EFFECT OF SOME IPM TOOLS FOR THE SUPPRESSION OF POD BORER (*Euchrysops cnejus*) ATTACKING YARD LONG BEAN

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CERTIFICATE

This is to certify that the Thesis entitled, "EFFECT OF SOME IPM TOOLS FOR THE SUPPRESSION OF POD BORER (*Euchrysops cnejus*) ATTACKING YARD LONG BEAN" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh in the partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M. S.) IN ENTOMOLOGY, embodies the result of a piece of bona fide research work carried out by M. JAMAL UDDIN bearing Registration No. 00844 under my supervision and guidance. No part of the Thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

(Dr. Md. Mizanur Rahman)

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DEDICATED

TO

MY BELOVED PARENTS

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EFFECT OF SOME IPM TOOLS FOR THE SUPPRESSION OF POD BORER (*Euchrysops cnejus*) ATTACKING YARD LONG BEAN

By

M. JAMAL UDDIN

ABSTRACT

A study was undertaken to evaluate the effectiveness of some IPM tools for the suppression of pod borer (*Euchrysops cnejus*) attacking yard long bean. The experiment was conducted at She-e-Bangla agricultural University, Sher-e-Bangla Nagar Dhaka, during March to September 2007 & comprised of nine treatments. Those were T_1: Mechanical control (hand picking of larvae) at 7 days interval; T_2: Neem oil @ 5ml/ L of water at 7 days interval; T_3 : Neem oil @ 5 ml /L of water + Mechanical control at 7 days interval; T_4 : Suntap 50 SP@ 3 g /L of water at7 days interval; T_5 : suntap 50 SP @ 3 g /L of water +Mechanical control at 7days interval; T_6 : Shobicron 425 EC @ 2 ml / L of water at 7 days inrterval ; T_7: Shobicron 425 EC @ 2 ml /L of water +Mechanical control at 7 days interval; T_8: Neem seed kernel @ 10 g /L of water + Mechanical control at 7 days interval & T_9: Untreated control. Data recorded on infestation level , yield contributing characters & yield of yard long bean revealed that performance of treatment T_3 (Neem oil @ 5 ml /L of water + Mechanical control at 7 days interval) was superior throughout the season as compared to others; the lowest performance in the control treatment (T_9). The highest healthy pods in number (59.80) & weight (993.87 g), similarly the lowest infestation per plant in number (7.06 %) & weight (72.62 g) was recorded in T_3 treatment. The highest healthy pod length (54.20 cm) the height length of edible portion (48.64 cm) of partially infested pod, the highest yield (22.15 ton /ha) was recorded in the T_3 treatment; while the lowest healthy pod length (44.60 cm), lowest edible portion (30.11cm) of partially infested pod and the lowest yield (14.74 ton / ha) was recorded in the control treatment (T_9). The highest benefit cost ratio (3.53) was recorded in the T_3 treatment while the lowest benefit cost ratio (1.23) in T_8 treatment.

Chapter I
Introduction

CHAPTER I

INTRODUCTION

In Bangladesh, more than 60 different types of vegetables of indigenous and exotic origin are grown. Vegetables are usually considered as protective food and high-value crops as well as the cheaper source of vitamins and minerals, which are essential for maintaining sound health. Bangladesh has a serious deficiency in vegetables. The daily requirement of vegetables for a full grown person is 285 gm (Hossain and Awrangzeb, 1992). But in Bangladesh the per capita consumption of vegetable is only 50 gm per day, which is the lowest among the countries of South and South East Asia. As a result, chronic malnutrition is commonly seen in Bangladesh. Among the vegetables, the yard long bean, *Vigna sesquipedalis* is a delicious vegetable belonging to the Leguminosae family. It is a rich source of essential vitamins and commonly grown during kharif season. It contains 4.2 g protein, 110 mg calcium, 4.7 mg iron, 2.4 mg vitamin A and 35 mg vitamin C per 100 g serving. The importance of yard long bean is of high significance from growing season point of view. In Bangladesh, vegetables are produced less than 30% in kharif season and more than 70% in rabi season (Hossain and Awrangzeb, 1992). Yard long bean is grown almost in all districts of Bangladesh. Its cultivation intensity is found in Dhaka, Jessore, Comilla, Noakhali and Chittagong, but for the last ten years it has been seen growing extensively in Jessore, Khulna, Chittagong region as well (Aditya, 1993).

Despite the prospect of yard long bean 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 them, insect pests are the most important and cause significant yield losses in every season and every year. 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 and one species of pod borer. An FAO panel meeting held in Bangkok in 1975 identified the bean pod borer, as a legume pod borer (Reddy, 1975). Dina (1979) and Baker *et al.* (1980) found that it is a serious insect pest of leguminous vegetables Butani and Jotwani (1984) found that lepidopterous 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 bean pod borer, as cultural (Sharma, 1998), natural and applied biological (Karim, 1995) and chemical control measures (Rahman and Rahman, 1988). 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. 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.

Keeping the above situation in mind, the present study was undertaken to fulfill the following objectives:

1. To determine the effectiveness of some chemical and non-chemical control methods and their combination against pod borer;
2. To develop a suitable management technique for controlling the pod borer;
3. To determine the relationship between weather components with total healthy and infested pods;
4. To analyze the benefit cost ratio of various control measures against the pod borer.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The pod borer, *Euchrysops cnejus* is considered as an important and most damaging pest of yard long bean. Substantial works have been done regarding its geographical distribution, host range, seasonal abundance, population dynamics, its infestation intensity, losses incurred by them, existing IPM practices and others at home and abroad. Although the review could not be made so comprehensive due to limited scope and facility, it is hoped that most of the relevant information available in and around Bangladesh could be collected and reviewed. However, these studies are reviewed below covering the aforesaid areas:

2.1 Origin and distribution of pod borer

The pod borer has been considered as serious pest of grain legumes in the tropics and sub-tropics, because of its extensive host range, destructiveness and more wide distribution (Taylor, 1967; Raheja, 1974). With continuous changes in global environment, its floral and faunal compositions, the insect may spread further in places beyond its known distribution.

2.2 Host range of pod borer

The pod borer, *Euchrysops cnejus* is a polyphagous insect, which have been reported to feed on various types of plants, both cultivated and wild. Akinfenwa (1975) and Atachi and Djihou (1994) reported that the insect has been observed to feed on 39 host plants; most of these plants were leguminous. Among the host plants, the most frequent ones are *Cajanus cajan, Vigna unguiculata, Phaseolus lunatus* and *Pueraria phaseoloids.* In Asia, it is an important pest of pigeon pea, common bean, soybean, red gram and cowpea

(Singh and Jackel, 1988). The insect has been reported to consume and survive well on pigeon pea, cowpea and hyacinth beans (Ramasubramanian and Sumdara Babu, 1988). Babu (1989) found hyacinth bean was the most favorable food plant for pod borer including Bangladesh. *Euchrysops cnejus* is a tropical insect attacking several species of food legums in Asia, Africa, Central America, and South America. In absence of the preferred hosts, the insect would perpetuate on alternate and wild hosts such as *Vigna tribola, Crotularia* spp., *Phaseolus* spp. and pigeonpea (Taylor, 1967).

2.3 Biology and life history strategies

Adults of pod borer, *E. cnejus* are small, dark gray in color with white brown patterns of the wings (Plate#1). The color patterns can be more conspicuous on the fore wings, with a silvery white brown spot at the apical margin, than on the hind wings. The females have brownish abdomen with bifid hairy ovipositors. After emergence from the pupae, adult males and females mate, which may sometimes take place until the early morning, some males would mate more than once, although females usually mate once (Jackai *et al.* 1990). But some males may not be successful in finding females.

Usually a female moth oviposits up to 400 eggs during her lifetime (Okeyo-Owuor and Ochieng, 1981). The eggs are normally deposited on the under surface of plants parts (Vishakantaiah an Babu, 1980; Rai, 1983).

The eggs are white in color, which become translucent later. The eggs are oval, dorsoventrally flattened and have faint reticulate sculpturing on the delicate chorion (Okeyo-Owuor and Ochieng, 1981). The mean incubation period is 3 days under at around 25-28°C and over 80% relative humidity (Vishakantiah and Babu, 1980).

Plate 1. Adult of pod borer, *Euchrysops cnejus* on the leaf of yard long bean

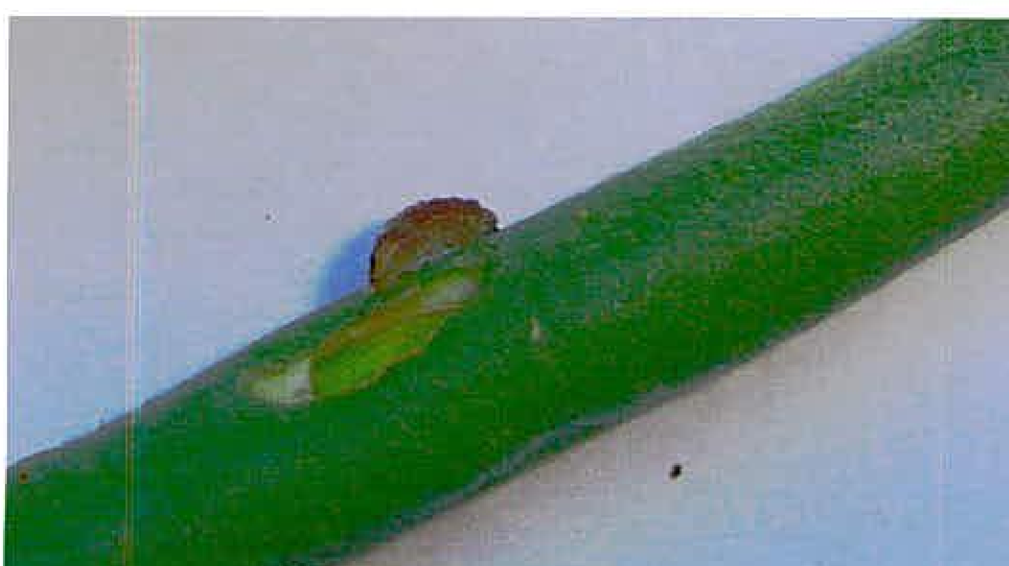

Plate 2. Larvae of pod borer, *Euchrysops cnejus* with infesting fruit of yard long bean

After hatching the first instar larvae, move on the surface of leaves, flower buds and flowers for few minutes before starting feeding (Plate 2). A larva has to pass through 5 (five) instars before moulting into a pupa. The larvae are creamy white in color with dark brown head and prothoracic shield. At the early stage, the body of larva bears light spots becomes turn into dark spots at the fifth instar, which are distinctly visible. A larva at the fifth instar feeds voraciously on flower buds, flowers and pods. The total larval period is 10-14 days. Differences in weather conditions, particularly the humidity in different regions might also have caused variations in duration of this larval period.

The fifth instar larva stops feeding and the body shrunk before entering into the pupal stage. To pupate, the larva spins silken threads around it in a net fashion and moult into a pupa within the silken cocoon covered under dried leaves on soil. The pupa is reddish brown in color. The lower development threshold temperature for pupae is 15.6 - 17.8°C and the upper threshold is 28°C to 34°C (Sharma, 1998). The pupal period is average 9 days.

The female moths have been found to live 11 or 12 days, whereas the males live 9 or 10 days at around 28°C (Singh, 1983).

2.4 Seasonal abundance

In general, the insect population fluctuates from month to month, season to season, even year to year. Information about seasonal abundance of pod borer is scanty. According to Sharma (1998), yard long bean borer population builds up is related to the cumulative rainfall and the number of rainy days between crop emergence to flowering and the insects have two overlapping generations in a year in most places of its distribution. According to Saxena *et al.* (1992), the insect population of pod borer larvae was occurring in their peak levels of bean pod during the beginning of the second week of

January to the first week of February. And the insect larvae were in their peak presence in flowers around the middle of December, after which the population declined in flowers in Srilanka. A high larval density of *Euchrysops cnejus* in host corps planted in mid October.

In Bihar of India, Akhauri *et al.* (1994) observed that in early pigeon pea the larval density increased from mid-October to the end of November, with the occurrence of peak larval density in the last week of November.

2.5 Nature of damage of pod borer

Euchrysops cnejus is a very important pest causing serious damages to the yard long bean in Bangladesh. Taylor (1978) reported that the pod borer (*Euchrysops cnejus)* as a pest of tropical grain legume, it causes damage in pigeon pea both by boring into the flower and pod as well as by webbing flowers, pods and leaves to form clusters (Rahman, 1989). Babu (1989) found that the -hyacinth bean was the most favorable food plant for *Euchrysops cnejus.* Including Bangladesh, *Euchrysops cnejus* is a tropical insect attacking several species of food legumes in Asia, Africa, Central America, and South America. In Asia, it is an important pest of pigeon pea, common bean, soybean, red gram and cowpea (Singh and Jackal, 1988). It damages buds, flowers and pod which severely affect grain yield (Singh and Taylor, 1978). At flowering stage, the larvae entered into the flower buds and flowers. The attacked buds and flowers subsequently withered. In a seriously infested field, large numbers of infested flower buds and flowers were often encountered. With the onset of pod formation, the insect larvae started attacking the pods. The infested flower bud, flower and pods were found webbed together (Karim, 1993). The first and second instar larvae fed mostly on the inner walls of the young pods by scrapping. The larvae of later instars, in most cases, entered into the pods, bored the seed and fed on the seeds by making circular holes; but the holes

A

B

Plate 3. Infested yard long bean (A & B) by pod borer, *Euchrysops cnejus*

were often plugged with excreta. Occasionally they consumed the entire seed (Plate 3). They also burrow into flower buds and hollow them out. Sometimes leaves are spun together and caterpillars feed within the web (Das and Islam, 1985; Singh, 1983). A developing larva, after entering into a pod, usually did not leave it until its food was totally exhausted. The infested pod often became unfit for human consumption. However, under natural conditions larval feeding punctures were found on some pods. But no larva finally developed in them. In most of the field collected infested pod only one larva was found pod, while there were two larvae per pod in only a few cases (Das and Islam, 1985). *Euchrysops cnejus* is an important pest which attack pods and extruded frass is usually a rather obvious indicator of such damage (Emden, 1980).

2.6 Yield loss due to pod borers

Pod borer is very important pest of the bean. In recent study, it was found to cause maximum damage in pigeon pea in Bangladesh (Rahman, 1989). As an important pest of leguminous vegetables, substantial works have been done on *Euchrysops cnejus.* The susceptibility of bean genotype to pod borer, *E. cnejus* was studied at the Regional Agricultural Research Station, Jamalpur. Out of 32 genotypes, the highest percentage of infestation was found in Bata (Mirsharai) (16.81+ 1.21%), and the lowest percentage of infestation in sword bean (0.74 + 0.05%) (Kabir *et al.* 1983). The pod borers were found to cause 38% yield loss through flower and pod damage and have been reported as the most important pests of pigeon pea in Bangladesh (Rahman *et al.* 1981). Pod borer is considered as a major pest of legumes in Africa, Asia, South and Central America and Austrilia causing yield loss ranging between 20% and 60%. When dimethoate applied the highest (78%) flower damage by pod borer and grain yield of 684 kg /ha was achieved. But when applied methomy flower damage was 6.2 and grain yield was 1240 kg /ha as against 80.1% flower damage and 102 kg /ha grain yield in control. Pod borer in one of the important insect pests of french bean. Studies at the Sokoine Univeristy of Agriculture (Morogoro, Tanzania) have indicated that uncontrolled populations of pod bores, particularly pod borer decreased the seed yield by 20-50% in some local cultivars (Karel, 1985). In Kenya, studies have revealed that pod borer is the most important pest of cowpea, reducing yields by up to 80% (Okeyo-Owuor and Ochieng, 1981).

2.7 Management of pod borer

2.7.1 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. The populations of pod borer, *E. cnejus* were fluctuated with agro meteorological factors. The distribution of rainfall over time is more crucial than the total amount in determining the fluctuations of pod borer populations. Thus, the adjustment of planting dates is suggested as an IPM tactic to avoid the development of damaging levels of pod borer infestations (Alghali, 1993).

2.7.2 Use of neem oil

Neem *(Azadirachta indica)* seed oil, a botanical pesticide has 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 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 pests 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).

Ahmed and Grainge (1985) 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). Field trial 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 trial showed that piperanyl butoxide increased the efficacy of neem and the combination was as active as cypermethrin (0.025%) against *P. 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). 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 *P. 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 *P. xylostella* and Pyralid, *Hellula undalis* on cabbage was achieved with weekly application of 25 or 50 gm neem kernel powder/liter of water (Dreyer, 1986). 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).

Entomologists 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 *Nilaparvata 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 *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 effect 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 stays separately on the upper surface of the water. Detergent in water helps neem oil to emulsify in the water. In a field observation neem oil used as soap emulsifier with water. Although, they (Krishanaiah and Kalode, 1991) have never mentioned the dose of the emulsifier in their trial. 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.

2.7.3 Biological control

The role of natural enemies for reducing the insect population of pod borer was significant. The populations of pod borer were fluctuated with agro meteorological factors. The distribution of rainfall over time is more crucial than the total amount in determining the fluctuations of pod borer populations. Thus, the adjustment of planting dates is suggested as an IPM tactic to avoid the development of damaging levels of pod borer infestations (Alghali, 1993). Neem oil, Neem oil emulsifiable concentrate, Neem oil slurry emulsifiable Colicefitrtte and 5% neem oil emulsifiable concentrate from the seeds of the neem plant, were tested against pod borer under laboratory condition (Jackai and Oyediran, 1991). The role of natural enemies on reducing population was significant. Parasitoids cause death by their stinging activity during host selection and some parasitized larvae and pupae carcasses decayed in the soil. Diseases and parasitism alone contributed significantly to the total generation mortality. These factors contributed significantly to the low survivability obscurest in the field (Okeyo-Owuor *et al,* 1991). It was found that pod borer was attacked by a rich fauna of parasitoids, pathogens and predators. Seven parasitoids were observed to attack larvae and pupae of the Pod borer but no egg parasitoids were found. Large number of parasitoids has been reported by some authors to feed on borer larvae and some on pupae. It was found *Phanerotoma* sp. and *Braunsia* sp. to be the most important parasitoids in Nigeria. Some pathogenic microorganisms were isolated from dead larvae and pupae, among these Protozoa, *Nosema sp* and the bacteria, *Bacillius sp.* were the most common (Okeyo-Owuor *et al.,* 1991). One parasitoid, namely, *Bracon greeni* was reared from the field collected pest larvae. Usua and Singh (1978) recorded some other parasitoids of pod borer without any reference of *Bracon greeni.* From each of the parasitized larvae 3-8 parasitoids emerged. Control of pod borer by microbial insecticide *Bacillus thuringiensis* and aqueous extracts of neem seed kernel powder (25- 50 g) neem kernel powder/L of water) starting from flowering is very effective (Karim, 1995). It was found that twice after flowering application treatments of microbial insecticide thuricide, dipel, and bactospene were as effective as fenvalerate and deltamethrin to reduce numbers of borer larvae and flower damage. It was observed that antibiosis of 18 cowpea cultivars resistance against pod borer, such resistance with morphological, biochemical and biophysical traits could enhance the low levels of resistance in cowpea crop and ultimately lead to the effective management of the pest. *Nosema marucae* (Microspora: Nosematidae) is a pathogen of pod borer. The development of *Nosema marucae* was followed in its host, the legume pod borer (Odindo and Jura, 1992). Preliminary studies were reported on the population of the legume pod borer using a pheromone trap at Mbita, Kenya (Okeyo-Owuor and Agwaro, 1982). The female pod borer moths produce a pheromone product, which attracts males from the field at night.

Proper management of the crop fields so that conservation and augmentation of these agents are optimized might further enhances the reduction of the pest porn through biological control agents.

2.7.4 Control with 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 pod borer on cowpea (Singh, 1977; Lalasangi, 1988). Cypermethrin was sprayed at 0.2 kg a.i./ha to control different densities of 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 pod borer 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 pod borer on cow pea (Atachi and Sourokou, 1989). Broadley (1977) obtained control of pod borer 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 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 1ml 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.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, during March to September, 2007 to evaluate the effectiveness of some IPM tools for the management of pod borer (*Euchrysops cnejus*) of yard long bean. In this study removal of infested bean pod, spraying of neem oil and chemical insecticide along with an untreated control and some of their integrations were utilized.

Required adopted materials and methodology are described below under the following sub-heading:

3.1 Location

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^{0}74^{\prime}$N latitude and $90^{0}35^{\prime}$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 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.

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.

3.4 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The target land was divided into 21 equal plots (2 m × 2 m) with plot to plot distance 1m and block to block distance 1m. Each plot contains 4 pits (30 cm × 30 cm ×20 cm), pit to pit distance 1m. 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 yard long 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 middle of March, 2007 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 April 15, 2007 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 and discarding the others. Propping of each plant by bamboo sticks (1.75 m) was provided on about 1.5 m high from ground level for additional support and to allow normal creeping. At initial vegetative and fruiting stage, bean aphids were found sporadically and were controlled by hand picking. Weeding and mulching in the plots were done, whenever necessary.

3.7 Design of experiment

The experiment was laid out with seven treatments including one untreated control and replicated three times using Randomized Complete Block Design (RCBD).

3.8 Treatments

To evaluate the effectiveness of some IPM tools for the management of pod borer of yard long bean, the following treatments were tested-

T_1: Mechanical control (removal of infested pod)

T_2: Neem oil @ 5 ml/L of water

T_3: Neem oil @ 5 ml/L of water + T_1

T_4: Suntap 50SP @ 3 g/L of water

T_5: Suntap 50SP @ 3 g/L of water + T_1

T_6: Shobicron 425EC @ 2 ml/L of water

T_7: Shobicron 425 EC @ 2 ml/L of water + T_1

T_8: Neem seed kernel 10 g/L of water + T_1

T_9: Untreated control

3.9 Collection of neem oil, trix detergent and preparation for spraying

The neem oil was collected from Chawkbazar, Dhaka and the trix liquid detergent was collected from the local market of Agargaon bazaar. All sprays were made according to the methods described earlier. For each neem oil application 30 ml neem oil (@ 10 ml/liter of water i.e., 3%) was mixed with 9 ml of trix detergent (@ 3 ml/liter of water i.e., 1%) per liter of water. The mixture within the spray machine was shaked well and sprayed on the upper and lower surfaces of the plants of the treatment until the drop runoff from the plant. Three liters spray material was required to spray in three plots of each replication.

The insecticide treated plots were also sprayed following the procedure described earlier. The insecticide was sprayed on the treated plots following the same manner as indicated before. The same quantity of spray material was required to spray three plots of the target treatment. The benefit-cost ratio was calculated following Ali and Karim (1991).

3.10 Data collection and calculation

The effectiveness of each treatment in reducing pod borer infestation was evaluated on the basis of some pre-selected parameters. The following parameters were considered during data collection.

3.11 Number and weight of healthy and infested fruits

Data were collected on the basis of the number and weight of healthy and infested fruits in each treatment. The marketable fruits were harvested at every alternate day intervals at early, mid and late fruiting stages.

3.12 Fruit infestation

3.12.1 Percent fruit infestation by number

After harvesting the healthy fruit and the infested fruits were separated by visual observation. The number of healthy fruits and infested fruits were counted and the percent fruit initiation for each treatment was calculated by using the following formula:

$$\textbf{\% Fruit infestation by number} = \frac{\text{Number of Infested fruit}}{\text{No. of Healthy fruit + No. of Infested fruit}} \times 100$$

3.12.2 Percent fruit infestation by weight

After harvest at each fruiting (early, mid and late) stage, the total fruits were sorted into healthy and infested once for each treatment. On the basis of weight of healthy fruit and infested fruit the percent fruit infestation was calculated.

$$\text{\% Fruit infestation by weight} = \frac{\text{Weight of infested fruit}}{\text{Wt. of healthy fruit} + \text{Wt. of infested fruit}} \times 100$$

3.13 Pod length (cm)

The mean lengths of pods per plant per plot were measured at all stages.

3.14 Fruit yield

Fruit yield was measured by adding the total harvest attaining from all harvest in individual plot and converted into per hectare yield.

3.15 Edible and non-edible part of fruit

The edible part and non-edible part of the fruit was also measured.

3.16 Increase or decrease over control:

Increase or decrease over control was calculated using the following formula:

$$\text{Percent increase over control} = \frac{\text{Value in treated plot} - \text{value in untreated}}{\text{Value in untreated control plot}} \times 100$$

$$\text{Percent decrease over control} = \frac{\text{Value in untreated control plot} - \text{Value in treated plot}}{\text{Value in untreated control plot}} \times 100$$

3.17 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significance of the difference among the treatments. The mean values of all the parameters were evaluated and analysis of variance was performing by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

3.18 Economic analysis of IPM tools

The economic analysis of economic of Benefit cost ratio (BCR) was analyzed on the basis of total expenditure of the perspective treatment along with the total return from that particular treatment. In this study BCR was analyzed for a hectare of a land. For this analysis following parameters were considered.

Treatment wise management cost

This was calculated by adding the costs incurred for labors and inputs for each treatment including untreated control during the entire cropping season.

Yield of yard long bean

The total yield after every harvest was calculated separately for each treatment and accumulated at the end of the final harvest. The total yield of each treatment was converted for determining yield (ton ha^{-1}). The yield was utilized to calculate the gross return.

Gross return

This was measured by multiplying the total yield by the unit price of yard long bean at the cultivation period.

Adjusted net return

A separate formula was used for determining adjusted net return. The adjusted net return was determined by subtracting the net return with particular treatment form the net return with untreated control plot.

Benefit cost ratio (BCR)

Finally the benefit cost ratio (BCR) was calculated by utilizing the formula

$$\textbf{Benefit cost ratio (BCR)} = \frac{\text{Adjusted net return}}{\text{Total management cost}}$$

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effect of some IPM tools for the suppression of pod borer of yard long bean. Experimental plot of yard long bean at vegetative phase, reproductive phase and healthy pod in neem oil treated plot during the growing season are shown in plate 3 and plate 4, respectively. The results have been presented and discussed, and possible explanations have been given under the following headings:

4.1 Fruiting condition of yard long bean against pod borer in different growth stage by number

Statistically significant variation was recorded in number of healthy fruit per plant at early, mid and late harvesting stage for different IPM tools, which were used for suppressing of pod borer in yard long bean under the present trial presented in Table 1.

4.1.1 Early fruiting stage

In terms of healthy fruit per plant, the highest number of healthy fruit (17.00) was recorded in T_3 [Neem oil @ 5 ml/L of water + Mechanical control (removal of infested pod)] which was statistically similar with T_2 (Neem oil @ 5 ml/L of water) (16.20) and T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control) (15.80) respectively, followed by the treatment T_4 (Suntap 50SP @ 3 g/L of water) (14.20) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control) (14.00), respectively. On the other hand, the lowest number of healthy fruit (10.40) was recorded in T_9 (untreated control plot), which was followed by T_1 (Mechanical control) (12.40), T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) (13.40) and T_6 (Shobicron 425 EC @ 2 ml/L of water) (13.00), respectively.

Table 1. Effect of different control options for suppressing pod borer of yard long bean at early, mid and late harvesting stage by number during July to September, 2007

Treatments	At early stage			At mid stage			At late stage		
	Healthy pod (No.)	Infested pod (No.)	% infestation	Healthy pod (No.)	Infested pod (No.)	% infestation	Healthy pod (No.)	Infested pod (No.)	% infestation
T_1	12.40 c	2.40 ab	16.23 b	20.00 de	4.40 ab	18.16 b	11.20 bc	2.60 b	18.84 b
T_2	16.20 a	1.20 ef	6.96 f	26.80 ab	3.00 e	10.07 ef	13.20 ab	1.60 ef	10.79 fg
T_3	17.00 a	1.00 f	5.52 f	28.20 a	2.40 f	7.88 f	14.60 a	1.40 f	8.73 g
T_4	14.20 bc	1.60 cde	10.21 de	25.20 abc	3.40 de	11.86 de	12.60 ab	2.00 cde	13.77 def
T_5	15.80 ab	1.40 def	8.12 ef	26.60 ab	3.00 e	10.14 ef	13.20 ab	1.80 def	11.99 ef
T_6	13.40 c	1.80 cd	11.86 cd	24.00 bc	3.80 cd	13.69 cd	12.00 bc	2.20 bcd	15.49 cd
T_7	14.00 bc	1.80 cd	11.30 cd	24.60 bc	3.60 cd	12.79 cd	12.40 ab	2.00 cde	14.16 de
T_8	13.00 c	2.00 bc	13.32 c	22.20 cd	4.00 bc	15.29 c	11.40 bc	2.40 bc	17.31 bc
T_9	10.40 d	2.80 a	21.16 a	17.20 e	4.80 a	21.98 a	10.00 c	3.20 a	24.23 a
$LSD_{(0.05)}$	1.810	0.461	2.536	3.168	0.468	2.454	2.048	0.458	2.978
CV(%)	7.45	15.00	12.60	7.67	7.52	10.47	9.63	12.40	11.44

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 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: Mechanical control (removal of infested pod)
T_2: Neem oil @ 5 ml/L of water
T_3: Neem oil @ 5 ml/L of water + T_1
T_4: Suntap 50SP @ 3 g/L of water
T_5: Suntap 50SP @ 3 g/L of water + T_1
T_6: Shobicron 425EC @ 2 ml/L of water
T_7: Shobicron 425EC @ 2 ml/L of water + T_1
T_8: Neem seed kernel 10 g/L of water + T_1
T_9: Untreated control

Considering the infested fruit per plant, the lowest number of infested fruit (1.00) was recorded in T_3 which was statistically similar with T_2 (1.20) and T_5 (1.40), respectively and followed by T_4 (1.60), T_6 (1.80) and T_7 (1.80), respectively. On the other hand, the highest number of infested fruit (2.80) was recorded in T_9 untreated control plot, which was statistically identical with the treatment T_1 (2.40) and followed by the treatment T_8 (2.00).

The rate of fruit infestation per plant was the lowest (5.52%) in T_3, which was statistically similar with T_2 (6.96%) and T_5 (8.12%) followed by T_4 (10.21%), T_7 (11.30%) and T_6 (11.86%). On the other hand, the highest percentage of infested fruit (21.16%) was recorded in T_9 followed by T_1 (16.23%) and T_8 (13.32%).

4.1.2 Mid fruiting stage

In terms of healthy fruit per plant, the highest number of healthy fruit (28.20) was recorded in T_3, which was statistically similar with the treatment T_2 26.80), T_5 (26.60) and T_4 (25.20), respectively and followed by the treatment T_7 (24.60) and T_6 (24.00), respectively. On the other hand, the lowest number of healthy fruit (17.20) was recorded in T_9 (untreated control plot), which was followed by T_1 (Mechanical control) (2.00) and T_8 (22.20), respectively.

Considering the infested fruit per plant, the lowest number of infested fruit (2.40) was recorded in T_3 which was followed by T_2 (3.00), T_5 (3.00) and T_4 (3.40), respectively (Table 1). On the other hand, the highest number of infested fruit (4.80) was recorded in T_9 (untreated control), plot which was statistically identical with T_1 (4.40) and followed by T_8 (4.00). Again, T_6 (3.80) and T_7 (3.60) performed moderate number of infested fruits.

The rate of fruit infestation per plant was the lowest (7.88%) in T_3, which was statistically similar with T_2 (10.07%) and T_5 (10.14%) followed by T_4 (11.86%), T_7

(12.79%) and T_6 (12.69%). On the other hand, the highest percentage of infested fruit (21.98%) was recorded in untreated control plot (T_9) which was followed by T_1 (18.16%) and T_8 (15.29%) (Table 1).

4.1.3 Late fruiting stage

In terms of healthy fruit per plant, the highest number of healthy fruit (14.60) was recorded in T_3, which was statistically similar with the treatment T_2 (13.20), T_5 (12.60), T_4 (12.60) and T_7 (12.40), respectively and followed by T_6 (12.00), T_8 (11.40) and T_1 (11.20), respectively (Table 1). On the other hand, the lowest number of healthy fruit (10.00) was recorded in T_9 (untreated control plot).

Considering the infested fruit per plant, the lowest number of infested fruit per plant (1.40) was recorded from the treatment T_3 which was statistically similar with the treatment T_2 (1.60) and T_5 (1.80) (Table 1). On the other hand, the highest number of infested fruit (3.20) was recorded in T_9 untreated control plot which was followed by the treatment T_1 (2.60) and followed by the treatment T_8 (2.40). Again the treatment T_6 (2.20) and T_7 (2.00) performed moderate number of infested fruits.

The rate of fruit infestation per plant was the lowest (7.73%) in T_3 which was statistically similar with T_2 (10.79%) and followed by T_5 (11.99%), T_4 (13.77%), T_7 (14.16%) and T_6 (15.49%). On the other hand, the highest percentages of infested fruit (24.23%) was recorded from T_9 (untreated control plot), which was followed by T_1 (18.84%) and T_8 (17.31%) (Table 1). From the above findings, it was observed that the effect of neem oil was the best from all other treatment components in controlling pod borer. This finding is similar with other authors. Jacob and Sheila (1994) reported that 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 antifeedant properties with 23.89.

4.2 Fruiting condition of yard long bean against pod borer in different growth stage by weight

Statistically significant variation was recorded in weight of healthy fruit per plant at early, mid and late harvesting stage for different IPM tools, which were used for suppressing of pod borer in yard long bean under the present trial presented in Table 2.

4.2.1 Early fruiting stage

Considering the healthy fruit per plant, the highest weight of healthy fruit per plant (310.77 g) was recorded in T_3, which was statistically similar with the treatment T_2 (Neem oil @ 5 ml/L of water) (296.83 g) and followed by the treatment T_5 (290.77 g) (Table 2). On the other hand, the lowest weight of healthy fruit (191.90 g) was recorded in T_9 (Untreated control), which was followed by T_1 (228.83 g) and T_8 (237.00 g), respectively. Again moderate weight of total healthy fruit was recorded in T_4 (260.63 g), T_7 (256.43 g) and T_6 (245.30 g), respectively.

In terms of infested fruit per plant, the lowest weight of infested fruit per plant (16.70 g) was recorded in T_3 which was statistically similar with T_2 (20.00 g) and T_5 (23.40 g), respectively followed by T_4 (26.83 g), T_6 (30.22 g) and T_7 (30.07 g), respectively (Table 2). On the other hand, the highest weight of infested fruit (47.07 g) was recorded in T_9 (untreated control) plot which was statistically identical with the treatment T_1 (40.37 g) and followed by T_8 (33.65 g).

The lowest fruit infestation per plant in weight (5.10%) was recorded from T_3 which was statistically similar with T_2 (6.32%) and T_5 (7.462%) and followed by T_4 (9.32 %), T_7 (10.470%) and T_6 (10.97%). On the other hand, the highest infested fruit (19.65%) was recorded in T_9, which was followed by T_1 (15.01%) and T_8 (12.47%)(Table 2).

Table 2. Effect of different control measures for the suppressing pod borer of yard long bean at early, mid and late harvesting stage by weight during July to September, 2007

Treatments	At early stage			At mid stage			At late stage		
	Wt. of healthy pod	Infested pod	% infestation	Wt. of healthy pod	Infested pod	% infestation	Wt. of healthy pod	Infested pod	% infestation
T_1	228.83 e	40.37 ab	15.01 b	329.00 e	65.83 b	16.75 b	169.62 cd	36.33 b	17.65 b
T_2	296.83 ab	20.00 ef	6.32 f	441.48 ab	44.32 f	9.12 f	199.43 ab	22.73 f	10.23 fg
T_3	310.77 a	16.70 f	5.10 f	462.97 a	36.23 g	7.26 g	220.13 a	19.68 g	8.21 g
T_4	260.63 c	26.83 cde	9.32 de	418.33 abc	51.98 e	11.05 e	189.85 bc	27.17 e	12.62 de
T_5	290.77 b	23.40 def	7.46 ef	439.42 abc	46.73 f	9.61 f	198.10 ab	25.58 ef	11.44 ef
T_6	245.30 cde	30.22 cd	10.97 cd	394.67 cd	57.20 cd	12.71 d	181.07 bc	30.82 cd	14.61 cd
T_7	256.43 cd	30.07 cd	10.47 cd	404.90 bcd	54.25 de	11.82 de	186.95 bc	28.13 de	13.15 de
T_8	237.00 de	33.65 bc	12.47 bc	366.85 de	60.40 c	14.17 c	172.57 cd	33.33 bc	16.19 bc
T_9	191.90 f	47.07 a	19.65 a	283.58 f	71.50 a	20.16 a	150.33 d	45.17 a	23.10 a
$LSD_{(0.05)}$	18.84	7.632	2.606	42.18	4.588	1.265	22.19	3.015	2.073
CV (%)	4.22	14.79	14.00	6.19	4.88	5.84	6.92	5.83	8.47

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 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: Mechanical control (removal of infested pod)
T_2: Neem oil @ 5 ml/L of water
T_3: Neem oil @ 5 ml/L of water + T_1
T_4: Suntap 50SP @ 3 g/L of water
T_5: Suntap 50SP @ 3 g/L of water + T_1
T_6: Shobicron 425EC @ 2 ml/L of water
T_7: Shobicron 425EC @ 2 ml/L of water + T_1
T_8: Neem seed kernel 10 g/L of water + T_1
T_9: Untreated control

4.2.2 Mid fruiting stage

Considering the healthy fruit per plant, the highest weight of healthy fruit per plant (462.97 g) was recorded in T_3, which was statistically similar with T_2 (441.48 g), T_5 (439.42 g) and T_4 (418.33 g), respectively and followed by T_7 (404.90 g) and T_6 (394.67 g), respectively (Table 2). On the other hand, the lowest weight of healthy fruit (283.58 g) was recorded in T_9 (untreated control plot) which was followed by T_1 (329.00 g) and T_8 (366.85 g), respectively.

In terms of infested fruit per plant, the lowest weight of infested fruit per plant (36.23 g) was recorded in T_3 which was followed by T_2 (44.32 g) and T_5 (46.73 g) and T_4 (51.98 g), respectively (Table 2). On the other hand, the highest weight of infested fruit (71.50 g) was recorded in T_9 (untreated control) plot, which was followed by T_1 (65.83 g) and followed by T_8 (60.40 g). Again T_6 (57.20 g) and T_7 (54.25 g) gave moderate weight of infested fruits.

The lowest fruit infestation per plant in weight (7.26%) was recorded in T_3 which was statistically similar with T_2 (9.12%) and T_5 (9.61%) and followed by T_4 (11.05%), T_7 (11.82 %) and T_6 (12.71%). On the other hand, the highest infested fruit (20.16%) was recorded in T_9 (untreated control plot) which was followed by T_1 (16.75%) and T_8 (14.179%) (Table 2). 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).

4.2.3 Late fruiting stage

In terms of healthy fruit per plant, the highest weight of healthy fruit per plant (220.13 g) was recorded in T_3 which was statistically similar with T_2 (199.43 g) and T_5 (198.10 g), respectively and followed T_4 (189.85 g) and T_7 (186.95 g) and T_6 (181.07 g), respectively

(Table 2). On the other hand, the lowest weight of healthy fruit (150.33 g) was recorded in T_9 (Untreated control plot) which was followed by T_1 (169.62 g) and T_8 (172.57 g).

Considering the infested fruit per plant, the lowest weight of infested fruit per plant (19.68 g) was recorded in T_3 which was followed by T_2 (22.73 g) and T_5 (25.58 g) (Table 2). On the other hand, the highest weight of infested fruit (45.17 g) was recorded in T_9 which was followed by T_1 (36.33 g) and T_8 (33.33 g). Again T_6 (30.82 g) and T_7 (28.13 g) performed moderate weight of infested fruits.

The lowest fruit infestation per plant in weight (8.21%) was recorded in T_3 which was statistically similar with T_2 (10.23%) and followed by T_5 (11.44%), T_4 (12.62%), T_7 (13.15%) and T_6 (14.61%). On the other hand, the highest infested fruit (23.10%) was recorded from T_9 (untreated control plot), which was followed by T_1 (17.65%) and T_8 (16.19%) treatment (Table 2). From the above findings, it was also observed that the effect of neem oil was the best from all other treatments components in controlling pod borer. Fagoonee (1986) used neem in vegetable crop protection in Mauritius and showed that neem seed kernel extract was found to be effective. He also found that neem extract alternate with insecticides gave best protection against *Helicovarpa armigera*

The comparative effectiveness of different management practices on percent infestation reduction over control at different fruiting stage for management of pod borer is shown by Figure 1, 2 and 3.

In terms of early fruiting stage (Figure 1), the highest percent (74.04%) reduction of infestation over control was found in T_3, followed by T_2 (67.83%), T_5 (62.03%) and T_4

(52.56%) and the lowest (23.61%) in T_1 treatment, followed by T_8 (36.53%) and T_6 (44.17%).

Considering the mid fruiting stage (Figure 2), The highest percent (63.98%) reduction of infestation over control was found in the treatment T_3, followed by T_2 (54.76%), T_5 (52.33%) and T_4 (45.18%) and the lowest (16.91%) in T_1 treatment, followed by the treatment T_8 (29.71%) and T_6 (36.95%)

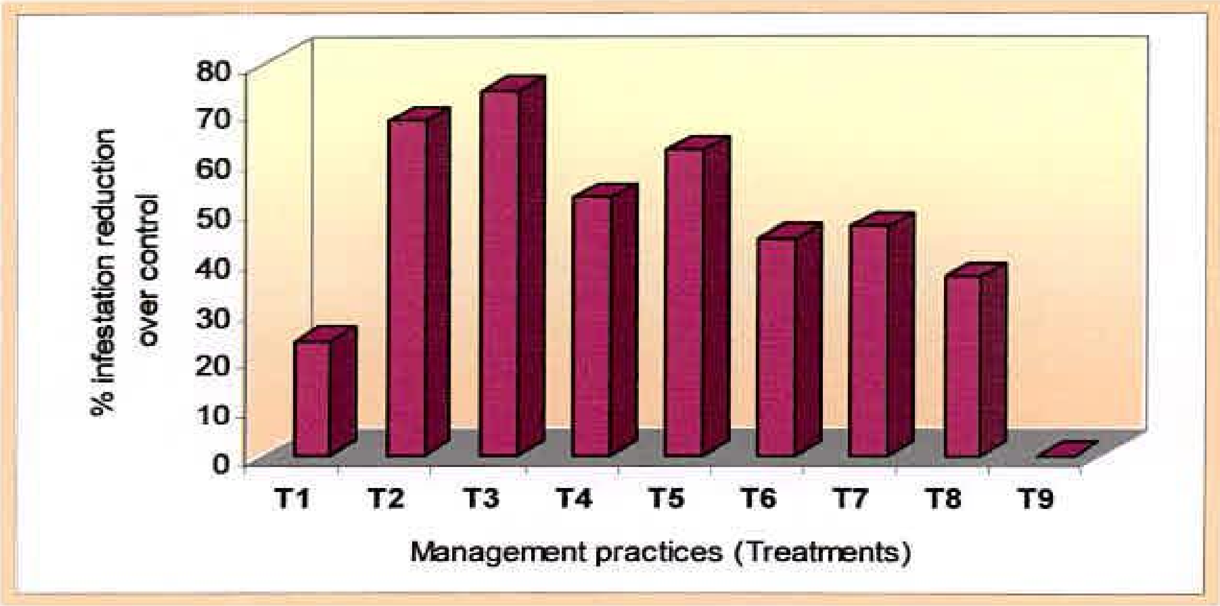

Figure 1. Effect of different management practices on percent infestation reduction over control at early fruiting stage

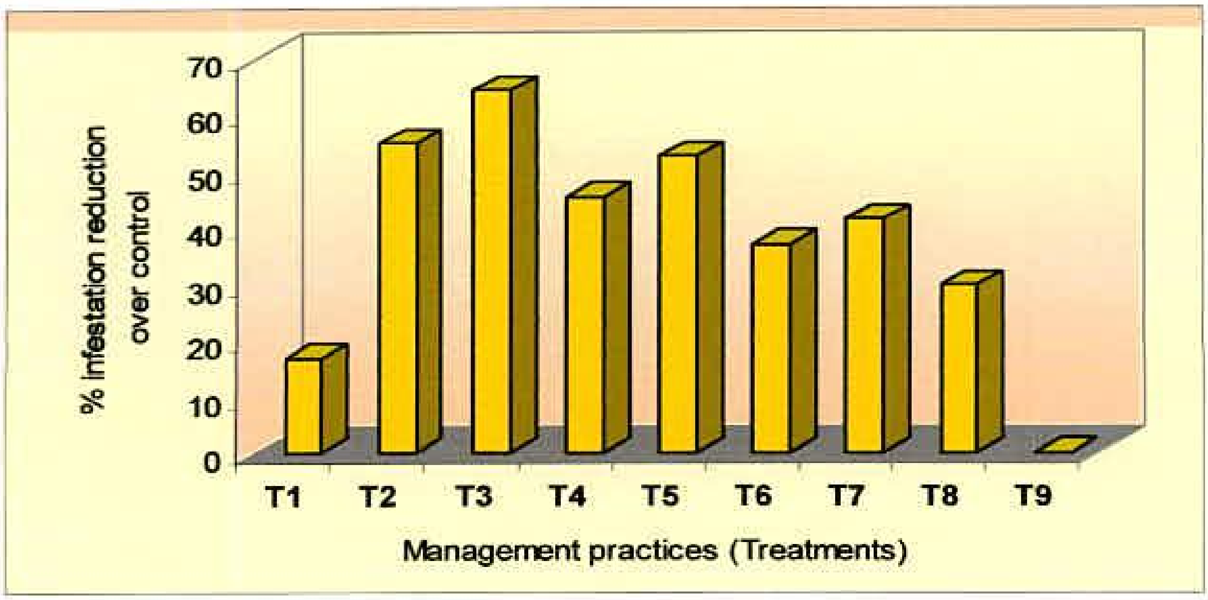

Figure 2. Effect of different management practices on percent infestation reduction over control at mid fruiting stage

Again, in terms of late fruiting stage (Figure 3), the highest percent (64.45%) reduction of infestation over control was found in T_3, followed by T_2 (55.71%), T_5 (50.47%) and T_4 (45.36%) and the lowest (23.54%) in T_1 treatment, followed by the treatment T_8 (29.91%) and T_6 (36.75%)

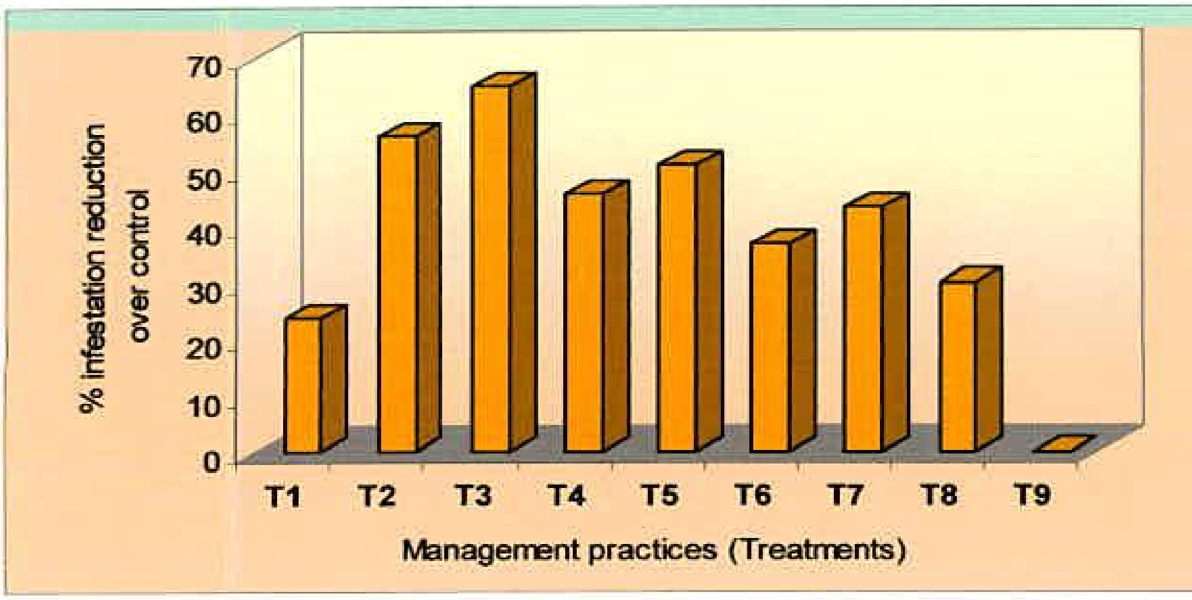

Figure 3. Effect of different management practices on percent infestation reduction over control at late fruiting stage

4.3 Throughout the growing season by number

The highest number of healthy fruit per plant (59.80) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar with the treatment T_2 (Neem oil @ 5 ml/L of water) (56.20) and T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control) (55.60), respectively followed by the treatment T_4 (Suntap 50SP @ 3 g/L of water) (52.00) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control) (51.00) , respectively (Table 3). On the other hand, the lowest number of healthy fruit (37.60) was recorded in T_9 (untreated control plot), which was followed by the treatment T_1 (Mechanical control) (43.60), T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) (46.60) and T_6 (Shobicron 425EC @ 2 ml/L of water) (49.40), respectively.

The lowest number of infested fruit per plant (4.80) was recorded from the treatment T_3 which was followed by the treatment T_2 (5.80) and T_5 (6.20), T_4 (7.00), T_6 (7.80) and T_7 (7.40), respectively (Table 3). On the other hand, the highest number of infested fruit (10.80) was recorded in T_9 (untreated control plot), which was followed by T_1 (9.40) and T_8 (8.40).

The lowest fruit infestation per plant in number (7.06%) was recorded in T_3 treatment which was followed by T_2 (8.73%), T_5 (9.25%), T_4 (10.84%), T_7 (11.54%) and T_6 (12.19%). On the other hand, the highest infested fruit (17.81%) was recorded in T_9 which was followed by T_1 (15.38%) and T_8 (13.39%) (Table 3). The highest reduction over control (60.36%) throughout the cropping season by. number was recorded in T_3 and the lowest (13.64%) was in T_1.

Table 3. Effect of different control measures for the suppressing of pod borer of yard long bean throughout the growing season in terms of fruit per plant by number and weight during July to September, 2007

Treatments	Yard long bean by number				Yard long bean by weight (gm)			
	Healthy pod	Infested pod	% infestation	% Reduction over control	Healthy Pod	Infested pod	% infestation	% Reduction over control
T_1	43.60 e	9.40 b	15.38 b	13.64	727.45 e	142.53 b	16.42 b	20.79
T_2	56.20 ab	5.80 e	8.73 e	50.98	937.75 b	87.05 g	8.49 f	59.04
T_3	59.80 a	4.80 f	7.06 f	60.36	993.87 a	72.62 h	6.81 g	67.15
T_4	52.00 bc	7.00 d	10.84 d	39.14	868.82 c	105.98 ef	10.86 e	47.61
T_5	55.60 ab	6.20 e	9.25 e	48.06	928.28 b	95.72 fg	9.35 f	54.90
T_6	49.40 cd	7.80 cd	12.19 cd	31.56	821.03 cd	118.23 cd	12.60 d	39.22
T_7	51.00 c	7.40 d	11.54 d	35.20	848.28 c	112.45 de	11.70 de	43.56
T_8	46.60 de	8.40 c	13.39 c	24.82	776.42 de	127.38 c	14.09 c	32.03
T_9	37.60 f	10.80 a	17.81 a	--	625.82 f	163.73 a	20.73 a	--
$LSD_{(0.05)}$	4.166	0.789	1.460	--	54.41	11.01	1.107	--
CV(%)	4.79	6.07	7.15	--	3.76	5.58	5.18	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 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: Mechanical control
T_2: Neem oil @ 5 ml/L of water
T_3: Neem oil @ 5 ml/L of water + T_1
T_4: Suntap 50SP @ 3 g/L of water
T_5: Suntap 50SP @ 3 g/L of water + T_1
T_6: Shobicron 425EC @ 2 ml/L of water
T_7: Shobicron 425EC @ 2 ml/L of water + T_1
T_8: Neem seed kernel 10 g/L of water + T_1
T_9: Untreated control

4.4 Throughout the growing season by weight

The highest weight of healthy fruit per plant (993.87 g) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was followed (937.75 g and 928.28 g) with T_2 (Neem oil @ 5 ml/L of water) (Table 2). On the other hand, the lowest weight of healthy fruit (625.820 g) was recorded in T_9 (untreated control plot) which was followed by T_1 (Mechanical control) (727.45 g) and T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) (776.42 g), respectively. Again moderate weight of total healthy fruit was recorded in T_4 (Suntap 50SP @ 3 g/L of water) (868.82 g), T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control) (848.28 g) and T_6 (Shobicron 425EC @ 2 ml/L of water) (821.03 g), respectively.

The lowest weight of infested fruit per plant (72.62 g) was recorded in T_3 which was followed by T_2 (20.00 g), T_5 (23.40 g), T_4 (26.83 g), T_6 (30.22 g) and T_7 (30.07 g), respectively (Table 2). On the other hand, the highest weight of infested fruit (163.73 g) was recorded in T_9 (untreated control plot), which was followed by T_1 (142.53 g) and T_8 (127.38 g).

The lowest fruit infestation per plant in weight (6.81%) was recorded in T_3 which was followed by T_2 (8.49%), T_5 (9.35%), T_4 (10.86%), T_7 (11.70%) and T_6 (12.60%). On the other hand, the highest infested fruit (20.73%) was recorded from T_9 (untreated control plot), which was followed by T_1 (16.42%) and T_8 (14.09%) (Table 3). The highest reduction over control (67.15%) throughout the cropping season by weight was recorded in T_3 and the lowest (20.79%) was in T_1. The pod borers were found to cause 38% yield loss through flower and pod damage and have been reported as the most important pests of pigeon pea in Bangladesh (Rahman *et al.*, 1981)

4.5 Relationship between healthy fruit and temperature, humidity and rainfall

4.5.1 Relationship between healthy fruit and temperature

The data on healthy fruit by weight were regressed against temperature and a positive linear relationship was obtained between them. It was evident from the Figure 4 that the equation $y = 35.572x - 154.49$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.445$) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the healthy fruit yield increased with the increase of temperature.

4.5.2 Relationship between healthy fruit and relative humidity

Correlation study was done to establish a relationship between healthy fruit by weight and relative humidity (%). From the study it was revealed that non significant correlations existed between the characters (Figure 5). The regression equation $y = 2.6694x + 678.29$ did not good fit to the data and the value of the co-efficient of determination ($R^2 = 0.1039$). From this it can be concluded that there were no relationship between relative humidity and healthy fruit.

4.5.3 Relationship between healthy fruit and rainfall

When the data on healthy fruit in weight and rainfall were regressed a positive relationship was obtained between these two characters. Here the equation $y = -0.0035x + 876.56$ did not good fit to the data, and the value of the co-efficient of determination ($R^2 = 0.0002$) showed that the fitted regression line had a non significant regression coefficient. The increase in rainfall there is no increase of healthy fruit (Figure 6).

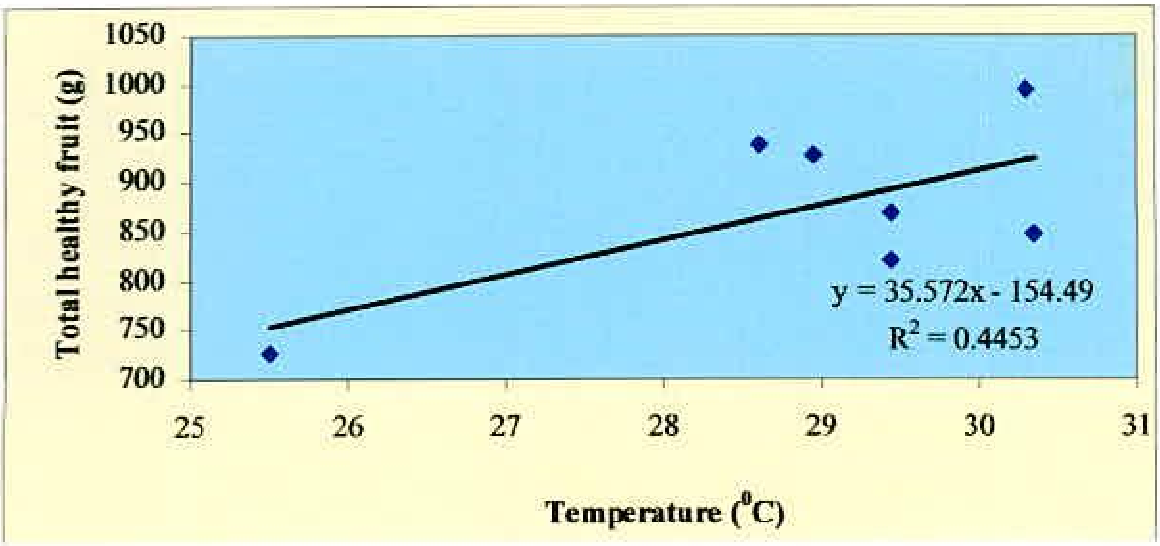

Figure 4. Relationship between temperature and total healthy fruit per plant of yard long bean

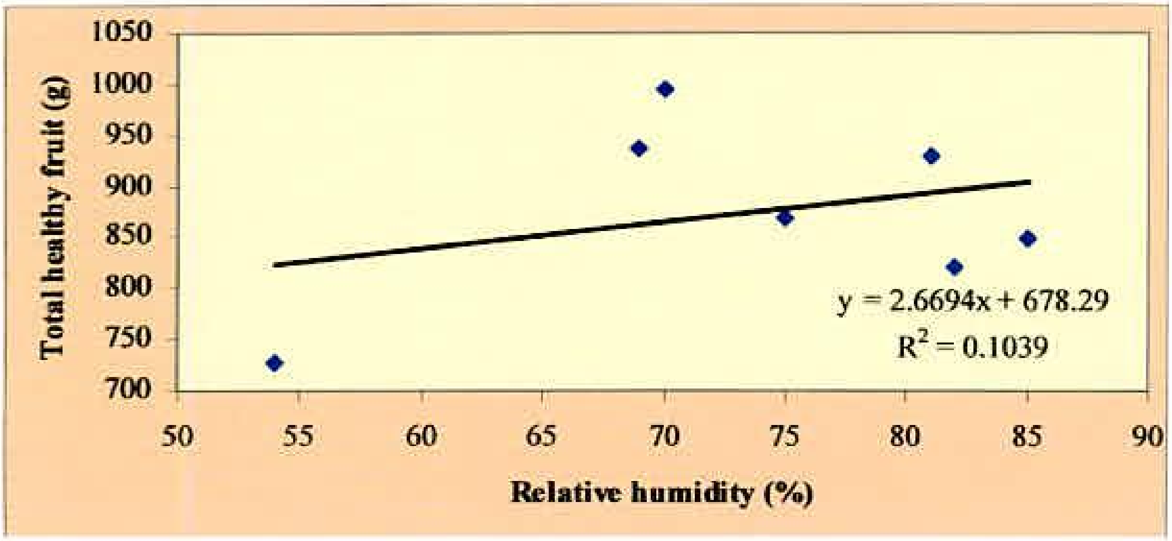

Figure 5. Relationship between relative humidity and total healthy fruit per plant of yard long bean

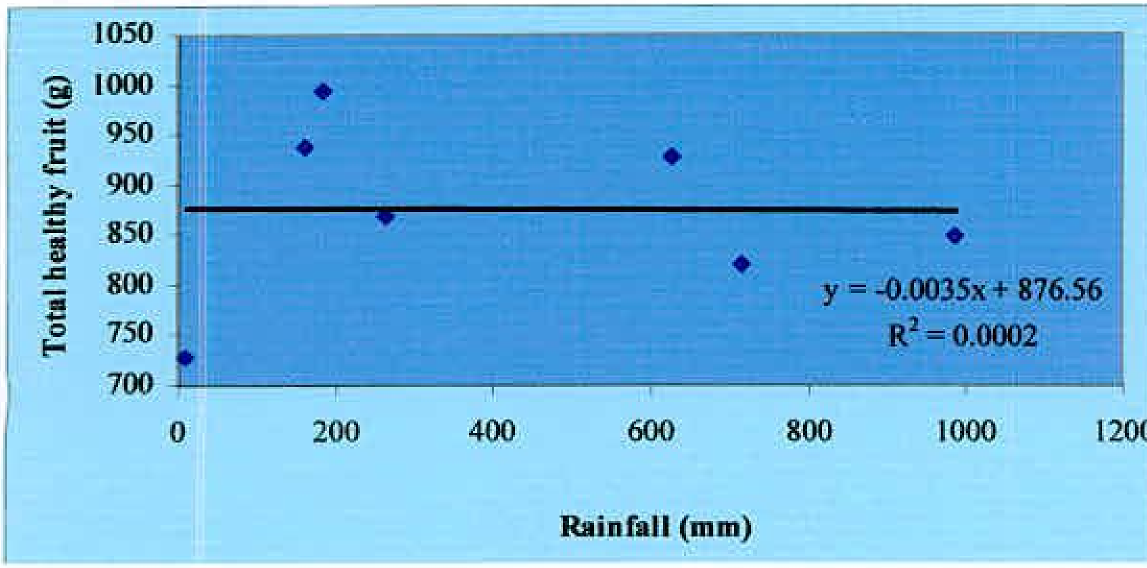

Figure 6. Relationship between rain fall and total healthy fruit per plant of yard long bean

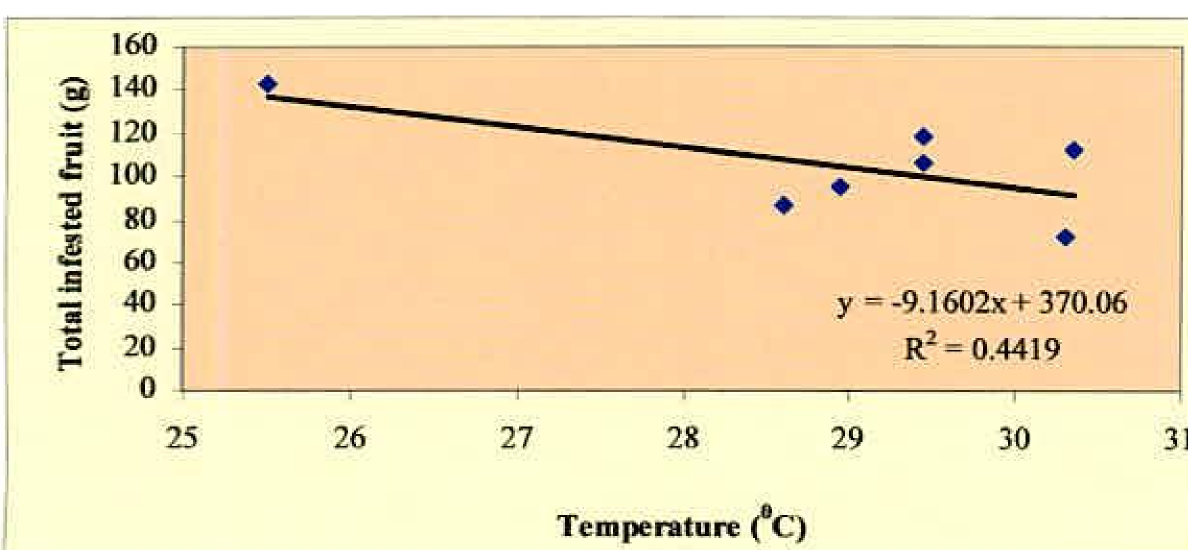

Figure 7. Relationship between temperature and total infested fruit per plant of yard long bean

4.5.4 Relationship between infested fruit and temperature

The data on infested fruit by weight were regressed against temperature and a positive linear relationship was obtained between them. It was evident from the figure 7 that the equation $y = -9.1602x + 370.06$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.44195$) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the infested fruit yield increased with the increase of temperature.

4.5.5 Relationship between infested fruit and relative humidity

Correlation study was done to establish a relationship between infested fruit by weight and relative humidity (%). From the study it was revealed that non significant correlations existed between the characters (Figure 8). The regression equation $y = -0.6035x + 149.43$ gave a not good fit to the data and the value of the co-efficient of determination ($R^2 = 0.0794$). From this it can be concluded that there was no relationship between relative humidity and weight of infested fruit.

4.5.6 Relationship between infested fruit and rainfall

When the data on infested fruit in weight and rainfall were regressed a positive relationship was obtained between these two characters. Here the equation $y = 0.0038x + 103.33$ gave a not good fit to the data, and the value of the co-efficient of determination ($R^2 = 0.0036$) showed that the fitted regression line had a non significant regression coefficient. The increase in rainfall there is no increase of infested fruit (Figure 9). The distribution of rainfall over time is more crucial than the total amount in determining the fluctuations of pod borer populations. Thus, the adjustment of planting dates is suggested as an IPM tactic to avoid the development of damaging levels of pod borer infestations (Alghali, 1993)

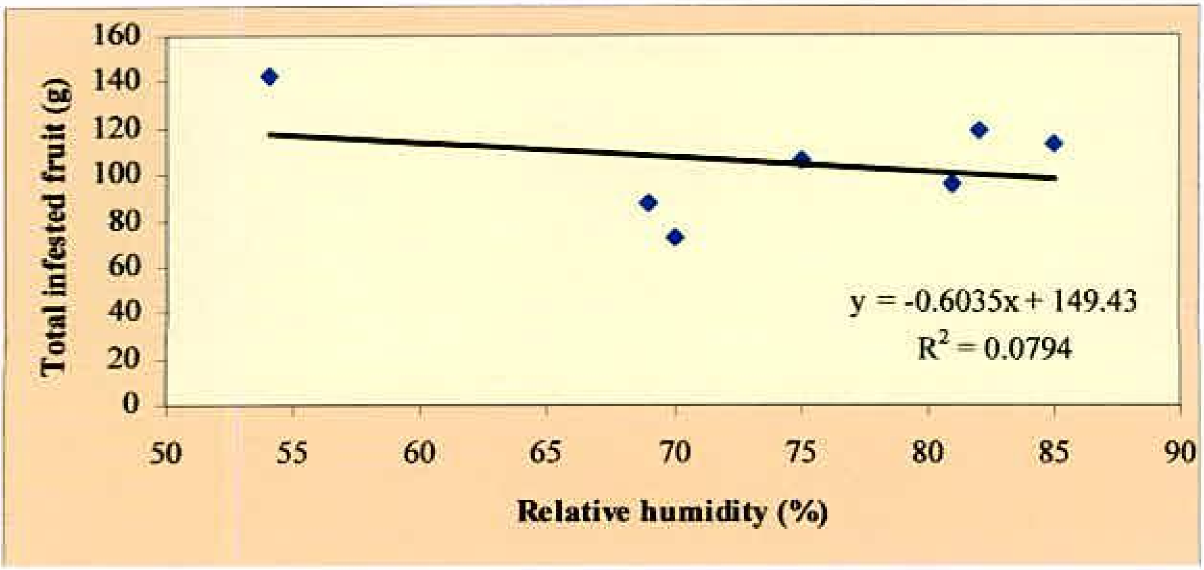

Figure 8. Relationship between relative humidity and total infested fruit per plant of yard long bean

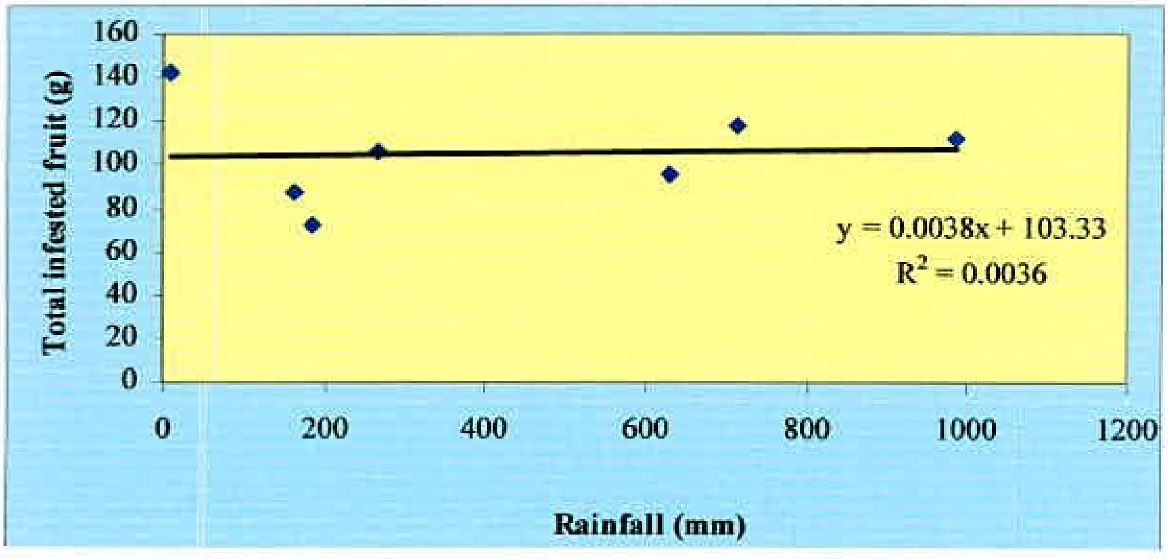

Figure 9. Relationship between rain fall and total infested fruit per plant of yard long bean

Therefore, it was observed that there was no relationship among different weather component with the total healthy and infested pod of yard long bean except with the temperature. It might be concluded from the above findings that proper management i.e Neem oil application could reduce the increased infestation of pod borer due to high temperature.

4.6 Yield contributing characters and yield

4.6.1 Length of edible part

The highest length of edible part (48.64 cm) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (47.17 cm, 46.70 cm and 42.84 cm) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively and closely followed (43.03 cm and 40.70) by T_4 (Suntap 50SP @ 3 g/L of water) and T_6 (Shobicron 425EC @ 2 ml/L), respectively (Table 4). On the other hand, the lowest (30.11 cm) was recorded in T_9 (untreated control) which was closely followed (35.59 cm, and 38.55 cm) by T_1 (Mechanical control) and T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control), respectively.

4.6.2 Edible portion

The highest edible portion (89.75%) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (88.00%, 87.45% and 84.00%) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively and closely followed (83.07% and 80.55%) by T_4 (Suntap 50SP @ 3 g/L of water) and T_6 (Shobicron 425EC @ 2 ml/L), respectively (Table 4). On the other hand, the lowest edible portion (67.50%) was recorded in T_9 (untreated control), which was closely followed (75.08%, and 79.00%) by T_1 (Mechanical control) and T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control), respectively.

Table 4. Effect of different control measures for the suppressing of pod borer of yard long bean in terms of edible and non edible part by length and portion during July to September, 2007

Treatments	Length of edible part (cm)	Edible portion (%)	Length of non-edible part (cm)	Non edible portion (%)
T_1	35.59 d	75.08 d	17.51 b	24.92 b
T_2	47.17 ab	88.00 ab	9.25 e	12.00 de
T_3	48.64 a	89.75 a	7.42 f	10.25 e
T_4	43.03 bc	83.07 bc	11.55 d	16.93 cd
T_5	46.70 ab	87.45 ab	9.69 e	12.55 de
T_6	40.70 cd	80.55 cd	12.81 cd	19.45 bc
T_7	42.84 abc	84.00 abc	11.95 d	16.00 cde
T_8	38.55 cd	79.00 cd	13.92 c	21.00 bc
T_9	30.11 e	67.50 e	19.22 a	32.50 a
$LSD_{(0.05)}$	1.015	5.336	1.452	5.336
CV(%)	5.22	3.78	7.89	16.75

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 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: Mechanical control

T_2: Neem oil @ 5 ml/L of water

T_3: Neem oil @ 5 ml/L of water + Mechanical control

T_4: Suntap 50SP @ 3 g/L of water

T_5: Suntap 50SP @ 3 g/L of water + Mechanical control

T_6: Shobicron 425EC @ 2 ml/L of water

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

T_8: Neem seed kernel 10 g/L of water + Mechanical control

T_9: Untreated control

4.7.3 Length of non-edible part

The lowest length of non edible part (7.42 cm) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was closely followed (9.25 cm, 9.69 cm, 11.25 cm) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively (Table 4). On the other hand, the highest length of non edible part (19.22 cm) was recorded in T_9 (untreated control), which was closely followed (17.51 cm, and 13.92 cm) by T_1 (Mechanical control) and T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control), respectively. Moderate length of non edible part (11.55 cm and 12.81 cm) was observed from T_4 (Suntap 50SP @ 3 g/L of water) and T_6 (Shobicron 425EC @ 2 ml/L), respectively.

4.7.4 Non edible portion

The lowest non edible portion (10.25%) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control, which was statistically similar (12.00%, 12.55% and 16.00%) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively and closely followed (16.93% and 19.45%) by T_4 (Suntap 50SP @ 3 g/L of water) and T_6 (Shobicron 425EC @ 2 ml/L), respectively (Table 4). On the other hand, the highest non edible portion (32.50%) was recorded in T_9 (untreated control) which was closely followed (24.92%, and 21.00%) by T_1 (Mechanical control) and T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control), respectively.

Plate 3. Experimental plot (vegetatative stage) of yard long bean

Plate 4. A single plot (fruiting stage) of yard long bean

4.7.5 Number of pod per plant

The highest number of healthy fruit per plant (64.00) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (62.00 and 61.80) with T_2 (Neem oil @ 5 ml/L of water) and T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control), respectively and closely followed (59.00 and 58.40) by T_4 (Suntap 50SP @ 3 g/L of water) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively (Table 5). On the other hand, the lowest number of pod per plant (48.40) was recorded in T_9 (untreated control), which was closely followed (53.00, 55.00 and 57.20) by T_1 (Mechanical control), T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) and T_6 (Shobicron 425EC @ 2 ml/L of water), respectively.

4.7.6 Healthy pod length

The highest healthy pod length (54.20 cm) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (53.60 cm, 53.40 cm, 51.80 cm, 51.00 cm and 50.53 cm) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control), T_4 (Suntap 50SP @ 3 g/L of water) T_6 (Shobicron 425EC @ 2 ml/L) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively (Table 5). On the other hand, the lowest healthy pod length (44.60 cm) was recorded in T_9 (untreated control, which was closely followed (47.40 cm and 48.80 cm) by T_1 (Mechanical control) and T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control), respectively.

Table 5. Effect of different control measures for the suppressing of pod borer of yard long bean in terms of healthy pod per plant, pod length, diameter, yield per plot and hectare during July to September, 2007

Treatments	Number of pod per plant	Healthy pod length (cm)	Healthy pod diameter (mm)	Yield per plot (kg)	Yield per hectare (ton)	Increase over control (%)
T_1	53.00 d	47.40 cd	20.00 cd	7.21 cd	16.02 cd	8.68
T_2	62.00 ab	53.60 a	25.40 ab	9.63 a	21.39 a	45.12
T_3	64.60 a	54.20 a	26.20 a	9.97 a	22.15 a	50.27
T_4	59.00 bc	51.80 ab	24.40 ab	9.02 ab	20.05 ab	36.02
T_5	61.80 ab	53.40 a	25.00 ab	9.55 a	21.23 a	44.03
T_6	57.20 cd	50.53 abc	22.60 bc	8.23 bc	18.28 bc	24.02
T_7	58.40 bc	51.00 abc	23.80 ab	8.83 ab	19.62 ab	33.11
T_8	55.00 cd	48.80 bc	22.20 bc	7.84 bc	17.42 bc	18.18
T_9	48.40 e	44.60 d	18.20 d	6.63 d	14.74 d	--
$LSD_{(0.05)}$	4.107	3.425	2.972	1.122	2.493	--
CV(%)	4.11	3.91	7.44	7.58	7.58	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 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: Mechanical control

T_2: Neem oil @ 5 ml/L of water

T_3: Neem oil @ 5 ml/L of water + Mechanical control

T_4: Suntap 50SP @ 3 g/L of water

T_5: Suntap 50SP @ 3 g/L of water + Mechanical control

T_6: Shobicron 425EC @ 2 ml/L of water

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

T_8: Neem seed kernel 10 g/L of water + Mechanical control

T_9: Untreated control

A.

B.

Plate 5. Healthy fruit produced (A & B) in neem oil treated plot (T_2)

4.7.7 Healthy pod diameter

The highest healthy pod diameter (26.20 mm) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (25.40 mm, 25.00 mm, 24.40 mm and 23.80 mm) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control), T_4 (Suntap 50SP @ 3 g/L of water) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively (Table 5). On the other hand, the lowest healthy pod diameter (18.20 mm) was recorded in T_9 (untreated control) which was closely followed (20.00 mm and 22.20 mm and 22.60 mm) by T_1 (Mechanical control), T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) and T_6 (Shobicron 425EC @ 2 ml/L), respectively.

4.7.8 Yield per plot

The highest yield per plot (9.97 kg) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (9.63 kg, 9.55 kg, 9.02 kg and 8.83 kg) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control), T_4 (Suntap 50SP @ 3 g/L of water) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively (Table 5). On the other hand, the lowest yield per plot (6.63 kg) was recorded in T_9 (untreated control), which was closely followed (7.21 kg, 7.84 kg and 8.23 kg) by T_1 (Mechanical control), T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) and T_6 (Shobicron 425EC @ 2 ml/L), respectively.

4.7.9 Yield per hectare

The highest yield per hectare (22.15 ton) was recorded in T_3 (Neem oil @ 5 ml/L of water + Mechanical control), which was statistically similar (21.39 ton, 21.23 ton, 20.05 ton and 19.62 ton) with T_2 (Neem oil @ 5 ml/L of water), T_5 (Suntap 50SP @ 3 g/L of water + Mechanical control), T_4 (Suntap 50SP @ 3 g/L of water) and T_7 (Shobicron 425EC @ 2 ml/L of water + Mechanical control), respectively (Table 5). On the other hand, the lowest yield per hectare

(14.74 ton) was recorded from T_9 (untreated control, which was closely followed (16.02 ton, 17.42 ton and 18.28 ton) by T_1 (Mechanical control), T_8 (Neem seed kernel @ 10 g/L of water + Mechanical control) and T_6 (Shobicron 425EC @ 2 ml/L), respectively. The highest increase over control (20.27%) was recorded for T_3 and the lowest (8.68%) was recorded in T_1. The pod borers were found to cause 38% yield loss through flower and pod damage and have been reported as the most important pests of pigeon pea in Bangladesh (Rahman *et al.*, 1981).

This study indicated that the IPM tools T3 comprising neem oil @ 5 ml/lit of water + mechanical control applied at 7 days after interval might be considered as the best component on the basis of its effectiveness in reducing pod borer infestation, increasing total yield and healthy pod yield.

Table 6. Cost of production of yard long bean for different pod borer due to the effect of different control measures during July to September, 2007

Treatments	Cost of pod borer Management (Tk./ha)	Yield of yard long bean (t/ha)	Gross return (Tk./ha)	Net Return (Tk./ha)	Adjusted net return (Tk./ha)	Benefit cost ratio
T_1	6000	16.02	240,300	234,300	13,200	2.20
T_2	22000	21.39	320,850	298,850	77,750	3.53
T_3	26000	22.15	332,250	306,250	85,150	3.28
T_4	22000	20.05	300,750	278,750	57,650	2.62
T_5	26000	21.23	318,450	292,450	71,350	2.74
T_6	21000	18.28	274,200	253,200	32,100	1.53
T_7	25000	19.62	294,300	269,300	48,200	1.93
T_8	18000	17.42	261,300	243,300	22,200	1.23
T_9	--	14.74	221,100	221,100	--	--

T_1: Mechanical control

T_2: Neem oil @ 5 ml/L of water

T_3: Neem oil @ 5 ml/L of water + Mechanical control

T_4: Suntap 50SP @ 3 g/L of water

T_5: Suntap 50SP @ 3 g/L of water + Mechanical control

T_6: Shobicron 425EC @ 2 ml/L of water

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

T_8: Neem seed kernel 10 g/L of water + Mechanical control

T_9: Untreated control

4.8 Cost analysis

Economic analysis of different control measures were integrated for the control of yard long bean pod borer, *E. cnejus*, is presented in Table 6.

In this study, the untreated control (T_9) did not require any pest management cost. But the costs were involved in mechanical control T_1 (6000 Tk./ha) for the removal of the infested fruit/part of fruit. The cost for the treatment of neem oil @ 5 ml per liter of water T_2 (22000 Tk./ha) was incurred for neem oil, trix liquid detergent, preparation and its application. For Suntap 50SP @ 3 g/L of water applied (22000 Tk./ha) treatments. The cost was involved for insecticide and its application. For Shobicron 425 EC @ 2 ml/L of water applied (21000 Tk./ha) treatments. The cost was involved for insecticide and its application. Mechanical control included with others added the value of pesticides and mechanical control.

Considering the controlling of yard long bean pod borer highest benefit cost ratio (3.53) was recorded in T_2 (Neem oil @ 5 ml/L of water followed by T_2 (3.28), T_5 (2.74), T_4 (2.62), T_1 (2.20) and the lowest benefit cost ratio was recorded in T_9 (1.23), and followed by T_6 (1.53) and T_8 (1.93) (Table 6).

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e Bangla Nargar, Dhaka, Bangladesh from March to September'2007 and the evaluation of some IPM tools for the suppression of pod borer (*Euchrysops cnejus*) Lycaenidae, Lepidoptera attacking yard long bean. Neem oil, removal of infested flower and fruits and chemical insecticide along with an untreated control and some of their integrations were utilized in this study. The treatment were T_1: Mechanical control; T_2: Neem oil @ 5 ml/L of water; T_3: Neem oil @ 5 ml/L of water + Mechanical control; T_4: Suntap 50SP @ 3 g/L of water; T_5: Suntap 50SP @ 3 g/L of water + Mechanical control; T_6: Shobicron 425EC @ 2 ml/L of water; T_7: Shobicron 425EC @ 2 ml/L of water + Mechanical control; T_8: Neem seed kernel 10 g/L of water + Mechanical control and T_9: Untreated control. Data were recorded on healthy and infested infestation level and yield contributing characters and yield of yard long bean.

At early stage, the highest number of healthy fruit per plant (17.00) was recorded from T_3 and the lowest number of healthy fruit (10.40) was recorded in T_9 (Untreated control) treatment. The lowest number of infested fruit per plant (1.00) was recorded from T_3 treatment and the highest number of infested fruit (2.80) was recorded in T_9 treatment. The lowest fruit infestation per plant in number (5.52%) was recorded from T_3 treatment, while the highest infested fruit (21.16%) was recorded from T_9 treatment. At mid stage, the highest number of healthy fruit per plant (28.20) was recorded from T_3 and the lowest number of healthy fruit (17.20) was recorded in T_9. The lowest number of infested fruit per plant (2.40) was recorded from T_3 treatment and the highest number of infested fruit (4.80) was recorded in T_9 treatment. The lowest fruit infestation per plant in number (7.88%) was recorded from T_3 treatment and the highest infested fruit (21.98%) was recorded from T_9 treatment. At late fruiting stage, the highest number of healthy fruit per plant (14.60) was recorded from T_3 treatment and the lowest number of healthy fruit (10.000) was recorded in T_9. The lowest number of infested fruit per plant (1.40) was recorded from T_3 treatment and the highest number of infested fruit (3.20) was recorded in T_9 treatment. The lowest fruit infestation per plant in number (7.73%) was recorded from T_3 treatment and the highest infested fruit (24.23%) was recorded from T_9 treatment.

At early fruiting stage the highest weight of healthy fruit per plant (310.77 g) was recorded from T_3 treatment and the lowest weight of healthy fruit (191.90 g) was recorded from T_9. The lowest weight of infested fruit per plant (16.70 g) was recorded from T_3 treatment and the highest weight of infested fruit (47.07 g) was recorded in T_9 treatment. The lowest fruit infestation per plant in weight (5.10%) was recorded from T_3 treatment and the highest infested fruit (19.65%) was recorded from T_9 treatment. At mid fruiting stage, the highest weight of healthy fruit per plant (462.97 g) was recorded from T_3 and the lowest weight of healthy fruit (283.58 g) was recorded in T_9. The lowest weight of infested fruit per plant (36.23 g) was recorded from T_3 treatment and the highest weight of infested fruit (71.50 g) was recorded in T_9 treatment. The lowest fruit infestation per plant in weight (7.26%) was recorded from T_3 treatment and the highest infested fruit (20.16%) was recorded from T_9 treatment. At late fruiting stage the highest weight of healthy fruit per plant (220.13 g) was recorded from T_3 and the lowest weight of healthy fruit (150.33 g) was recorded in T_9. The lowest weight of infested fruit per plant (19.68 g) was recorded from T_3 treatment and the highest weight of infested fruit (45.17 g) was recorded in T_9 treatment. The lowest fruit infestation per plant in weight

(8.21%) was recorded from T_3 treatment and the highest infested fruit (23.10%) was recorded from T_9 treatment.

Throughout the growing season the highest number of healthy pod per plant (59.80) was recorded from T_3 (Neem oil @ 5 ml/L of water + Mechanical control) and the lowest number of healthy fruit (37.60) was recorded in T_9 treatment. The lowest number of infested fruit per plant (4.80) was recorded from T_3 treatment and the highest number of infested fruit (10.80) was recorded in T_9 treatment. The lowest fruit infestation per plant in number (7.06%) was recorded from T_3 treatment while, the highest infested fruit (17.81%) was recorded from T_9 treatment. On the other hand the highest weight of healthy fruit per plant (993.87 g) was recorded from T_3 and the lowest weight of healthy fruit (625.820 g) was recorded from T_9. The lowest weight of infested fruit per plant (72.62 g) was recorded from T_3 treatment and the highest weight of infested fruit (163.73 g) was recorded in T_9 treatment. The lowest fruit infestation per plant in weight (6.81%) was recorded from T_3 treatment and the highest infested fruit (20.73%) was recorded from T_9 treatment.

The highest length of edible part (48.64 cm) was recorded from T_3 and the lowest (30.11 cm) was recorded from T_9. The highest edible portion (89.75%) was recorded from T_3 and the lowest edible portion (67.50%) was recorded from T_9. The lowest length of non edible part (7.42 cm) was recorded from T_3 and the highest length of non edible part (19.22 cm) was recorded from T_9. The lowest non edible portion (10.25%) was recorded from T_3 and the highest non edible portion (32.50%) was recorded from T_9. The highest number of healthy fruit per plant (64.00) was recorded from T_3 and the lowest number of pod per plant (48.40) was recorded in T_9. The highest healthy pod length (54.20 cm) was recorded from T_3 and the lowest healthy pod length (44.60 cm) was recorded from T_9.

The highest healthy pod diameter (26.20 mm) was recorded from T_3 and the lowest healthy pod diameter (18.20 mm) was recorded from T_9. The highest yield per hectare (22.15 ton) was recorded from T_3 and the lowest yield per hectare (14.74 ton) was recorded from T_9. The highest benefit cost ratio (3.53) was recorded in the treatment T_2 and the lowest benefit cost ratio (1.23) was recorded from T_9.

From the present study, the cooperative evaluation of some IPM components against pod borer of Yard long bean indicated that the neem oil @ 5 ml/lit of water + mechanical control spread at reproductive stages would be the best practices for reducing pod borer infestation and damage of yard long bean . As there was an increasing tendency of pod borer infestation beginning from early to late fruiting stages, control measure should be taken at early and mid fruiting stages for effective and profitable yard long bean cultivation. But control actions at flower initiation and late fruiting stages would not be economically sound because of lower number of fruits in the plant.

Therefore, neem oil spray might be selected as non hazardous component of IPM against pod borer for economic yard long bean cultivation in Bangladesh.

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 and other performance.
2. Another chemical and botanical insecticide may be used for comparative study among the chemical and botanical insecticides.

3. Some commonly available botanical insecticides such as ash, tobacco and alomonda leaf extract may be used for easily attend to the poor people of our country.
4. Interval schedule of insecticides may be rearranged to identify the optimum range of interval of insecticides application.

Chapter VI

REFERENCES

CHAPTER VI

REFERENCES

Aditya, D.K. 1993. Vegetable production and development in Bangladesh. Consultancy report, AVRDC – USAID (ARP II) project, 22 November, 1992–31 may 1993. Horticulture Research Center, BARI, Joydebpur, Gazipur. pp. 3- 24.

Ahmed, S. and Grainge, M. 1985. Potential of the neem tree *(Azadirachta indica)* for pest control and rural development. *Econ. Botany*. **4**: 201-209.

Akhauri, R.K., Sinha, M.M. and Yadav, R.P. 1994. Population build-up and relative abundance of pod borer complex in early pigeonpea, *Cajanus cajan* (L.) *Millsp. J. Entomol. Res.* **18:** 121-126.

Akinfenwa, S. 1975. Biological Study of *Maruca testulalis* (Geyer) (Lepidoptera: Pyralidae) in Zaria area of northern Nigeria. M.Sc. Thesis, Ahmadu Bellow University, Nigeria.

Alam M.Z. 1969. Insect pest of vegetables and their control in East Pakistan. The Agricultural Information service, Department of Agriculture; 3, R.K. Mission Road, Dacca -3, East Pakistan. P. 146.

Alam, S.1991 . Efficacy evaluation of neem and farmer field trail. **In**: Proceedings of the midterm Project Review meeting. Botanical pest control project. Phase –II . 28-31. July, 1991, Dhaka, Bangladesh.

Alghali, A.M.1993 . The effects of some agrometeoraological factors on fluctuation of the legume pod borer, *Maruca testulalis* Geyer (Lepidoptera: Pyralidae), on two cowpea varieties in Nigeria. *Insect Sci. and App.* **14**(1): 55-59.

Ali, M.I. and Karim, M.A. 1991. Rational insecticide use for the control of the cotton Jassid, *Amrasca biguttula* (Shir.) (Cicadellidae : Homoptera) and the spotted ballwarm, *Earias vittella (F) (Noctuidae: Lepidoptera)* on cotton in Bangladesh. *Tropical .Pest Manage.* **37** (1) : 66-70.

Amoako-Atta, B., Omolo, E.0. and Kidega, E.K. Influence of maize, cowpea and sorghum intercropping systems on stem-pod borer infestations, *Insect Sci. Applic.* **4:** 47-57.

Anonymous, 1988. FAO Production Year Book. Food and Agriculture Organization United Nations. Rome, Italy, **43:** 190-193.

Anonymous, 1994. Integrated control of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. At Jessore. In**:** Annual Research Report 1993-94. BARI, Joydebpur, Gazipur, Bangladesh. pp. 50-51.

Anonymous, 1995. Training manual, summer and all season vegetable and spice production. Horticulture Research and Development Project, DAE and BADC, Dhaka. p 130.

Atachi, P. and Djihou, Z.C. 1994. Record of host plants of *Maruca testulalis* (Geyer) (Lepidopera: Pyralidae) in the republic of Benin. *Ann. Sot. Ent. A.* 30: 169-174.

Babu, P.C.S. 1988. Toxicity of insecticides to the aphid *A. craccivora* Koch. and to the coccinellid predator *M. sexmaculatus* F. on cowpea and hyacinth bean. *Madras Agril. Journal*. **75**(11-12): 409-413.

Babu, S.P.C 1989. Comparative biology of the spotted pod borer, *Maruca testulalis* (Geyer) on three host plants. *Leg. Res*. **12** (4): 177-178.

Baker, A.K., Abu, B., Haron, A.R.B. and Aziz, Z.B.A. 1980. Mungbean in Malaysia *Rev. Appl, Ent*. **68**(1). p 60.

Begum, R. A 1993. Techniques of growing legume vegetable, **In:** Chadha, M.L., Hossain, A.K.M.A. and Hossain, S. M.M. (Eds.). Intensive Vegetable Growing and Its Utilization. A compilation of lecture materials of training course held at BARI, Joydebpur, Gazipur, Bangladesh, in collaboration with AVRDC-BARC/BARI-USAID. 22-25 November 1993. pp. 92-128.

Begum, R.A. 1993. Techniques of growing legume vegetable. **In:** Intensive vegetable growing and its utilization. A compilation of lecture materials of training course held in BARI, Joydebpur, Gazipur, Bangladesh. 22-25 November, 1993. p. 94.

Bottrell, D.G. 1979. Integrated pest management . Superintendent of Documents. U.S. Government Printing Office .Washington D.C. 120 p.

Broadley, R.H. 1977. The bean pod borer in north Queensland. *Queensl. Agric. J.* **103:** 274-278.

Butani, D.K. and Jotwani, M.G. 1984. Insects in vegetables. Periodical Expert Book Agency, D-42, Vivek – Vihar, Delhi-110032, India. pp. 69-79, 91-93.

Dandale, H.G., Khan, K.M., Thakaie, H.S. and Borle, M.N. 1984. Comparative efficacy of synthetic pyrethroids against pod borer complex of red gram. *Indian J. Ent.* **43** (4): 416-419.

Das, G.P. and. Islam, M.A. 1985. *Maruca testulalis* (Lepidoptera: Pyralidae): An important pest of country bean in Bangladesh. *Bangladesh J. Agri.* **10**(1): 57- 66.

Dina, S.O. 1979. *Maruca testulalis* Geyer (Lepidopera: Pyralidae), a pest of soybean in Nigeria. Tropical Grain Legume Bull. **11**(12): 28-30.

Dreyer, M. 1987 . Field and Laboratory trail with simple neem products against pests of vegetable and field crops in Togo. **In:** Procedings of the 3rd Neem *Conference, Nairobi, Kenya 1986 (Eds . Schmutterer , H. and Ascher, K.R.S.);* GTZ press, Eschborn , West Germany. p 431.

Emden van, H.F. 1980. Insects and mites of Legume Crops. (R.J. Summerfield and A.H. Bunting, eds), advances in legume science, Vol. 1 of the proceedings of the international legume conference, Kew, 31 July – 4 August 1978, held under the auspices of the Royal Botanic Gardens, Kew, the Missouri Botanical Garden, and the University of Reading. pp. 187-197.

Ezueh, M. I. and Taylor, A.T. 1984. Effects of time of intercropping with maize on cowpea susceptibility to three major pests. *Trop. Agric.* **61:** *82-86.*

Fagoonee, I. 1986. Use of neem in vegetable crop protection in Mauritius. In Natural pesticides from the neem tree. Botanical pest research in Philippines. *Philippines Entomologist.* **7**(1): 1-30.

Fisher, N.M., Raheja, A.K. and Elemo, K.A. 1987 Insect pest control for cowpea in crop mixtures. *Exp. Agric.* **23**, 9-20.

Grainge, M. and Ahmed, S. 1988. Handbook of plant with pest control properties, John Wiley and Sons. New York.

Grubben, G.J.H. 1977. Tropical vegetables and their genetic resources. International Board for plant genetic resources, Rome, Italy.

Haider , J. Marutomo and Azad, A.k. 1991. Estimatation of microbial biomass carbon and nitrogen in Bangladesh. Soil Sci. Plant Nutr. **37**(4): 591-599.

Hill, D.S. 1983. Agricultural Insect Pests of the Tropics and Their Control. Cambridge University Press. London- New York, p. 746.

Hoque, M.M. 1982. Guidelines to vegetable production in Bangladesh, Handout for training on cropping systems BARI, Joydebpur, Dhaka, during 5-17 April 1982.

Hossain, A. and. Awrangzeb, S. N. H 1992. Vegetable production policies, plans and future directions. **In:** Proceeding on Vegetable production and marketing. AVRDC, BARI, BARC and USAID. pp. 21-30.

Hossain, Q.T. 1990. Status and management of vegetable pests in Bangladesh. **In:** Status and management of major vegetable pests in the Asia-Pacific region (With special focus towards integrated pest management). Technical highlights of the Expert consultation on integrated pest management (IPM) in major vegetable crops held from 14-16 November, 1988 at the Regional office for Asia and Pacific (RAPA) Food and Agriculture Organization of the United Nations, Bangkok, Thailand. 28p.

Islam, B.N. 1983. Pesticidal action of neem and certain indigenous plants and weeds of Bangladesh . **In:** proc. 2nd Neem conf. Rauischholzhausen . F.R. Germany, May 25-28, 1983.

Islam, B.N. 1986. Use of some extract from Meliaceae and Annonaceae for control of rice hispa , *Dicladispa armigera* OL. and the pulse beetle , *Callosobruchus chinensis.* Pp. 217-242. In: proc. 3rd Int .Neem conf. Nirobi ,1986 .

Islam, M. A. 1999. Integrated pest (Insects) management of vegetables. Consultancy, report, 18 November 1998 to 17 May 1999. AVRDC – USAID Bangladesh project, Horticulture Research center, BARI, Gazipur -1701.

Jackai, L. E. N., Ochieng, R. S. and Raulston, J. R. 1990 Mating and oviposition behavior of the legume pod borer, *Maruca testulalis. Entomol. Exp. Appl. 59,* 179-186.

Jacobson, M. 1985. The neem tree; Natural resistance par excellence, .**In:** *Natural resistance of plants to pests . M.B. Green and P. A. Hedin (ed)* ACS symposium series 296 . pp. 220-231.

Jacobson, S. and Sheila, M.K. 1994. Studies on the antifeedent activity of some plant products against the leaf cutting caterpillar, *Silepa docilis* Bult, on brinjal and wooly bear, *Pericallia ricini* F. on castor . *Indian J. Ent.* **56**(3): p. 276.

Kabir, K. H., Mia, M. D., Begum R. and Bhuiya, S. I. 1983. Screening of country bean against pod borer. *Bangladesh Hort.* **11**(2): 39-41.

Karel, A. K. 1985. Yield losses from and control of bean pod borers, *Maruca testulalis* G. (Lepidoptera: Pyralidae) and *Heliothis armigera* (Lepidoptera : Noctuidae). *J. Econ. Entomol*. **78**(6): 1323 1326.

Karim, M. A., 1993. Vegetable protection (Insect). Consultancy report. AVRDC – USAID (ARP II) project, 31 December, 1992 -29 April, 1993. Horticulture Research Center, BARI, Joydebpur , Gazipur. pp. 6-53.

Karim, M. A., 1994. Vegetable and spices insect pests and their control. A lecture intraining course on winter vegetable and spices production. Horticulture Research Development project. Joydebpur, Bangladesh .

Karim, M. A., 1995. Management of insect pests of vegetables. **In:** M. L. Chadha, K. U. Ahmad, S. Shanmugasundaram and A. Quasem 1995. (eds.) vegetable crops agribusiness. Proceeding of a workshop held at BARC, Dhaka, Bangladesh 2-4 May 1995. AVRDC, BARC and BARI.

Ketkar, S. C. M. 1976. Utilization of neem (*A. indica Juss*) and its by-products. Nana Dengle Sadhana press. Poona, India.

Krishnaiah , N. V. and Kalode, M. B. 1991. Feasibility of rice insect pest control with Botanical pesticide. **In:** proceedings of the midterm project Review meting. Botanical pest control project. Phase-II . 28-31. July, 1991, Dhaka, Bangladesh .

Lalasangi, M. S. 1988. Bionomics, loss estimate and control of pod borer, *Maruca testulalis* (Geyer) (Lepidoptera: Pyralidae) on cowpea (*Vigna unguiculata (L.) Walp) Mysor J. Agric. Sci*. **22**:187-188.

Nair, M. R. G. K.1986. Insects and mites of corps in India. Revised Edition. *Indian Coun. Agric. Res.*, New Delhi. 408 p.

Ogunwolu, E.O. 1990. Damage to cowpea by the legume pod borer, *Maruca testulalis* (Geyer), as influenced by infestation density. Nigeria. *Tropic. Pest Manage.* **36**(2): 138-140.

Okeyo-Owuor, J. B. O. and Agwaro, P.O. 1992. Studies on the legume pod-borer *Maruca testulalis* (Geyer) III. The use of a pheromone trap in population studies. *Insect Sci. Appl.* **3** (2 & 3): 233-235

Okeyo-Owuor, J.B. and Ochieng, R.S.1991. Studies on the legume pod borer, *Maruca testulalis* (Geyer)-I. Life cycle and behavior. *Insect Sci. Appl.* **1**: 263-268.

Palanginan, E.L and Saxena, R.C. 1991. Field evaluation of neem seed bitters and neem seed kernel extract for the control of green leafhopper and Tungro in Rice. *In:* Proceedings of the midterm Project Review meting. Botanical pest control project. Phase – II . 28-31. July, 1991, Dhaka, Bangladesh.

Pedigo, L.P. 1999. Entomology and Pest Management. Prentice and Hall Incorporation, London.

Raheja, A. J. 1974. Report on the insect pests of grain legumes in northern Nigeria. In: Proceedings, 1st IITA Grain Legume Improvement Workshop, 1973. International Institute for Tropical Agriculture, Ibadan, pp. 295-299.

Rahman, M. M., Mannan, M. M. and Islam, M. A. 1981. Pest survey of major summer and winter pulses in Bangladesh. Proceeding of national workshop on pulses,18-19 August, 1981, BARI, Joydebpur, Dhaka.

Rahman, M.M. 1989. Pest complex of flower and pods of pigeon pea and their control through insecticides application. *Bangladesh J. of Sci. Res.* **7**(1): 27-32

Rahman, M.M. and Rahman, M.S. 1988. Timing and frequency of insecticide application against *Maruca testulalis* infesting short-duration pigeon pea in Bangladesh. *Leg. Res.* **11**(4): 173-179

Ramasubramanian, G. V. and Sundara Babu, P.C. 1988. Effect of host plants on some biological aspects of spotted pod-borer, *Maruca testulalis* (Lepidoptera: Pyralidae). *Indian. J. Agric. Sci.* 58, 618-620

Ramasubramanian, G. V. and Sundara Babu, P.C. 1989a. Comparative biology of the spotted pod-borer, *Maruca testulalis* (Geyer) on three host plants. *Leg. Res.* **12**(4), 177-178

Ramasubramanian, G.V. and Sudara Babu, P. C. (1989). Ovipositional preference of Spotted pod borer *Maruca testulalis* (Geyer) (Lepidoptera: Pyralidae) *Leg. Res.* **12** (4): 193-195

Rashid, M. M. 1986. Vegetables in Bangladesh, Bangla Academy, Dhaka, Bangladesh.

Rashid, M. M. 1993. Begun Paribarer Shabji. In: Shabji Biggan (in Bangla). First ed. Bangla Academy, Dhaka, Bangladesh.

Reddy, B. 1975. Reviews of pest, Disease, and Weed problems in Rain fed Crops in Asia and the Far East (RAFE-RP23). FAO, Rome.

Saxena, K. B., Jayasekera, S. J. B. A. and Ariyaratne. H. P. 1992. *Pegeonea Adoption and Production Studies in Sri Lanka.* Department of Agriculture. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh.

Saxena, R.C. 1988. Insecticies from neem. **In:** Insecticiedes of Plantorigin (Eds. Arnsason, J.T.; B. J. R Philogene and P. Morand),. ACS 387. Washington. pp. 110-135.

Sharma, H. C. 1998. Legume pod borer. *Maruca viturula:* Insect plant relationships. *Insect Sci. Appl.*

Sharma, H. C. 1998. Bionomics, host plant resistance and management of the legume pod borer, *Maruca vitrata,* a review. *Crop Protec.* **17**:373-386.

Simmonds, M. S. J., Vans H. C. and Blaney, W.M. 1992. Pesticides for the year 2000: Mycochemicals and botanicals. **In**: Pest management and the environment in 2000. P. 127-164.

Singh, J. P. 1983. Crop Protecion in the Tropics. Vikas publishing House Pvt. Lts. New Delhi 110002. pp. 192-202

Singh, S. R. 1977. *Maruca testulalis* (G). In: J. Kranz, H. Schmutterer, and W. Koch (ed.), Diseases, pest and weeds in tropical crops. Verlag Paul Parey, Berlin. pp. 457-459.

Singh, S. R. and Jackal, L. E. N. 1988. The legume pod borer, *Maruca testulalis* (Geyer): Past, Present and Future Research. **9** (1): 1-5

Singh, S.R., and Taylor, T. A. 1978. Pest of grain legumes and their control in Nigeria. In: pests of grain legumes: ecology and control. Singh, S. R. van Emden, H.F., and Taylor, T. A. (eds.) London, UK: Academic Press. pp. 99-111.

Sombatisiri, K. and Tigvattanont, S. 1987. Effects of neem extract on some insect pest of economic importance in Thailand. In: Natural Pesticides from the neem tree and other Tropical Tries (Eds. Schmutterer, H. and Ascher, K. R. S.), GTZ pres, Eschborn, West Germany.

Stoll, G. 1992. Natural crop protection in the Tropics. Verlag Josef Margraf Scintific Book, Muhlstr. 9, Weikersheim, FR Germany. 188 p.

Taylor, T. A. 1967. The bionomics of *Maruca testulalis* Gey. (Lepidoptera: Pyralidae), a major pest of cowpea in Nigeria, *J. West Africa Sci. Assoc.* 12, 111-129.

Taylor, T. A. 1978. *Maruca testulalis,* an important pest of tropical grain legumes. In: R. S. Sing, H. van Emden and T. A Taylor (eds.) Pests of Grain Ecology and Control. Academic Press, London. pp. 193-200.

Thompson, H.C. 1951. Vegetable crops. Fourth edition. McGraw Hill Book Company, Inc. London. 611 p.

Usua, E.J. and Singh, S.R. 1978. Parasites and predators of the cowpea pod borer, *Maruca testulalis* (Lepidoptera: Pyralidae), *Nigerian J. Entomol.* **3**(1): 100-102.

Vishakantaiah, M. and Jagadeesh Babu, C. S. 1980. Bionomics of the webworm, *Maruca testulalis* (Lepidoptera: Pyralidae). *Mysore J. Agric.*

Warthen, T. D. Jr. 1979. *A. indica,* a source of insect feeding inhibitors and growth regulators. USDA. *Agric. Res.* Results NE ser. 4.

Zaman, S. M. H. 1992. Irrigated Crop Production Manual. *Dept. of Agril. Ext.*, Amader Bangla press, Azimpur, Dhaka, pp. 7-8.