MAJOR INSECT PESTS OF YARD LONG BEAN *(VIGNA SESQUIPEDALIS)* AND THEIR MANAGEMENT

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MAJOR INSECT PESTS OF YARD LONG BEAN
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BY

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TO

MY BELOVED PARENTS

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CERTIFICATE

This is to certify that thesis entitled, **"Major Insect Pests of Yard Long Bean *(Vigna sesquipedalis)* and their Management"** 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 Naznin Aktar, Registration No. 04-01427 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.

Dated: December 10
Place: Dhaka, Bangladesh

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Prof. Dr. Mohammed Ali
Supervisor

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Dated: December 10 The Authoress

Place: SAU, Dhaka

MAJOR INSECT PESTS OF YARD LONG BEAN *(VIGNA SESQUIPEDALIS)* AND THEIR MANAGEMENT

ABSTRACT

The present study was conducted at the Sher-e-Bangla Agricultural University, Sher-e-Bangla nargar, Dhaka, Bangladesh during from April to August 2011 for major insect pests of yard long bean *(Vigna sesquipedalis)* and their management. The seeds of BARI yard long bean-1 were used as the test crop for the experiment. The experiment consisted of the following treatments: T_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval; T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval; T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval; T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval; T_5: Suntap 50WP @ 3 g/L of water at 10 days interval; T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval; T_7: Neem seed kernel powder @10 g/L of water at 10 days interval and T_8: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on the number of pests per plant, number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight, yield contributing characters and yield of yard long bean were recorded and statistically significant differences were calculated for different treatments. Incidence of major insect pests of yard long bean was recorded for the entire cropping season and pod borer, aphid and epilachna beetle were observed. At early, mid and late pod stage, the lowest % pod infestation (in number) (1.77%, 2.78% and 3.30%) was observed from T_5 treatment, while the highest infestation (8.93%, 12.28% and 17.12%) was recorded in T_8 treatment. Similar results/trends were found for pod infestation in weight basis. The highest yield per hectare was recorded from T_5 (26.87 ton), while the lowest yield was recorded from T_8 (12.20 ton).

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CHAPTER I

INTRODUCTION

The yard long bean (*Vigna sesquipedalis*) is a delicious vegetable belongs to the family leguminosae and the other names include Chori, Bora and Snake bean. It is a rich source of essential vitamins and commonly grown during kharif seasons thus the importance of yard long bean is highly significant in respect to its growing season. Because in these regions less than 30% of the vegetables are produced in kharif season and more than 70% are in rabi season (Hossain and Awrangzeb, 1992). It is grown almost in all districts of Bangladesh. Its concentration is found in Dhaka, Jessore, Comilla, Noakhali and Chittagong but for the last ten years yard long bean have been seen growing extensively in Jessore, Khulna, Chittagong region as well (Adity, 1993).

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 generally face various problems 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. Although no regular statistical records are kept, as per conservative estimate the yield loss in yard long bean due to insect pests is reported to be about 12-30% (Hossain and Awrangzeb, 1992).

According to Alam (1969), it is attacked by nine different insect species. Mohiuddin *et al*. (2009) reported that the key insects of yard long bean are pod borer (*Maruca vitrata*), aphid (*Lipaphis erysimi*) and epilachna beetle (*Epilachna* *dodecastigma*). Dina (1979) and Baker *et al*. (1980) found that pod borer is a serious insect pest of leguminous vegetables. Butani and Jotwani (1984) found that lepidoterous larvae as pests causing damage by boring tender or mature pods. Bean pod borer is able to establish itself from vegetative to reproductive stage. At the early stage of plant growth, the bean pod borer, attack the crop making clusters of leaves, tendrils and young shoots of the plant and later at flowering and pod setting stages of plants, the insect bore into these reproductive organs, where the insect feeds internally (Karim, 1993).

There are several pest control methods for controlling pests of yard long bean, as cultural (Sharma, 1998), mechanical and applied biological (Karim, 1995) and chemical control measures (Rahman and Rahman, 1988). Pest control measures include application of synthetic pesticides, sulfur, lime, soap and kitchen ashes. Infestations are too heavy for hand picking/cleaning. Bean pod borers frequently feed internally on infested plant parts while living inside the clusters 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 pest. Neem oil is a promising and less exploited approach in this context.

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 went on 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. 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.

Therefore, the present study was undertaken with the following objectives;

1. To identify the major insect pests of yard long bean.
2. To determine the effectiveness of different control methods against the insect pests of yard long bean.
3. To identify the most effective control measures against the insect pests of yard long bean.

CHAPTER II

REVIEW OF LITERATURE

Yard long bean is one of the important summer vegetable in Bangladesh as well as many countries of the world. There are many insect pests of the vegetable. Among them pod borer (*Maruca vitrata*), aphid (*Lipaphis erysimi*) and epilachna beetle (*Epilachna dodecastigma*) are of serious is considered as the damaging and has profound yield loss in yard long bean production in Bangladesh. Farmers mainly control the insect pests of yard long bean 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 related to the information of damaging insects pests and research findings related to their control through chemicals and botanicals so far been done at home and abroad have been reviewed in this chapter.

2.1 Insect pests of leguminous plant 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) in screenhouse cages in the Punjab, India, during August-October 1986. Nymphal development lasted for 8.38, 8.30 and 8.25 days. Nymphal survival was highest on okra (96%), followed by aubergine (95%) and *Capcicum annuum* (92%). Adult longevity was 11.66, 11.48 and 10.95 days on aubergines, *Capcicum annuum* and *Hibiscus esculntum*, respectively, and the generation time was 19.35, 19.94 and 19.22 days on these crops.

Kumar and Urs (1988) evaluated the seasonal incidence of *Earias vittella* on bean 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* 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) @ 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.

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* 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 (LT_{50}) 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 bean 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 cowpea (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 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, 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 (Karim, 1993). The life cycle of *Tetranychus macfarlanei*, a pest 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 29.67^0C 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.

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 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 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 /L 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, 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 29.67^0C 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.

Dubey *et al*. (1998) conducted a field experiment in Madhya Pradesh 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 bean 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.

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.

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 Use of Chemical Insecticide

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.

Search of review reveals that bear pod bean control is dominated by chemical approaches. In India, a number of insecticides have been evaluated for the control of pod borer in pulses including pigeon pea (Rahman, 1989). 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 (Singh, 1977; Lalasangi, 1988). 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). 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 dimethoate was not as effective as cypermethrin (Rahman and Rahman, 1988). A schedule of insecticide sprays using decis (Deltamethrin) and systoate (Dimethoate) on 35, 45, 55 and 65 days after planting was investigated in Benin in 1985 to determine the most effective treatment against the pyralid *M. testulalis* on cow pea (Atachi and Sourokou, 1989). Broadley (1977) obtained control of *M. testulalis* with methomyl when applied at 337-450g (a.i.)/ha. Because of hidden nature of larval and pupal stages of the pest, it is difficult to control Maruca pod borer by chemical or other conventional means. 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 (Rahman, 1989). 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). Dandale *et al.* (1984) reported the superiority of cypermethrin, fenvalerate and endosalfan in reducing pod borer infestation in red gram. Spraying of synthetic pyrethroid insecticides at the rate of 1 ml per liter of water has been recommended for the control of the pest (Karim, 1993). Among the various control measures so far been reported for the management of the pod borer, chemical control appeared as comparatively effective and predominant one.

2.3 Use of Neem product

Neem (*Azadirachta indica*) 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. Stoll (1992) summarized the potential benefits of botanical pesticides which diminish the risk of resistance development,, natural enemy elimination, secondary out break of pest 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).

During last two decades neem oil and extracts from leaves and seeds have been evaluated as plant protectant against a wide range of arthropod and nematode pests in several countries of the world. Although, most of the trails are laboratory based but it is not scanty in case of field condition. Ketkar (1976) reviewed 95 and Jacobson (1985) reviewed 133 papers on neem and documented neem's potential in the management of arthropods pests (Warthen, 1979).

Grainge and Ahmed (1988) and 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.

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).

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. 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). The leaf extract of neem tested against the leaf caterpillar of brinjal, *Selepa docilis* Bult. 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).

Entomologist of many countries including India, The Philippines, Pakistan and Bangladesh have 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 (Jayaraj, 1991). Damage by leaf folders was reduced by 3% neem oil. Neem seed kernel extracts reduced egg deposition on rice seedling by *Nephotettix* spp. and *Nilaparbata 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 (Jayaraj, 1991). At 3%, the initial phytotoxicity effects is 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 mixe neem oil with the water. Neem oil normally stay separately on the upper surface of the water. In a field observation of neem oil Krishanaiah and Kalode (1991) used soap as emulsifier with water.

CHAPTER III

MATERIALS AND METHODS

The present study was conducted at the Sher-e-Bangla Agricultural University, Sher-e-Bangla nargar, Dhaka, Bangladesh during from April to August 2011 for major insect pests of yard long bean (*Vigna sesquipedalis*) and their management. Required materials and methodology are described below under the following sub-headings:

3.1 Location

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagor, Dhaka, Bangladesh. The location of the experimental site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil testing Laboratory, SRDI Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix I.

3.3 Weather condition of the experimental site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy 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). Details of the metrological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka and presented in Appendix II.

3.4 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The target land was divided into 24 equal plots with plot to plot distance of 1 m, block to block distance is1 m and plant to plant distance is 1.2 m. Standard dosages of cowdung and fertilizers were applied as recommended by Rashid (1993) for yard long bean @ 12kg of cowdung, 60 gm urea, 100 gm TSP and 100 gm MP respectively per pit. Again 30gm urea was applied as top dressing after each flush of flowering and fruiting in three equal splits.

3.5 Collection of seed, seedling raising and transplanting

The seeds of BARI long yard bean-1 were collected from Bangladesh Agricultural Research Institute (BARI), for rapid and uniform germination the seeds of yard long bean were soaked for 12 hours in water. Seeds were then directly sown in the 28^{th} April, 2011 in polyethylene bags (12 cm × 18 cm) containing a mixture of equal proportion well decomposed cowdung and loam soil. Seeds were sown in bags and irrigated regularly. After germination the seedlings were sprayed with water by a hand sprayer. Water was sprayed once a day for one week. Seedlings were placed in a shady place and were transplanted on May 13, 2011 in the pits of the experimental field after 15 days of germination. At the time of transplanting, polyethylene bag was cut and removed carefully in order to keep the soil intact with the root of the seedling.

3.6 Cultural practices

After transplanting, a light irrigation was given. Subsequent irrigation was applied in all the plots as and when needed. After 7 days of transplanting a single healthy seedling with luxuriant growth per pit was allowed to grow discarding the others, propping of each plant by bamboo sticks (1.75 m) was provided on about 1.5m high from ground level for additional support and to allow normal creeping. Weeding and mulching in the plots were done, whenever necessary.

3.7 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 × 3.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.8 Treatments:

The experiment consists of the following management practices:

T_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval

T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval

T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval

T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval

T_5: Suntap 50WP @ 3 g/L of water at 10 days interval

T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval

T_7: Neem seed kernel powder @ 10 g/L of water at 10 days interval

T_8: Untreated control

3.9 Monitoring and data collection

The yard long bean 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 fruit
- Fruit infestation in number (%)
- Weight of healthy fruits
- Weight of infested fruit
- Fruit infestation in weight (%)
- Edible part of fruit (%)
- Non-edible part of fruit (%)
- Number of pods per plant
- Number of seeds per pod
- Pod length (cm)

- Pod diameter (mm)
- Yield per plot (kg)
- Yield per hectare (ton)

Apparatus and Instruments Used

Samples were collected from field in Petridishes using fine camel hair brush, sweep net, aspirator. Aspirator was used for collecting leaf beetle. Hand magnifying glass, insect collection box and bottles with ethanol were used for identification, collection and preservation of insect pests. Stereoscopic microscope fitted with camera was used for taking exclusive photograph. Weighing balance was used for taking weight of healthy and infested pods. Polythene bag, mosquito net and iron cases were used for adult moth identification.

3.10 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:

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

3.11 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:

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

3.12 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}.

3.13 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performing by the ‘F’ (variance ratio) test. The significance of the difference among the treatment of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted for major insect pests of yard long bean (*Vigna sesquipedalis*) and their management. Data on the following parameters - number of pests plant^{-1}, number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight, yield contributing characters and yield of yard long bean 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 insect pests of yard long bean was recorded for the entire cropping season and pod borer, aphid and epilachna beetle were observed (Plate 1). Data were taken from each plant at early, mid and late pod stages to identify the major insect pests of yard long bean incidence.

4.1.1 Early pod stage

Statistically significant variation was found at early pod stage pod borer, aphid and epilachna beetle as major insect pests of yard long bean (Table 1). In case of pod borer, the lowest number per plant (1.20) was recorded from T_5 (Suntap 50 WP @ 3 g/L of water at 10 days interval) which was statistically identical (2.60) with T_3 (Actara 25WG @ 0.5 g/L of water at 10 days interval) and closely followed (3.60) by T_1 (Shobicorn 425EC @ 2 ml/L of water at 10 days interval) and T_6 (Quinalphos 25EC @ 3 ml/L of water at 10 days interval), whereas the highest number (18.40) was found from T_8 (untreated control) followed (5.41, 4.60 and 4.40) by T_4 (Diazinon 60EC @ 3 ml/L of water at 10 days interval), T_7 (Neem seed kernel powder 10 g/L of water at 10 days interval) and T_2 (Ripcord 10 EC @ 1 ml/L of water at 10 days interval). In case of aphid, no aphid was observed from T_4 (0.00), while the highest number (14.33) was obtained from T_8 (control) which was statistically similar with other treatment of the experiment. In case of epilachna beetle, the no beetle was recorded from T_3, T_5 and T_6 whereas, the highest number (13.33) was obtained from T_8 which was statistically identical with other treatment of the experiment.

4.1.2 Mid pod stage

At mid pod stage pod borer, aphid and epilachna beetle were observed as major insect pests of yard long bean (Table 2). In case of pod borer, the lowest number per plant was found from T_5 (4.00) which was statistically identical with T_3 (5.00), T_1 (5.40) and T_6 (5.40) and closely followed by T_2 (7.40), T_7 (7.40) and T_4 (7.60), whereas the highest number was observed from T_8 (27.40). In case of aphid, lowest number aphid (10.0 per plant) was recorded from T_1, T_3, T_5 and T_6, which was followed by T_2 (13.33) and T_7 (16.67), while the highest number was obtained from T_8 (33.33) which was closely followed by T_4 (20.00) treatment of the experiment. In case of epilachna beetle, no beetle was obtained from T_5 followed by T_3 (3.33), T_6 (3.33), T_1 (6.67) and T_2 (6.67) whereas, the highest number (16.67) was recorded from T_8 which was statistically identical with T_4 (10.00) and T_7 (10.00) treatment of the experiment.

Table 1. Effect of different treatments on major insect pests per plant (by number) at early pod stage of yard long bean

Treatment	Pod borer	Aphid	Epilachna beetle
T_1	3.60 cd	6.67 ab	3.33 b
T_2	4.40 bc	6.67 ab	6.67 ab
T_3	2.60 de	3.33 ab	0.00 b
T_4	5.41 b	10.00 ab	6.67 ab
T_5	1.20 e	0.00 b	0.00 b
T_6	3.60 cd	3.33 ab	0.00 b
T_7	4.60 bc	6.67 ab	6.67 ab
T_8	18.40 a	14.33 a	13.33 a
$LSD_{(0.05)}$	1.433	9.063	7.761
Level of Significance	0.01	0.01	0.01
CV(%)	12.97	9.33	5.83

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder @ 10 g/L of water at 10 days interval
T_8: Untreated control

a. Pod borer(*Maruca vitrata*)

b. Jute hairy caterpillar (*Spilosoma obliqua*)

c. Aphid(*Lipaphis erysimi*)

Plate 1. Photograph showing major insect pests of yard long bean a. Pod borer (*Maruca vitrata*) b. Jute hairy caterpillar (*Spilosoma obliqua*) c. Aphid(*Lipaphis erysimi*)

Table 2. Effect of different treatments on major insect pests per plant (by number) at mid pod stage of yard long bean

Treatment	Pod borer	Aphid	Epilachna beetle
T_1	5.40 bc	10.00 d	6.67 bc
T_2	7.40 b	13.33 cd	6.67 bc
T_3	5.00 bc	10.00 d	3.33 bc
T_4	7.60 b	20.00 b	10.00 ab
T_5	4.00 c	10.00 d	0.00 c
T_6	5.40 bc	10.00 d	3.33 bc
T_7	7.40 b	16.67 bc	10.00 ab
T_8	27.40 a	33.33 a	16.67 a
$LSD_{(0.05)}$	2.395	5.571	8.437
Level of Significance	0.01	0.01	0.01
CV(%)	7.03	11.02	7.93

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

4.1.3 Late pod stage

Pod borer, aphid and epilachna beetle as major insect pests of yard long bean showed statistically significant variation at late pod stage (Table 3). In case of pod borer, the lowest number per plant was recorded from T_3 (1.60) and T_5 (1.60) which was closely followed by T_6 (3.60), T_1 (3.80), T_2 (5.20), T_7 (5.40), whereas the highest number was found from T_8 (24.00) which was followed by T_4 (6.20). In case of aphid, lowest number aphid (10.0 per plant) was found from T_3 and T_5 treatments, which was followed by T_1 (13.33) and T_3 (13.33), while the highest number was obtained from T_8 (23.33) which was statistically similar with T_4 (20.00) and closely followed by T_2 (16.67) and T_7 (16.67) treatment of the experiment. In case of epilachna beetle the lowest number was obtained from T_3 (4.00) and T_5 (4.00) which was statistically identical with T_6 (4.33), T_1 (5.00), T_2 (5.33) and T_7 (5.67) and closely followed by T_4 (5.99) whereas, the highest number (26.34) was recorded from T_8 treatment of the experiment.

According to Alam (1969) yard long bean was attacked by nine different insect species. Reddy (1975) consensus that aphids are the most damaging pest on this crop; farmers said they can reduce yields up to 75-100%. Mohiuddin *et al*. (2009) reported that the key insects of yard long bean are pod borer, aphids and epilachna beetle. Butani and Jotwani (1984) found lepidoterous larvae as pests causing damage by boring tender or mature pods.

Table 3. Effect of different treatments on major insect pests per plant (by number) at late pod stage of yard long bean

	Pod borer	Aphid	Epilachna beetle
T_1	3.80 c	13.33 bc	5.00 bc
T_2	5.20 bc	16.67 bc	5.33 bc
T_3	1.60 d	10.00 c	4.00 c
T_4	6.20 b	20.00 ab	5.99 b
T_5	1.60 d	10.00 c	4.00 c
T_6	3.60 c	13.33 bc	4.33 bc
T_7	5.40 bc	16.67 bc	5.67 bc
T_8	24.00 a	23.33 a	26.34 a
$LSD_{(0.05)}$	1.964	6.191	1.759
Level of Significance	0.01	0.01	0.01
CV(%)	13.11	10.76	5.09

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

4.2 Pod bearing status

4.2.1 Pod bearing status at early pod stage

Statistically significant differences were obtained in number of healthy, infested pods, percent infestation at early pod stage for different treatments in controlling major pest of yard long bean (Table 4). The highest number of healthy pods per plant was recorded from T_5 (10.24) which was closely followed by T_7 (9.83), T_3 (9.81), T_4 (9.04) and T_1 (8.63) and followed by T_2 (8.53) and T_6 (8.53), while the lowest number of healthy pods was obtained from T_8 (8.23) which was statistically identical with T_2 and T_6 treatments. The lowest number of infested pods per plant was observed from T_5 (0.18) which was closely followed by T_3 (0.25). On the other hand, the highest number of infested pods was obtained from T_8 (0.73) followed by T_1 (0.58), T_2 (0.58), T_6 (0.58), T_7 (0.55) and T_4 (0.52) treatment. In terms of percent pod infestation, the lowest infested pods per plant in number was observed from T_5 (1.77%) which was closely followed by T_3 (2.56%), again the highest infested pods (8.93%) was recorded in T_8 which was followed by T_2 (6.83%), T_6 (6.83%), T_1 (6.70%) treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_5 (80.18%) and the lowest reduction of pod infestation over control was recorded from T_6 (23.52%) and T_2 (23.52%) treatment.

Healthy and infested pod, % infestation in terms of weight showed statistically significant variation at early pod stage for different management practices in controlling major pest of yard long bean (Table 5). In the weight of healthy pods, the highest weight per plant was recorded from T_5 (138.50 g) which was closely

Table 4. Effect of different treatments in controlling major insect pests of yard long bean at early pod stage in terms of pod infestation (by number)

Treatment	Pods by number			
	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	8.63 bc	0.58 a	6.70 b	24.97
T_2	8.53 c	0.58 a	6.83 b	23.52
T_3	9.81 b	0.25 b	2.56 d	71.33
T_4	9.04 b	0.52 a	5.97 c	33.15
T_5	10.24 a	0.18 b	1.77 e	80.18
T_6	8.53 c	0.58 a	6.83 b	23.52
T_7	9.83 b	0.55 a	5.54 c	37.96
T_8	8.23 c	0.73 a	8.93 a	--
$LSD_{(0.05)}$	0.821	0.215	0.621	--
Level of Significance	0.001	0.01	0.01	--
CV(%)	8.97	5.98	11.02	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

Table 5. Effect of different treatments in controlling major insect pests of yard long bean at early pod stage in terms of pod infestation (by weight)

Treatment	Pods by weight (g)			
	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	115.20 d	11.55 c	9.11 c	49.49
T_2	111.45 d	16.31 b	12.76 b	29.27
T_3	132.10 b	8.44 d	6.01 e	66.71
T_4	122.65 c	11.05 c	8.26 c	54.19
T_5	138.50 a	7.15 d	4.91 f	72.79
T_6	101.40 e	15.52 b	13.26 b	26.50
T_7	130.00 b	10.11 c	7.22 d	60.00
T_8	87.00 f	19.15 a	18.04 a	0.00
$LSD_{(0.05)}$	3.934	1.642	0.861	--
Level of Significance	0.01	0.01	0.01	--
CV(%)	7.43	5.98	11.05	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

followed by T_3 (132.10 g), T_7 (130.00 g), while the lowest weight of healthy pods was obtained from T_8 (87.00 g) which was closely followed by T_6 (101.40 g). The lowest weight of infested pods per plant was observed from T_5 (7.15 g) which was statistically identical with T_3 (8.44 g) and closely followed by T_7 (10.11 g), T_4 (11.05 g), and T_1 (11.55 g). On the other hand, the highest weight of infested pods was obtained from T_8 (19.15 g) followed by T_2 (16.31 g) and T_6 (15.52 g) treatment. In relation to the % pod infestation, the lowest infested pods per plant in weight was observed from T_5 (4.91%) which was closely followed by T_3 (6.01%), again the highest infested pods was recorded in T_8 (18.04%) followed by T_6 (13.26%) and T_2 (12.76%) treatment. Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_5 (72.79%) and the lowest reduction of pod infestation over control from T_6 (26.50%) treatment.

4.2.2 Pod bearing status at mid pod stage

Statistically significant differences were obtained in number of healthy, infested pods, percent infestation at mid pod stage for different management practices in controlling major pest of yard long bean (Table 6). In the number of healthy pods, the highest number per plant was recorded from T_5 (11.11) which was statistically similar with T_3 (10.94), T_7 (10.12) and followed by T_4 (9.79), T_1 (9.73) and T_2 (9.05), while the lowest number of healthy pods was obtained from T_8 (8.51) which was statistically identical with T_6 (8.68) treatments. The lowest number of infested pods per plant was observed from T_5 (0.31) which was closely followed by T_3 (0.46) and T_7 (0.50). On the other hand, the highest number of infested pods was obtained from T_8 (1.04) followed by T_2 (0.82), T_1 (0.79) and T_4 (0.79) treatment. In relation to the % pod infestation, the lowest infested pods per plant in number was observed from T_5 (2.78%) which was closely followed by T_3 (4.19%), again the highest infested pods was recorded in T_8 (12.28%) followed by T_6 (11.63%), T_2 (9.10%), T_1 (8.16%) and T_4 (8.11%) treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_5 (77.36%) and the lowest from T_6 (5.29%) treatment.

Healthy and infested pod, % infestation in terms of weight showed statistically significant variation at mid pod stage for different management practices in controlling major pest of yard long bean (Table 7). In the weight of healthy pods, the highest weight per plant was recorded from T_5 (199.30 g) which was statistically identical with T_3 (192.10 g) and closely followed by T_7 (185.42 g) and T_6 (181.40 g), while the lowest weight of healthy pods was obtained from T_8 (141.57 g) which was closely followed by T_2 (151.45 g). The lowest weight of infested pods per plant was observed from T_5 (16.55 g) which was closely followed by T_3 (18.25 g). On the other hand, the highest weight of infested pods was obtained from T_8 (31.40 g) followed by T_6 (25.50 g) treatment. In relation to the % pod infestation, the lowest infested pods per plant in weight (7.67%) was observed from T_5 which was closely followed by T_3 (8.68%), again the highest infested pods (18.15%) was recorded in T_8 followed by T_2 (13.51%) and T_6 (12.32%) treatment. Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_5 (57.76%) and the lowest reduction of pod infestation over control from T_2 (25.60%) treatment.

Table 6. Effect of different treatments in controlling major insect pests of yard long bean at mid pod stage in terms of pod infestation (by number)

Treatment	Pods by number

	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	9.73 ab	0.79 b	8.16 b	33.55
T_2	9.05 b	0.82 b	9.10 b	25.90
T_3	10.94 a	0.46 c	4.19 c	65.88
T_4	9.79 ab	0.79 b	8.11 b	33.96
T_5	11.11 a	0.31 d	2.78 d	77.36
T_6	8.68 b	1.01 a	11.63 a	5.29
T_7	10.12 ab	0.50 c	4.98 c	59.45
T_8	8.51 b	1.04 a	12.28 a	--
$LSD_{(0.05)}$	1.456	0.062	1.076	--
Level of Significance	0.01	0.01	0.01	--
CV(%)	7.91	6.09	10.02	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

Table7. Effect of different treatments in controlling major insect pests of yard long bean at mid pod stage in terms of pod infestation (by weight)

Treatment	Pods by weight (g)			
	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	177.10 c	22.55 c	11.29 c	37.78

T_2	151.45 e	23.65 c	13.51 b	25.60
T_3	192.10 a	18.25 e	8.68 e	52.21
T_4	162.30 d	20.05 d	11.00 c	39.43
T_5	199.30 a	16.55 f	7.67 f	57.76
T_6	181.40 b	25.50 b	12.32 b	32.11
T_7	185.42 b	19.62 d	9.57 d	47.29
T_8	141.57 f	31.40 a	18.15 a	0.00
$LSD_{(0.05)}$	6.021	0.631	0.865	--
Level of Significance	0.01	0.01	0.01	--
CV(%)	9.00	6.89	12.05	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

4.2.3 Pod bearing status at late pod stage

Statistically significant differences were obtained in number of healthy, infested pods, percent infestation at late pod stage for different management practices in controlling major pest of yard long bean (Table 8). In the number of healthy pods, the highest number per plant was recorded from T_5 (13.06) which was statistically similar with T_3 (12.53), T_7 (12.00) and followed by T_6 (10.91), T_2 (10.31), T_1 (10.17) and T_4 (10.09), while the lowest number of healthy pods was obtained from T_8 (10.00). The lowest number of infested pods per plant was observed from T_5 (0.43) which was statistically identical with T_3 (0.52) and closely followed by T_7 (0.63). On the other hand, the highest number of infested pods was obtained from T_8 (1.71) followed by T_6 (1.44) treatment. In relation to the % pod infestation, the lowest infested pods per plant in number was observed from T_5 (3.30%) which was closely followed by T_3 (4.18%), again the highest infested pods was recorded in T_8 (17.12%) followed by T_6 (13.21%), T_2 (11.51%) treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_5 (80.72%) and the lowest reduction of pod infestation over control from T_6 (22.84%) treatment.

Healthy and infested pod, % infestation in terms of weight showed statistically significant variation at late pod stage for different management practices in controlling major pest of yard long bean (Table 9). In the weight of healthy pods, the highest weight per plant was recorded from T_5 (152.50 g) which was statistically identical with T_7 (150.00 g) and T_3 (149.31 g), while the lowest weight of healthy pods was obtained from T_8 (99.20 g) which was closely followed by T_6 (113.40 g). The lowest weight of infested pods per plant was observed from T_5 (14.56 g) which was statistically similar with T_3 (15.45 g). On the other hand, the highest weight of infested pods was obtained from T_8 (25.78 g) which was statistically identical with T_6 (22.98 g) treatment. In relation to the % pod infestation, the lowest infested pods per plant in weight was observed from T_5 (8.72%) which was closely followed by T_3 (9.38%), again the highest was recorded in T_8 (20.63%) followed by T_6 (16.85%) treatment. Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_5 (57.75%) and the lowest from T_6 (18.31%) treatment.

Dandale *et al.* (1984) reported that four sprays of 0.08% cypermethrin afforded complete protection against *Maruca testulalis* on pigeon pea in Bangladesh. Rahman and Rahman (1988) reported that dimethoate was not as effective as cypermethrin. Several commonly used insecticides such as endosulfan, carbaryl, methomyl, monocrotophos have been found effective against *Maruca testulalis* G. on cowpea (Lalasangi, 1988). Kumar *et al*. (1989) reported that 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.

Table 8. Effect of different treatments in controlling major insect pests of yard long bean at late pod stage in terms of pod infestation (by number)

Treatment	Pods by number			
	Healthy	Infested	% Infestation	Reduction over control (%)
T_1	10.17 b	0.91 d	9.16 c	46.50
T_2	10.31 b	1.19 c	11.51 b	32.77
T_3	12.53 a	0.52 ef	4.18 d	75.58
T_4	10.09 b	0.87 d	8.64 c	49.53
T_5	13.06 a	0.43 f	3.30 e	80.72
T_6	10.91 b	1.44 b	13.21 b	22.84
T_7	12.00 a	0.63 e	5.31 d	68.98
T_8	10.00 b	1.71 a	17.12 a	--
$LSD_{(0.05)}$	0.751	0.089	2.541	--
Level of Significance	0.01	0.01	0.01	--
CV(%)	9.94	5.44	11.06	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

Table 9. Effect of different treatments in controlling major insect pests of yard long bean at late pod stage in terms of pod infestation (by weight)

Treatment	Pods by weight (g)			
	Healthy	Infested	% Infestation	Reduction over control (%)

T_1	128.52 c	19.44 b	13.14 d	36.30
T_2	125.34 c	23.67 a	15.88 c	22.99
T_3	149.31 a	15.45 c	9.38 f	54.54
T_4	138.65 b	18.43 b	11.73 d	43.12
T_5	152.50 a	14.56 c	8.72 g	57.75
T_6	113.40 d	22.98 a	16.85 b	18.31
T_7	150.00 a	17.44 b	10.42 e	49.51
T_8	99.20 e	25.78 a	20.63 a	0.00
$LSD_{(0.05)}$	4.871	2.981	0.789	--
Level of Significance	0.01	0.01	0.01	--
CV(%)	6.77	8.92	11.89	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

4.3 Effect of temperature, rainfall and humidity on pod borer of long yard bean at different harvesting time

With increasing of temperature at different harvesting time, percent pod infestation of long yard bean increasing both in number and weight (Figure

1) and it was highest in late harvesting i.e. the month of July and August, when the highest mean temperature was raised at 28.6^{0}C.

Percent pod infestation trend was found more or less similar when the mean rainfall was around 100 mm and the trend was increasing when the mean rainfall was 163 mm (Figure 1).

Like temperature positive effect was also found in case of relative humidity. With increasing relative humidity, percent fruit infestation increased and with the decreasing relative humidity, percent fruit infestation decreased. It was highest in late harvesting time when the highest relative humidity was 69% (Figure 1).

Lal *et al*. (1990) reported that *Amrasca biguttula biguttula* infestation increase with 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, irrespective of their level of susceptibility to attack. Under these weather conditions, the pest population was reduced by 72.6%.

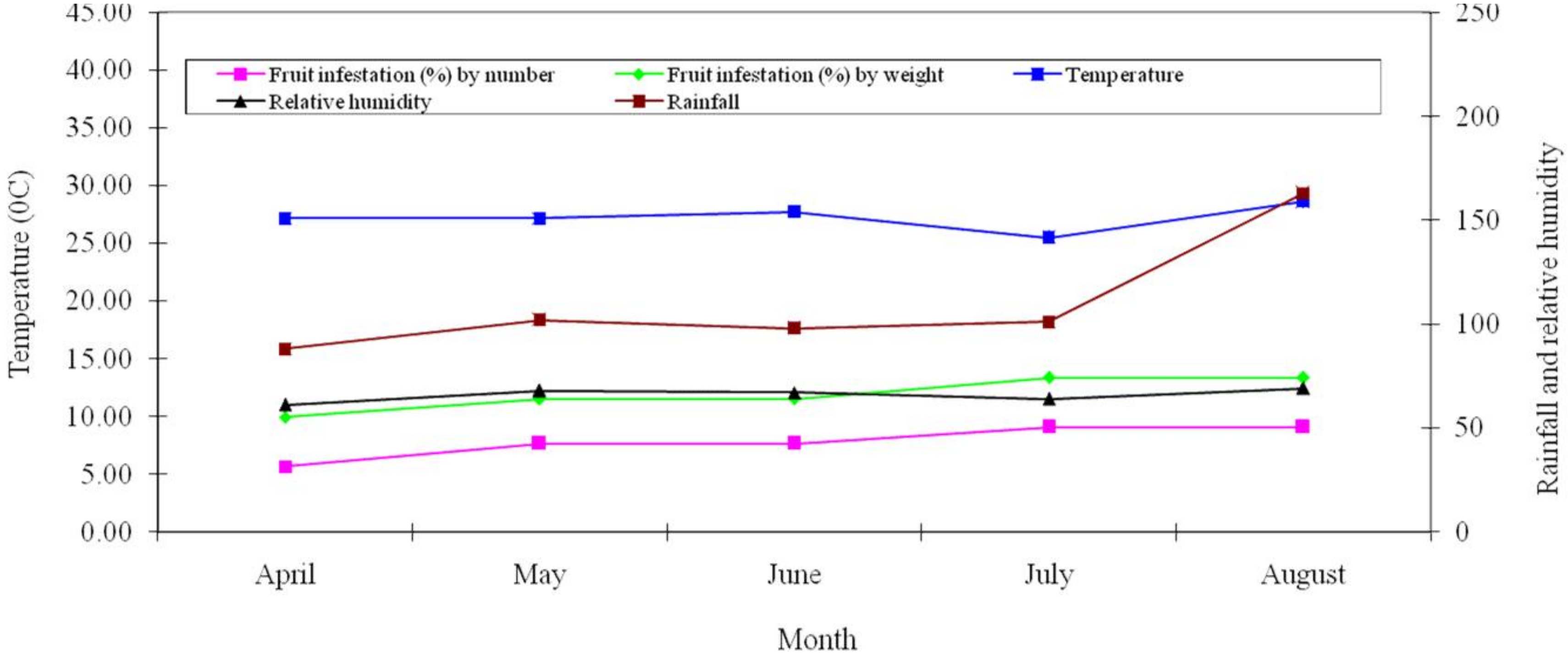

Figure 1. Relationship between pod infestation in number and weight with temperature, relative humidity & rainfall

4.4 Yield contributing characters and yield of yard long bean

4.4.1 Length of edible part

Length of edible part of yard long bean showed statistically significant variation for different treatments in controlling major insect pests (Table 10). The longest edible part was measured from T_5 (44.67 cm) which was statistically identical with T_3 (44.25 cm), T_7 (43.10 cm), T_4 (42.53 cm) T_1 (42.41 cm) and T_2 (42.00 cm) while the shortest edible part was obtained from T_8 (32.58 cm), followed by T_6 (39.85 cm) treatments.

4.4.2 Edible portion

Statistically significant variation was recorded for edible portion of infested yard long bean showed for different management practices in controlling major insect pests (Table 10). The highest edible portion was recorded from T_5 (89.00%) which was statistically identical with T_3 (86.54%), T_7 (86.43%) and T_4 (86.09%) and closely followed by T_1 (83.60%), whereas the highest edible portion was obtained from T_8 (64.59%), followed by T_6 (76.23%) treatments.

4.4.3 Length of non-edible part

Length of non-edible part of yard long bean showed statistically significant variation for different management practices in controlling major insect pests (Table 10). The shortest non-edible part was measured from T_5 (6.69 cm) which was closely followed by T_3 (10.22 cm) and T_7 (10.66 cm), while the longest non-edible was measured from T_8 (14.94 cm) which was similar with T_6 (14.49 cm) treatments.

Table 10. Effect of different treatments in terms of edible and non edible part by length and portion of yard long bean

Treatment	Length of edible part (cm)	Edible portion (%)	Length of non-edible part (cm)	Non edible portion (%)
T_1	42.41 ab	83.60 bc	12.05 b	16.40 d
T_2	42.00 ab	80.90 c	13.65 a	19.10 c
T_3	44.25 a	86.54 ab	10.22 c	13.46 e
T_4	42.53 ab	86.09 ab	13.70 a	13.91 e
T_5	44.67 a	89.00 a	6.69 d	11.00 f
T_6	39.85 b	76.23 d	14.49 a	23.77 b
T_7	43.10 ab	86.43ab	10.66 c	13.57 e
T_8	32.58 c	64.59 e	14.94 a	35.41 a
Level of Significance	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	3.097	3.580	1.243	1.436
CV(%)	5.08%	6.99%	7.02%	9.11

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

4.4.4 Non-edible portion

Statistically significant variation was recorded for non-edible portion of infested yard long bean showed for different management practices in controlling major insect pests (Table 10). The shortest non-edible portion was recorded from T_5 (11.00%) which was closely followed by T_3 (13.46%), T_7 (13.57%) and T_4 (13.91%), whereas the highest non-edible portion was measured from T_8 (35.41%), followed by T_6 (23.77%) treatments.

4.4.5 Number of pods per plant

Number of pods per plant of yard long bean showed statistically significant variation for different management practices in controlling major insect pests (Table 11). The highest number of pods per plant was recorded from T_5 (67.05) which was statistically identical with T_3 (65.70), T_7 (65.00) and T_4 (64.58), while the slowest number was recorded from T_8 (49.10) which was followed by T_6 (58.20) treatments.

4.4.6 Healthy pod length

Length of healthy pod of yard long bean showed statistically significant variation for different management practices in controlling major insect pests (Figure 2). The longest healthy pod was recorded from T_5 (58.84 cm) which was statistically identical with T_3 (58.22 cm), T_7 (57.17 cm) and closely followed by T_4 (56.26 cm) and T_1 (55.89 cm), while the shortest healthy pod was measured from T_8 (30.81 cm) followed by T_6 (54.53 cm) treatments (Plate 2).

Table 11. Effect of different treatments in terms of pods per plant in number and weight in terms of healthy pod per plant, pod length, diameter, yield per plot and hectare of yard long bean

Treatment	Number of pod per plant	Yield per plot (kg)	Yield per hectare (ton)	Increase over control (%)
T_1	62.42 bc	21.90 ab	24.33 b	79.42
T_2	60.81 cd	21.20 ab	23.56 b	73.75
T_3	65.70 ab	23.95 a	26.61 a	96.24
T_4	64.58 abc	21.65 ab	24.06 b	77.43
T_5	67.05 a	24.18 a	26.87a	98.16
T_6	58.20 d	19.70 b	21.89 c	61.43
T_7	65.00 ab	22.20 ab	24.67 b	81.93
T_8	49.10 e	12.20 c	13.56 c	--
Level of Significance	0.01	0.01	0.01	
$LSD_{(0.05)}$	3.773	2.723	1.682	--
CV(%)	4.16%	8.67%	7.89	--

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_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval
T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval
T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval
T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval
T_5: Suntap 50WP @ 3 g/L of water at 10 days interval
T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval
T_7: Neem seed kernel powder 10 g/L of water at 10 days interval
T_8: Untreated control

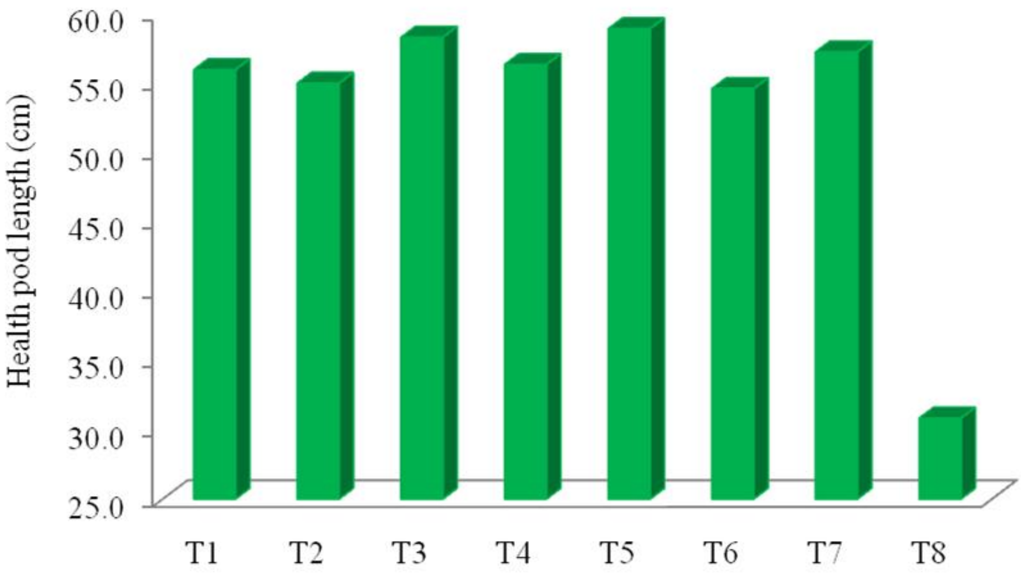

Figure 2. Effect of different treatments in terms of healthy pod length of yard long bean

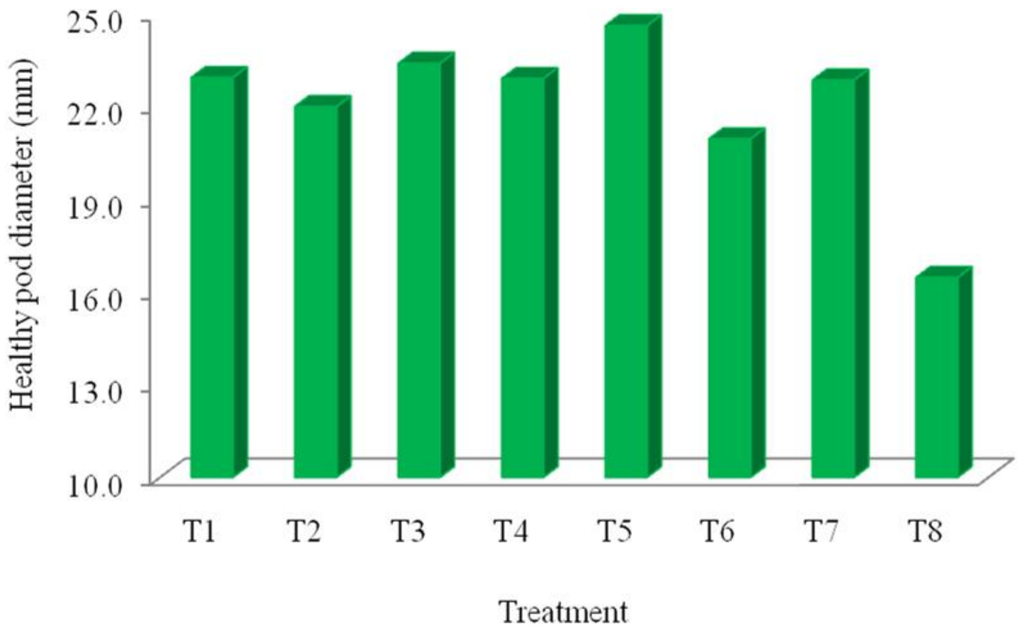

Figure 3. Effect of different treatments in terms of healthy pod diameter of yard long bean

4.4.7 Healthy pod diameter

Diameter of healthy pod of yard long bean showed statistically significant variation for different management practices in controlling major insect pests (Figure 3). The highest diameter of healthy pod was recorded from T_5 (24.59 mm) which was statistically identical with T_3 (23.37 mm), T_1 (22.91 mm), T_4 (22.88 mm), T_7 (22.83 mm) and closely followed by T_2 (21.97 mm), while the shortest was found from T_8 (16.45 mm) followed by T_6 (20.93 mm) treatments.

4.4.8 Yield per plot

Yield per plot of yard long bean showed statistically significant variation for different management practices in controlling major insect pests (Table 11). The highest yield per plot was recorded from T_5 (24.18 kg) which was statistically identical with T_3 (23.95 kg), T_7 (22.20 kg), T_1 (21.90 kg), T_4 (21.65 kg) and T_2 (21.20 kg) closely followed by T_6 (19.70 kg), while the lowest from T_8 (12.20 kg).

4.4.8 Yield per hectare

Yield per hectare of yard long bean showed statistically significant variation for different management practices in controlling major insect pests (Table 11). The highest yield per hectare was recorded from T_5 (26.87 ton) which was statistically identical with T_3 (26.61 ton), T_7 (24.67 ton), T_1 (24.33 ton), T_4 (24.06 ton) and T_2 (23.56 ton) and, while the lowest yield per hectare was recorded from T_8 (12.20 ton). Yield increase over control was estimated and the highest value was found from the treatment T_5 (98.16%) and the lowest of yield increase over control from T_6 (61.43%) treatment. Yield loss in yard long bean due to insect pests is reported to be about 12-30% (Hossain and Awrangzeb, 1992).

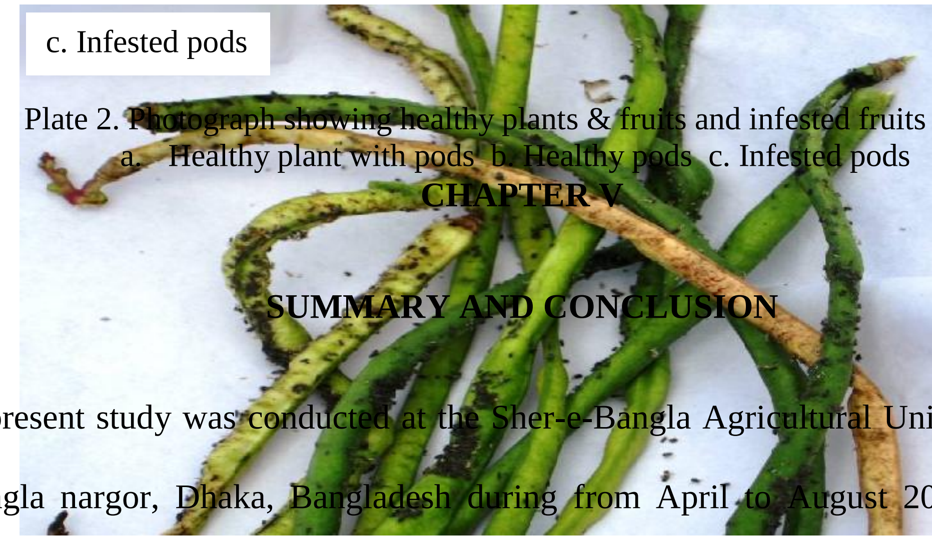

Plate 2. Photograph showing healthy plants & fruits and infested fruits
a. Healthy plant with pods b. Healthy pods c. Infested pods

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted at the Sher-e-Bangla Agricultural University, Sher-e-Bangla nargor, Dhaka, Bangladesh during from April to August 2011 for major insect pests of yard long bean (*Vigna sesquipedalis*) and their management. The seeds of BARI long yard bean-1 were used as the test crop for the experiment. The experiment consisted of the following management practices: T_1: Shobicorn 425EC @ 2 ml/L of water at 10 days interval; T_2: Ripcord 10EC @ 1 ml/L of water at 10 days interval; T_3: Actara 25WG @ 0.5 g/L of water at 10 days interval; T_4: Diazinon 60EC @ 3 ml/L of water at 10 days interval; T_5: Suntap 50WP @ 3 g/L of water at 10 days interval; T_6: Quinalphos 25EC @ 3 ml/L of water at 10 days interval; T_7: Neem seed kernel powder @10 g/L of water at 10 days interval and T_8: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on the number of pests per plant, number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight, yield contributing characters and yield of yard long bean were recorded and statistically significant differences was recorded for different treatments.

In case of pod borer, at early pod stage, the lowest number per plant (1.20) was recorded from T_5 whereas the highest number (18.40) was found from T_8. In case of aphid, no aphid was observed from T_4 (0.00), while the highest number (14.33) was obtained from T_8. In case of epilachna beetle, the no beetle was recorded from T_3, T_5 and T_6 whereas, the highest number (13.33) was obtained from $T_{8.}$ At mid pod stage in case of pod borer, the lowest number per plant was found from T_5 (4.00), whereas the highest number was observed from T_8 (27.40). In case of aphid, lowest number aphid was recorded from T_1, T_3, T_5 and T_6 and the number was (10.00) for all the treatment, while the highest number was obtained from T_8 (33.33). In case of epilachna beetle, the no beetle was obtained from T_5 (0.00) whereas, the highest number (16.67) was recorded from T_8. In case of pod borer, the lowest number per plant was recorded from T_3 (1.60) and T_5 (1.60), whereas the highest number was found from T_8 (24.00). In case of aphid, lowest number aphid was found from T_3 and T_5 and the number was (10.00) for the treatments, while the highest number was obtained from T_8 (23.33).

At early pod stage, in number in relation to the % pod infestation, the lowest infested pods per plant in number was observed from T_5 (1.77%), again the highest infested pods was recorded in T_8 (8.93%) treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_5 (80.18%) and the lowest reduction of pod infestation over control from T_6 (23.52%) and T_2 (23.52%) treatment. In relation to the % pod infestation, the lowest infested pods per plant in weight was observed from T_5 (4.91%), again the highest infested pods was recorded in T_8 (18.04%). Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_5 (72.79%) and the lowest reduction of pod infestation over control from T_6 (26.50%) treatment.

At mid pod stage, in relation to the % pod infestation, the lowest infested pods per plant in number was observed from T_5 (2.78%), again the highest infested pods was recorded in T_8 (12.28%) treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_5 (77.36%) and the lowest from T_6 (5.29%) treatment. In relation to the % pod infestation, the lowest infested pods per plant in weight was observed from T_5 (7.67%), again the highest infested pods was recorded in T_8 (18.15%). Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_5 (57.76%) and the lowest reduction of pod infestation over control from T_2 (25.60%) treatment.

At late pod stage, in relation to the % pod infestation, the lowest infested pods per plant in number was observed from T_5 (3.30%) and the highest infested pods was recorded in T_8 (17.12%). Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_5 (80.72%) and the lowest reduction of pod infestation over control from T_6 (22.84%) treatment. In relation to the % pod infestation, the lowest infested pods per plant in weight was observed from T_5 (8.72%), again the highest was recorded in T_8 (20.63%) followed by T_6 (16.85%) treatment. Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_5 (57.75%) and the lowest from T_6 (18.31%) treatment.

The longest edible part was measured from T_5 (44.67 cm) while the shortest edible part was measured from T_8 (32.58 cm). The highest edible portion was recorded from T_5 (89.00%), whereas the highest edible portion was measured from T_8 (64.59). The shortest non-edible part was measured from T_5 (6.69 cm), while the longest non-edible was measured from T_8 (14.94 cm). The shortest non-edible portion was recorded from T_5 (11.00%), whereas the highest non-edible portion was measured from T_8 (35.41). The highest number of pods per plant was recorded from T_5 (67.05), while the slowest number was recorded from T_8 (49.10). The longest healthy pod was recorded from T_5 (58.84 cm), while the shortest healthy pod was measured from T_8 (30.81 cm). The highest diameter of healthy pod was recorded from T_5 (24.59 mm), while the shortest was found from T_8 (16.45 mm). The highest yield per plot was recorded from T_5 (24.18 kg), while the lowest from T_8 (12.20 kg). The highest yield per hectare was recorded from T_5 (26.87 ton) while the lowest yield per hectare was recorded from T_8

(12.20 ton). Yield increase over control was estimated and the highest value was found from the treatment T_5 (98.16%) and the lowest of yield increase over control from T_6 (61.43%) treatment.

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