 c	8.80 c	46.80
T_6	11.40 b	1.60 b	12.31 b	32.55	156.06 c	19.2 2 b	10.97 b	33.68
T_7	11.60 b	1.00 d	7.97 d	56.33	157.84 bc	12.05 d	7.13 d	56.89
T_8	10.13 c	2.27 a	18.25 a	--	138.46 d	27.48 a	16.54 a	--
$LSD_{(0.05)}$	1.058	0.241	1.659	--	13.96	2.825	1.447	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	5.06	12.82	11.23	--	4.88	12.32	10.93	--

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

At mid fruiting stage different management practices in controlling major sucking pests of okra showed significant differences in terms of healthy, infested fruit, % infestation and infestation reduction over control in weight basis (Table 4). The highest weight of healthy fruit per plant (180.34 g) was obtained from T_1, while the lowest weight of healthy fruits was observed in T_8 (138.46 g). The lowest weight of infested fruits per plant was obtained from T_1 (4.88 g) which was statistically identical with T_3 (5.66 g), whereas the highest weight of infested fruits was found in T_8 (27.48 g). The lowest infested fruits per plant was observed from T_1 (2.64%) which was statistically identical with T_3 (3.07%) and closely followed by T_2 (4.95%) and T_4 (6.38%), while the highest infested fruits was observed in T_8 (16.54%) which was close to T_6 (10.97%) treatment. Fruit infestation reduction over control in weight was estimated and the highest value was found from the treatment T_1 (84.04%) and the lowest reduction of fruit infestation over control from T_6 (33.68%) treatment.

4.2.3 Fruit bearing status at late fruiting stage

Healthy and infested fruit, % infestation and infestation reduction over control in number basis at late fruiting stage showed significant differences due to different management practices in controlling major sucking pests of okra (Table 5). The highest number of healthy fruit per plant (10.40) was estimated from T_1 which was followed by T_3 (10.00) and T_2 (9.73), whereas the lowest number of healthy fruits was recorded in T_8 (7.20) followed by T_6 (8.67) and T_7 (8.93) treatment. In case of infested fruit, the lowest number of infested fruits per plant was attained from T_1 (0.33) followed by T_3 (0.60) and T_4 (0.73), whereas the highest number of infested fruits was recorded in T_8 (2.00) followed by T_6 (1.60) treatment. In terms of % fruit infestation, the lowest infested fruits per plant in number was found from T_1 (3.12%) followed by T_3 (5.66%) and T_2 (6.99%). Inversely the highest infested fruits was recorded in T_8 (21.75%) followed by T_6 (15.72%) treatment. Fruit infestation reduction over control in number was estimated and the highest value was recorded from the treatment T_1 (85.66%) and the lowest reduction of fruit infestation over control was observed from T_6 (27.72%) treatment (Table 5).

Statistically significant variation was recorded in terms of healthy, infested fruit, % infestation and infestation reduction over control in weight basis different management practices in controlling major sucking pests of okra at late fruiting stage (Table 5). In the context of healthy fruit, the highest weight of healthy fruits per plant (154.58 g) was found from T_1 followed by T_3 (147.77 g) and T_2 (143.46 g). On the contrary, the lowest weight of healthy fruits was obtained from T_8 (107.21 g)

Table 5. Effect of different pest management practices in controlling major sucking insect pests of okra at late fruiting stage in terms of fruits per plant in number and weight

Treatments	Fruits in number per plant				Fruits in weight (g) per plant			
	Healthy	Infested	% Infestation	Reduction over control (%)	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	10.40 a	0.33 g	3.12 f	85.66	154.58 a	4.51 g	2.85 f	85.06
T_2	9.73 abc	0.73 ef	6.99 de	67.86	143.46 abc	8.66 ef	5.68 de	70.21
T_3	10.00 ab	0.60 f	5.66 e	73.98	147.77 ab	7.21 f	4.65 e	75.62
T_4	9.33 bcd	0.87 e	8.51 d	60.87	139.05 bcd	9.98 e	6.72 d	64.76
T_5	9.13 bcd	1.27 c	12.17 c	44.05	134.87 bcd	13.91 c	9.34 c	51.02
T_6	8.67 d	1.60 b	15.72 b	27.72	127.86 d	17.21 b	11.99 b	37.13
T_7	8.93 cd	1.07 d	10.71 c	50.76	132.55 cd	11.95 d	8.30 c	56.48
T_8	7.20 e	2.00 a	21.75 a	--	107.21 e	25.27 a	19.07 a	--
$LSD_{(0.05)}$	0.860	0.157	2.007	--	13.50	1.644	1.557	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	5.35	8.38	10.83	--	5.67	7.61	10.37	--

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

followed by and T_6 (127.86 g) treatment. In relation to the infested fruit, the lowest weight of infested fruits per plant was recorded from T_1 (4.51 g) close to T_3 (7.21 g) and T_2 (8.66 g), whereas the highest weight of infested fruits was found in T_8 (25.27 g) close to T_6 (17.21 g) treatment. In case of the % fruit infestation in weight, the lowest infested fruits per plant was recorded from T_1 (2.85%) close to T_3 (4.65%) and T_2 (5.68%), while the highest infested fruits was observed in T_8 (19.07%) close to T_6 (11.99%) treatment. Fruit infestation reduction over control in weight was estimated and the highest value was recorded from the treatment T_1 (85.06%) and the lowest reduction of fruit infestation over control was found from T_6 (37.13%) treatment.

4.2.4 Fruit bearing status at total fruiting stage

Different management practices in controlling major sucking pests of okra showed significant differences in terms of number of healthy, infested fruit, % infestation and infestation reduction over control at total fruiting stage for (Table 6). For healthy fruit, the highest number of healthy fruit per plant (31.73) was recorded from T_1 which was statistically similar with T_3 (31.00) and closely followed by T_2 (29.73) and the lowest number of healthy fruits was observed in T_8 (22.73) which was closely followed by T_6 (26.20), T_5 (27.40) and T_7 (27.07) treatments. In context of infested fruit, the lowest number of infested fruits per plant was recorded from T_1 (0.87) which was closely followed by T_3 (1.33), whereas the highest number of infested fruits was found in T_8 (5.33) which was closely followed by T_6 (4.00) treatment. Considering the % fruit infestation, the lowest infested fruits per plant in number was recorded from T_1 (2.66%) which was close to T_3 (4.13%), consequently the highest infested fruits was recorded in T_8 (18.99%) which was closely followed by T_6 (13.24%) treatment. Fruit infestation reduction over control in number was estimated and the highest value was obtained from the treatment T_1 (85.99%) and the lowest reduction of fruit infestation over control from T_6 (30.28%) treatment (Table 6).

Statistically significant differences were observed due to different management practices in controlling major sucking pests of okra in weight basis in terms of healthy, infested fruit, % infestation and infestation reduction over control at total fruiting stage under the present trial (Table 6). In case of healthy fruit, the highest weight of healthy fruit per plant (434.74 g) was found from T_1 which was statistically similar with and T_3 (423.82 g) and close to T_2 (406.47 g). On the other hand, the lowest weight of healthy fruits was recorded in T_8 (311.68 g) which was close to T_6 (358.79 g) treatment. In the context of the infested fruit, the lowest weight of infested fruits per plant was recorded from T_1 (10.97 g) followed by T_3 (16.05 g), while the highest weight of infested fruits was recorded in T_8 (63.31 g) followed by T_6 (45.11 g) treatment. Considering % fruit infestation in weight, the lowest infested fruits per plant was found from T_1 (2.46%) which was closely followed by T_3 (3.65%), whereas the highest infested fruits was recorded in T_8 (16.88%) followed by T_6 (11.17%) treatment. Fruit infestation reduction over control in weight was estimated and the highest value was recorded from the treatment

Table 6. Effect of different pest management practices in controlling major sucking pests of okra at total fruiting stage in terms of fruits per plant by number and weight

Treatments	Fruits in number per plant				Fruits in weight (g) per plant			
	Healthy	Infested	% Infestation	Reduction over control (%)	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	31.73 a	0.87 g	2.66 h	85.99	434.74 a	10.97 g	2.46 h	85.07
T_2	29.73 bc	1.80 e	5.71 f	69.93	406.47 bc	21.46 e	5.02 f	69.54
T_3	31.00 ab	1.33 f	4.13 g	78.25	423.82 ab	16.05 f	3.65 g	77.85
T_4	28.60 cd	2.20 d	7.15 e	62.35	392.07 cd	25.83 d	6.19 e	62.44
T_5	27.40 de	3.20 c	10.45 c	44.97	373.31 de	36.77 c	8.96 c	45.63
T_6	26.20 e	4.00 b	13.24 b	30.28	358.79 e	45.11 b	11.17 b	32.22
T_7	27.07 de	2.53 d	8.57 d	54.87	369.38 de	29.44 d	7.39 d	55.16
T_8	22.73 f	5.33 a	18.99 a	--	311.68 f	63.31 a	16.88 a	--
$LSD_{(0.05)}$	1.740	0.395	0.860	--	23.93	4.127	0.731	--
Level of Significance	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	6.54	8.37	5.54	--	8.56	7.57	5.41	--

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 (85.07%) and the lowest reduction of fruit infestation over control was observed from T_6 (32.22%) treatment (Table 6).

Ranganath *et al*. (1997) reported that dichlorovs at 0.2% were the most effective against the okra pest and reducing damage to 9.1 to 9.5% as compared with 32.9% in control. Jayaraj (1991) reported that neem seed kernel extracts (3-5%) were effective against *Nilaparbata lugens, Marasmia patnalis, Oxya nitidula* and neem leaf extract, is less effective than neem seed kernel extract.

4.3 Yield contributing characters and yield of okra

4.3.1 Plant height at harvest

Plant height of okra at harvest showed statistically significant variation for different management practices in controlling major sucking pests of okra (Table 7). The tallest plant was measured from T_1 (227.62 cm) which was followed by T_3 (222.37 cm), T_2 (217.93 cm), T_4 (215.45 cm) and T_5 (204.33 cm) while the shortest plant was measured from T_8 (190.96 cm), followed by T_6 (199.05 cm) and T_7 (201.17 cm) treatments.

4.3.2 Plant diameter at harvest

Plant diameter of okra at harvest showed significant variation might be due to different management practices in controlling major sucking pests of okra (Figure 1). The maximum diameter of plant was observed from T_1 (2.60 cm) whereas the minimum diameter of plant was recorded from T_8 (2.02 cm) treatment.

Table 7. Effect of different pest management practices on yield contributing characters and yield of okra

Treatments	Plant height (cm)	Days for sowing to 1st flowering	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/plant	Fruit yield/hectare
T_1	227.62 a	43.07 c	18.69 a	1.39 a	32.60 a	15.94 a
T_2	217.93 ab	43.60 bc	18.12 abc	1.34 ab	31.40 ab	15.32 abc
T_3	222.37 ab	43.33 bc	18.28 ab	1.36 ab	32.20 a	15.80 ab
T_4	215.45 abc	44.40 bc	17.55 bcd	1.33 ab	30.80 ab	14.76 abcd
T_5	204.33 abc	45.60 abc	17.39 bcd	1.27 abc	30.20 abc	14.18 bcd
T_6	199.05 bc	47.53 ab	16.89 d	1.24 bc	29.60 bc	13.47 d
T_7	201.17 bc	45.00 bc	17.16 cd	1.25 bc	30.60 abc	14.00 cd
T_8	190.96 c	49.33 a	15.45 e	1.20 c	28.20 c	11.64 e
$LSD_{(0.05)}$	23.00	3.976	0.970	0.111	2.266	1.504
Level of Significance	0.05	0.05	0.01	0.05	0.05	0.01
CV(%)	6.26	5.02	7.18	5.06	4.21	5.97

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

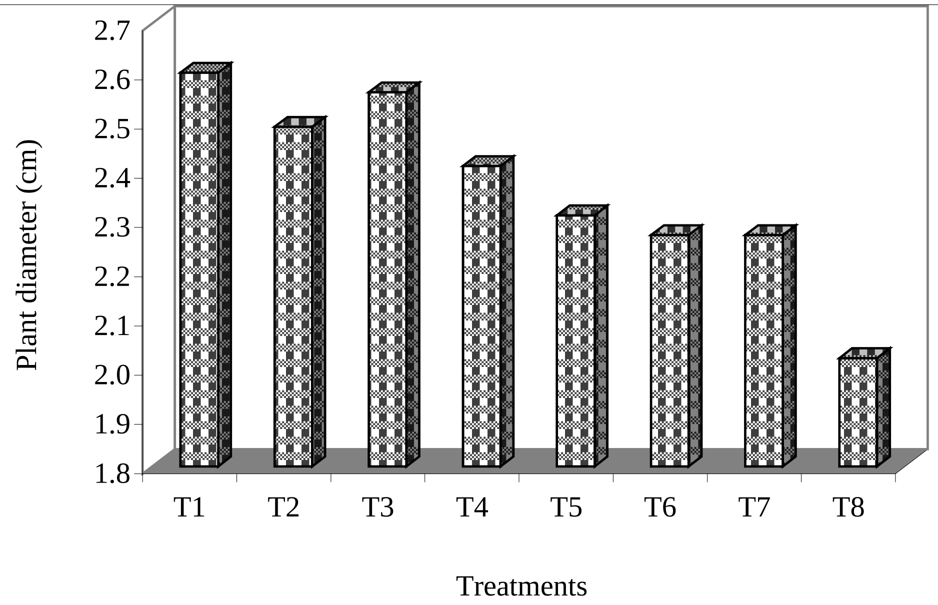

Figure 1. Effect of some pest management practices on plant diameter of okra

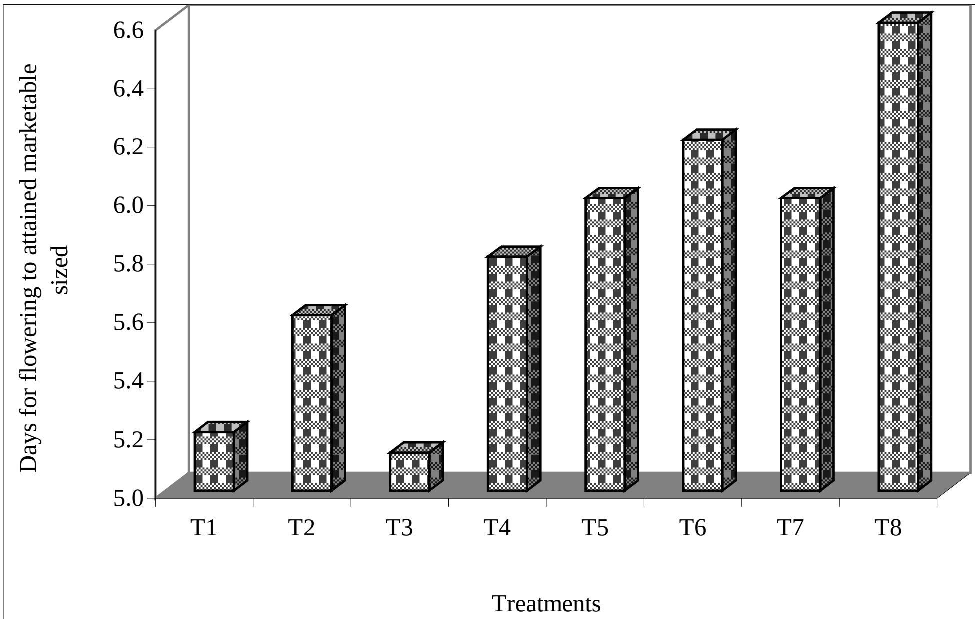

Figure 2. Effect of some pest management practices on days for flowering to attained marketable sized pods of okra

4.3.3 Days for sowing to 1st flowering

Different management practices in controlling major sucking pests of okra showed significant differences in terms of days for sowing to 1st flowering (Table 7). The minimum days for sowing to 1st flowering was attained from T_1 (43.07) which was statistically similar with T_3 (43.33), T_2 (43.60), T_4 (44.40) and T_7 (45.00), whereas the maximum days from T_8 (49.33) which was statistically identical with T_6 (47.53) treatment.

4.3.4 Days for flowering to attained marketable size

Days for flowering to attain marketable sized varied significantly due to different management practices in controlling major sucking pests of okra (Figure 2). The minimum days for flowering to attained marketable sized was found from T_3 (5.13) which was statistically similar with T_1 (5.20), T_2 (5.60), T_4 (5.80) and T_5 (6.00). On the other hand, the maximum days for flowering to attained marketable sized was recorded from T_8 (6.60) which was statistically identical with T_6 (6.20) treatment.

4.3.5 Fruit length

Statistically significant variation was recorded in terms of fruit length of okra due to different management practices in controlling major sucking pests of okra (Table 7). The longest fruit was observed from T_1 (18.69 cm) which was statistically similar with T_3 (18.28 cm) and T_2 (18.12 cm) and closely followed by T_4 (17.55 cm) and T_5 (17.39 cm), again the shortest fruit was recorded from T_8 (15.45 cm) which was closely followed by T_6 (16.89 cm) treatment.

4.3.6 Fruit diameter

Fruit diameter of okra showed statistically significant differences for different management practices in controlling major sucking pests of okra (Table 7). The highest diameter of fruit was recorded from T_1 (1.39 cm) which was statistically similar with T_3 (1.36 cm), T_2 (1.34 cm), T_4 (1.33 cm) and T_5 (1.27 cm), whereas the lowest diameter of fruit was obtained from T_8 (1.20 cm) which was closely followed by T_6 (1.24 cm) and T_7 (1.25 cm) treatment.

4.3.7 Number of fruits per plant

Different management practices in controlling major sucking pests of okra varied significantly in terms of number of fruits per plant of okra (Table 7). The maximum number of fruits per plant was obtained from T_1 (32.60) which was statistically similar with T_3 (32.20), T_2 (31.40), T_4 (30.80), T_7 (30.60) and T_5 (30.20). On the other hand, the minimum number of fruits per plant was found from T_8 (28.20) which was followed by T_6 (29.60) and treatment.

4.3.8 Weight of individual fruit

Weight of individual fruit of okra showed statistically significant variation due to different management practices in controlling major sucking pests of okra (Figure 3). The highest weight of individual fruit was recorded from T_1 (14.42 g) which was statistically similar with T_3 (14.33 g), T_2 (14.05 g), T_4 (13.94 g), T_5 (13.82 g) and T_5 (13.74 g), again the lowest weight of fruits per plant was observed from T_8 (12.53 g) which was closely followed by T_6 (13.22 g) and treatment.

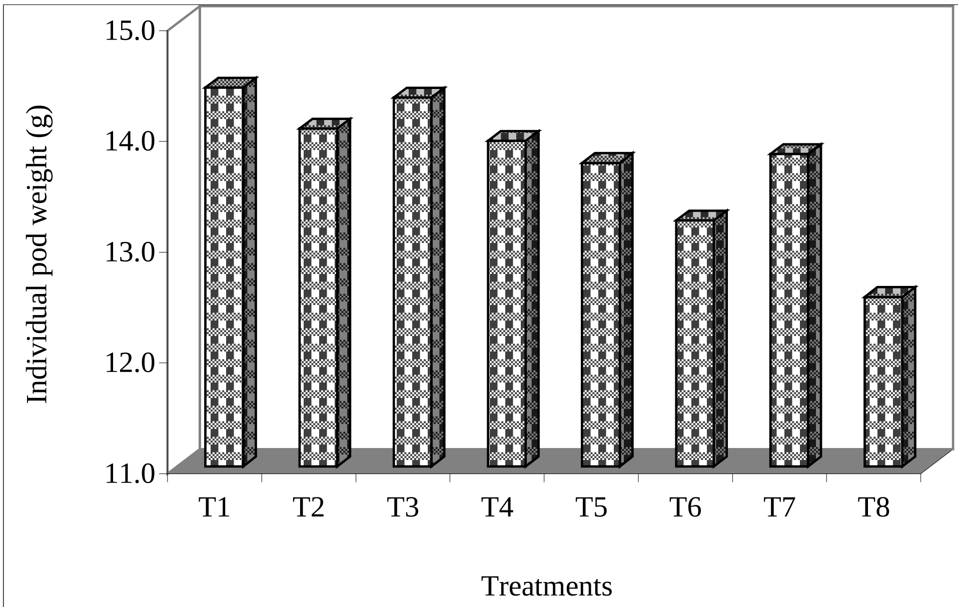

Figure 3. Effect of some pest management practices on individual pod weight of okra

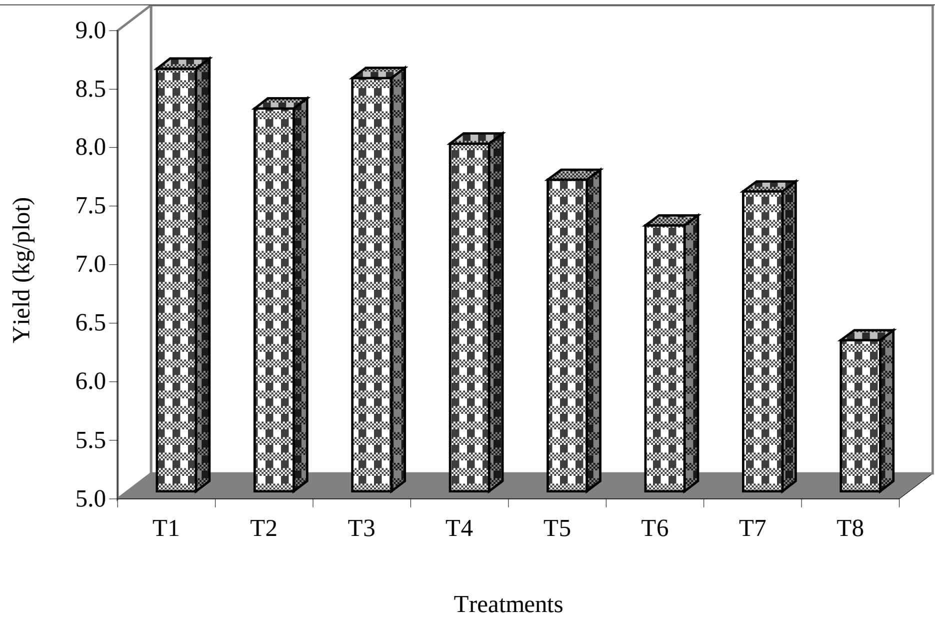

Figure 4. Effect of some pest management practices on pod yield per plot of okra

4.3.9 Yield of fruits per plot

Statistically significant variation was recorded in terms of yield of fruits per plot of okra due to different management practices in controlling major sucking pests of okra (Figure 4). The highest yield of fruits per plot was obtained from T_1 (8.61 kg) which was statistically similar with T_3 (8.53 kg), T_2 (8.27 kg), T_4 (7.97 kg) and closely followed by T_5 (7.66 kg) and T_7 (7.56 kg), consequently the lowest yield per plot was recorded from T_8 (6.29 kg) which was closely followed by T_6 (7.27 kg) and treatment.

4.3.10 Yield of fruits per hectare (estimated)

Yield of fruits per hectare of okra showed statistically significant differences for different management practices in controlling major sucking pests of okra (Table 7). The highest yield of fruits per hectare was observed from T_1 (15.94 ton) which was statistically similar with T_3 (15.80 ton), T_2 (15.32 ton), T_4 (14.76 ton) and closely followed by T_5 (14.18 ton) and T_7 (14.00 ton), while the lowest yield per hectare was found from T_8 (11.64 ton) which was closely followed by T_6 (13.47 ton) and treatment. Faqir and Gul (1998) reported that yield was highest in plots treated with monocrotophos + alpha-cypermethrin (11.85 t/ha), which was not significantly different from 10.31 t obtained in imidacloprid treated plots. Singh and Brar (1994) reported that crops protected from the insect pests gave a greater fruit yield than the control and the losses in yield varied from 32.06 to 40.84%.

4.4 Cost benefit analysis

Economic analysis of different control measures were integrated for the control of sucking pest of okra and are presented in Table 8.

In this study, the untreated control (T_8) did not require any pest management cost. But the costs were involved in chemical control. Treatment T_1 (Admire 200 SL @ 0.5 ml/L of water at 7 days interval), T_2 (Actara 25 WG @ 1 g/L of water at 7 days interval) and T_7 (Shobicron 425 EC@ 2 ml/L of water at 7 days interval) requires the cost of pesticides admire, actara and shobicron) and their application cost. The cost for the treatment T_3 (Neem oil @ 5 ml/L of water at 7 days interval) and T_4 (Neem seed kernel extract @ 5 g/L of water at 7 days interval) was incurred for neem oil, and neem kernel extract, preparation and its application. T_5 (Petroleum oil (sparrow 888 plus) @ 2ml/L of water at 7 days interval) and T_6 (Detergent @ 5 ml/L of water at 7 days interval) required for the cost of products, preparation and their application.

Considering the controlling of okra sucking pest highest benefit cost ratio (2.91) was recorded in the treatment T_1 followed by T_2 (2.68), T_3 (2.47), T_5 (2.18), T_6 (1.61) and T_4 (1.60) the lowest benefit cost ratio was recorded from T_7 (1.15) (Table 8).

Table 8. Cost of production of okra under different pest management practices and benefit

Treatments	Cost of pest Management (Tk.)	Fruit yield (t/ha)	Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)
T_1	11,000	15.94	159400	148400	32000
T_2	10,000	15.32	153200	143200	26800
T_3	12,000	15.80	158000	146000	29600
T_4	12,000	14.76	147600	135600	19200
T_5	8,000	14.18	141800	133800	17400
T_6	7,000	13.47	134700	127700	11300
T_7	11,000	14.00	140000	129000	12600
T_8	0	11.64	116400	116400	--

Market price of okra @ Tk. 10 per kg

T_1: Admire 200 SL @ 0.5 ml/L of water	T_2: Actara 25 WG @ 1 g/L of water
T_3: Neem oil @ 5 ml/L of water	T_4: Neem seed kernel extract @ 5 g/L of water
T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water	T_6: Detergent @ 5 ml/L of water
T_7: Shobicron 425 EC@ 2 ml/L of water	T_8: Control

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted to study effectiveness of insecticides against the major sucking pests of okra. The experiment consists of the management practices (T_1: Admire 200 SL @ 0.5 ml/L of water; T_2: Actara 25 WG @ 1 g/L of water; T_3: Neem oil @ 5 ml/L of water; T_4: Neem seed kernel extract @ 5 g/L of water; T_5: Petroleum oil (sparrow 888 plus) @ 2ml/L of water; T_6: Detergent @ 5 ml/L of water; T_7: Shobicron 425 EC@ 2 ml/L of water and T_8: Control). The experiment was designed with Randomized Complete Block Design (RCBD) with three replications. Data on different pest incidence their level of infestation, yield attributes and yield were collected and recorded.

Major sucking pests of okra viz. Jassid, white fly and aphid were recorded for the entire cropping season. At early fruiting stage, the lowest number of jassid per plant (0.07) was found from T_1, whereas the highest number (2.13) was observed from T_8. In case of aphid, the lowest number of aphid per plant (0.07) was recorded from T_1 and T_3, while the highest number was obtained from T_8 (1.47). In case of white fly, the lowest number of fly per plant (0.13) was obtained from T_1, whereas the highest number was found from T_8 (2.20). At mid fruiting stage for jassid, the lowest number of jassid per plant was recorded from T_1 (0.13) and the highest number was found from T_8 (2.80). In context of aphid, the lowest number of aphid per plant was found from T_1 (0.13), whereas the highest number was obtained from T_8 (2.53). Considering white fly, the lowest number of white fly per plant (0.20) was observed from T_1 consequently the highest number was found from T_8 (3.00). At late fruiting stage in response to jassid, the lowest number of jassid per plant was obtained from T_1 (0.27) and the highest number was found from T_8 (2.40). However, the lowest number of aphid per plant (0.13) was recorded from T_1, whereas the highest number was observed from T_8 (2.13). In relation to fly, the lowest number of white fly per plant (0.20) was found from T_1 and T_3 while the highest number was obtained from T_8.

At total fruiting stage, in considering number, the highest number of healthy fruit per plant (31.73) was recorded from T_1 and the lowest number of healthy fruits was observed in T_8 (22.73). In context of infested fruit, the lowest number of infested fruits per plant was recorded from T_1 (0.87), whereas the highest number of infested fruits was found in T_8 (5.33). Considering the % fruit infestation, the lowest infestation per plant in number was recorded from T_1 (2.66%), consequently the highest infestation was recorded in T_8 (18.99%). Fruit infestation reduction over control in number was estimated highest value in T_1 (85.99%) and the lowest in T_6 (30.28%) treatment. In weight basis in case of healthy fruit, the highest weight of healthy fruit per plant (434.74 g) was found from T_1 and, the lowest weight of healthy fruits was recorded in T_8 (311.68 g). In the context of the infested fruit, the lowest weight of infested fruits per plant was recorded from T_1 (10.97 g), while the highest weight of infested fruits was recorded in T_8 (63.31 g). For % fruit infestation in weight, the lowest infested fruits per plant was found from T_1 (2.46%), whereas the highest infested fruits was recorded in T_8 (16.88%) treatment. Fruit infestation reduction over control in weight was estimated and the highest value was recorded from the treatment T_1 (85.07%) and the lowest reduction of fruit infestation over control was observed from T_6 (32.22%) treatment.

The tallest plant was measured from T_1 (227.62 cm), while the shortest plant was found from T_8 (190.96 cm). The highest and the lowest diameter of plant was observed from T_1 (2.60 cm) and T_8 (2.02 cm), respectively. Minimum days for sowing to 1st flowering was attained from T_1 (43.07), whereas maximum days from T_8 (49.33). T_3 (5.13) showed minimum days for flowering to attained marketable sized and T_8 (6.60) showed maximum days for flowering to attained marketable sized was recorded from. The longest fruit was found in T_1 (18.69 cm) while the shortest fruit was recorded from T_8 (15.45 cm). The highest diameter of fruit was recorded from T_1 (1.39 cm) whereas the lowest diameter of fruit was obtained from T_8 (1.20 cm).

The maximum number of fruits per plant was obtained from T_1 (32.60) and the minimum number of fruits per plant was found from T_8 (28.20). The highest weight of individual fruit was recorded from T_1 (14.42 g), again the lowest weight of fruits per plant was observed from T_8 (12.53 g). The highest yield of fruits per plot was obtained from T_1 (8.61 kg), consequently the lowest yield per plot was recorded from T_8 (6.29 kg). The highest yield of fruits per hectare was observed from T_1 (15.94 ton), while the lowest yield per hectare was found from T_8 (11.64 ton). Considering the controlling of okra sucking pest highest benefit cost ratio (2.91) was recorded in the treatment T_1 and the lowest from T_7 (1.15).

Conclusion

Among the treatment Admire 200 SL @ 0.5 ml/L of water at 7 days interval was more effective for the controlling of insect pests as well as highest yield contributing characters and yield of Okra.

Recommendations

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability;
2. Other management practices may be included in the future study.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from February to August 2009

Month (2009)	*Air temperature (^0c)		*Relative humidity (%)	*Rain fall (mm) (total)
	Maximum	Minimum		
February	27.1	16.7	67	30
March	31.4	19.6	54	11
April	33.2	21.1	61	88
May	34.1	20.2	78	102
June	35.1	22.4	67	98
July	31.4	19.6	64	101
August	33.6	23.6	69	163

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix II. Characteristics of experimental field soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45