BIOEFFICACY OF SOME INSECTICIDES AGAINST MAJOR INSECT PESTS OF FRENCH BEAN, *PHASEOLUS VULGARIS* L.

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CERTIFICATE

This is to certify that thesis entitled, "**BIOEFFICACY OF SOME INSECTICIDES AGAINST MAJOR INSECT PESTS OF FRENCH BEAN, *PHASEOLUS VULGARIS* L.**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the result of a piece of *bona fide* research work carried out by **SHYAMOL KUMAR ROY**, Registration No. **05-01796** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2011
Place: Dhaka, Bangladesh

……..……
Prof. Dr. Mohammed Ali
Supervisor

Dedicated

To

My Beloved Parents

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ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University farm during January to March 2011 to study on the bioefficacy of some insecticides against major insect pests of French bean (*Phaseolus vulgaris* L.). The experiment was laidout in a Randomized Complete Block Design with four replications. The treatments of the experiment were T_1: Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}, T_2: Shobicron 425EC @ 2 ml L^{-1}, T_3: Actara 25WG @ 0.3 g L^{-1}, T_4: Chlorpyriphos 20EC @ 3 ml L^{-1}, T_5: Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}, T_6: Fortap 50SP (Cartap) @ 3 g L^{-1} and T_7: Control treatment. Results showed that the lowest number of whitefly $plant^{-1}$ (10.12, 5.58, 3.28 and 1.24 at 20, 40, 60 DAS and at harvest respectively), jassid $plant^{-1}$ (7.32, 4.22, 2.54 and 0.00 at 20, 40, 60 DAS and at harvest respectively) and aphid $plant^{-1}$ (10.04, 6.67, 4.82 and 2.18 at 20, 40, 60 DAS and at harvest respectively), the lowest infestation intensity by whitefly (5.92%), jassid (5%) and aphid (14.25%), the lowest infested bean yield $plant^{-1}$ (9.60 and 16.00 g at 60 and 85 DAS), highest healthy bean yield $plant^{-1}$ (166.40 and 284.80 g at 60 and 85 DAS), highest total healthy yield (11.28 t ha^{-1}), lowest total infested yield (0.64 t ha^{-1}) and highest gross return (Tk. 232000.00 ha^{-1}) were obtained from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4). In terms of percent reduction or increase over control, the highest percent reduction of whitefly $plant^{-1}$ (24.70, 63.91, 81.44 and 94.39% at 20, 40, 60 DAS and at harvest respectively), jassid $plant^{-1}$ (64.01, 67.60, 62.52 and 69.92% at 20, 40, 60 DAS and at harvest respectively) and aphid $plant^{-1}$ (24.85, 63.59, 80.15 and 92.21% at 20, 40, 60 DAS and at harvest respectively) over control, highest percent reduction of infested bean yield $plant^{-1}$ over control (81.82 and 76.74% at 60 and 85 DAS) and highest increase of healthy bean yield $plant^{-1}$ over control (215.20 and 178.10% at 60 and 85 DAS) were also achieved from the same treatment (T_4). Hence Chlorpyriphos 20EC performed best to suppress the insect pests (whitefly, jassid and aphid) of French bean. Fortap 50SP was next to the performance of Chlorpyriphos 20EC.

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LIST OF ACRONYMS

ABBREVIATIONS		ELABORATIONS
%	=	Percent
^{0}C	=	Degree Centigrade
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
g	=	gram (s)
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
LSD	=	Least Significant Difference
m	=	Meter
MP	=	Muriate of Potash
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
t/ha	=	ton/hectare
TSP	=	Triple Super Phosphate

CHAPTER I
INTRODUCTION

French bean is originated in South and Central America. The beans have been cultivated in that part of the world since ancient time and were brought over to Europe after the Spanish conquest. Because they come from a tropical climate, French bean needs a warm soil to germinate and grow. The pods of which are known as string bean. Scientifically known as *Phaseolus vulgaris* L. and the name is green bean. The color of the French bean is deep emerald and ting seed can be found within their pods. It's grown very rapidly and produces a large crop of delicious bean. There are many different kinds of French bean but the easiest one to grow is the bush varieties. Most people grow varieties have green pods. It's best to grow stingless varieties so that the whole pod to be picked and eaten when young.

The French bean belongs to the family of Fabaceae. It's not a major crop in Bangladesh. It's basically wild types of bean. Its production is more than any other bean. This is grown in high land in Rabi season. The disease and insect infestation rate is comparatively lower than others. Recently BARI has been released two varieties BARI bush bean -1, BARI bush bean-2 of French bean for cultivation purpose in large scale. This crop can be grown in medium to high land with minimum rainfall. The soil P^H range is 5.5-7.0 and suitable temperature for the growth of French bean is between 15^0C to 27^0C while the minimum temperature required for the germination of seed is 10^0C.

Picking of French beans begins 9 weeks after sowing and continues for about 3 weeks when the weather is dry (Nderitu and Anyago, 1993). French beans require an optimum temperature range of 16 - 25^oC (Bunting, 1961) and friable loam soil that is

well drained with high levels of organic matter and a pH of 6.5-7.5 (HCDA, 1996). Higher fruit productivity is achieved in cooler weather. Frost, dry winds, long rains and fog periods are harmful (MOALDM, 1995). Irrigation is vital to maintain continuous production (Legget, 1992).

French beans (*Phaseolus vulgaris* L.) are grown by both small and large scale farmers for fresh and processing market. Production is constrained by western flower thrips (*Frankliniella occidentalis*), bean flower thrips (*Megalurothrips sjostedti*), bean fly or bean stem maggot (*Ophiomyia* spp.), aphids (*Aphis fabae*) and whiteflies (*Bemisia tabaci*).

Chemical control is generally being advocated for the management of insect pests of French bean. The control of aphids, jassid and whitefly in Bangladesh is principally carried out by the conventional use of insecticides. Many workers have tried to control this pest with varying degrees of success by frequent application of insecticides as foliar treatments (Chowdhury and Roy, 1975). It is difficult to emphasize the effectiveness of particular synthetic insecticides out of many commercially available ones against a certain insect pest. These chemicals should be applied at appropriate dose and at right time against the target pests. For controlling the pests successfully and to save biological agents, judicious application of insecticides is very essential.

In this study, an effort was taken to find out the most effective insecticide in controlling the aphid, whitefly and jassid of French bean. The control is very important to reduce losses due to these pests. But we should control these pest causing the least or without environmental pollution.

Therefore the present experiment was undertaken with the following objectives.

Objectives:

1. To identify the major insects pests attack in field of French bean.

2. To develop a suitable management practice for controlling those insect pests.

CHAPTER II

REVIEW OF LITERATURE

Bean crops play a vital role in the diet of the people of Bangladesh. Nutritionally, they are two to three times richer in protein than cereal grains and have remained the least expensive source of protein for people since the dawn of civilization. In fact, until today, bean crops or pulses provide the only high protein component of the average diet of the vast majority of the people of Bangladesh.

Listed the following insect pests according to their common name, scientific name, family name and their order:

Common name	**Scientific name**	**Family name**	**Order**
Aphid	*Aphis fabae*	Aphididae	Homoptera
Jassid	*Amrasca devastans*	Cicadellidae	Homoptera
Whitefly	*Bemicia tabaci*	Aleyrodidae	Homoptera

2.1 Aphid

Aphids are tiny sucking insect from family Aphididae. Adult aphids are pear-shaped, measuring less than 1/8" in length. The most common aphids on house plants are the light green ones (pear aphids), but aphids can also be found colored pink, white, grey and black. Additionally, winged aphids can appear when colonies are established and fly to infect new plants. Juvenile aphids (nymphs) look like smaller versions of the adults. The aphid is a serious damaging pest of French bean and has been identified as

a major pest of French bean in India. The growth of older plants becomes slowly stunted.

Aphids cause damage by sucking sap from new growth. They tend to cluster at the growth end of plants and attach to soft, green stems. As a result, the new foliage may look crinkled or stunted and the aphids are usually plainly visible around the stem. If the infestation is bad enough, the plant will begin to drop leaves. Finally, like mealy bugs, aphids secrete honeydew that encourages the growth of sooty mold and fungus.

Outside, aphid eggs survive the winter by attaching to woody growth. In the spring, eggs hatch into females. The females give birth to nymphs without mating, and the nymphs rapidly mature into adults (about 10 days). Males are born in the fall and begin to mate with the females to produce eggs in preparation for the long winter. Indoors, however, there is no winter to slow their reproduction, and females can continue to produce nymphs all year without pause. Thus, the aphid population can quickly get out of control.

2.2 Jassid

Jassid is another important pest in French bean. Both nymphs and adults suck the plant sap and introduce salivary toxins that impair photosynthesis in proportion to the amount of feeding. 1st and 2nd instar nymphs feed near bases of the leaf veins, later instars get distributed all over the leaves but feed chiefly on the under surface of leaves (Sachan, 1986).

2.3 Whitefly

The adult whitefly is a tiny soft bodied and pale yellow, change to white within a few hours due to wax on the body and wings (Haider *et al.*, 1996). Eggs are laid indiscriminately almost always on the under surface of the young leaves (Hirano *et*

al., 1993). Eggs are pear shaped and 0.2mm long. One female can lay upto 136 eggs in its life time in French bean (Baldev, 1988). The nymphs are pale, translucent white, oval, with convex dorsum and flat elongated ventral side. The whitefly adults and nymphs feed on the plant sap from the underside of the leaves. The secrete honeydew, which later helps the growth of sooty mould fungus thus reducing the photosynthetic area. The infested plants became weakened due to sucking of the plant sap from the leaves and also due to the reduction of photosynthesis of the infested plant parts (Naresh and Nene, 1980). Young plant may even be killed in case of severe whitefly infestation in French bean (Srivastava and Singh, 1976). The infested parts become yellowish, the leaves become wrinkle, curl downwards and eventually fallen off. This happens mainly due to viral infection where the whitefly acts as a mechanical vector of many viral diseases.

2.4 Management of insect pests

A Field studies were conducted by Sinha *et al.* (1992) in India during 1982-83 to determine the efficacy of sprays of the parathyroid insecticides Deltamethrin, Permethin, Cypermethrin and Fenvalerate, and the Organophosphorus insecticides Fenitrothion, Methyl-demeton [Demeton-methyl] and Dimethoate to control infestations of *Thrips tabaci* on onions. Cypermethrin applied at 60 and 120 g ha^{-1}, and Deltamethrin applied at 24 g ha^{-1} reduced pest numbers effectively for up to 8 days after application. Fenitrothion applied at 600 g ha^{-1} was as effective as the pyrethroid insecticides. None of the chemicals had any effect after 15 days. There were no phytotoxic effects on onions and no residues were detected.

A field study was conducted by Nderitu (2010) to evaluate the combined effectiveness of insecticides and varietal resistance in the control of thrips infestation and damage at

Kabete, Central Kenya. Four test varieties (Amy, Monel, Samantha and Impala) of French beans (*Phaseolus vulgaris* L.) and four insecticides (Lambda-Cyhalothrin (Karate 1.75EC), Petroleum spray oil (DC Tron 500ML), Spinosad (Tracer 480SC) and Fipronil (Regent 50SC)) were used. The experiment was set in a split plot design, with variety forming the main plot and insecticide the subplot. Results show both varieties and insecticides influenced thrips infestation independently. For example, Tracer 480SC and Regent 50SC sprayed plots had the lowest thrips numbers across all varieties. Individual thrips species infestation differed across the treatments. For example, the mean number of *Frankliniella occidentalis* (Pergande) in Karate 1.75EC sprayed plots was higher and significant compared to plots sprayed with Tracer 480 SC and Regent 50 SC but mean number of *Megalurothrips sjostedti* Trybom was not significantly different in all plots except those sprayed with DC Tron 500ML and the control (unsprayed) plots. The research concludes by discussing the implications and applicability of the findings in French bean IPM systems in Kenya.

A field trial was conducted by Mohite *et al.* (1994) in Maharashtra, India, in 1983-85, the following insecticides are recommended for controlling *Thrips tabaci* on onion: 0.03% Quinalphos (Ekalux), 0.02% Dichlorvos (Nuvan), 0.02% Methyl-demeton [Demeton-S-methyl] (Metasystox), 0.03% Monocrotophos (Nuvacron), 0.02% Dimethoate (Rogor), 0.02% Phosphamidon (Dimecron), 0.03% Bromophos-methyl (Nexion methyl) and 0.02% Endosulfan (Endocel).

A field trial was conducted by Srivastrava and Gupta (1992) during the kharif seasons of 1988, 1989 and 1990 at the Regional Research Station, Nashik, to control *jassid* using systemic insecticides. Four systemic insecticides (Monocrotophos at 0.05% and 0.1% Phorate at 0.5 kg a.i. ha^{-1} and 1.0 kg a.i. ha^{-1}, Carbofuran at 0.5 kg a.i. ha^{-1} and

1.0 kg a.i. ha^{-1} and Dimethoate at 0.05% and 0.1%) were assessed. Monocrotophos and Dimethoate were sprayed 3 times at fortnightly intervals 30 days after transplanting and the rest were side-dressed 30 days after transplanting. The data on jassid infestation were recorded. Three years' pooled data were analyzed and it was found that minimum incidence and jassid population were in the treatment with Monocrotophos at 0.1%. The maximum bulb yield and cost-benefit ratio were also obtained in this treatment.

Field trials on the control of *Thrips tabaci* in onions grown for seed were carried out in 1989 and 1990 by Hoekstra and Hoek (1993). One to two sprays with synthetic pyrethroids such as Cypermethrin, Deltamethrin and Permethrin reduced suction damage to the crop compared with standard treatment with Parathion. No reduction in yield as a result of suction damage was observed.

An experiment was carried out by Tanzini *et al.* (1993) in Sao Paulo, Brazil, in 1991-92 to evaluate the influence of potassium fertilizer on the effectiveness of Carbofuran for the control of aphid on groundnut (*Arachis hypogaea*). The treatments consisted of NP with 150 kg of ammonium sulfate and 445 kg of superphosphate per ha; NPK with 52 or 104 or 156 kg of potassium chloride per ha; NP2K ; NP3K; NP + Carbofuran; NPK + Carbofuran; NP2K + Carbofuran; and NP3K + Carbofuran. The number of nymphs and adults found in 20 leaflets per plot and yields were determined. The results showed that large and normal dosages of K caused an increase in the effect of Carbofuran for the control of the pest. Lowest efficiency of the insecticide occurred in plots without K. Highest yield was obtained in treatments with double dosage of K and it was lowest in the absence of this macronutrient.

Borah (1995) carried out an experiment to evolve a cheaper and effective control of *Bemisia tabaci* and minimizing the incidence of yellow mosaic virus [Mungbean yellow mosaic bigeminivirus] in green gram [*Vigna radiata*], Cypermethrin (0.01, 0.015%), Deltamethrin (0.0028, 0.0042%), Dimethoate (0.03, 0.045%) and Malathion (0.05, 0.075%) were tested as foliar sprays during summer 1993 and 1994 in field trials in Assam, India. Foliar application with Cypermethrin, Deltamethrin and Dimethoate 50 days after sowing proved quite effective in reducing the incidence of *B. tabaci* and the virus.

Chemical control is one of the widely practiced methods of controlling insect pests. Modern insecticides are both effective and reliable and almost all the countries of the world are relying to then more and more for the solution of insect problem. But their excessive and indiscriminate use has resulted in the development of insecticide resistance against the pests and causing environmental pollution (Babu, 1988).

Chhabra and Kooner (2004) reported that treatments with Aldicarb and Monocrotophs, Dimethoate, Malathion or Endosulfan gave significant control of jassid. For the control of hairy caterpillar of French bean Diazinon 50 EC or Nuvacton 40 WSC @ 1.5ml per liter of water can be used.

Different indices for developing an insecticide application schedule against *Euchrysops cncjus* were evaluated in French bean and Fenitrothion @ 0.1% when egg number reached about 5.2 per meter was found as the best schedule for it (Raja, 2005).

Different insecticides (Carbosulfan, Thiamethoxam, Phorate, Sarbofuran and Chlorpyrifos) were evaluated as seed treatments, soil application and as spray against insect pests (leaf miner, *Aproaerema modicella*; stem fly, *Melanagromyza sojae*;

girdle beetle, *Obereopsis brevis*; whiteflies, *Bemisia tabaci*; and jassids) of soyabean seedlings in Parbhani, Maharashtra, India, during the 1998/99 kharif season by Salunke *et al.*(2004). All the treatments were significantly superior over the control. carbosulfan 25 DS at 30 g kg^{-1} seed recorded the lowest number of leaf miner larvae and consequently the leaf damage. Percent stem tunnelling was lowest in Phorate 10 G at 10 kg ha^{-1} whereas the lowest infestation of girdle beetle was recorded in Carbofuran 3 G at 30 kg ha^{-1}. The most effective treatment against whitefly was Thiamethoxam 70WS at 3 g kg^{-1} seed and Chloropyrifos 20EC at 1.5 litres ha^{-1} against the jassids. The highest yield (27.57 q ha^{-1}) was recorded in Carbosulfan 25DS at 30 g kg^{-1} seed followed by Thiamethoxam 70WS at 3 g kg^{-1} seed (25.54 q ha^{-1}).

Experiments were conducted by Azam *et al*. (2002) with leaves and seeds extracts of eight sub-tropical plants, namely, *Acacia nilotica, Annona squamosa, Azadirachta indica, Boswellia sacra, Crotolaria juncea, Jatropa dhofarica, Myrtus communis* and *Sueda aegyptica* by steeping 12.5 g of shaded dried leaf/seed powder of the plants in 62.5 ml water-ethanol (1 : 4 v/v) for 24 h. The extracts were suction filtered. Required quantity of filtrate was diluted with water to get 1, 1.5, 2 and 2.5% spray solutions, respectively. Tomato leaves with whitefly nymphs were used to test the insecticidal properties of the extracts. The leaves were kept in contact on filter papers for 2 h just before spraying and for 24 h after spraying of extracts. The filter papers were sprayed with Ninhydrin (0.4% in ethanol) and kept in oven at a temperature of 80ºC for 2 min, which developed purple spots due to honeydew secreted by whitefly nymphs. The difference between the number of spots before and after spray gave the mortality of nymphs. Data were analyzed by analysis of variance using statistical analysis system for the mortality of nymphs for all the extracts including control. The mortality of

nymphs in different plant extracts at different concentrations was significant (<0.05) and there was no interaction among plant extracts with varying concentrations.

Field experiments carried out by Brar *et al.* (1993) in Ludhiana, Indian Punjab, during 1989-91 showed that out of 6 insecticidal treatments, Carbofuran and Phorate (both at doses of 0.75 and 1 kg a.i.ha^{-1}) were the most effective insecticides against *Ophiomyia phaseoli* in peas.

Field studies were conducted by Eapen (1994) in Karnataka, India, during 1989-93 to determine the efficacy of 3 granular pesticides, alone and in combination with neem oil to control various soil-borne pests of Cardamom. Among the pesticides, Phorate applied at 5 and 2.5 g a.i. $clump^{-1}$ gave the highest reduction in damage by *Sciothrip cardamomi* (32.9 and 29.2%), followed by Quinalphos (18.6 and 15.4%). Carbofuran was effective only at 5 g a.i. $clump^{-1}$. The reduction in damage due to *S. cardamomi* was attributed to the protection of tender capsules by the pre-monsoon application of pesticides. Therefore, a single application of a broad spectrum pesticide, such as Phorate, was more convenient and economical than the usual recommendation of 6-7 applications of spray.

Four granular insecticides (Carbofuran, Chorate, Quinalphos applied at 0.75 and 1.0 kg a.i. ha^{-1} each, and Cartap hydrochloride applied at 0.75, 1.0 and 1.5 kg a.i. ha^{-1}) were evaluated for the control of stemfly (*Ophiomyia phaseoli)* of mungbean. All of the tested insecticides were found effective (Dhiman *et al.,* 1993). Ahmad (1987) observed that pre sowing soil application of Carbofuran or Furadan 3G, Aldicarb 10G or Phroate 10G at 1 kg a.i. ha^{-1} gave significant control of stemfly damage. Gupta and Singh (1984a) obtained the largest increase in grain yield by controlling stemfly of mungbean with Aldecarb and Desulforton

Four granular insecticides (Carbofuran, Phorate and Quinalphos applied at 0.75 and 1.0 kg a.i. ha^{-1} each, and Cartap hydrochloride applied at 0.75, 1.0 and 1.5 kg a.i. ha^{-1}) were evaluated by Dhiman *et al.* (1993) for the control of *Ophiomyia phaseoli* in field studies conducted in India. Carbofuran and Phorate at both conchs were the most effective in reducing plant mortality and increasing the crop yield. The insecticide-treated plots also showed fewer incidences of wilt and *Aschochyta* blight on the foliage. The plots treated with Phorate and Quinalphos (at 1.0 kg) and sprayed twice with Bavistin [Carbendazim] (0.05%) gave the maximum level of control of the disease.

Granular formulations of Phorate, Mephosfolan, Disulfoton, Carbofuran and Aldicarb were tested in the field by Gupta and Singh (1992) in India as soil applications against *Megalurothrips distalis* on green gram (*Vigna radiata*). Up to 3 applications at up to 2.0 kg a.i. ha^{-1} were made, and all treatments reduced infestation. Yields and benefit: cost ratios were greatest for one application at 2.0 kg a.i. ha^{-1}.

Heungens and Buysse (1992) observed that the possibility of chemical control of *Frankliniella occidentalis* on flowering azaleas [Rhododendron] with systemic insecticides in the irrigation water in pseudo-hydroponic systems was investigated. Omethoate, Methamidophos, Carbofuran, Aldicarb, Oxamyl and Methomyl were added to the irrigation water at 50 p.p.m. and given 10 times over 5 weeks. At 1 week after the treatments had been completed, mortalities of larvae of 84.1, 95.4, 73.7, 58.4, 82.2, 86.8% were observed for each insecticide, respectively. Three weeks after the treatments the control effect on larvae had severely decreased with the exception of Methamidophos, 80.9%. No effects were observed on adults. It was concluded that this method of application of systemic insecticides was effective and may be of

particular use for pest control in ornamental crops with dense leaf volume, which are difficult to spray effectively.

In field trials carried out by Srivastava *et al.*(1992) in Nasik, Maharashtra, India, during 1985-87, 6 insecticides were evaluated in 7 treatment combinations involving a total of 3 sprays/season in each treatment for the control of onion thrips [*Thrips tabaci*]. The maximum net return was recorded with the combined treatment of Carbofuran, Malathion and Fenvalerate, followed by Endosulfan and 2 applications of Methyl-demeton [Demeton-S-methyl].

Kumar and Sharma (2003) reported that Lindane and Carbofuran (basal dressing), Monocrotophos, Dimethoate, Phosphamidon, Malathion and Nimbecidine (spray) and two Biopesticide, Biolep and Halt [Cypermethrin] were evaluated during rabi season of 1998-99 at the University farm, narendra nagar, faizabad, Uttar Pradesh, India. All the insecticidal treatments were significantly superior to the control. Among the treated plots the minimum and maximum plant mortalities were observed in the plots treated with Lindane (basal dressing) and Halt (spray), respectively. There was no significant reduction in plant mortality with the basal dressing of Lindane and Carbofuran.

Kundu, and Mishra (1993) studied the effect of some granular insecticides on *Melanagromyza sojae* and 7 species of plant parasitic nematodes (*Tylenchorhynchus vulgaris, Helicotylenchus indicus, Pratylenchus penetrans, Rotylenchulus reniformis, Heterodera cajani, Meloidogyne incognita* and *Hoplolaimus indicts [Basirolaimus indicus*]) was studied in soybean fields in Delhi, India, during 1988. Seeds were treated with *Rhizobium japonicum* [*Bradyrhizobium japonicum*] before sowing and Phorate, Quinalphos, Mephosfolan and Carbofuran were drilled into the soil. Only

Phorate, Quinalphos and Mephosfolan significantly reduced infestation by *M. sojae. R. japonicum* significantly increased the number of nodules, both with and without insecticides. The populations of all nematodes were reduced in insecticide-treated plots. Increased yields were observed for plots treated with insecticides and *R. japonicum*.

Nawrocka (2003) reported that the control (using insecticides Benfuracarb at 120 g, Clorpyrifos at 250 g+Cypermethrin at 25 g, Diazinon at 210 g and Carbosulfan at 150 g ha^{-1}) is most effective when treatments are executed on the turn of the first ten days of June (2 treatments at an interval of 7 days) and at the stage when 50% onion tops have folded down (2 treatments, as above).

Nayak *et al.*(2004) conducted a field experiments in Pantnagar, Uttar Pradesh, India, to evaluate the efficacy of different combinations of insecticides, i.e. Carbofuran as basal at 1 kg ha^{-1}, Imidacloprid as seed treatment at 0.008 kg a.i. ha^{-1} and Thiamethoxam sprayed 7 days after germination (DAG) at 0.025 kg a.i. ha^{-1}, along with the application of neem seed kernel extract (25 kg ha^{-1}), *Bacillus thuringiensis* (Bt) (1.25 kg ha^{-1}), Dichlorvos (0.2 kg a.i. ha^{-1}), Monocrotophos (0.2 kg ha^{-1}) and Endosulfan (0.35 kg a.i. ha^{-1}) at flowering and podding stages, against thrips and whitefly infesting black gram during summer and kharif 2002. The treatment differences were statistically significant. Application of Monocrotophos and Endosulfan at the flowering and podding stages of the crop effectively controlled whitefly and thrips populations and increased the yield of black gram.

Prorate or Carbofuran granules at the rate of 1 to 2 kg a.i. ha^{-1} and foliar sprays of Dimethoate, Fenithion, Phosphamidon were effective in reducing whitefly and jassid population of French bean (Yadav *et al.*, 1979). Ahmad (1987) stated that two

applications of Dimethoate or Monocrotophos at 45 and 60 DAS gave effective control of pod borer damage.

Rai and Solanki (2002) reported that leaf curl in chilli due to thrips, Scirtothrips dorsalis (upward curling) and mite, *Polyphagotarsonemus latus* (downward curling) is one of the important limiting factors in the cultivation of chilli in India. Mites and thrips are mainly congregated on the top canopy of the plant i.e. mites on the lower surface and thrips on the upper surface of the leaf for feeding and multiplication, and aphids (*Myzus persicae*) mostly on the bottom canopy preferring lower leaf surface. The pests were active from October to December, causing leaf curling in the plant. Application of Carbofuran 3G at 1 kg a.i. ha^{-1} 15 days after transplanting (DAT) followed by Dicofol 0.04% 45, 60, 75 and 90 DAT was most effective against the mite. neemectin 0.15 at 0.0006% Azadirachtin followed by Endosulfan 0.075% and neem product followed by microbial pesticide (*Bacillus thuringiensis subsp. kurstaki* (Bt)) at 1 kg ha^{-1} were highly effective against the thrips. In case of aphid control, Endosulfan followed by Dicofol and neem product followed by Bt were effective. Monocrotophos was toxic to the predatory mite, *Amblyseius ovalis*, whereas plant product alternatives with microbial pesticide were safer. Although the highest yield of green chilli fruit (5 t ha^{-1}) was recorded with Endosulfan followed by Dicofol, it was comparable to that of botanical pesticide followed either by Endosulfan or by microbial pesticides.

Studies on relative toxicity and persistence of Folidol-M 50 EC [Parathion-methyl], Azodrin 40 EC [Monocrotophos], Sumicidin 20 EC [Fenvalerate] and Ripcord 10 EC [Cypermethrin] against *Bemisia tabaci* on soyabeans were carried out by Hussain *et*

al. (1994) in Pakistan. After 24 h all the insecticides were effective, but toxicity decreased with time.

The available techniques for controlling insect pests are conveniently categorized in order of complexity as cultural, mechanical, physical, biological, chemical, genetic, regulatory and biotechnological methods. Among these techniques, chemical method is widely and frequently used.

Weerawan (2008) studied with six upland cotton cultivars with different morphological characters were tested during the cotton growing season of 2006 to determine the changes in leaf characters due to plant growth regulator. mepiquat chloride (cotton growth regulator) sprayed at first flowering stage reduced mid vein and hair lengths on lamina as well as on mid vein but increased lamina thickness and hair density on mid vein. Cotton growth regulator did not show significant effect on jassid infestation. Jassid injuries were higher in treated plots but the results were not significant. No interaction between cultivar and growth regulator spray was observed. Cultivar differences on jassid infestation and injury were highly significant. The cotton growth regulator mainly reduced the number of jassid eggs laid per leaf. However, mid vein shortening seemed to be more responsible for lowering egg deposition than changes in leaf hairiness.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with details of the materials and methods used during the period of January to March 2011. It includes a brief description of the site of experiment, soil and climatic condition of the experimental site, materials used for experiments, treatments, design of experiment, method of cultivation, method of data collection, statistical analysis etc.

3.1 Experimental site

The experiment was conducted at the experiment field under the Entomology Department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, during the period of January to March 2011. The experimental site was shown in Appendix I.

3.2 Climate

During experimentation minimum and maximum temperature (13.46 ºC and 33.80ºC respectively), relative humidity (44.95 to 55.53) and rainfall (0 to 25mm) were recorded at an interval of 10 days and presented in Appendix II.

3.3 Soil

The soil of the experimental land was clay loam texture, p^H range 5.2 to 5.7, organic matter 1.12% and belongs to the Grey Terrace soils (AEZ-28).

3.4 Design of experiment

The experiment was laidout in a Randomized Complete Block Design (RCBD) with four replications in the field (Appendix III).

3.5 Land preparation

A tractor drawn disc plough followed by harrowing opened the land. For ensuring good tiller was used. Tractor drawn labeler was used to level the land. Urea, TSP and MP fertilizers were applied as recommended for bush bean cultivation @ 45 kg Urea, 140 kg TSP and 140 kg MP, respectively per hectare during land preparation. The basal dose of fertilizer and well decomposed cowdung 10 t ha^{-1} were mixed into the soil during final land preparation.

The whole field was divided into four equal blocks having 1 m space between the blocks and each block was again sub-divided into 7 plots (2.5m × 2m each) as treatment plots with 0.6 m space between them. The spacing was 30 cm between rows and 40 cm between plants.

3.6 Seed source and sowing

The French bean seeds (BARI bush bean- 1) were collected from Pulse Research Centre, BARI, Joydebpur, Gazipur. The seeds were subjected to germination test before sowing. In all cases, the rate of germination was found to be more than 90%. Three seeds per pit were sown in each plot of the experimental field. Seeds of French bean were sown on 15 January 2011.

3.7 Cultural practices

After sowing, a light irrigation was given. Subsequent irrigations were applied in all the plots and whenever required. Thinning, weeding, and mulching were done at 15, 30 and 45 DAT to keep the field free from weeds and better establishment of crops. A number of irrigation was applied throughout the whole growing season. Damaged seedlings were replaced immediately by new ones in the experimental field from other.

3.8 Treatment of the experiment

The treatments of the present study were assigned as follows:

(i) T_1 = Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}

(ii) T_2 = Shobicron 425EC @ 2 ml L^{-1}

(iii) T_3 = Actara 25WG @ 0.3 g L^{-1}

(iv) T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}

(v) T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}

(vi) T_6 = Fortap 50SP (Cartap) @ 3 g L^{-1} and

(vii) T_7 = Untreated Control

Insecticides were procured from local market.

3.9 Procedure of spray application

Bamper, Shobicron, Actara, Chlorpyriphos, Sinothrin and Fortap were sprayed in assigned plots at 15, 35 and 55 days after germination of plant and dosages by using Knapsack sprayer. The spraying was always done in the afternoon to avoid bright sunlight. The spray materials were applied uniformly to obtain complete coverage of whole plants of the assigned plots. 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.

3.10 Data collection

After five days of spray, data was collected on the following parameters

i) Incidence of whitefly $plant^{-1}$ by number,

ii) Incidence of jassid $plant^{-1}$ by number,

iii) Incidence of aphid $plant^{-1}$ by number,

iv) Weight of infested bean $plant^{-1}$,

v) Weight of healthy bean $plant^{-1}$,

vi) Total healthy yield (t ha^{-1}),

vii) Total infested yield (t ha^{-1}) and

viii) Gross return (tk ha^{-1})

3.11 Procedure of recording data

i) Incidence of whitefly by number

Number of whitefly was counted from randomly selected five plants at 20 days interval started at 20 DAS to harvest and then averaged to number of whitefly $plant^{-1}$.

ii) Incidence of jassid by number

Number of jassid was counted from randomly selected five plants at 20 days interval started at 20 DAS to harvest and then averaged to number of jassid $plant^{-1}$.

iii) Incidence of aphid by number

Number of aphid was counted from randomly selected five plants at 20 days interval started at 20 DAS to harvest and then averaged to number of aphid $plant^{-1}$.

iv) Weight of infested bean

Weight of infested bean $plant^{-1}$ was measured from randomly selected five plants at harvest. Infested bean was separated from total bean and average infested bean $plant^{-1}$ was calculated.

v) Weight of healthy bean

Weight of healthy bean $plant^{-1}$ was measured from randomly selected five plants at harvest. Healthy bean was separated from total bean and average healthy bean $plant^{-1}$ was calculated.

vi) Total healthy yield

Total healthy bean plot^{-1} was collected from 5 m^2 plot at harvest and healthy bean was separated and weighed and then converted it to t ha^{-1}.

vii) Total infested yield

Total infested bean plot^{-1} was collected from 5 m^2 plot at harvest and infested bean was separated and weighed and then converted it to t ha^{-1}.

viii) Percent reduction over control

Percent reduction over control was calculated by the following formula

$$\% \text{ reduction over control} = \frac{S - T}{S} \times 100$$

Here, S = Value of sole treatment, T = Value of Treated treatment (without sole treatment).

ix) Percent increase over control

Percent increase over control was calculated by the following formula

$$\% \text{ reduction over control} = \frac{T - S}{S} \times 100$$

Here, S = Value of sole treatment, T = Value of treated treatment (without sole treatment)

x) Infestation intensity

Infestation intensity was calculated by the following formula

$$\text{Infestation intensity} = \frac{P_1 - P_2}{P_1} \times 100$$

Here, P_1 = Number of total plant plot^{-1}

P_2 = Number of infested plant plot^{-1}

xi) Gross return (Tk ha^{-1})

Gross return was measured by the following formula

Gross return = Total production (kg) × Price per kg (Tk.)

3.12 Statistical analysis

All data were analyzed by MSTAT-C software for analysis of variance (ANOVA). Treatment means were separated by applying Least Significant Difference (LSD) test.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the experiment. The study was conducted to study on the bioefficacy of some insecticides against major insect pests of French bean (*Phaseolus vulgaris* L.). The analysis of variance on different plant growth and yield characteristics obtained from the present investigation are presented in Appendices IV–VIII. The insect pests that attack French bean were whitefly, jassid and aphid. The results have been discussed and possible interpretations have been made regarding whitefly, jassid and aphid incidence under the following sub headings.

4.1 Incidence of whitefly at different days after sowing

Insecticidal application had a significant effect on the incidence of whitefly in French bean (Table 1). With the application of different insecticides, the number of whitefly was gradually decreased and severity was observed. It was evident that the lowest incidence of whitefly (10.12, 5.58, 3.28 and 1.24 per plant at 20, 40, 60 DAS and at harvest respectively) was observed in the plot that was treated with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) which was statistically identical with T_6 , Fortap 50SP (Cartap) @ 3 g L^{-1}) 1 ml L^{-1}) at 20 DAS (10.24) but closely followed at 40, 60 DAS and per plant at harvest (6.84, 5.12 and 2.84 respectively). It was also evident that at all growth stages of other treatments effect in terms of whitefly incidence were significantly different from T_4. On the other hand, the highest incidence of whitefly in the crop field (13.44, 15.46, 17.67 and 22.12 per plant at 20, 40, 60 DAS and at harvest respectively) was found in control treatment (T_7) which was also significantly different from all other treatments. Among the treated six treatments (without

control), the highest incidence of whitefly (12.38, 11.15, 9.18 and 4.12 per plant at 20, 40, 60 DAS and at harvest respectively) was observed in the treatment of Actara 25WG @ 0.3 g L^{-1} (T_3) and T_2 (Shobicron 425EC @ 2 ml L^{-1}) and T_5 (Sinothrin 10EC @ 1 ml L^{-1}) showed moderate results.

As stated in Table 1, remarkable variation was observed in terms of percent reduction of whitefly incidence over control by number as influenced by different treatment application. It was observed that the highest reduction of whitefly over control (24.70, 63.91, 81.44 and 94.39% at 20, 40, 60 DAS and at harvest respectively) was observed with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the lowest (7.88, 27.88, 48.05 and 81.37% at 20, 40, 60 DAS and at harvest respectively) was observed in Actara 25WG @ 0.3 g L^{-1} (T_3) which was very close to Shobicron 425EC @ 2 ml L^{-1} (T_2) and Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5). The treatment T_1 Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}) and T_6 Fortap 50SP (Cartap) @ 3 g L^{-1}) showed moderate results compared to higher percent reduction of whitefly over control. The order of the effectiveness among the treatments was Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) > Fortap 50SP (Cartap) @ 3 g L^{-1} (T_6) > Bamper 20SL (Imidacloprid) @ 0.5ml L^{-1} (T_1) > Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) > Shobicron 425EC @ 2 ml L^{-1} (T_2) > Actara 25WG @ 0.3 g L^{-1} (T_3) at the time of all growth stages.

Table 1: Effect of different insecticides application in controlling whitefly in French bean at different days after sowing (DAS)

Treatment	Incidence of whitefly (No. plant^{-1})				Percent reduction over control			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	10.36 d	8.15 e	6.98 e	3.18 d	22.92c	47.28 c	60.50 c	85.62 c
T_2	12.14 b	10.04 c	8.14 c	3.98 c	9.67e	35.06 e	53.93 e	82.01 e
T_3	12.38 b	11.15 b	9.18 b	4.12 b	7.89f	27.88 f	48.05 f	81.37 e
T_4	10.12 d	5.58 g	3.28 g	1.24 f	24.70a	63.91 a	81.44 a	94.39 a
T_5	12.00 bc	9.12 d	7.32 d	3.67 c	10.71d	41.01 d	58.57 d	83.41 d
T_6	10.24 d	6.84 f	5.12 f	2.84 e	23.81b	55.76 b	71.02 b	87.16 b
T_7	13.44 a	15.46 a	17.67 a	22.12 a	--	--	--	--
$LSD_{0.05}$	0.038	0.244	0.146	0.044	0.312	1.283	1.628	1.344
CV (%)	7.288	7.846	8.554	7.244	7.816	8.144	8.327	7.452
SE	0.148	0.064	0.054	0.062	0.116	0.068	0.059	0.060

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level as per Least Significant Difference (LSD) test. Values are mean of three replications.

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

4.2 Incidence of jassid

The severity of jassid incidence in the crop field was significantly affected due to different insecticide application (Table 2). With the application of different insecticides, the number of jassid was gradually decreased and severity was observed. It was evident that the lowest number of jassid (7.32, 4.22, 2.54 and 0.00 per plant at 20, 40, 60 DAS and at harvest respectively) was observed in the plot that was treated with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4).

But Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1} (T_1), Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) and Fortap 50SP (Cartap) @ 3 g L^{-1} (T_6) also gave promising results for effective control of jassid. On the other hand, the highest incidence of jassid in the crop field (9.89, 11.84, 14.2 and 17.36 per plant at 20, 40, 60 DAS and at harvest respectively) was found in control treatment (T_7) which was also significantly different from all other treatments. Among the treated six treatment (without control), the highest incidence of jassid (9.04, 8.54, 5.96 and 3.65 per plant at 20, 40, 60 DAS and at harvest respectively) was observed in the treatment of Actara 25WG @ 0.3 g L^{-1} (T_3).

As affirmed in Table 2, remarkable variation was observed in terms of percent reduction of jassid incidence over control by number as influenced by different treatment application. It was observed that the highest reduction of jassid over control (64.01, 67.60, 62.52 and 69.92% at 20, 40, 60 DAS and at harvest respectively) was observed with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4). On the other hand, the lowest (8.59, 27.87, 58.20 and 78.97% at 20, 40, 60 DAS and at harvest respectively) was observed in Actara 25WG @ 0.3 g L^{-1} (T_3) which was very close to the treatment of T_2 (Shobicron 425EC @ 2 ml L^{-1}). The treatment T_1 (Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}) and T_6 (Fortap 50SP (Cartap) @ 3 g L^{-1}) also showed comparatively

higher percent reduction of jassid over control. The order of the effectiveness among the treatments was Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) > Fortap 50SP (Cartap) @ 3 g L^{-1} (T_6) > Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1} (T_1) > Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) > Shobicron 425EC @ 2ml L^{-1} (T_2) > Actara 25WG @ 0.3 g L^{-1} (T_3) at the time of all growth stages.

Table 2: Effect of different insecticides application in jassid controlling in French bean at different days after sowing (DAS)

Treatment	Incidence of jassid (No. plant^{-1})				Percent reduction over control			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	7.88 e	5.48 e	4.18 d	2.46 e	20.32 c	53.72 c	70.69 c	85.83 c
T_2	8.86 c	7.32 c	5.38 c	3.24 c	10.41 e	38.18 e	62.27 d	81.34 d
T_3	9.04 b	8.54 b	5.96 b	3.65 b	8.595 f	27.87 f	58.20 e	78.97 e
T_4	7.32 g	4.22 g	2.54 f	0.00 g	25.99 a	64.36 a	82.19 a	100.0 a
T_5	8.42 d	6.45 d	4.26 d	2.98 d	14.86 d	45.52 d	70.13 c	82.83 d
T_6	7.56 f	5.00 f	3.76 e	2.04 f	23.56 b	57.77 b	73.63 b	88.25 b
T_7	9.89 a	11.84 a	14.26 a	17.36 a	--	--	--	--
$LSD_{0.05}$	0.156	0.104	0.086	0.058	1.025	2.118	1.084	1.872
CV (%)	7.178	6.354	8.242	8.543	7.446	6.849	8.019	7.012
SE	0.228	0.166	0.024	0.086	0.186	0.092	0.018	0.092

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level as per Least Significant Difference (LSD) test. Values are mean of three replications.

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

4.3 Infestation intensity of jassid

The infestation intensity by jassid had significantly affected due to different insecticide application (Figure. 1). It was evident that the lowest infestation intensity by jassid (5%) was observed in the plot that was treated with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the highest infestation intensity (29.17%) was achieved by control treatment (T_7). The treatment of Fortap 50SP (Cartap) @ 3 g L^{-1} (T_6) also showed comparatively lower infestation intensity by jassid. Among the treated plots, the highest infestation intensity (20.83%) by jassid was observed from Actara 25WG @ 0.3 g L^{-1} (T_3).

The order of the effectiveness among the treatments in terms of infestation intensity by jassid was Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) > Fortap 50SP ((Cartap) @ 3 g L^{-1} (T_6) > Bamper 20SL(Imidacloprid) @ 0.5ml L^{-1} (T_1) > Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) > Shobicron 425EC @ 2 ml L^{-1} (T_2) > Actara 25WG @ 0.3 g L^{-1} (T_3) > Control treatment (T_7) at the time of harvest.

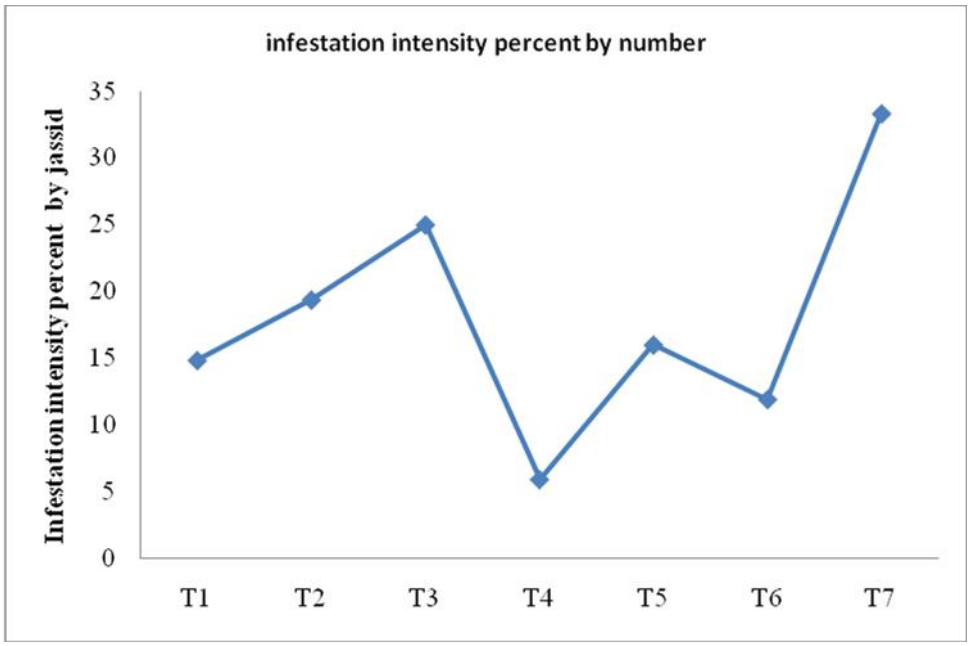

Figure 1. Infestation intensity of plant by jassid after the use of different insecticide at the time of harvest

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

4.4 Incidence of aphid

Incidence of aphid in the crop field had significantly affected due to different insecticide application (Table 3). Gradually decreased trend was found for controlling aphid with the application of different insecticide. It was observed that the lowest incidence of aphid (10.04, 6.67, 4.82 and 2.18 per plant at 20, 40, 60 DAS and at harvest respectively) was observed in the plot that was treated with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) which was significantly different from all other treatments. On the other hand, the highest incidence of aphid in the crop field (13.36, 18.32, 24.28 and 28.00 per plant at 20, 40, 60 DAS and at harvest respectively) was found in control treatment (T_7) which was also significantly different from all other treatments. Among the treated six treatment (without

control), the highest incidence of aphid (12.22, 10.18, 8.32 and 5.54 per plant at 20, 40, 60 DAS and at harvest respectively) was observed in the treatment of Actara 25WG @ 0.3 g L^{-1} (T_3) and T_1 Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}) and T_6 Fortap 50SP (Cartap) @ 3 g L^{-1}) showed moderate results.

As acknowledged in Table 3, considerable difference was observed in terms of percent reduction of aphid incidence among the treatments over control by number as influenced by different treatment application. It was observed that the highest reduction of aphid over control (24.85, 63.59, 80.15 and 92.21% at 20, 40, 60 DAS and at harvest respectively) was observed with Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the lowest (8.53, 44.43, 65.73 and 80.21% at 20, 40, 60 DAS and at harvest respectively) was observed in Actara 25WG @ 0.3 g L^{-1} (T_3). The treatment, T_2 (Shobicron 425EC @ 2 ml L^{-1}, and T_5 Sinothrin 10EC (Cypermethrin) showed comparatively less efficient results but T_1 Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}) and T_6 Fortap 50SP (Cartap) @ 3 g L^{-1}) showed comparatively higher performance. The order of the effectiveness among the treatments was Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) > Fortap 50SP ((Cartap) @ 3 g L^{-1} (T_6) > Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1} (T_1) > Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) > Shobicron 425EC @ 2 ml L^{-1} (T_2) > Actara 25WG @ 0.3 g L^{-1} (T_3) at the time of all growth stages.

Table 3: Effect of different insecticides application in bean aphid controlling in French bean at different days after sowing (DAS)

Treatment	Incidence of aphid (No. plant^{-1})				Percent reduction over control			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	11.07 d	8.12 e	6.36 e	4.12 e	17.14 c	55.68 c	73.81 c	85.29 c
T_2	11.88 c	9.26 c	7.45 c	5.34 bc	11.08 e	49.45 e	69.32 e	80.93 e
T_3	12.22 b	10.18 b	8.32 b	5.54 b	8.533 f	44.43 f	65.73 f	80.21 f
T_4	10.04 f	6.67 g	4.82 g	2.18 g	24.85 a	63.59 a	80.15 a	92.21 a
T_5	11.65 cd	8.84 d	7.16 cd	4.85 d	12.80 d	51.75 d	70.51 d	82.68 d
T_6	10.62 e	7.86 f	5.18 f	3.14 f	20.51 b	57.10 b	78.67 b	88.79 b
T_7	13.36 a	18.32 a	24.28 a	28.00 a	--	--	--	--
$LSD_{0.05}$	0.184	0.146	0.074	0.068	0.864	1.019	1.004	1.207
CV (%)	7.478	6.842	8.394	8.149	7.064	6.552	7.221	8.063
SE	0.088	0.176	0.144	0.188	0.072	0.104	0.052	0.098

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level as per Least Significant Difference (LSD) test. Values are mean of three replications.

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

4.5 Weight of infested bean (g)

Weight of infested bean yield plant^{-1} was significantly influenced by different insecticide application mentioned in different treatments (Table 4). Results indicated that the lowest infested bean yield plant^{-1} (9.60 and 16.00 g at 60 and 85 DAS) was achieved by the treatment of Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) which was significantly different from all other treatments. Again, the second lowest per plant infested yield plant^{-1} (13.6 and 33.6 g at 60 and 85 DAS) was achieved from T_6 Fortap 50SP (Cartap) @ 3 g L^{-1}) which was also different from all other treatments. On the other hand, the highest infested bean yield plant^{-1} (52.80 and 68.80 g at 60 and 85 DAS) was obtained from control treatment (T_7). But among the treated plot (without control), the highest infested bean yield plant^{-1} (45.60 and 63.20 g at 60 and 85 DAS) was observed in T_3 (Actara 25WG @ 0.3 g L^{-1}) which was closely followed by T_5 Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}).

Percent reduction of infested bean yield plant^{-1} over control. As shown in Table 4, the highest percent reduction over control (81.82 and 76.74% at 60 and 85 DAS) was observed in T_4 (Chlorpyriphos 20EC @ 3 ml L^{-1}) where the lowest percent reduction over control (13.64 and 8.14% at 60 and 85 DAS) was obtained from T_3 (Actara 25WG @ 0.3 g L^{-1}). The treatment T_6 (Fortap 50SP (Cartap) @ 3 g L^{-1}) also showed comparatively higher percent reduction of infested bean yield plant^{-1} over control (66.67 and 51.17% at 60 and 85 DAS). The order of the effectiveness among the treatments was Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) > Fortap 50SP (Cartap) @ 3 g L^{-1} (T_6) > Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1} (T_1) > Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) > Shobicron 425EC @ 2 ml L^{-1} (T_2) > Actara 25WG @ 0.3 g L^{-1} (T_3) at the time of all growth stages.

Table 4: Effect of different insecticides application in controlling of insect pest in French bean on weight of infested bean at different days after sowing (DAS)

Treatment	Weight of infested bean (g) plant^{-1}		Percent reduction over control	
	1st harvest at 60 DAS	2nd harvest at 85 DAS	1st harvest at 60 DAS	2nd harvest at 85 DAS
T_1	35.20 d	54.40 c	33.33 c	20.93 c
T_2	40.80 c	60.80 b	22.73 e	11.63 e
T_3	45.60 b	63.20 b	13.64 f	8.140 f
T_4	9.60 f	16.00 e	81.82 a	76.74 a
T_5	39.20 c	55.20 c	25.76 d	19.77 d
T_6	17.60 e	33.60 d	66.67 b	51.16 b
T_7	52.80 a	68.80 a	--	--
$LSD_{0.05}$	2.361	3.458	1.112	2.026
CV (%)	7.549	8.326	7.038	7.894
SE	0.158	0.188	0.027	0.075

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level as per Least Significant Difference (LSD) test. Values are mean of three replications.

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

4.6 Weight of healthy bean

Weight of healthy bean plant^{-1} was also significantly influenced by different insecticide application mentioned in different treatments (Table 5). Results indicated that the highest healthy bean yield plant^{-1} (166.40 and 284.80 g at 60 and 85 DAS) was achieved by the treatment of Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) which was significantly different from all other treatments. Again, the second highest per plant

healthy yield plant^{-1} (159.20 and 205.60 g at 60 and 85 DAS) was achieved from T_6 (Fortap 50SP (Cartap) @ 3 g L^{-1}) which was also significantly different from all other treatments. On the other hand, the lowest healthy bean yield plant^{-1} (52.80 and 102.40 g at 60 and 85 DAS) was obtained from control treatment (T_7). But among the treated plot (without control), the lowest healthy bean yield plant^{-1} (96.80 and 150.40 g at 60 and 85 DAS) was observed in T_3 (Actara 25WG @ 0.3 g L^{-1}).

In terms of percent increase of healthy bean yield plant^{-1} over control as shown in Table 5, the highest percent increase over control (215.20 and 178.10% at 60 and 85 DAS) was observed in T_4 (Chlorpyriphos 20EC @ 3 ml L^{-1}) where the lowest percent increase over control (83.33 and 46.88% at 60 and 85 DAS) was obtained from T_3 (Actara 25WG @ 0.3 g L^{-1}). The treatment T_6 Fortap 50SP (Cartap) @ 3 g L^{-1}) also showed comparatively higher percent increase of healthy bean yield plant^{-1} over control (201.50 and 100.80% at 60 and 85 DAS). The treatment of T_1 (Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}) and T_5 (Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}) showed moderate results. The order of the effectiveness among the treatments was Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) > Fortap 50SP ((Cartap) @ 3 g L^{-1} (T_6) > Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1} (T_1) > Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} (T_5) > Shobicron 425EC @ 2 ml L^{-1} (T_2) > Actara 25WG @ 0.3 g L^{-1} (T_3) at the time of all growth stages.

Table 5: **Effect of different insecticides application in controlling of insect pest in French bean on weight of healthy bean at different days after sowing (DAS)**

Treatment	Weight of healthy bean (g) plant^{-1}		Percent increase over control	
	1st harvest at	2nd harvest at 85	1st harvest at	2nd harvest at

	60 DAS	DAS	60 DAS	85 DAS
T_1	126.00 c	171.60 c	138.60 c	67.58 c
T_2	107.20 e	162.40 e	103.00 e	58.590 d
T_3	96.80 f	150.40 f	83.330 f	46.880 e
T_4	166.40 a	284.80 a	215.20 a	178.10 a
T_5	116.80 d	164.80 d	121.20 d	60.940 d
T_6	159.20 b	205.60 b	201.50 b	100.80 b
T_7	52.80 g	102.40 g	--	--
$LSD_{0.05}$	3.68	4.94	4.8520	3.1490
CV (%)	8.32	7.27	7.92	7.04
SE	0.14	0.12	0.028	0.019

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level as per Least Significant Difference (LSD) test. Values are mean of three replications.

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

4.7 Total healthy yield

Total healthy yield was significantly influenced by different insecticide application mentioned in different treatments (Table 6). Results indicated that the highest healthy bean yield ha^{-1} (11.28 t ha^{-1}) was achieved by the treatment of Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) which was significantly different from all other treatments. Again, the second highest healthy yield ha^{-1} (9.12 t ha^{-1}) was achieved from T_6 Fortap 50SP (Cartap) @ 3 g L^{-1}) which was also significantly different from all other treatments. On the other hand, the lowest healthy bean yield ha^{-1} (3.88 t ha^{-1}) was obtained from control treatment (T_7). But among the treated plot (without control), the lowest healthy bean yield ha^{-1} (6.18 t ha^{-1}) was observed in T_3 (Actara 25WG @ 0.3 g L^{-1}). The results obtained from Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1} in T_1 (7.44 t ha^{-1}) and Sinothrin 10EC (Cypermethrin) 1 ml L^{-1} in T_5 (7.04 t ha^{-1}) showed moderate healthy fruit yield ha^{-1}.

4.8 Total infested yield

Weight of total infested bean yield ha^{-1} was significantly influenced by different insecticide application mentioned in different treatments (Table 6). Results indicated that the lowest infested bean yield ha^{-1} (0.64 t ha^{-1}) was achieved by the treatment of Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) which was significantly different from all other treatments. Again, the second lowest infested yield ha^{-1} (1.28 t ha^{-1}) was achieved from T_6 (Fortap 50SP (Cartap) @ 3 g L^{-1}) which was also significantly different from all other treatments. On the other hand, the highest infested bean yield ha^{-1} (3.04 t ha^{-1}) was obtained from control treatment (T_7). But among the treated plot (without control), the highest infested bean yield ha^{-1} (2.72 t ha^{-1}) was observed in T_3 (Actara 25WG @ 0.3 g L^{-1}) which was closely followed by Shobicron 425EC @ 2 ml L^{-1}, T_2 (2.54 t ha^{-1}).

4.9 Gross return

From the economic point of view, effective pest management of a crop application of different causes a great gross return. Under the present study applied insecticides showed variable performance for managing the insect pests of French bean (Table 6). The affectivity was not same and varied significantly and this is why a great variation was occurred in terms of gross return. Results showed that the highest gross return (Tk. 232000.00 ha^{-1}) was achieved from Chlorpyriphos 20EC @ 3 ml L^{-1}(T_4) treated plot where the lowest gross return (Tk. 108000.00 ha^{-1}) came from control treatment. The second highest gross return Tk. 195200.00 ha^{-1}) was observed from Fortap 50SP (Cartap) @ 3 g L^{-1} treated plot (T_6) which was close to the treatment of T_1 (Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}) treated plot (Tk. 171200.00 ha^{-1}). Under the treated plot, the lowest gross return (Tk. 150800.00 ha^{-1}) was observed from Actara 25WG @ 0.3 g L^{-1} (T_3).

Table 6: **Effect of different insecticides application in controlling of insect pest in French bean on marketable yield and economic returns**

Treatment	Total healthy yield (t ha^{-1})	Total infested yield (t ha^{-1})	Gross return (Tk ha^{-1})
T_1	7.44 c	2.24 c	171200.00 c
T_2	6.74 de	2.54 c	160200.00 e
T_3	6.18 e	2.72 b	150800.00 f
T_4	11.28 a	0.64 e	232000.00 a
T_5	7.04 c	2.36 d	164400.00 d
T_6	9.12 b	1.28 d	195200.00 b
T_7	3.88 f	3.04 a	108000.00 g
$LSD_{0.05}$	0.538	0.129	13.196
CV (%)	7.843	6.348	8.142
SE	0.114	0.118	0.129

Figures in the same column accompanied by the same letter(s) are not significantly different at 5% level as per Least Significant Difference (LSD) test. Values are mean of three replications.

Average price of healthy French bean @ tk 20 kg^{-1} and infested French bean @ tk 10 kg^{-1}

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control and
DAS = Days after sowing

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

A field experiment was conducted at Sher-e-Bangla Agricultural University farm during January to March 2011 to study on the bioefficacy of some insecticides against major insect pests of French bean (*Phaseolus vulgaris* L.).

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications in the field. The whole field was divided into four equal blocks having 1 m space between the blocks and each block was again sub-divided into 7 plots (2.5m × 2m each) as treatment plots with 0.6 m space between them. The spacing was 30 cm between rows and 40 cm between plants. The treatments of the present study were assigned as (i) T_1 = Bamper 20SL (Imidacloprid) @ 0.5 ml L^{-1}, (ii) T_2 = Shobicron 425EC @ 2 ml L^{-1}, (iii) T_3 = Actara 25WG @ 0.3 g L^{-1}, (iv) T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}, (v) T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}, (vi) T_6 = Fortap 50SP (Cantap) @ 3 g L^{-1} and (vii) T_7 = Untreated control.

Data was collected on Incidence of whitefly plant^{-1} by number, Incidence of jassid plant^{-1} by number, Incidence of aphid plant^{-1} by number, Weight of infested bean plant^{-1}, Weight of healthy bean plant^{-1}, Total healthy yield (t ha^{-1}), Total infested yield (t ha^{-1}) and Gross return (Tk ha^{-1})

Results showed that the lowest number of whitefly plant^{-1} (10.12, 5.58, 3.28 and 1.24 at 20, 40, 60 DAS and at harvest respectively), jassid plant^{-1} (7.32, 4.22, 2.54 and 0.00 at 20, 40, 60 DAS and at harvest respectively) and aphid plant^{-1} (10.04, 6.67, 4.82 and 2.18 at 20, 40, 60 DAS and at harvest respectively) were obtained from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the highest number of whitefly plant^{-1} (13.44, 15.46,

17.67 and 22.12 at 20, 40, 60 DAS and at harvest respectively), jassid plant^{-1} (9.89, 11.84, 14.2 and 17.36 at 20, 40, 60 DAS and at harvest respectively) and aphid plant^{-1} (13.36, 18.32, 24.28 and 28.00 at 20, 40, 60 DAS and at harvest respectively) were obtained from Control treatment (T_7). But in case of treated plot the highest number of whitefly plant^{-1} (12.38, 11.15, 9.18 and 4.12 at 20, 40, 60 DAS and at harvest respectively), jassid plant^{-1} (9.04, 8.54, 5.96 and 3.65 at 20, 40, 60 DAS and at harvest respectively) and aphid plant^{-1} (12.22, 10.18, 8.32 and 5.54 at 20, 40, 60 DAS and at harvest respectively) were obtained from Actara 25WG @ 0.3 g L^{-1} (T_3).

In terms of percent reduction over control, the highest percent reduction of whitefly plant^{-1} (24.70, 63.91, 81.44 and 94.39% at 20, 40, 60 DAS and at harvest respectively), jassid plant^{-1} (64.01, 67.60, 62.52 and 69.92% at 20, 40, 60 DAS and at harvest respectively) and aphid plant^{-1} (24.85, 63.59, 80.15 and 92.21% at 20, 40, 60 DAS and at harvest respectively) were obtained from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the lowest percent reduction of whitefly plant^{-1} (7.88, 27.88, 48.05 and 81.37% at 20, 40, 60 DAS and at harvest respectively), jassid plant^{-1} (8.59, 27.87, 58.20 and 78.97% at 20, 40, 60 DAS and at harvest respectively) and aphid plant^{-1} (8.53, 44.43, 65.73 and 80.21% at 20, 40, 60 DAS and at harvest respectively) were obtained from Actara 25WG @ 0.3 g L^{-1} (T_3).

In terms of infestation intensity by major insect the lowest infestation intensity by whitefly (5.92%), by jassid (5%) and by aphid (14.25%) were obtained from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the highest infestation intensity by whitefly (33.33%), by jassid (29.17%) and by aphid (41.67%) were obtained from Control treatment (T_7). But in case of treated plot the highest infestation intensity by whitefly (25%), by jassid (20.83%) and by aphid (29.17%) were obtained from Actara 25WG @ 0.3 g L^{-1} (T_3).

Again, the lowest infested bean yield plant^{-1} (9.60 and 16.00 g at 60 and 85 DAS) and highest healthy bean yield plant^{-1} (166.40 and 284.80 g at 60 and 85 DAS) were obtained from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the highest infested bean yield plant^{-1} (52.80 and 68.80 g at 60 and 85 DAS) and lowest healthy bean yield plant^{-1} (52.80 and 102.40 g at 60 and 85 DAS) were obtained from Control treatment (T_7).

But in case of treated plots, the highest infested bean yield plant^{-1} (45.60 and 63.20 g at 60 and 85 DAS) and lowest healthy bean yield plant^{-1} (96.80 and 150.40 g at 60 and 85 DAS) were obtained from Actara 25WG @ 0.3 g L^{-1} (T_3). Again, the highest percent reduction of infested bean yield plant^{-1} over control (81.82 and 76.74% at 60 and 85 DAS) and highest increase of healthy bean yield plant^{-1} over control (215.20 and 178.10% at 60 and 85 DAS) were achieved from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the lowest percent reduction of infested bean yield plant^{-1} over control (13.64 and 8.14% at 60 and 85 DAS) and lowest increase of healthy bean yield plant^{-1} over control (83.33 and 46.88% at 60 and 85 DAS) were achieved from Control treatment (T_7).

In respect of yield ha^{-1}, the highest total healthy yield (11.28 t ha^{-1}) and lowest total infested yield (0.64 t ha^{-1}) were obtained from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the lowest total healthy yield (3.88 t ha^{-1}) and highest total infested yield (3.04 t ha^{-1}) were obtained from Control treatment (T_7). But within treated plots the lowest total healthy yield (6.18 t ha^{-1}) and highest total infested yield (2.72 t ha^{-1}) were obtained from Actara 25WG @ 0.3 g L^{-1} (T_3). In terms of gross return, the highest return (Tk. 232000.00 ha^{-1}) was also achieve from Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) where the lowest return (Tk. 232000.00 ha^{-1}) was also achieve from Control treatment (T_7) and under the treated plot, the lowest gross return (Tk. 150800.00 ha^{-1}) was observed from Actara 25WG @ 0.3 g L^{-1} (T_3).

CONCLUSION

From the study, it may be concluded that incidence of whitefly, jassid and bean aphid was lowest with the application of Chlorpyriphos 20EC @ 3 ml L^{-1} (T_4) and consequently with this treatment, highest total healthy fruit yield, lowest infested fruits and highest gross return were found while control treatment showed the lowest performance.

The overall study revealed that Chlorpyriphos 20EC @ 3 ml L^{-1} significantly reduced pest infestation that ranks this treatment as the best in respect of reducing insect pest, increasing fruit yield and above all gross return.

Recommendation

Considering the above findings of the study following recommendations can be drawn:

- Chlorpyriphos 20EC should be applied against whitefly, aphid and jassid infesting French bean effective control measures.
- Further intensive field studies based on Chlorpyriphos 20EC should be done.
- More number of insecticides should be included in further elaborative research for controlling insect pests of French bean.

CHAPTER VI

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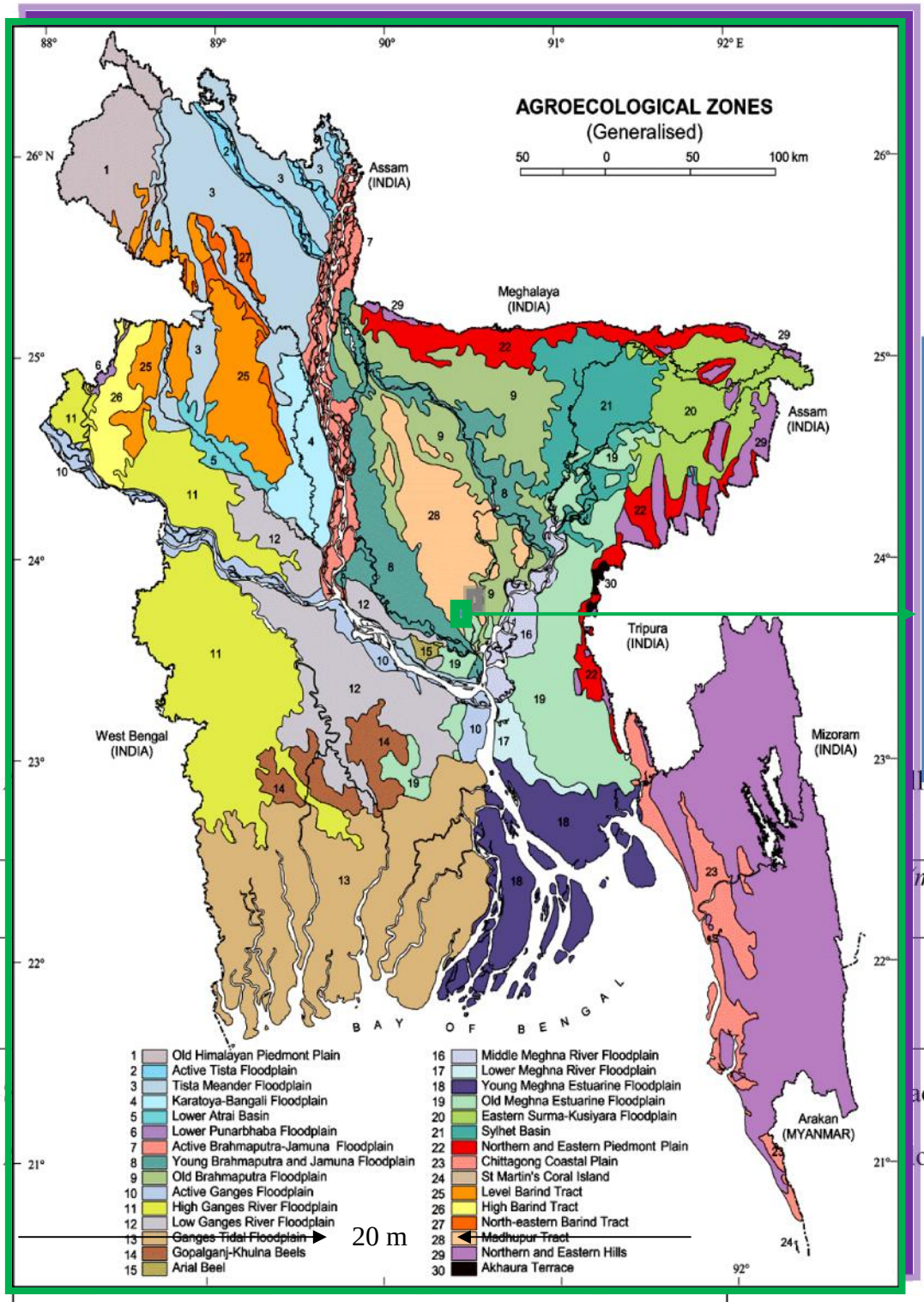
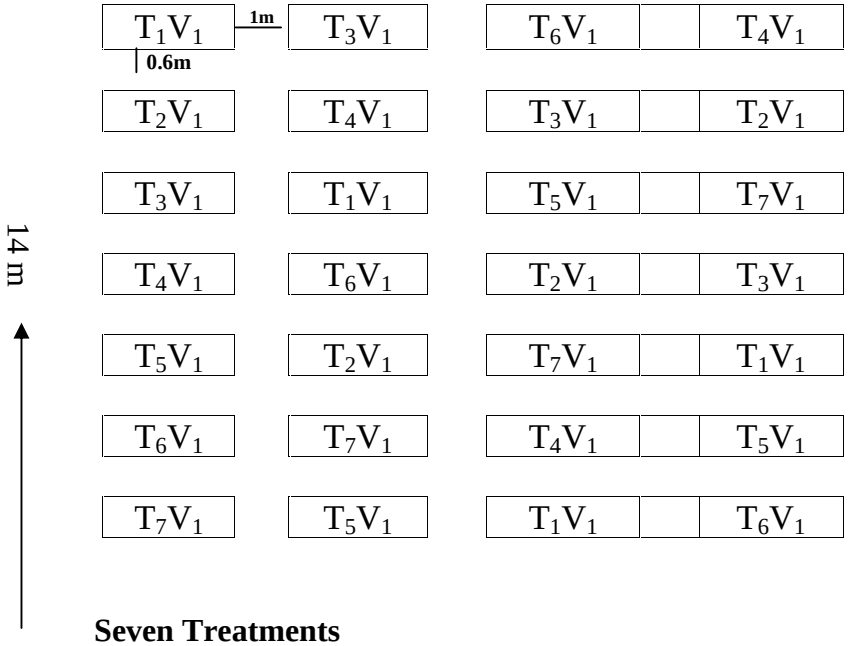
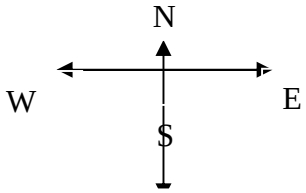
APPENDICES

Appendix I. Map showing the experimental site



The experimental site





Plot size: 2.5m x 2 m
Spacing between plots: 60 cm
Spacing between replication: 1 m

Seven Treatments

T_1 = Bamper 20 SL (Imidacloprid) @ 0.5 ml L^{-1}
T_2 = Shobicron 425EC @ 2 ml L^{-1}
T_3 = Actara 25WG @ 0.3 g L^{-1}
T_4 = Chlorpyriphos 20EC @ 3 ml L^{-1}
T_5 = Sinothrin 10EC (Cypermethrin) 1 ml L^{-1}
T_6 = Fortap 50 SP (Cartap) @ 3 g L^{-1}
T_7 = Untreated Control
V_1 = Variety (BARI bush bean-1)

Ap esources

Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B.

hysical and chemical properties of the initial soil

Characteristics	*Value*
Particle size analysis	
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix V. Effect of different management practices of insect pest in French bean on the incidence of whitefly at different days after sowing (DAS)

Source of variation	Degrees of Freedom	Mean square of incidence of whitefly plant^{-1} at different days after sowing			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.004	0.002	0.006	0.012
Factor A	6	1.012*	2.034*	2.118*	2.354*
Error	12	0.155	1.116	0.145	1.004

Appendix VI: Effect of different management practices of insect pest in French bean on the incidence of jassid at different days after sowing (DAS)

Source of variation	Degrees of Freedom	Mean square of incidence of jassid plant^{-1} at different days after sowing			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.014	0.004	0.004	0.004
Factor A	5	2.216*	3.362*	3.844*	4.169*
Error	10	0.385	0.512	1.126	2.321

Appendix VII: Effect of different management practices of insect pest in French bean on the incidence bean aphid at different days after sowing (DAS)

Source of variation	Degrees of Freedom	Mean square of incidence of aphid plant^{-1} at different days after sowing			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.002	0.004	0.014	0.018
Factor A	6	3.326*	3.458*	4.118*	3.569*
Error	12	0.245	1.566	2.328	1.112

Appendix VIII: Infestation intensity of plant by whitefly, jassid and aphid after the use of different insecticide application at the time of harvest

Source of variation	Degrees of Freedom	Mean square of infestation intensity by		
		whitefly	jassid	Aphid
Replication	2	0.014	0.006	0.108
Factor A	6	4.246*	4.362*	5.485*
Error	12	2.116	3.446	2.128

Appendix IX: Effect of different management practices of insect pest in French bean on weight of infested bean at different days after sowing (DAS)

Source of variation	Degrees of Freedom	Mean square of incidence of weight of infested bean plant^{-1} (g)	
		First harvest at 60 DAS	Second harvest at 85 DAS
Replication	2	0.004	0.033
Factor A	6	1.348*	3.368*
Error	12	0.325	1.246

Appendix X: Effect of different management practices of insect pest in French bean on marketable yield

Source of variation	Degrees of Freedom	Mean square of	
		Total healthy yield (t ha^{-1})	Total infested yield (t ha^{-1})
Replication	2	0.002	0.004
Factor A	6	3.368*	4.268*
Error	12	1.005	1.211