EFFECTIVENESS OF SOME BIOPESTICIDES AND CHEMICAL PESTICIDES TO MANAGE LEGUME POD BORER (*Maruca vitrata*) ON YARD LONG BEAN

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CERTIFICATE

This is to certify that the thesis entitled '**Effectiveness of Some Biopesticides and Chemical Pesticides to Manage Legume Pod Borer (*Maruca vitrata*) on Yard Long Bean**' submitted to the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the results of a piece of bonafide research work carried out by **Saddam Hossan**, Registration No. **11-04471** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2017
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TO

MY BELOVED MOTHERS

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EFFECTIVENESS OF SOME BIOPESTICIDES AND CHEMICAL PESTICIDES TO MANAGE LEGUME POD BORER (*Maruca vitrata*) ON YARD LONG BEAN

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ABSTRACT

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2017 to evaluate the effectiveness of some biopesticides and chemical pesticides to manage legume pod borer (*Maruca vitrata*) on yard long bean. The seeds of BARI yard long bean-1 were used as the test crop in this experiment. The experiment comprised of the following bio-pesticides and chemical pesticides as treatment- T_0: Untreated control; T_1: Neem oil @ 4 ml/L of water at 7 days interval; T_2: Neem seed kernel @ 30 g/L of water at 7 days interval; T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval; T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval; T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval and T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Recorded data showed statistically significant variation for different treatments. At early pod development stage, the lowest infested pods per plant in number and weight basis was observed from T_1 (1.26% and 5.33%)) treatment, again the highest infested pods (14.32% and 17.46%) was recorded in T_0 treatment. At mid pod development stage, the lowest infested pods per plant in number and weight basis was observed from T_1 (2.42% and 5.76%) treatment, whereas the highest infested pods (16.68%and 18.12%) was recorded in T_0. At late pod development stage, the lowest infested pods per plant in number and weight basis was observed from T_1 (3.03% and 6.50%) treatment again the highest infested pods (17.84% and 19.87%) was recorded in T_0 treatment. The highest yield was recorded from T_1 (21.76 t/ha), whereas the lowest yield from T_0 (14.15 t/ha) treatment. The highest benefit cost ratio (2.51) was estimated for T_1 treatment and the lowest (1.26) for T_4 treatment. Among the different control measures, spraying of Neem oil @ 4 ml/L of water at 7 days interval was the better for the controlling pod borer of yard long bean.

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SOME COMMONLY USED ABBREVIATIONS

FULL WORD	ABBREVIATION
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Co-efficient of variation	cv
Days After Sowing	DAS
and others	*et al.*
Etcetera	etc
Journal	J.
Least Significance Difference	LSD
Muriate of Potash	MoP
Sher-e-Bangla Agricultural University	SAU
Soil Resources Development Institute	SRDI
Triple Superphosphate	TSP

Chapter 1

Introduction

CHAPTER I

INTRODUCTION

The yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) is a delicious food legumes vegetable belongs to the family leguminosae which originated in West Africa, is now extensively grown throughout Southeast Asia, Europe, Oceania and North America (Anon., 2014). It is a rich source of essential vitamins and commonly grown during kharif seasons thus the importance of is highly significant in respect to its growing season. Yard long bean is habitually consumed as immature pods as a source of protein (24–27%), vitamins, minerals and fibres also (Singh *et al.*, 1990). Yard long bean are important as high quality livestock fodder and also residual nitrogen suppliers in soil through fixing atmospheric nitrogen. It is grown almost all districts of Bangladesh although concentration is found in Dhaka, Jessore, Comilla, Noakhali and Chittagong but for the last ten years bean have been seen growing extensively in Jessore, Khulna, Chittagong region of Bangladesh (Uddin, 2013).

Yard long bean is one of the economically important vegetable crops in Bangladesh. The area occupied by this crop was 5896.34 hectare and the production was 21674 ton during the year 2013- 2014 (Anon., 2014). It is one of the vegetables having exporting potential in Bangladesh. In our country farmers generally face various problems including the availability of quality seeds, fertilizer and manures, irrigation facilities, modern information cultivation practices, pests and disease in cultivation of yard long bean (Rashid, 1993). Among these, insect pests are the most important and cause enormous quantity of yield losses in every season and every year in yard long bean. The estimated the yield loss in yard long bean due to insect pests is about 12-30% although no regular statistical records are kept as per conventional system of our country (Hossain and Awrangzeb, 1992). Among different insect pests, flower and pod-feeding borer cause serious yield losses to edible legumes particularly in tropical and sub-tropical zones (Rouf and Sardar, 2011).

Yard long bean is attacked by nine different insect species in Bangladesh (Uddin, 2013). Mohiuddin *et al*. (2009) reported that the key insects of yard long bean are pod borer (*Maruca vitrata*), Aphid (*Lipaphis erysimi*) and Epilachna beetle (*Epilachna varivestis*). Pod borer, a genetically complex species (Margam *et al*., 2011; Periasamy *et al*., 2015), is recognized as one of the most serious legume pests (Shanower *et al*., 1999) due to an extensive host range, high damage potential and cosmopolitan distribution (Margam *et al*., 2011). Larvae of pod borer feed on flowers, stems, peduncles and pods of food legumes, thus damage occurs at all developmental stages from seedling to pod harvesting stages, however greatest damage by pod borer was occurred at flowering stage (Singh and Jackai, 1988). For example, typical yield losses on yard long bean due to pod borer range from 20-88% at flowering stage (Singh *et al*., 1990).

Yard long bean growers face serious losses at pod harvest caused by *M. vitrata* infestation and consequently employ an array of agronomic management regimes such as application of conventional insecticides which cause adverse effects to the environment and human health, but fail to achieve satisfactory level of control (Srinivasan *et al*., 2012; Yule and Srinivasan, 2014). There are several insect pests control methods for controlling insect pests of yard long bean, as cultural (Sharma, 1998), mechanical and applied biological control (Karim, 1995) and chemical control measures (Rahman and Rahman, 1988). In general pest control measures included application of synthetic pesticides, sulfur, lime, soap and kitchen ashes. Infestations are too heavy for hand picking/cleaning. Bean pod borers frequently feed internally on infested plant parts while living inside the clusters or pods, insecticide applications, particularly a single application, may often fail to provide successful control of the insect pests (Begum, 1993). As a result, multiple applications of control measure are required for controlling this pest. Neem oil is a promising and less exploited approach in this context. Among the various control measures so far been reported for the management of the pod borer, bio-pesticides appeared as comparatively effective and predominant one.

Various legume insect pest management strategies have been successfully used. They include biological control (Cox *et al.*, 2006; Ugine *et al.*, 2007), botanical pesticide mixtures such as aqueous neem and eucalyptus leaf extracts (Oparaeke *et al.*, 2006), cultural control (Nampala *et al.*, 2002) and chemical control (Heitholt *et al.*, 2006; Seal *et al.*, 2006). The tendency, however, has been to rely heavily upon chemicals for control of such insect pests. This is because fungicides and insecticides are considered to be reliable because of their quick and effective action (Adejumo, 2005; Seal *et al.*, 2006). A survey on pesticide use in vegetables revealed that only about 15% and 16% of the farmers received information from the pesticide dealers and extension agents respectively (Uddin, 2013). 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. Indiscriminate uses of insecticides are reported to cause insecticide resistance in insect pests, resurgence and secondary pests' outbreak.

Generally, insecticides are highly effective, rapid in curative action and relatively economical. Recently, a large number of bio-pesticides with chemicals have been reported as an effective control measure of insect pests in yard long bean. To overcome and minimize the pests attack on yard long bean and to increase the ultimate production of this vegetable crop, the research work will be drawn in various countries in various ways. Under the above mention situation, the present study was under taken to fulfill the following objectives:

- To explore the extent of damage by pod borer on yard long bean;
- To evaluate the potentiality of some bio-pesticides and chemical pesticides for the management of pod borer of yard long bean.

Chapter 2

Review of literature

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh as well as many countries of the world yard long bean is considered as one of the important summer vegetable. There are many insect pests of the vegetable and among them pod borer, is the serious insect is considered as the damaging and has profound yield loss in this crop in Bangladesh. Farmers mainly control these insect pests through use of different chemicals. The concept of integrated management of insect pests expanded momentum as mankind became more safely about environment. Use of bio-pesticides is the recent approaches for pest control that was commonly practiced but the information was not conclusive in context of Bangladesh as well as the world. Nevertheless, some of the important and informative works related to the information of damaging pod borer and research findings related to their control measures through bio-pesticides and chemicals so far been done at home and abroad have been reviewed in this chapter under the following headings:

2.1 Effect of different bio-pesticides in controlling insect pests

Kumar *et al.* (2014) conducted an experiment and reported that *Maruca vitrata* Fabricius (legume pod borer, LPB), the most serious economic pest of legume crops in the tropics, is primarily controlled by chemical pesticide application with serious consequences for the ecosystem and human health. In this study, various concentrations of three commercial biopesticides, NeemBaan, Bactospeine (Bacillus thuringiensis (Bt) subsp. kurstaki) and Florbac® (Bt aizawai), were tested either in the field or laboratory or in both conditions. In the laboratory experiments, different concentrations of NeemBaan exhibited significant effects on the mortality of all the tested larval instars and a mortality rate of over 80% was recorded at a dose of 3000 ppm. Bactospeine was found to be more effective against M. vitrata than Florbac. Bactospeine applied at a lower dose of 500 ppm caused 100% mortality in the first-instar and second-instar larvae; however, at the same dose, Florbac® caused mortality of only 26.67%

(first instar) and 20% (second instar). In the field experiments, a higher dose of NeemBaan® (6000 ppm) significantly reduced pod damage to approximately 20% in both the first and second cropping seasons. In conclusion, neem- and Bt-based biopesticide products have insecticidal potential to be used in an integrated pest management strategy for controlling *M. vitrata* in Thailand.

Jagdish *et al.* (2014) conducted a field experiment to evaluate the relative efficacy of eight biopesticides against gram pod borer legume pod borer. The population was recorded at different days after spraying of insecticides and it was found that the number of larvae varied non-significantly different from the control in both spray application. Significant effect of bio-pesticides on percent webbing by *M. vitrata*, at First spray application showed minimum (32.00/25shoots) in NSKE 5.0 % @ 50 g/lit .The pod borer *M. vitrata* was found lowest in Spinosad 45%ww @73g.ai/ha (4.50%) , followed by NSKE 5% (4.81%) and *B. bassiana* DOR SC @ 1.89gm/lit (5.39%) as compared to control (14.49%). Grain yield varied from maximum of 1200 kg/ha in Spinosad 45%ww @ 73g.ai/ha followed by 1191.67 kg/ha as compared to 708.33kg/ha in untreated control condition.

Yule and Ramasamy (2013) conducted an experiment and reported that the legume pod borer (*Maruca vitrata*) is a major destructive insect found on the yard-long bean, causing serious damage from the flowering stage. This study was conducted to evaluate the effects of selected bio-pesticides against *M. vitrata*. Among six commercially available bio-pesticides, only *Bacillus thuringiensis* subsp. kurstaki and *B. thuringiensis* subsp. aizawai were found to be more effective against *M. vitrata* under laboratory conditions, while neem was least effective. In a field trial both *B. thuringiensis* formulations significantly reduced pod damage compared with untreated plots of the yard-long bean. These results suggest that *B. thuringiensis* formulations could become important components in an integrated pest management strategy for controlling *M. vitrata* on the yard-long bean in Thailand. However, the results of the current study imply the need for additional field trials with combinations of microbial, botanical, and chemical pesticides rather than a single bio-pesticide per treatment in the management of *M. vitrata*.

Byrappa *et al.* (2012) carried out an investigation at the Agriculture Research Station, Balajigapade, Chickaballapura district. The evaluated biopesticides were NSKE (5%), HaNPV (250 LE/ha), Bt (1kg/ha), neem oil (2%), Panchagavya (3%), Clerodendron + Cow urine extract (10%) and sequential spray of HaNPV-Bt -NSKE, Bt-NSKE-HaNPV and NSKE-HaNPVBt. FYM (9.5 t/ha) and bio-digester liquid (6,500 L/ha) were applied to organic plots. Sequential spray of insecticidal spray (Carbaryl-Endosulfan-Malathion) and recommended dose of FYM (7 t/ha), fertilizer (25:50:25 kg NPK/ha) were applied to inorganic plot. Pod borers viz., *Helicoverpa armigera* (Hübner), *Maruca testulalis* Geyer, *Exelastis atomosa* Walshinghan, *Sphenarches caffer* Zeller, *Etiella zinkenella* (Treitschke), *Lampides boeticus* Linnaeus, *Adisura atkinsoni* Moore emerged as serious pests during cropping period. Sequential spray of insecticides carbarylendosulfan-malathion applied at 45, 55 and 70 DAG, respectively recorded less insect pests abundance. Among biopesticides, sequential application of NSKE-HaNPV-Bt was effective against insect pests. HaNPV was effective against *H. armigera* larvae, but ineffective to other pod borers. Panchagavya and clerodendron + cow urine extract were ineffective in reducing the pod borer incidence. Among biopesticides treated plots, sequential application of NSKE-HaNPV-Bt recorded higher grain yield (10.01q/ha) whereas, package of practices followed treatment (inorganic plot) recorded 11.37 q/ha grain.

Visalakshmi *et al.* (2005) investing the impact of IPM against *H. armigera* on chickpea and the IPM included five sprays i.e. neem-Ha NPV-endosulfan-neem - Ha NPV + bird perches @ one /plot on the day of first spray. They found that neem effectively reduced the oviposition by *H. armigera* throughout the cropping period. The integration of various {PM components was found to be the best in reducing the pod damage (10.4%) with highest grain yield (1264.4 kg/ha) with 58.5% increase in yield over control (797.9 kg/ha) and highest cost benefit ratio 1:3.01. Among various IPM components, neem and NPV were as effective as endosulfan in reducing the larval population and pod damage.

Hussan (1999) tested the insecticidal efficacy of neem extracts to eggs and second larvae of *Helicoverpa armigera* using potters toward, spray at concentration at 100, 150 and 200 mg/liter at neem seed karnel extract containing 2.5 per cent Azadirachtin. An artificial food source for larvae was also treated with neem seed karnel extract and reported it as strongly antifeedant. The results indicated that neem has the potential to contribute to the control of *Helicoverpa armigera* (Hub.)

Jacob and Sheila (1994) carried out an experiment to test the leaf extract of neem against the leaf caterpillar *Selepa docilis* at 5% concentration and reported a high anti-feedant action with a feeding ratio of 28.29 followed by 3% having only medium anti-feedant properties with 23.89 as the feeding ratio.

Simmonds *et al.* (1992) reported that seeds and leaves of the neem tree comprehend 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. The active terpenoids in neem leaves include thionemone, nimbin and deactylnimbin.

Stoll (1992) recorded the potential benefits of different botanical pesticides which diminish the risk of resistance development, natural enemy elimination, secondary out break of pests and ensure overall safety to the environment.

Jayaraj (1991) stated that Entomologist of many countries including India, The Philippines, Pakistan and Bangladesh has conducted various studies of neem against different insect pests with a particular concentration of the neem extract. Neem seed kernel extracts (3-5%) were effective against *Nilaparbata lugens, Nephotettix* spp., *Marasmia patnalis, Oxya nitidula* and Asian gall midge. He also reported that neem leaf extract is less effective than neem seed kernel extract. But the same extract of 5-10% was highly effective, inclusive of *Scirpophaga incertulus* and thrips.

Krishnaiah and Kalode (1991) reported that most of the cases, the user of neem oil use it at different doses ranged from 0.5-50% when they use different emulsifier to mixe neem oil with the water. After mixing neem oil normally stays separately on the upper surface of the water.

Grainge and Ahmed (1988) reported from an experiment that the good effectiveness of neem oil against 87 arthropods and 5 nematodes, 100 insects and mites and 198 different species of insects, respectively. They also reported that neem seed oil, as a botanical pesticide have also been used to control different insect pests of important agricultural crops in different countries of the world. More than 2000 species of plants have been reported to posses' insecticidal properties and the neem tree is one of the important among them.

Dreyer (1987) conducted an experiment and reported that neem product have been used to control vegetable pests under field condition and good control of *Plutella xylostella* and Pyralid, *Hellula undalis* was control effectively with weekly application of 25 or 50 g neem kernel powder/liter of water. He also reported that 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. In Thailand, a field investigation revealed that piperanyl butoxide increased the efficacy of neem and the combination was as active as cypermethrin (0.025%) against *Plutella xylostella* and *Spodoptera litura*, which revealed that neem oil with synthetic insecticides may have some synergetic effect in controlling insect pests.

2.2 Effect of chemical insecticide in controlling insect pests

Kumbhar *et al*. (2017) carried out an experiment at pulse section of Agriculture Research Institute (ARI) Tandojam. The results revealed that the control plot showed maximum population of *Helicoverpa armigera* throughout the study period. Whereas, after spraying novel pesticide (Radiant) at 100 ml/acre, results were maximum found as (0.75, 0.70, 0.80/plant) after 24 hours, (0.86, 0.80, 0.91/plant) after 48 hours, (0.91, 0.97, 0.94/plant) after 72 hours, (1.03, 1.08, 1.14/plant) after one week and (1.41, 1.68, 1.98/plant) after two weeks. Whereas, after the spraying of (Belt) at 50 ml/acre results (0.75, 0.80, 0.75/plant) after 24 hours, (0.80, 0.75, 0.91/plant) after 48 hours, (0.86, 0.91, 0.96/plant) after 72 hours, (1.01, 1.10, 1.05/plant) after one week and (1.41, 1.71, 1.98/plant) after two weeks were depicted. The result further revealed that (0.75, 0.70, 0.75/plant) after 24 hours, (0.86, 0.80, 0.86/plant) after 48 hours, (0.96, 1.01, 0.89/plant) after 72 hours, (0.98, 1.17, 1.10/plant) after one week and (1.42, 1.68, 1.98/plant) after two weeks after the application of (Steward) at 90 ml/acre. In conclusion the study resulted that Radiant pesticide showed maximum effects on the population reduction of *H. armigera* in Chickpea crop followed by Belt and Steward, respectively.

Yule and Srinivasan (2014) conducted experiments and reported that the potential of bio-pesticide application under field conditions in combination with chemical pesticides against the pest moth *Maruca vitrata* on yard-long bean. Four field trials were conducted at two locations (AVRDC East and Southeast Asia Regional Research and Training Station, and farmers' fields in Kamphaeng Saen, Thailand). Findings revealed that the yard-long bean pod damage by *M. vitrata* was significantly reduced by 23-85%, with substantial yield increases (22-190%) in *Bacillus thuringiensis*-based treatments in combination with cypermethrin, when compared with the untreated check. Although the combined effect of cypermethrin with *Beauveria bassiana* or neem-based treatments was better than the untreated check, the pod damage was still higher in these treatments, and infestation was recorded up to 26.87% compared with *B.*

thuringiensis subsp. *aizawai*-treated plots. Based on the findings it may be concluded that *B. thuringiensis* is a promising component for integrated pest management strategies against *M. vitrata* on yard-long bean in Thailand.

Muthomi *et al*. (2008) carried out an experiment to assess the effectiveness of dimethoate 40 EC and copper oxychloride mixture in the management of legume pests and diseases was tested in field experiments. Grain legumes used were the common bean (*Phaseolus vulgaris* L. var. GLP 2), the lima bean (*Phaseolus lunatus* L.), the green gram (*Vigna radiate* L.), the lablab (*Lablab purpureus* L.) and the chickpea (*Cicer arietinum*). Findings reveled that the pesticides spray significantly reduced the incidence of legume pod borer. Pod and seed damage were significantly reduced in lablab, chickpea and green gram. Only lablab, chickpea and green gram showed significant increase in number of pods per plant and total seed yield resulting from pesticide spray. In addition, the quality of yield increased through reduction of shrivelled and discoloured seeds due to diseases. The study showed that the use of dimethoate and copper oxychloride was beneficial for the management of the common insect pests and diseases in legumes. However, studies on the optimum number of sprays, time of application and use of other control measures that are ecologically viable for the management of the pests ought to be done.

Misra *et al.* (2003) conducted an experiment and reported that combinations of selective insecticides, predators and parasites, cultural methods and resistant cultivars have potential of controlling the pest on a sustainable manner. In groundnut, monitoring pest populations to time insecticide spray application is combined with the use of cultural methods and resistant cultivars.

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

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

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

Rai and Satpathy (1999) carried out an experiment to find out the effect of sowing date and insecticides in controlling the insect pests of okra in Varanasi, Uttar Pradesh, India and reported that monocrotophos at 500 g a.i./ha controlled the jassids more effectively than cypermethrin at 50 g a.i./ha.

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

Faqir and Gul (1998) carried out a field experiment in Pakistan with okra cv. T-13, Richgreen, Perking dwarf, Pussagreen, Climsonspinless [*Clemson Spineless*] and Swat local with dimethoate 40 EC, dichlorvos 100 EC, imidacloprid 200 SL, methylparathion [parathion-methyl] 50 EC and monocrotophos + alpha-cypermethrin 42 EC were tested against cicadellids (*Amrasca devastans* [*A. biguttula* biguttula]). The findings revealed that imidacloprid 200 SL was effective in controlling the pest over a longer time period than the other insecticides used in this study. Yield was highest in plots treated with monocrotophos + alpha-cypermethrin (11.85 t/ha), which was not significantly different from 10.31 t obtained in imidacloprid treated plots. All the cultivars were susceptible to the pest of cicadellids.

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

Arora *et al*. (1996) given an overview of the insect pests insect pest infestation during 2 cropping seasons (spring-summer and rainy season). For conducting the experiment various management practices including the appropriate timing of sowing, judicious use of fertilizers, use of resistant cultivars, physical control, botanical insecticides (neem seed extracts), microbial control (*Bacillus thuringiensis*) were more effective than the control and the use of economic thresholds to take spraying decisions.

Karim (1995) carried out an experiment and reported that application of deltamethrin, cypermethrin or fenvalerate or cyfluthrin (Bethroid 0.50 EC) @ 1.0 ml/L of water may be helpful for the control of the pod borer. The red spider mite, *Tetranychus macfarlanei*, so far recorded as a minor pest in South and Central Gujarat, India, is rapidly becoming a pest causing considerable damage, aubergines.

Rai *et al.* (1995) conducted an experiment to assess the rate or multiplication of *T. macfarlanei* when they were reared on okra leaves under laboratory conditions at 29.67^0C average temperature and 87.30% average relative humidity. The maximum female birth (mx = 6.18) was on day 11 of the pivotal age. Under a given set of conditions and food supply, the mite was able to multiply on okra leaves. In the stable age-distribution, a 93% contribution was made by immature stages including egg, larva, protonymph and deutonymph.

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

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.

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

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

Atachi and Sourokou (1989) carried out an experiment with a schedule of insecticide sprays using decis (Deltamethrin) and systoate (Dimethoate) on 35, 45, 55 and 65 days after planting (DAP) to determine the most effective controlling measures against the pyralid *M. testulalis* on cowpea. Findings revealed that the 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 against pyralid *M. testulalis*. However, at lower infestation level, application of insecticide would not be economically and environmentally advisable.

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

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

Srinivasan and Krishnakumar (1988) carried out an experiment in Karnataka, India to determine the optimum time and spray interval for application of 0.05% monocrotophos (Nuvacron 40 EC) for the control of the cicadellid, *Amrasca biguttula biguttula*. From the findings of the experiment it was revealed that two applications of monocrotophos, 21 and 35 days after germination, gave the most effective and economical control. They also reported that the application of carbofuran (Furadan 3G) @ 1 kg a.i./ha at sowing did not control cicadellids in later stages of crop growth and yield was reduced by 37.9% in comparison with the most effective treatment.

Kumar and Urs (1988) evaluated the seasonal incidence of *Earias vittella* on bean in Karnataka, India and reported that infestation of shoots and fruits started in the 2nd and 6th weeks after germination, respectively. Crops sown in any month had infested shoots from the 3rd to 5th weeks in both years of the study. The infestation level on fruits varied from 8.4 to 53.8 and 9.2 to 73.2% in different weeks. The pooled data revealed an infestation level varying from 12.6% to 32.6% and 13.6% to 46.7% in crops sown in different months, respectively. Infestation was more severe in crops sown in warmer months than in those sown in rainy or cooler months.

As per the above cited reviews, it may be concluded that bio-pesticides with chemical pesticides play an important role for controlling pod borer of yard long bean and also help for attaining optimum growth and as well as highest yield. The literature revealed that the effects of bio-pesticides with chemical pesticides have not been studied well and have no definite conclusion for the effectiveness of different control methods against pod borer in yard long bean in the agro climatic condition of Bangladesh.

Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to evaluate the effectiveness of some biopesticides and chemical pesticides to manage legume pod borer on yard long bean. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area and also the materials that were used for the experiment i.e. treatment and design of the experiment, growing of crops, data collection and data analysis procedure of this experiment has been presented under the following headings-

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from April to August, 2017.

3.1.2 Experimental location

The present research work was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Climatic condition

The climatic condition of experimental site is subtropical and characterized by three distinct seasons, the Rabi from November to February and the Kharif-I, pre-monsoon period or hot season from March to April and the Kharif-II monsoon period from May to October. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix II. During the experimental period the maximum temperature (36.5^0C), highest relative humidity (84%) and highest rainfall (567 mm) was recorded in the month of July, 2017, whereas the minimum temperature (23.1^0C), minimum relative humidity (67%) and total rainfall (117 mm) was recorded for the month of April, 2017.

3.1.4 Soil characteristics

The general soil type of the experimental field was Shallow Red Brown Terrace soil and it is belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28). A composite sample of the experimental field was made by collecting soil from several spots of the field at a depth of 0-15 cm before starting of the experiment. The collected soil was air-dried, grind and and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 5.8 and 1.16%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay. Details morphological, physical and chemical properties presented in Appendix III.

3.2 Experimental details

3.2.1 Planting material

The seeds of BARI yard long bean-1 were used as the test crop under the study.

3.2.2 Treatment of the experiment

The experiment comprised six treatments including an untreated control of the following bio-pesticides and chemical pesticides -

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

3.2.3 Collection and preparation of treatment components

3.2.3.1 Preparation of neem seed kernel

Neem seeds were selected as a botanicals under the research work.

Preparation of neem seed kernel solution

Drying and grinding:

- After collection of neem seeds were washed with water and kept in the shade up to 15 days for air-drying.
- The dried materials (seed/fruit) were ground separately with electrical grinder and sieving through 0.66 mm diameter sieve to obtain fine dusts.
- The dust was being preserved into plastic pot at low temperature upto Use.

3.2.3.2 Preparation of neem leaf extract

The leaves of neem used for the experiment was collected from trees in and around the university campus. After bringing leaves to the laboratory, they were washed in running tap water. Firstly, the plant materials were kept in the shade for air-drying and then dried in the oven at 60^0C to gain constant weight. Dusts were prepared by pulverizing the dried leaves with the help of a grinder. Then dusts were passed through a 25-mesh diameter sieve to obtain fine and uniform materials. The dusts were preserved in airtight condition in polythene bags and were used mixed with trix detergent @ 10 ml/L of water.

3.2.3.3 Application of different treatments

Neem oil, neem seed kernel extract, Bishkatali leaf extract and Oshtad, Voliam Flexi, Spinosad were sprayed in assigned plots and dosages by using knapsack sprayer. The spraying was always done in the afternoon to avoid bright sunlight to safe the foraging beneficial insects. The spray materials were applied uniformly to obtain complete coverage of whole plants of the assigned plots in 7 days interval. Caution was taken to avoid any drift of the spray mixture to the adjacent plots at the time of the spray application. At each spray application the spray mixture was freshly prepared.

3.2.4 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, where the experimental area was divided into three equal blocks representing the replications to minimize the soil heterogenetic effects. Each block was divided into 7 equal unit plots demarked with raised bunds for allocating different treatments. Thus the total numbers of plots were 21. The unit plot size was 3.0 m × 2.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.3 Growing of crops

3.3.1 Seed collection and sprouting

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 before sowing in the polyethylene bags.

3.3.2 Raising of seedlings

Seeds were directly sown in the 23th April, 2017 in polyethylene bags (12 cm × 18 cm) containing a mixture of equal proportion of well decomposed cowdung and irrigated regularly to bring moist condition for proper seed germination. After germination the seedlings were sprayed with water by a hand sprayer for easy uprooting and it was done once a day for one week.

3.3.3 Land preparation

The main plot which select for conducting the experiment was opened in the last week of April, 2017 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed accordingly. The experimental main plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated 3.3.4 were mixed with the soil of each unit plot.

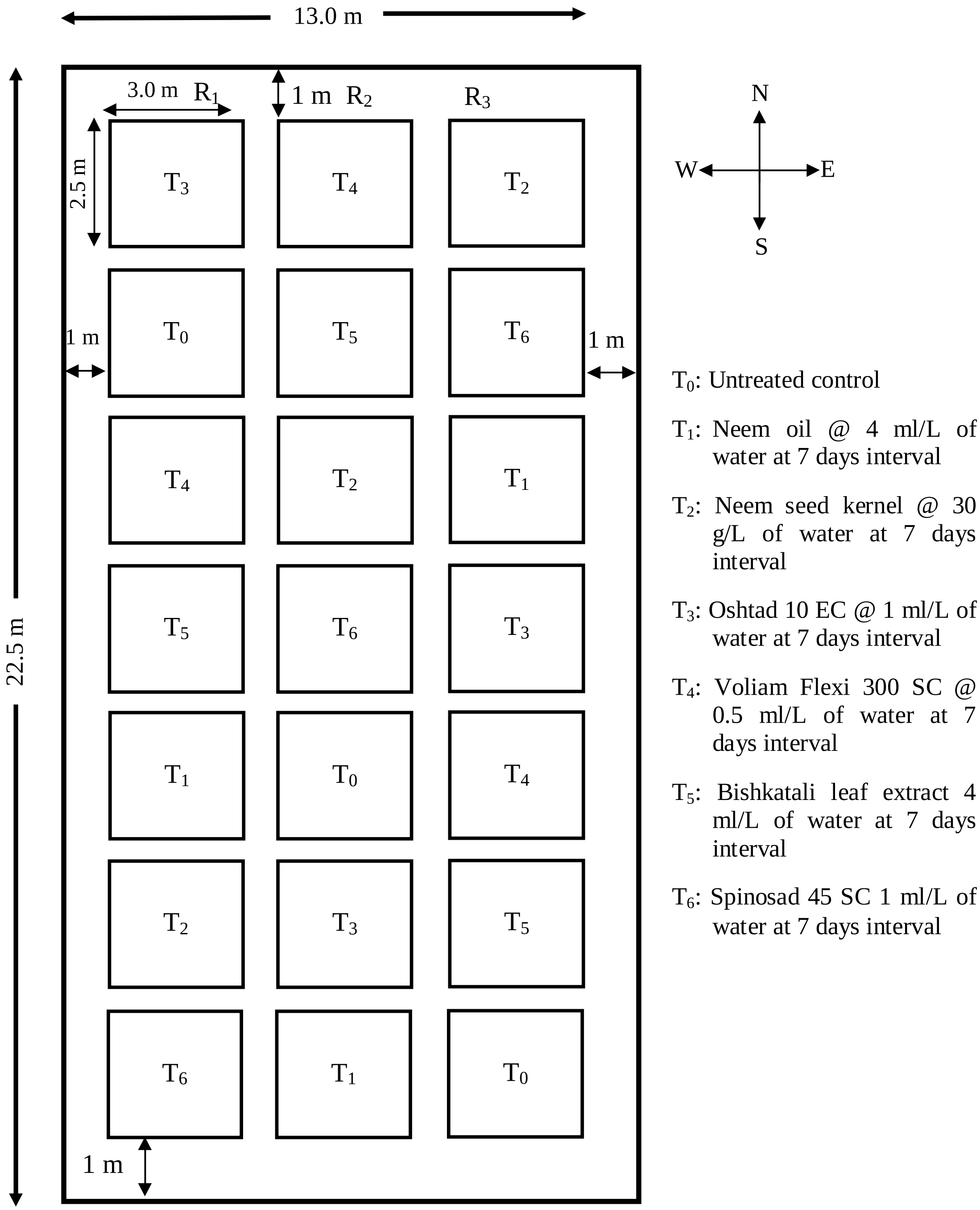


Figure 1. Layout of the experimental plot

3.3.4 Fertilizers and manure application

Standard dosages of cowdung and fertilizers were applied as recommended by Rashid (1993) for yard long bean @ 12 kg of cowdung, 60 g urea, 100 g TSP and 100 g MP respectively per pit of each plot. Again 30 g urea was applied as top dressing after each flush of flowering and fruiting in three equal splits.

3.3.5 Transplanting of seedling

Seedlings were placed in a shady place and were transplanted on May 08, 2017 in the pits of each plot 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. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were done.

3.3.6.1 Irrigation and drainage

Irrigation was provided to maintain moist condition in the early stages to establishment of the seedlings and then irrigated when ever necessary throughout the entire growing period. No water stress was encountered in reproductive phase.

3.3.6.2 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 30 DAT and 60 DAT by mechanical means.

3.4 Harvesting of pods

Harvesting of pods was done when the pods attained marketable sized**.** The optimum marketable sized pods were collected by hand picking of each plot and yield was converted into t/ha.

3.5 Monitoring and data collection

The yard long bean plants under different treatment were closely examined at regular intervals. The following data were collected during the course of the experiment.

- Number of healthy fruits
- Number of infested fruit
- Fruit infestation in number (%)
- Weight of healthy fruits
- Weight of infested fruit
- Fruit infestation in weight (%)
- Length of edible portion (cm)
- Edible portion of fruit (%)
- Length of non-edible portion (cm)
- Non-edible portion of fruit (%)
- Number of pods per plant
- Length of healthy pods (cm)
- Diameter of healthy pods (mm)
- Yield per plot (kg)
- Yield per hectare (ton)

3.6 Apparatus and instruments used

Weighing balance was used for taking weight of healthy and infested pods. Polythene bag, mosquito net and iron cases were used for adult moth identification.

3.7 Determination of pod infestation in number

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

$$\% \text{ Pod infestation} = \frac{\text{Number of infested pods}}{\text{Total number of pods}} \times 100$$

3.8 Determination of pod infestation in weight

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

$$\% \text{ Pod infestation} = \frac{\text{Weight of infested pods}}{\text{Total weight of pods}} \times 100$$

3.9 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the characters were calculated and analysis of variance was performed by using MSTAT-C software. The significance of the difference among the treatments means was estimated by the by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to evaluate the effectiveness of some biopesticides and chemical pesticides to manage legume pod borer on yard long bean. Data on number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight basis, yield contributing characters and yield of yard long bean were recorded. The analyses of variance (ANOVA) of the data on different recorded parameters are presented in Appendix IV-XI. The results have been presented and discussed, and possible explanations have been given under the following headings and sub-headings:

4.1 At early pod development stage

4.1.1 Pod bearing status in number basis

Number of healthy and infested pods, infestation percentage at early pod development stage showed statistically significant differences due to different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 1). The highest number of healthy pods per plant (20.53) was recorded from T_1 (Neem oil @ 4 ml/L of water at 7 days interval) treatment which was statistically similar (19.07 and 18.80) to T_6 (Spinosad 45 SC 1 ml/L of water at 7 days interval) and T_2 (Neem seed kernel @ 30 g/L of water at 7 days interval) and closely followed (17.60, 16.80 and 16.40) by T_3 (Oshtad 10 EC @ 1 ml/L of water at 7 days interval), T_4 (Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval) and T_5 (Bishkatali leaf extract 4 ml/L of water at 7 days interval) treatment and they were statistically similar, whereas the lowest number of healthy pods per plant (12.80) was found from T_0 (untreated control) treatment. The lowest number of infested pods per plant was obtained from T_1 (0.27) treatment which was statistically similar to T_6 (0.40) treatment and closely followed by T_2 (0.67) and T_3 (0.87) treatment. On the other hand, the highest number of infested pods was obtained from T_0 (2.13) treatment which was followed by T_5 (1.13) and T_4 (1.07) treatment and they were statistically similar.

Table 1. Effect of different bio-pesticides and chemical pesticides in controlling the insect pests of yard long bean at early pod development stage by number

Treatments	**Number of pods**		**Infestation**	
	Healthy	**Infested**	**Percentage (%)**	**Reduction over control (%)**
T_0	12.80 c	2.13 a	14.32 a	--
T_1	20.53 a	0.27 e	1.26 e	91.20
T_2	18.80 ab	0.67 d	3.43 d	76.05
T_3	17.60 b	0.87 cd	4.69 c	67.25
T_4	16.80 b	1.07 bc	5.99 b	58.17
T_5	16.40 b	1.13 b	6.47 b	54.82
T_6	19.07 ab	0.40 e	2.08 e	85.47
$LSD_{(0.05)}$	**2.591**	**0.245**	**1.173**	**--**
CV(%)	**8.36**	**14.66**	**12.07**	**--**

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

In case of percent pod infestation, the lowest infested pods per plant in number basis was observed from T_1 (1.26%) treatment which was statistically similar to T_6 (2.08%) and closely followed by T_2 (3.43%) treatment, again the highest infested pods (14.32%) was recorded in T_0 which was followed by T_5 (6.47%) and T_4 (5.99%) treatment and they were statistically similar. Pod infestation reduction over control in number was calculated and the highest value was found from the treatment T_1 (91.20%) and the lowest reduction of pod infestation over control was recorded from T_5 (54.82%) treatment. Yule and Srinivasan (2013) reported that yard long bean growers face serious losses at pod harvest caused by *M. vitrata* infestation and consequently employ an array of agronomic management regimes such as application of conventional insecticides which cause adverse effects to the environment and human health, but fail to achieve satisfactory level of control.

4.1.2 Pod bearing status in weight basis

Statistically significant differences was recorded in terms of weight of healthy and infested pods and infestation percentage at early pod development stage due to different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 2). In weight basis, the highest weight pods per plant was recorded from T_1 (183.61 g) treatment which was statistically similar to T_6 (178.64 g) and T_2 (172.62 g) closely followed by T_3 (165.00 g) treatment, while the lowest weight of healthy pods per plant (122.43 g) was found from T_0 treatment. The lowest weight of infested pods per plant was obtained from T_1 (10.34 g) treatment which was statistically identical to T_6 (11.33 g) treatment and closely followed by T_2 (12.60 g) treatment. On the other hand, the highest weight of infested pods was obtained from T_0 (25.83 g) treatment which was followed by T_5 (12.60 g) treatment. In terms of percent pod infestation, the lowest infested pods per plant in weight basis was observed from T_1 (5.33%) treatment which was statistically similar to T_6 (5.98%) and closely followed by T_2 (6.81%) treatment, again the highest infested pods (17.46%) was recorded in T_0 which was followed by T_5 (8.84%) and T_4 (8.17%) treatment and they were

Table 2. Effect of different bio-pesticides and chemical pesticides in controlling the insect pests of yard long bean at early pod development stage by weight

Treatments	Pods weight (g)		Infestation	
	Healthy	Infested	Percentage (%)	Reduction over control (%)
T_0	122.43 e	25.83 a	17.46 a	--
T_1	183.61 a	10.34 e	5.33 e	69.47
T_2	172.62 abc	12.60 cd	6.81 cd	61.00
T_3	165.00 bcd	13.92 bc	7.80 bc	55.33
T_4	158.16 cd	14.08 b	8.17 b	53.21
T_5	151.55 d	14.68 b	8.84 b	49.37
T_6	178.64 ab	11.33 de	5.98 de	65.75
$LSD_{(0.05)}$	**14.84**	**1.336**	**1.238**	--
CV(%)	**5.16**	**5.11**	**8.06**	--

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

statistically similar. Pod infestation reduction over control in weight basis was calculated and the highest value was found from the treatment T_1 (69.47%) and the lowest reduction of pod infestation over control was recorded from T_5 (49.37%) treatment. Neem leaf extract of 5-10% was highly effective, inclusive of controlling pod borer (Jayaraj, 1991).

4.2 At mid pod development stage

4.2.1 Pod bearing status in number basis

Statistically significant variation was recorded in number of healthy and infested pods and infestation percentage at mid pod development stage for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 3). The highest number of healthy pods per plant was recorded from T_1 (27.07) treatment which was statistically similar to T_6 (26.00), T_2 (24.80) and T_3 (24.27) and closely followed by T_4 (23.53), while the lowest number of healthy pods per plant was found from T_0 (19.33) treatment which was statistically similar to T_5 (22.27). The lowest number of infested pods per plant was obtained from T_1 (0.67) treatment which was statistically similar to T_6 (0.87) treatment and closely followed by T_2 (1.00) treatment. On the other hand, the highest number of infested pods was obtained from T_0 (3.87) treatment which was followed by T_5 (1.67) and T_4 (1.47) treatment and they were statistically similar. In terms of percent pod infestation, the lowest infested pods per plant in number basis was observed from T_1 (2.42%) treatment which was statistically similar to T_6 (3.22%) and T_2 (3.95%) treatment and they were statistically similar, whereas the highest infested pods (16.68%) was recorded in T_0 which was followed by T_5 (7.00%) and T_4 (5.91%) treatment and they were statistically similar. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (85.49%) and the lowest reduction of pod infestation over control was recorded from T_5 (58.03%) treatment. Dreyer (1987) earlier reported that neem product has been used to control pests under field condition and good control of pod borer.

Table 3. Effect of different bio-pesticides and chemical pesticides in controlling the insect pests of yard long bean at mid pod development stage by number

Treatments	Number of pods		Infestation	
	Healthy	Infested	Percentage (%)	Reduction over control (%)
T_0	19.33 d	3.87 a	16.68 a	--
T_1	27.07 a	0.67 e	2.42 e	85.49
T_2	24.80 abc	1.00 cd	3.95 de	76.32
T_3	24.27 abc	1.13 c	4.47 cd	73.20
T_4	23.53 bc	1.47 b	5.91 bc	64.57
T_5	22.27 cd	1.67 b	7.00 b	58.03
T_6	26.00 ab	0.87 de	3.22 de	80.70
$LSD_{(0.05)}$	**3.115**	**0.252**	**1.528**	**--**
CV(%)	**7.33**	**9.21**	**13.78**	**--**

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

4.2.2 Pod bearing status in weight basis

Weight of healthy and infested pods and infestation percentage at mid pod development stage showed statistically significant differences for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 4). In weight basis, the highest weight pods per plant was recorded from T_1 (227.26 g) treatment which was statistically similar to T_6 (224.80 g), T_2 (218.85 g), T_3 (215.65 g) and T_4 (209.25 g) treatment and closely followed by T_5 (201.65 g), while the lowest weight of healthy pods per plant (172.66 g) was found from T_0 treatment. The lowest weight of infested pods per plant was obtained from T_1 (13.93 g) treatment which was statistically similar to T_6 (16.05 g) treatment and closely followed by T_2 (18.34 g) treatment. On the other hand, the highest weight of infested pods was obtained from T_0 (38.12 g) treatment which was followed by T_5 (22.86 g) and T_4 (21.37 g) treatment and they were statistically similar. In terms of percent pod infestation, the lowest infested pods per plant in weight basis was observed from T_1 (5.76%) treatment which was statistically similar to T_6 (6.67%) and closely followed by T_2 (7.79%) treatment, again the highest infested pods (18.12%) was recorded in T_0 which was followed by T_5 (10.19%) and T_4 (9.28%) treatment and they were statistically similar. Pod infestation reduction over control in weight basis was estimated and the highest value was found from the treatment T_1 (68.21%) and the lowest reduction of pod infestation over control was recorded from T_5 (43.76%) treatment. Dreyer (1987) reported that a methanol suspension of 2-4% of the neem leaves have been used against the pod borer and it was as effective as either synthetic insecticides mevinphous (0.05%) or deltamethrin in (0.02%). On the other hand a field trail showed that piperanyl butoxide increased the efficacy of neem and the combination was as active as cypermethrin (0.025%) against *Plutella xylostella* and *Spodoptera litura*, which revealed that neem oil with synthetic insecticides, may have some synergetic effect in controlling insect pests of different vegetable crops (Yule and Srinivasan, 2013).

Table 4. Effect of different bio-pesticides and chemical pesticides in controlling the insect pests of yard long bean at mid pod development stage by weight

Treatments	Pods weight (g)		Infestation	
	Healthy	Infested	Percentage (%)	Reduction over control (%)
T_0	172.66 c	38.12 a	18.12 a	--
T_1	227.26 a	13.93 e	5.76 e	68.21
T_2	218.85 ab	18.34 cd	7.79 cd	57.01
T_3	215.65 ab	20.67 bc	8.75 bc	51.71
T_4	209.25 ab	21.37 b	9.28 bc	48.79
T_5	201.65 b	22.86 b	10.19 b	43.76
T_6	224.80 a	16.05 de	6.67 de	63.19
$LSD_{(0.05)}$	**17.15**	**2.734**	**1.678**	--
CV(%)	**4.59**	**7.11**	**9.92**	--

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

4.3 At late pod development stage

4.3.1 Pod bearing status in number basis

Number of healthy and infested pods and infestation percentage at late pod development stage varied significantly due to different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 5). The highest number of healthy pods per plant was recorded from T_1 (21.47) treatment which was statistically similar to T_6 (20.73), T_2 (20.47), T_3 (19.67) and T_4 (19.40) treatment and they were statistically similar, whereas the lowest number of healthy pods per plant was found from T_0 (13.53) treatment which was closely followed by T_5 (18.67). The lowest number of infested pods per plant was obtained from T_1 (0.67) treatment which was statistically similar to T_6 (0.87) treatment and closely followed by T_2 (1.07) treatment. On the other hand, the highest number of infested pods was obtained from T_0 (2.93) treatment which was followed by T_5 (1.93) treatment. In terms of percent pod infestation, the lowest infested pods per plant in number basis was observed from T_1 (3.03%) treatment which was statistically similar to T_6 (4.02%) and closely followed by T_2 (5.00%) treatment, again the highest infested pods (17.84%) was recorded in T_0 which was followed by T_5 (9.38%) treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (83.02%) and the lowest reduction of pod infestation over control was recorded from T_5 (47.42%) treatment.

4.3.2 Pod bearing status in weight basis

Statistically significant variation was observed in terms of weight of healthy and infested pods, percent infestation at late pod development stage for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 6). In weight basis, the highest weight pods per plant was recorded from T_1 (178.23 g) treatment which was statistically similar to T_6 (174.85 g), T_2 (171.28 g), T_3 (168.71 g) and T_4 (164.57 g) treatment, while the lowest weight of healthy pods per plant (127.68 g) was found from T_0 treatment

Table 5. Effect of different bio-pesticides and chemical pesticides in controlling the insect pests of yard long bean at late pod development stage by number

Treatments	Number of pods		Infestation	
	Healthy	Infested	Percentage (%)	Reduction over control (%)
T_0	13.53 c	2.93 a	17.84 a	--
T_1	21.47 a	0.67 f	3.03 f	83.02
T_2	20.47 ab	1.07 de	5.00 de	71.97
T_3	19.67 ab	1.27 d	6.06 d	66.03
T_4	19.40 ab	1.53 c	7.33 c	58.91
T_5	18.67 b	1.93 b	9.38 b	47.42
T_6	20.73 ab	0.87 ef	4.02 ef	77.47
$LSD_{(0.05)}$	**2.180**	**0.218**	**1.238**	**--**
CV(%)	**6.40**	**8.42**	**9.25**	**--**

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

Table 6. Effect of different bio-pesticides and chemical pesticides in controlling the insect pests of yard long bean at late pod development stage by weight

Treatments	Pods weight (g)		Infestation	
	Healthy	Infested	Percentage (%)	Reduction over control (%)
T_0	127.68 c	31.74 a	19.87 a	--
T_1	178.23 a	12.41 d	6.50 e	67.29
T_2	171.28 ab	16.52 bc	8.81 cd	55.66
T_3	168.71 ab	17.01 bc	9.17 bcd	53.85
T_4	164.57 ab	18.51 b	10.13 bc	49.02
T_5	161.66 b	19.44 b	10.73 b	46.00
T_6	174.85 ab	14.65 cd	7.73 de	61.10
$LSD_{(0.05)}$	**13.00**	**3.222**	**1.515**	**--**
CV(%)	**4.46**	**9.73**	**8.17**	**--**

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

which was followed by T_5 (161.66 g) treatment. The lowest weight of infested pods per plant was obtained from T_1 (12.41 g) treatment which was statistically similar to T_6 (14.65 g) treatment and closely followed by T_2 (16.52 g) and T_3 (17.01 g) treatment and they were statistically similar. On the other hand, the highest weight of infested pods was obtained from T_0 (31.74 g) treatment which was followed by T_5 (19.44 g) and T_4 (18.51 g) treatment and they were statistically similar. In terms of percent pod infestation, the lowest infested pods per plant in weight basis was observed from T_1 (6.50%) treatment which was statistically similar to T_6 (7.73%) and closely followed by T_2 (8.81%) and T_3 (9.17%) treatment and they were statistically similar, again the highest infested pods (19.87%) was recorded in T_0 which was followed by T_5 (10.73%) and T_4 (10.13%) treatment and they were statistically similar. Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_1 (67.29%) and the lowest reduction of pod infestation over control was recorded from T_5 (46.00%) treatment. Fagoonee (1986) conducted an experimeny with different neem products in vegetable crop protection in pod borer and showed neem seed kernel extract was found to be effective as deltamethrin (Decis) against the infestation of pod borer and found that neem extract alternate with insecticides gave best protection against these insect pests. Chakraborty *et al*. (2002) also reported from earlier experiment that application of methomyl (Lannate 40 SP; at 150, 300 and 450 g a.i./ha) and/or 60 g cypermethrin/ha or 250 g quinalphos/ha was best insecticides for controlling pod borer in yard long bean.

4.4 Yield attributes and yield of yard long bean

4.4.1 Length of edible portion

Length of edible portion of yard long bean varied significantly due to the application of different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean under the present study (Table 7). Data revealed that the longest edible portion was found from T_1 (43.63 cm) treatment which was statistically similar to other treatment of this study except T_0 and the shortest edible portion was observed from T_0 (36.68 cm) treatment.

4.4.2 Percentage of edible portion

Statistically significant variation was found for percentage of edible portion for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 7). The highest percentage of edible portion was observed from T_1 (96.73%) which was statistically similar with T_6 (95.67%), T_2 (92.33%) and T_4 (89.87%) and followed by T_4 (85.53%), while the highest percentage of edible portion was recorded from T_0 (56.53%) treatment.

4.4.3 Length of non-edible portion

Length of non-edible portion of yard long bean showed statistically significant differences for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 7). The shortest non-edible portion was found from T_1 (10.46 cm) which was statistically similar to T_6 (10.66 cm), T_2 (11.49 cm) and T_3 (11.74 cm), while the longest non-edible portion was recorded from T_0 (18.49 cm) treatment.

4.4.4 Percentage of non-edible portion

Statistically significant variation was observed for non-edible portion of infested yard long bean due to different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean under the present study (Table 7). The shortest non-edible portion was recorded from T_1 (3.27%) which was statistically similar to T_6 (4.33%), T_2 (7.67%) and T_4 (10.13%), whereas the highest non-edible portion was found from T_0 (43.47%) treatment.

Table 7. Effect of different bio-pesticides and chemical pesticides on edible and non edible part by length and portion of yard long bean

Treatments	Length of edible part (cm)	Edible portion (%)	Length of non-edible part (cm)	Non edible portion (%)
T_0	36.68 b	56.53 d	18.49 a	43.47 a
T_1	43.63 a	96.73 a	10.46 c	3.27 d
T_2	42.77 a	92.33 ab	11.49 bc	7.67 cd
T_3	42.34 a	89.87 ab	11.74 bc	10.13 cd
T_4	42.08 a	85.53 bc	12.10 b	14.47 bc
T_5	41.57 a	81.53 c	12.48 b	18.47 b
T_6	43.23 a	95.67 a	10.66 c	4.33 d
$LSD_{(0.05)}$	**3.933**	**7.585**	**1.278**	**7.585**
CV(%)	**5.29**	**4.99**	**5.75**	**9.32**

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

4.4.5 Number of pods per plant

Number of pods per plant of yard long bean showed statistically significant differences for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean (Table 8). The highest number of pods per plant was found from T_1 (70.67) which was statistically identical with T_6 (67.93), T_2 (66.80) and T_3 (64.80), whereas the lowest number was observed from T_0 (54.60) which was followed by T_5 (62.07) treatment.

4.4.6 Length of healthy pod

Length of healthy pod of yard long bean showed statistically significant variation for different bio-pesticides and chemical pesticides treatments in controlling pod borer of yard long bean under the present study (Figure 2). Data revealed that the longest healthy pod was observed from T_1 (37.74 cm) which was statistically similar with other treatments except T_0 and the shortest healthy pod was found from T_0 (31.31 cm) treatment.

4.4.7 Diameter of healthy pod

Statistically significant variation was recorded in terms of diameter of healthy pod of yard long bean for different bio-pesticides and chemical pesticides treatments in controlling pod borer (Figure 3). The highest diameter of healthy pod was found from T_1 (32.16 mm) which was statistically similar with other treatments except T_0, while the shortest was recorded from T_0 (26.32 mm) treatment.

4.4.8 Yield per plot

Yield per plot of yard long bean showed statistically significant variation for different bio-pesticides and chemical pesticides treatments in controlling pod borer (Table 8). The highest yield per plot was recorded from T_1 (16.32 kg) which was statistically similar with other treatment except T_0 and T_5, whereas the lowest was recorded from T_0 (10.61 kg) which was closely followed by T_5 (14.33 kg) treatment.

Table 8. Effect of different bio-pesticides and chemical pesticides on pods per plant in number, yield per plot and hectare of yard long bean

Treatments	Pods per plant (No.)	Yield per plot (kg)	Yield per hectare (ton)
T_0	54.60 c	10.61 c	14.15 c
T_1	70.67 a	16.32 a	21.76 a
T_2	66.80 ab	15.79 ab	21.05 ab
T_3	64.80 ab	15.29 ab	20.39 ab
T_4	63.80 b	14.73 ab	19.64 ab
T_5	62.07 b	14.33 b	19.10 b
T_6	67.93 ab	16.08 ab	21.44 ab
$LSD_{(0.05)}$	**5.800**	**1.676**	**2.235**
CV(%)	**5.06**	**6.40**	**6.40**

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

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

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

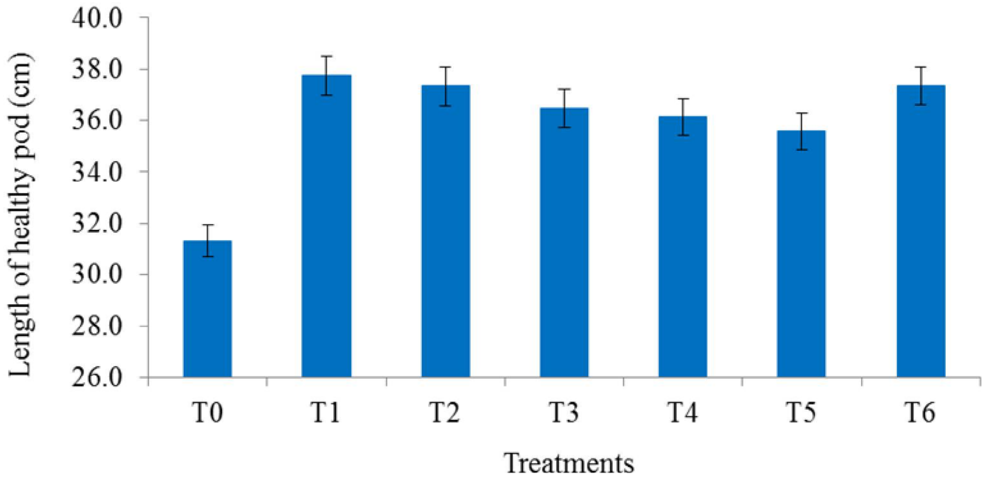


Figure 2. Effect of different bio-pesticides and chemical pesticides on length of healthy pod of yard long bean. (Vertical bars represent LSD value at 5% level of probability)

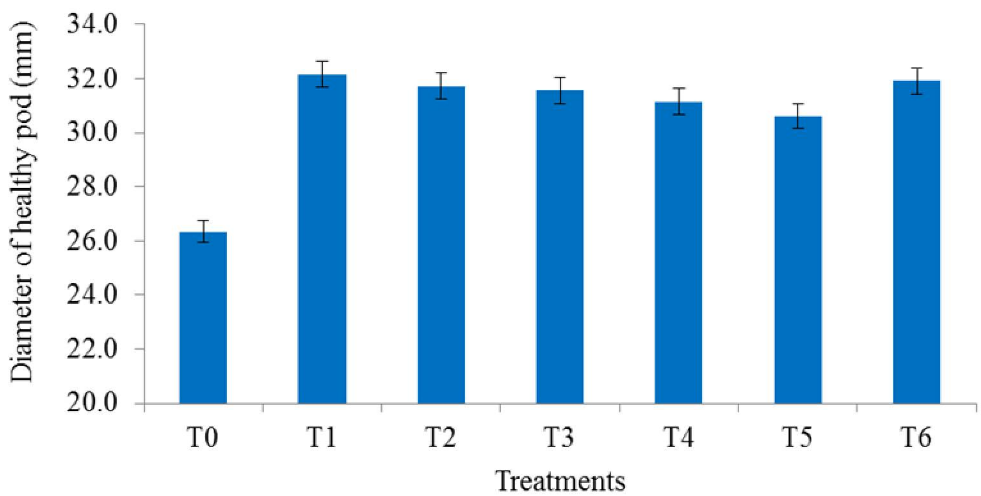


Figure 3. Effect of different bio-pesticides and chemical pesticides on diameter of healthy pod of yard long bean. (Vertical bars represent LSD value at 5% level of probability)

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

4.4.9 Yield per hectare

Yield per plot of yard long bean showed statistically significant variation for different bio-pesticides and chemical pesticides treatments in controlling pod borer (Table 8). The highest yield per hectare was recorded from T_1 (21.76 ton) which was statistically similar with other treatment except T_0 and T_5, whereas the lowest yield per hectare was recorded from T_0 (14.15 ton) which was closely followed by T_5 (19.10 ton).treatment. Yule and Srinivasan (2013) reported that yard long bean growers face serious losses at pod harvest caused by pod borer infestation and consequently employ an array of agronomic management regimes such as application of conventional insecticides which cause adverse effects to the environment and human health, but fail to achieve satisfactory level of control. Dubey *et al*. (1998) reported from earlier experiment that the filed application of 1 kg phorate a.i./ha basally + single spray of monocrotophos (0.05%) 30 DAS (days after sowing) followed by 4 sprays of cypermethrin (0.006%) (45, 55, 65 and 75 DAS) produced the lowest infestation on fruits (12.68%) and the highest marketable fruit yield.

4.5 Economic analysis

In case of yard long bean production, economic analysis was done in order to estimate the most profitable bio-pesticides and chemical pesticides based on cost and benefit of various treatments. The results of economic analysis of yard long bean cultivation revealed that T_1 treatment gave the highest net benefit as of Tk. 293,900/ha and the second highest was observed in T_6 as of Tk. 285,100/ha (Table 9). The highest benefit cost ratio (2.51) was estimated for T_1 treatment and the lowest (1.26) for T_4 treatment under the experiment. The highest BCR was found in the treatment T_1 which may be occur due to the minimum pest infestation especially pod borer compared to the other treatment and the highest yield of this treatment.

Table 9. Estimation of benefit for yard long bean cultivation by using different bio-pesticides and chemical pesticides

Treatments	Cost of pest Management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio
T_0	0	14.15	212250	212250	--	--
T_1	32500	21.76	326400	293900	81650	2.51
T_2	32500	21.05	315750	283250	71000	2.18
T_3	36500	20.39	305850	269350	57100	1.56
T_4	36500	19.64	294600	258100	45850	1.26
T_5	24500	19.1	286500	262000	49750	2.03
T_6	36500	21.44	321600	285100	72850	2.00

Price of yard long bean @ Tk. 15,000/ton

T_0: Untreated control

T_1: Neem oil @ 4 ml/L of water at 7 days interval

T_2: Neem seed kernel @ 30 g/L of water at 7 days interval

T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval

T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval

T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval

T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April to August, 2017 to evaluate the effectiveness of some biopesticides and chemical pesticides to manage legume pod borer on yard long bean. The seeds of BARI yard long bean-1 were used as the test crop in this experiment. The experiment comprised of the following bio-pesticides and chemical pesticides as treatment- T_0: Untreated control; T_1: Neem oil @ 4 ml/L of water at 7 days interval; T_2: Neem seed kernel @ 30 g/L of water at 7 days interval; T_3: Oshtad 10 EC @ 1 ml/L of water at 7 days interval; T_4: Voliam Flexi 300 SC @ 0.5 ml/L of water at 7 days interval; T_5: Bishkatali leaf extract 4 ml/L of water at 7 days interval and T_6: Spinosad 45 SC 1 ml/L of water at 7 days interval. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight basis, yield contributing characters and yield of yard long bean and observed statistically significant variation for different treatments.

At early pod development stage, in number basis, the highest number of healthy pods per plant (20.53) was recorded from T_1, whereas the lowest number (12.80) from T_0 treatment. The lowest number of infested pods per plant was obtained from T_1 (0.27) treatment and the highest number from T_0 (2.13) treatment. In terms of percent pod infestation, the lowest infested pods per plant in number basis was observed from T_1 (1.26%) treatment, again the highest (14.32%) in T_0 treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (91.20%) and the lowest from T_5 (54.82%) treatment. At early pod development stage in weight basis, the highest weight pods per plant was recorded from T_1 (183.61 g) treatment, while the lowest weight (122.43 g) was found from T_0 treatment. The lowest weight of infested pods per plant was obtained from T_1 (10.34 g) treatment and the highest weight from T_0 (25.83 g) treatment. In terms of percent pod infestation, the lowest infested pods per plant in weight basis was observed from T_1 (5.33%) treatment, again the highest infested pods (17.46%) in T_0 treatment Pod infestation reduction over control in weight basis was estimated and the highest value was found from the treatment T_1 (69.47%) and the lowest from T_5 (49.37%) treatment.

At mid pod development stage, the highest number of healthy pods per plant was recorded from T_1 (27.07) treatment, while the lowest number from T_0 (19.33) treatment. The lowest number of infested pods per plant was obtained from T_1 (0.67) treatment and the highest number from T_0 (3.87) treatment. In terms of percent pod infestation, the lowest infested pods per plant in number basis was observed from T_1 (2.42%) treatment, whereas the highest (16.68%) in T_0. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (85.49%) and the lowest from T_5 (58.03%) treatment. At mid pod development stage, the highest weight pods per plant was recorded from T_1 (227.26 g) treatment, while the lowest weight (172.66 g) from T_0 treatment. The lowest weight of infested pods per plant was obtained from T_1 (13.93 g) treatment and the highest weight from T_0 (38.12 g) treatment. In terms of percent pod infestation, the lowest infested pods per plant in weight basis was observed from T_1 (5.76%) treatment again the highest infested pods (18.12%) was recorded in T_0. Pod infestation reduction over control in weight basis was estimated and the highest value was found from the treatment T_1 (68.21%) and the lowest reduction of pod infestation over control was recorded from T_5 (43.76%) treatment.

At late pod development stage, the highest number of healthy pods per plant was recorded from T_1 (21.47) treatment, whereas the lowest number of healthy pods per plant was found from T_0 (13.53) treatment. The lowest number of infested pods per plant was obtained from T_1 (0.67) treatment and the highest number of infested pods was obtained from T_0 (2.93) treatment and the lowest infested pods per plant in number basis was observed from T_1 (3.03%) treatment again the highest infested pods (17.84%) was recorded in T_0 treatment. Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_1 (83.02%) and the lowest from T_5 (47.42%) treatment. At late pod development stage, in weight basis, the highest weight pods per plant was recorded from T_1 (178.23 g) treatment, while the lowest weight (127.68 g) from T_0 treatment. The lowest weight of infested pods per plant was obtained from T_1 (12.41 g) treatment and the highest weight from T_0 (31.74 g) treatment. In terms of percent pod infestation, the lowest infested pods per plant in weight basis was observed from T_1 (6.50%) treatment again the highest (19.87 in T_0 treatment. Pod infestation reduction over control in weight was estimated and the highest value was found from the treatment T_1 (67.29%) and the lowest from T_5 (46.00%) treatment.

The longest edible portion was observed from T_1 (43.63 cm) treatment and the shortest from T_0 (36.68 cm) treatment. The highest edible portion was recorded from T_1 (96.73%), while the highest from T_0 (56.53%) treatment. The shortest non-edible part was measured from T_1 (10.46 cm), while the longest from T_0 (18.49 cm) treatment. The shortest non-edible portion was recorded from T_1 (3.27%), whereas the highest from T_0 (43.47%) treatment. The highest number of pods per plant was recorded from T_1 (70.67), whereas the lowest number from T_0 (54.60) treatment. The longest healthy pod was recorded from T_1 (37.74 cm) and the shortest healthy pod from T_0 (31.31 cm) treatment. The highest diameter of healthy pod was recorded from T_1 (32.16 mm), while the shortest from T_0 (26.32 mm) treatment. The highest yield per plot was recorded from T_1 (16.32 kg), whereas the lowest from T_0 (10.61 kg) treatment. The highest yield per hectare was recorded from T_1 (21.76 ton), whereas the lowest yield per hectare from T_0 (14.15 ton) treatment. The highest benefit cost ratio (2.51) was estimated for T_1 treatment and the lowest (1.26) for T_4 treatment.

Conclusion

From the above discussion it can be concluded that among the different control measures, spraying of Neem oil @ 4 ml/L of water at 7 days interval was the better for the controlling pod borer of yard long bean and also attaining highest yield.

Recommendation

Due to some limitations a little number of biopesticides and chemical pesticides were used for the controlling pod borer of yard long bean. So, more biopesticides and chemical pesticides can be included for the further studies to find out the more profitable yield of yard long bean. However, further study of this experiment is also needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

REFERENCES

Adejumo, T.O. (2005). Crop protection strategies for major diseases of cocoa, coffee and cashew nut in Nigeria. *Africa J. Biotechnol*. **4**: 143-150.

Adiroubane, D. and Letchoumanane, S. (1998). Field efficiency of some botanical extracts for controlling major insect pests of okra. *Indian J. Agril. Sci*. **68**(3): 168-170.

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

Anonymous. (2014). Bangladesh Bureau of Statistics. Year book of Agricultural Statistics of Bangladesh 2012 (21st edition). Ministry of Planning. Government of the People's Republic of Bangladesh. P. 47

Arora, R.K., Dhillon, M.K., Harvir, S. and Singh, H. (1996). Management of different pest complex in Okra a research summation. *Annals. Agric. Bio. Res.* **1**(1-2): 37-45.

Atachi, P. and Sourokou, Z.C. (1989).Record of host plants of *Maruca testulalis* the republic of Benin. *Annl. Sot. Entomol.* **30**: 169-174.

Begum, R.A. (1993). Techniques of growing different legume vegetable, ***In*:** M.L. Chadha, A.K.M.A. Hossain and S.M.M. Hossain, (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.

Byrappa, A.M., Kumar, N.G. and Divya, M. (2012). Impact of biopesticides application on pod borer complex in organically grown field bean ecosystem. *J. Biopest*. **5**(2): 148-160.

Chakraborty, S., Pahari, A.K. and Chakraborty, S. (2002). Studies on the different control of important pests of okra by Lannate 40 SP. *Pestic. Res. J.* **14**(1): 100-106.

Cox, P.D., Matthews, L., Jacobson, R.J., Cannon, R., MacLeod, A. and Walters, K.F.A. (2006). Potential for the use of different biological agents for the control of Thrips palmi outbreaks. *Biocontrol. Sci. Technol.* **16**: 871-891.

Dikshit, A.K., Lal, O.P. and Srivastava, Y.N. (2000). Persistence of pyrethroid and nicotinyl insecticides on controlling pod borer of okra. *Pestic. Res. J.* **12**(2): 227-231.

Dreyer, M. (1987). Field and Laboratory trail with different simple neem products against pests of vegetable and field crops. *In*: Proceedings of the 3rd Neem Conference, Nairobi, Kenya 1986 (Editors: Schmutterer, H. and Ascher, K.) GTZ press, West Germany. pp. 425-440.

Dubey, V.K., Bhagat, K.P., Ganguli, R.N. and Yadu, Y.K. (1998). Effect of insecticides and plant products against shoot and fruit borer infestation of okra *Earias vittella* (Fab.). *Agril. Sci. Dig.* **18**(2): 120-122.

Faqir, G. and Gul, F. (1998). Evaluation of different insecticides and cultivars against pod borer infestation in okra. *Sarhad J. Agric.* **14**(4): 351-354.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). *Intl. Rice Res. Inst., A Willey Int. Sci.*, pp. 28-192.

Grainge, M. and Ahmed, S. (1988). Handbook of plant with different pest control properties, John Wiley and Sons. New York. pp. 12-18.

Heitholt, J.J., Knutson, A., Faff, J.B. and Langston, B. (2006). Early-season thrips infestation control and soybean yield in North Texas. *South Western Entomol.* **31**: 113-120.

Hossain, A. and Awrangzeb, S.N.H. (1992). Vegetable production polices plan and future directions for improvement. Proceeding on Vegetable production and marketing. AVRDC, BARI, BARC and USAID. pp. 21-30.

Hussan, M.A. (1999). Field evaluation of Helicoverpa armigera (Hub.) NPV formulation for control of chickpea pod borer. Natural resources Institute university of Greenwhich, Central Avenue. *4TB UK*. **19**(1): 51-60.

Jacob, Y. and Sheila, K. (1994). Comparison of capsules of sex pheromone of pod borer infestation. *Bol. Sani. Veg. Plant.* **18**(2): 427-434.

Jagdish, J., Agnihotri, M. and Sharma, R. (2014). Evaluation of some Bio-pesticides against some Important Lepidopteron Pests of Pigeonpea (*Cajanus cajan* L.) at Pantnagar, Uttarakhand, India. *Greener J. Agril. Sci*. **4**(6): 232-237.

Jayaraj, D.A. (1991). Neem seed kernel extracts on egg deposition of pod borer on different seedlings. *Trop. Pest Manag*. **36**(2): 138-140.

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

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

Krishnaiah, N.V. and Kalode, M.B. (1991). Feasibility of insect pest control with Botanical pesticide. **P**roceedings of the mid-term project Review meeting. Botanical pest control project in Bangladesh. Phase-II . 28-31. July, 1991, Dhaka, Bangladesh.

Kumar, K.K. and Urs, K.C.D. (1988). Population fluctuation of pod borer on okra in relation to abiotic factors. *Indian J. Plant Protect.* **16**(2): 137-142.

Kumar, N.K.K., Srinivasan, K. and Sardana, H.R. (1989). Evaluation of time of insecticidal application on the control of pod borer and aphid on okra. *Insect Sci. App*. **10**(3): 333-339.

Kumar, P., Huang, L. and Ramasamy, S. (2014). Effect of three commercial bio pesticides of neem (*Azadirachta indica*) and *Bacillus thuringiensis* on legume pod borer in Thailand. *Intl. J. Trop. Insect Sci.*, **34**(2): 80-87.

Kumbhar, M.M., Ali, S.S., Dhiloo, K.H., Kumbhar, I. and Veesar, R. (2017). Effect of novel insecticides against *Helicoverpa armigera* (HBN.) on chickpea crop under field conditions. *Intl. J. Sci., Res. Pub*. **7**(12): 387-393.

Margam, V.M., Coates, B.S., Ba, M.N., Sun, W., Binso-Dabire, C.L., Baoua, I., Ishiyaku, M.F., Shukle, J.T., Hellmich, R.L., Covas, F.G., Ramasamy, S., Armstrong, J., Pittendrigh, B.R., Murdock, L.L. (2011). Geographic distribution of phylogenetically-distinctlegumepodborer Maruca vitrata (Lepidoptera: Pyraloidea:Crambidae). *Mol .Biol. Rep*. **38**: 893–903.

Misra, H.P. and Senapati, B. (2003). Evaluation of new insecticides against okra pod borer. *Indian J. Agril. Sci.* **73**(10): 576-578.

Mohiuddin, M., Hossain, M.M., Rahman A.K.M.M., and Palash, M.S. (2009). Socio-economic study of insecticide use on different vegetable cultivation at farm level in Chittagong region in Bangladesh. *J. Bangladesh Agril. Univ*. **7**(2): 343-350.

Muthomi, J.W., Otieno, P.E., Cheminingwa, G.N., Nderitu, J.H. and Wagacha, J.M. (2008). Effect of chemical spray on insect pests and yield quality of food grain legumes of yard long bean. *J. Entom*. **5**: 156-163.

Nampala, P., Ogenga-Latigo, M.W., Kyamanywa, S., Adipala, E., Oyobo, N. and Jackai, L.E.N. (2002). Potential impact of intercropping on major cowpea field insect pests in Uganda. *Africa Crop Sci. J*. **10**: 335-344.

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

Oparaeke, A.M., Dike, M.C. and Amatobi, C.I. (2006). Botanical pesticide mixtures for insect pest management on cowpea walp plants-the legume flower bud thrips, Megalurothrips sjostedti Trybom. *J. Sus. Agric*. **29**: 5-13.

Periasamy, M., Schafleitner, R., Muthukalingan, K. and Ramasamy, S. (2015). Phylo-geographical structure in mitochondrial DNA of legume pod borer (*Maruca vitrata*) population in tropical Asia and sub-aharan Africa. **1**: 240-257.

Praveen, P.M. and Dhandapani, N. (2001). Eco-friendly management of major pests including pod borer of okra. *J. Veg. Crop Prodn*. **7**(2): 3-12.

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

Rai, A.B., Sejalia, A.S., Patel, C.B. and Kumar, S. (1995). The rate of natural increase of pod borer when reared on okra. *Gujarat Agril. Uni. Res. J*. **21**(1): 130-136.

Rai, S. and Satpathy, S. (1999). Influence of sowing date and insecticides on the incidence of fruit borer infestation on okra. *Veg. Sci*. **26**(1): 74-77.

Rashid, M.M. (1993). Begun Paribarer Shabji. Shabji Biggan (in Bangla edition). First edition. Bangla Academy, Dhaka, Bangladesh. P. 56.

Rouf, F.M.A., Sardar, M.A. (2011). Effect of crude seed extract of some indigenous plants for the control of legume pod borer (*Maruca vitrata* F.) on country bean. *Bangladesh. J. Agric. Res*. **36**: 41–50.

Seal, D.R., Ciomperlik, M., Richard, M.L. and Klassen, W. (2006). Comparative effectiveness of chemical insecticides against the chilli pod borer, on pepper and their compatibility with different natural enemies. *Crop Protect.* **25**: 949-955.

Sejalia, A.S., Rai, A.B., Patel, C.B. and Radadia, G.G. (1993). On the biological aspects of pod borer infesting okra in South Gujarat. *Gujarat Agril. Uni. Res. J.* **19**(1): 32-37.

Shanower, T.G., Romeis, J., Minja, E.M. (1999). Insect pests of pigeon pea and their different management practices. *Ann. Rev. Entomol.* **44**: 77–96.

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

Simmonds, M.S.J, Vans, H.C. and Blaney, W.M. (1992). Pesticides for the year 2000: Chemicals and botanicals. Pest management and the effect of environment in 2000. p. 127-164.

Singh, G. and Brar, K.S. (1994). Effect of dates of sowing on the incidence of pod borer species on okra. *Indian J. Ecol.* **21**(2): 140-144.

Singh, S.R., Jackai, L.E.N. (1988). The legume pod-borer: past, present and future research. *Insect Sci. App.* **1**(9): 1-5.

Singh, S.R., Jackai, L.E.N., DosSantos, J.H.R., Adalla, C.B. (1990). Different insect pests of Cowpea. In: Singh, S.R. (Edition), Insect pests of tropical food legumes. Wiley, Chichester, pp. 43-89.

Srinivasan, K. and Krishnakumar, N.K. (1988). Timing of scheduled insecticide application for control of pod borer on okra. *Indian J. Agril. Sci*. **58**(11): 828-831.

Srinivasan, R.,Yule, S.,Chang, J.C., Malini, P., Lin, M.Y., Hsu, Y.C., Schafleitner, R. (2012). Towards developing a sustainable management strategy for legume pod borer on Yard-long bean in South east Asia. In: Holmer, R., Linwattana, G., Nath, P., Keatinge, J.D.H. (Eds.), High value vegetables in south east Asia: production, supply and demand. AVRDC-The World VegetableCenter,Taiwan, pp. 76-82.

Stoll, G. (1992). Natural crop protection in the Tropics. Verilog Josef Margrave Scientific Book, Muhlstr. 9, Weikersheim, FR Germany. p. 188.

Uddin, M.S., Rahman, M.M., Alam, M.Z., Awal, A. and Mazed, M.A. (2013). Insect Pests of Yard Long Bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) in major yard long bean growing areas of Bangladesh. *The Agriculturists.* **11**(2)*:* 66-73.

Ugine, T.A., Wraight, S.P. and Sanderson, J.P. (2007). Effects of manipulating spray-application parameters on efficacy of the entomopathogenic fungus *Beauveria bassiana* against pod borer, infesting greenhouse impatiens crops. *Bio. Sci. Technol*. **17**: 193-219.

Verma, S. (1989). Efficacy and persistence of different insecticides against pod borer infesting in okra. *Plant. Protect. Bull.* **41**(1-2): 1-5.

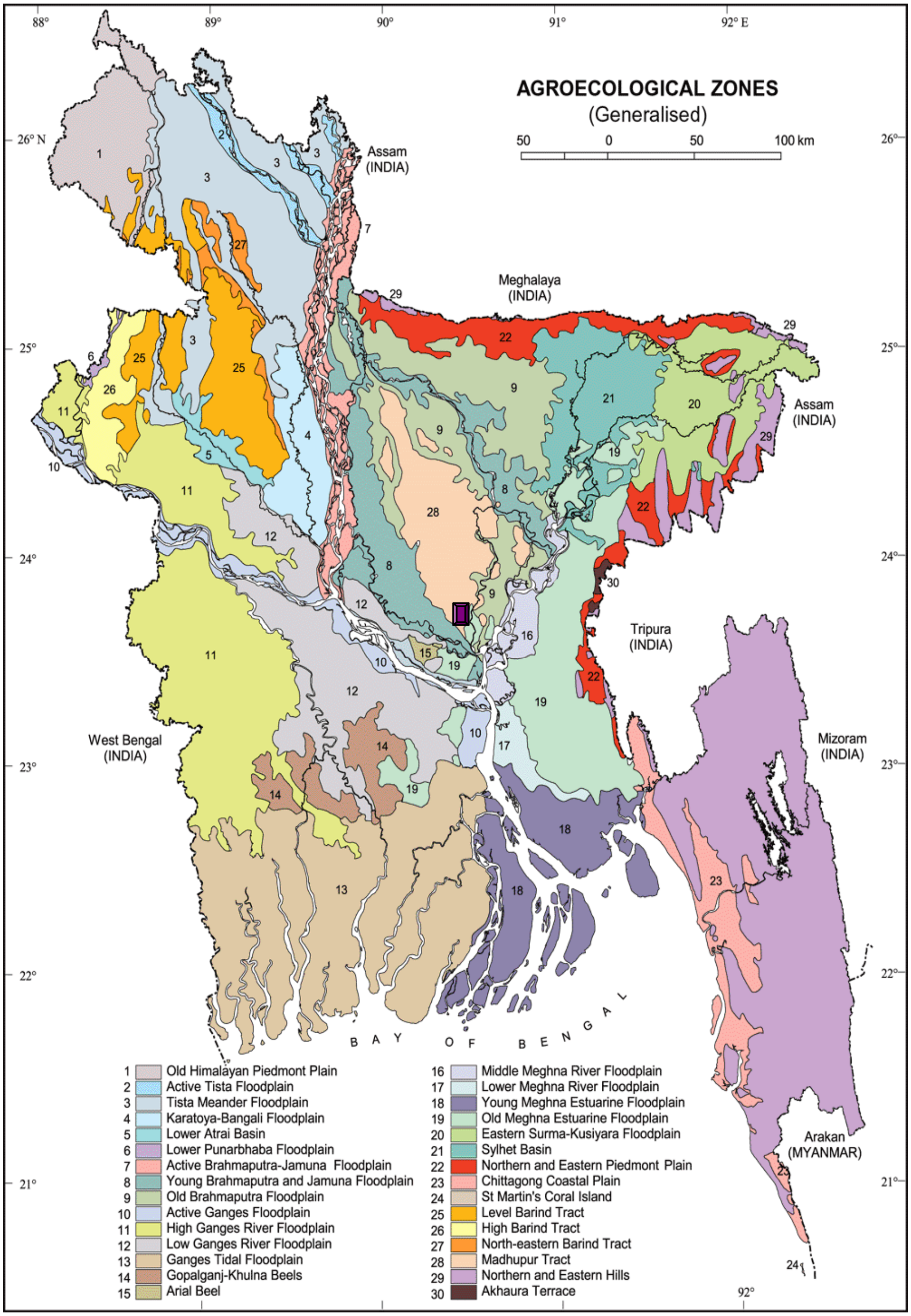
Visalakshmi, V., Rangarao, G.V. and Arjuna Rao, P (2005). Integrated pest management stratagies against pod borer in chickpea. *Indian J. Plant Protect.* **33**(1): 17-22

Yule, S. and Ramasamy, S. (2013). Evaluation of bio-pesticides against legume pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae), in laboratory and field conditions in Thailand. *J. Asia-Pacific Entom.* **16**(4): 357-360.

Yule, S., Srinivasan, R. (2014). Combining bio-pesticides with chemical pesticides to manage legume pod borer (*Maruca vitrata*) on yard-long bean in Thailand. *Intl. J. Pest Manag.* **60**(1): 67-72.

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site from April to August 2017

Month (2017)	Air temperature (^0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
April	34.4	23.1	67	117
May	34.9	26.7	73	302
June	35.7	22.7	79	465
July	36.5	24.3	84	567
August	36.3	23.8	82	305

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1207

Appendix III. Soil characteristics of the experimental field

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.8
Organic matter (%)	1.16
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix IV. Analysis of variance of the data in terms of pods per plant in number at early, mid and late pod development stage of yard long bean as influenced by different bio-pesticides and chemical pesticides

Source of variation	Degrees of freedom	Mean square								
		Early pod stage			Mid pod stage			Late pod stage		
		Healthy	Infested	% Infestation	Healthy	Infested	% Infestation	Healthy	Infested	% Infestation
Replication	2	0.015	0.046	0.073	0.135	0.711	0.267	0.804	1.274	2.346
Treatment	6	0.762**	0.215**	0.984**	0.691*	7.626**	13.232**	26.692**	17.084**	11.999*
Error	12	0.028	0.082	0.157	0.150	1.149	0.489	1.426	2.734	2.611

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data in terms of pods per plant in weight at early, mid and late pod development stage of yard long bean as influenced by different bio-pesticides and chemical pesticides

Source of variation	Degrees of freedom	Mean square								
		Early pod stage			Mid pod stage			Late pod stage		
		Healthy	Infested	% Infestation	Healthy	Infested	% Infestation	Healthy	Infested	% Infestation
Replication	2	0.020	1.934	0.511	0.241	1.277	0.057	0.291	1.482	0.486
Treatment	6	12.734**	20.701**	2.863**	11.688**	25.529**	6.233**	8.056**	20.166**	11.216**
Error	12	0.245	0.890	0.593	0.384	0.691	0.359	0.487	6.474	1.828

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of yard long bean as influenced by different bio-pesticides and chemical pesticides

Source of variation	Degrees of freedom	Mean square								
		Length of edible part (cm)	Edible portion (%)	Length of non-edible part (cm)	Non edible portion (%)	Number of pod per plant	Length of healthy pod (cm)	Diameter of healthy pod (mm)	Yield per plot (kg)	Yield per hectare (ton)
Replication	2	0.031	1.293	3.136	2.566	1.058	0.002	0.083	0.089	0.014
Treatment	6	3.491**	8.767**	12.983**	13.342**	10.711**	0.367**	1.111**	5.290**	0.326**
Error	12	1.153	2.985	4.091	3.278	3.269	0.089	0.194	0.599	0.023

**: Significant at 0.01 level of probability