INCIDENCE OF INSCT PESTS AND THEIR INTEGRATED MANAGEMENT ON SOYBEAN

A THESIS

By

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CERTIFICATE

This is to certify that thesis entitled, "INCIDENCE OF INSCT PESTS AND THEIR INTEGRATED MANAGEMENT ON SOYBEAN" 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 MD. ABDUR RAZZAK KHAN bearing Registration No. 06-01913 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

.....

(Prof. Dr. Md. Abdul Latif)
Supervisor

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The Author

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATE

INCIDENCE OF INSCT PESTS AND THEIR INTEGRATED MANAGEMENT ON SOYBEAN

ABSTRACT

To observe the insect pest complex and population dynamics of some major insect pests on soybean and to develop their integrated management practices two field experiments were conducted at experimental field of Sher-e-Bangla Agricultural University (SAU) during July 2012 to June 2013 in Randomized Complete Block Design (RCBD) with three replications. Insect pest complex and population dynamics of five major insect pests were recorded from unsprayed field. Effectiveness of plant materials, chemical insecticides, plant hormones and integrated pest management techniques were evaluated based on the incidence of insect pests and yield of soybean. Nineteen (19) insect pests of sixteen (16) families under six (6) orders were recorded from soybean field. Leaf beetle and semilooper were found as major leaf feeding, and aphid, jassid and whitefly were observed as major sucking insect pests of soybean. Incidence of these insect pests increased with the increasing of temperature, humidity and age of the crop and reached in peak at 40-50 days after sowing and then declined with age of the crop. Among the plant materials neem oil showed the best performance against leaf feeding and sucking insect pests and produced highest yield. Carbosulfan gave the best result in reducing insect pests and increasing yield of soybean over control. Among the IPM techniques, Plant Revitalization Hormone (PRH) alone showed the better performance in reducing insect pests and increasing yield of soybean than Carbosulfan, neem oil and/or combined use of them. Although Carbosulfan gave the best effectiveness for the management of soybean insect pest neem oil or PRH may be included as a component of integrated pest management for soybean from health hazard and environmental safety point of view.

CHAPTER I
INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] belongs to the family Leguminosae, sub family Papilionaceae. It is one of the major oil seed crops of the world. It is a fascinating crop with innumerable possibilities of not only improving agriculture, but also supporting industries. Soybean is one of the most important crop which is grown for oil and protein in both the rabi and kharif seasons. Seeds of soybean contain about 42% protein and 20% oil and provide 60% of the world supply of vegetable protein and 30% of the edible oil (Fehr, 1989). It also contains 20-30% carbohydrates (Natem *et al*., 2013). It is a rich source of amino acids, vitamins and minerals. Soybean, such an excellent crop, if grown extensively may reduce the fat and protein deficiency in the country.

The common people of Bangladesh cannot afford for animal protein like egg, milk, meat and fish in their daily diet because of their high cost (Wahab *et al*., 2002). Therefore, soybean can play a vital role to supplement proteinous food to the common people of Bangladesh.

Soybean can fix a considerable amount of nitrogen to the soil and can be a good crop in the rotation to enrich soil fertility. In the world it is cultivated mainly in USA, China, Brazil, Argentina and India. With a worldwide production estimated at 256 million metric tons, soybeans have significant, worldwide economic importance. Soybean crops supply half of the global demand for vegetable oil and protein (Oerke and Dehne, 2004). Brazil produced approximately 69 million metric tons of soybeans during the 2009/2010 growing season and is the second-largest producer after the USA, which produced around 91.4 million metric tons during the

same period (USDA, 2010). In Bangladesh both the production and production area of soybean is very low and it was cultivated as a minor crop only in few district locations. However, the level of production could still be increased if problems with insects could be avoided (Oerke, 2006). Consequently, to mitigate the negative consequences of pest outbreaks and improve profits, soybean growers attempt to control these phytophagous arthropods, which can reduce crop productivity (Zalucki *et al*., 2009).

In Bangladesh, about five thousand hectares of land is under soybean cultivation and annual production is approximately 4 thousand metric tons with an average yield of 1.5-2.3 t ha^{-1} (BARI, 2006). The low productivity of soybean both at national and state level is attributed to abiotic and biotic stresses like drought, weeds, insect pests and diseases. Among these, insect pests often pose a serious threat to soybean production by increasing cost of cultivation and impairing quality of the produce in many ways (Singh *et al*., 2000).

One of the major constraints to the successful soybean production in Bangladesh is the damage caused due to insect pests. Research reports reveal that 15-20 percent of the total soybean production is lost directly or indirectly by the attack of insect pests every year (Biswas, 2008). The luxuriant crop growth, soft and succulent foliage attracts many insects and provides unlimited source of food, space and shelter. Soybean crop is reported to be attacked by about 350 species of insects in many parts of the world (Luckmann, 1971). About 65 insect pests have been reported to attack soybean crop from cotyledon to harvesting stage (Jayappa, 2000; Thippaiah, 1997; Adimani, 1976 and Rai *et al*., 1973). Among them some are fatal to this crop and have changed their severity of attack in last few years.

Most noticeable pests are whitefly, aphids, jassids, leaf feeding caterpillars, mealy bugs, pod borer etc. Of which aphid causes 10 to 15% and whitefly causes 25% yield loss. It is important to note that soybeans are very tolerant of insect damage at many stages of crop development, and that noticeable damage (particularly leaf damage) does not necessarily translate to yield loss. Seeds damaged by pod-sucking bugs during early pod-fill are often lost at harvest, or are graded out post harvest, as they are lighter than undamaged seeds. Seeds damaged from mid pod-fill onwards are similar in weight to undamaged seeds, not lost at harvest or able to be graded out without resorting to color sorters.

All parts of the plant including plant leaves, stems and pods are subjected to attack by different species of insect in Bangladesh. Different species of insects cause serious damage by direct feeding as well as by transmitting various diseases (Daugerty, 2009). The frequency and severity of pest damage vary considerably between the growth stages. Thirty nine (39) species of insect pest have been recorded at the different growth stages of soybean in Noakhali region (Biswas, 2013). Of these, eight (8) species were recorded as the major pests and rests were minor importance. The most damaging insects were hairy caterpillar, leaf roller, common cutworm, pod borer, stem flies, bugs and whitefly were found to damage during vegetative, flowering and pod formation stage of the crop (Biswas *et al*., 2001). Thirteen species of insect pest and three species of natural enemies were recorded in the experimental field, soybean semilooper, soybean hairy caterpillar, soybean leaf roller, soybean fly, jassid, soybean pod borer, soybean leaf hopper, stink bug, black leaf beetle, short horned grass hopper, green leaf hopper, brown

plant hopper, cut worm and the natural enemies found were lady bird beetle, carabid beetle and spider (Rahman *et al.*, 2010).

To combat the obnoxious insects various control measures have been recommended by the researchers. Of which chemical control measures are reported to be more effective (Latif *et al.*, 1996). Dhaliwal and Arora (1998) reported that development of synthetic organic insecticides during 20th century initially provided spectacular results in suppressing the insect pests which led to abandonment of traditional pest control practices. Moreover, indiscriminate use of insecticides has led to problems like health hazards, insecticide resistance, pest resurgence and environmental pollution besides upsetting the natural ecosystem (Lakshmi and Verma, 1998). The researchers later recognized the harmful effects of pesticides and tried to bring eco-friendly approaches to reduce pesticide load in environment by using botanicals and bio-pesticides (Kundu and Trimohan, 1992; Kumar *et al.*, 2009). However, botanicals and bio-pesticides are quickly degradable, less hazardous to human health and not so harmful for the environment (Singh *et al.*, 2006). Moreover, reports are available on integrated pest management practices of soybean insect pests using plant extracts in India (Leatemia and Isman, 2004; Lakshmi and Verma, 1998).

The investigations on synthetic organic insecticides developed during 20th century initially provided spectacular results in suppressing the insect pests which led to abandonment of traditional pest control practices. However indiscriminate use of insecticides has led to problems like insecticide resistance, pest resurgence and environmental pollution besides upsetting the natural ecosystem.

The researchers later recognized the harmful effects of pesticides and tried to bring eco-friendly approaches to reduce pesticide load in environment by using botanicals and bio-pesticides. Moreover, plant based substances may be better alternative methods of pest management. Plant Revitalization Hormone (PRH) enhances plant growth as well as resists pest and diseases which might be an IPM tool for pest management. Therefore, it is an urgent need to study insect pests of soybean, their pest status and to develop integrated management practices against insect pests of soybean based on plant products. Keeping the above points in view, present study was designed and planned with the following objectives:

i. To observe the incidence of insect pests and their level of infestation on soybean.
ii. To determine population dynamics of different insect pest on soybean in relation to climatic factors and age of the crop.
iii. To develop an integrated pest management technique for suppressing major insect pests of soybean and increasing grain yield.

CHAPTER II
REVIEW OF LITERATURE

Soybean [*Glycine max* (L.) Merrill] is an important and well recognized and oil seed and grain legume crop all over the world. Several insect pests cause both qualitative and quantitative losses to the crop in the field of soybean. The damage caused by the pests either sporadically or in epidemic form every year all over Bangladesh. In this chapter tried to find the researches relevant to the topic and here shows some of them.

2.1 Incidence of insect pests in soybean

Biswas (2013) studied on Insect Pests of Soybean (*Glycine max* L.), their nature of damage and succession with the crop stages. Thirty nine species of insect pests were found to infest soybean crop at their different growth stages in Noakhali region of Bangladesh during January to May, 2010 and 2011. Among the recorded pest species, six species namely, hairy caterpillar, *Spilarctia obliqae* (Walker); leaf roller, *Lamprosema indicata* F; common cutworm, *Spodoptera litura* F; pod borer, *Helicoverpa armigera* (Hubner); stem fly, *Ophiomyia phaseoli* (Tryon) and white fly; *Bemisia tabaci* Genn. were considered as the major pests while the rests were of minor importance on the basis of population densities per plant, nature and extent of damages and yield reductions.

Netam *et al*. (2013) found five insects species, *viz.*, Girdle beetle, *Obereopsis brevis* tobacco caterpillar, *Spodoptera litura*, green semilooper, *Chryrodecxis acuta*, Jassids, *Empoasca kerri* and white flies, *Bemisia tabaci* were recorded as the major pests on soybean, variety JS 93-05 causing damage at various stages of the

crop. All these insects made their first appearance on the crop to a greater or lesser extent in the last week of July.

Among the minor pests, green stink bug (*Nezara viridula* L.), semilooper (*Plusia orichalcea* Fab.), Black cutworm (*Agrotis ipsilon* (Hufn.), leaf miner (*Stomopteryx* spp.), green grasshopper (*Attractomorpha crenulata* F.), pod bug (*Eusarcocoris* sp.) and aphid (*Aphis cracraccivora*) became occassionally important and caused serious damage to the soybean crop. Aphid, jassid and whitefly are also important as vectors for transmission of viral (YMV) diseases (Biswas 2008).

Biswas and Islam (2012) conducted a study on Infestation of Leaf Roller (*Lamprosema indicata* Fab.) in Soybean and observed that Leaf roller infestation occurred in the 3rd week of January at the vegetative and flowering stages (45-60 days after sowing=DAS) of the crop and continued up to pre-maturity period (80-85 DAS). The highest leaf roller population (0.9 and 1.00/plant in 2008 and 2009, respectively) and infestation (90% plant in 2008 and 95% plant in 2009) were recorded in the last week of February at the pod formation stage of the crop (65-70 DAS).

Biswas (2008) found fifty seven species of insects to attack the soybean crop at different growth stages in Bangladesh. Among these, the leaf roller (*Lamprosema indicata* Fab.) has appeared as the most damaging pest in recent years (Das, 1998; Biswas *et al.*, 2001). In addition to soybean crop, leaf roller also infests beans, cowpea, green gram, black gram and red gram (Nair, 1986).

Sastawa *et al.* (2004) reported that the number of insect defoliators and pod sucking bugs were significantly higher in soybean sown on 31st July in 2001 and on 28th August in 2002. Early sown crop recorded lower incidence of *S. litura*, *T. orichalcea* and *S. obliqua* compared to that of late sown crop as reported by Harish (2008).

Patil (2002) reported that soybean was attacked by 48 phytophagous insect species, among these the seedling borers, leaf eating caterpillar and pod borer were key pests during *kharif*. Whereas, leaf miner, white fly and leaf hopper were major pests during summer.

Jayappa (2000) reported 40 and 21 species of insects attacking soybean during *kharif* and summer seasons, respectively in Bangalore, Karnataka. 300 species of insect pests were infesting soybean, of which blue beetle, grey semilooper, green semilooper and stem fly were major insect pests in Madhya Pradesh (Singh *et al*., 2000).

Chaturvedi *et al.* (1998) reported that during *kharif* of 1995, 17 insect and one mite species were recorded infesting soybean variety JS 72-44 (Gaurav) sown on 15th July 1995 in Sehore, Madhya Pradesh, India. Of these, two damaged the stems, 10 defoliated the plants, five sucked the cell sap and one damaged the roots at different growth stages of the crop, immediately after the emergence of the cotyledons.

Thippaiah (1997) noticed 34 species of insects on soybean during *kharif* season and 25 species during summer season, in Bangalore, Karnataka. Among these, lepidopteran defoliators, *T. orichalcea, S. litura, Achaea janata* (Linn.) *and A. lactina* (L.) appeared only during *kharif* season where as *Spilosoma obliqua* (Walker) was noticed during both summer and *kharif* seasons.

Sontakke and Patro (1991) reported the incidence of about 20 insect pests on soybean in Western Orissa. Field studies were carried out during 1988-89 in Chiplima, Orissa, India, and the *kharif* crop of soybeans suffered greater damage by insect pests than the *rabi* crop. Lowest pest incidence and higher yields were recorded with early sowings in both seasons. The studies on date of sowing carried out at Dharwad also revealed the higher incidence of *S. litura* with late sown groundnut crop (Patil, 1995). Occurrences of 34 species of insects were observed during *kharif* and summer in Bangalore.

Soybean Leaf Roller is a major insect found in India, Thailand, the Philippines and other countries of Asia (Sachan and Gangwar, 1980). In addition to soybean crop, it also infests beans, cowpea, green gram, black gram and red gram (Nair, 1986). The semilooper, *Thysanoplusia orichalcea* was a pest mainly during *kharif* although it was observed in stray instances during summer also (Mundhe, 1980). Arunin (1978) gave an account of 10 species of insect pests of soybean out of 30 herbivorous species as being of economic importance in Thailand.

Adimani (1976) recorded 59 insect species belonging to 6 Orders occurring around Dharwad on soybean in Karnataka. The semilooper, *Thysanoplusia orichalcea* was a pest mainly during *kharif* although it was observed in stray instances during summer also (Mundhe, 1980).

Gangrade (1976) reported over 99 insect species attacking soybean crop at Jabalpur. But now the situation has changed and as many as 275 insect species have been recorded attacking soybean crop in India. Rai *et al.* (1973) recorded 24 insect species feeding on soybean in Karnataka, among them maximum damage was done by the larvae of *Lamprosoma indicata* F, *Stomopteryx subsecivella* Zeller,

Diacrisia oblique Walker and the gelechid shoot borer. A total of 267 insect species were reported from soybean fields in Arkansas by Tugwell *et al*. (1973).

Approximately 380 species of insects have been collected from soybean crop from many parts of the world (Luckmann, 1971). Saxena (1972) observed 32 insect pests and two non-insect pests of soybean in Madhya Pradesh. Fletcher (1922) was the earliest worker to report the incidence of nine species of insects occurring on soybean from India. About 85 species of insects belonging to six different Orders and a mite on soybean were reported from Madhya Pradesh by Gangrade (1962). Rawat *et al.* (1969) recorded over two dozen different species of arthropod pests of soybean from Madhya Pradesh, India.

2.2 Insect pest management of soybean

Natem *et al*. (2013) found preying upon the sucking Insects, were two species of lady bird beetle, *Coccinella septumpunctata* and *Menochilus sexmaculata* and two species of spiders, lynx spider and an unidentified golden preying spider. The latter was also a recorded preying on lepidopterous larvae. A predatory pentatomid bug, *Eocanthecona furcellata* was observed sucking the body sap of lepidopterous larvae.

Biswas and Islam (2012) in their study found that the highest seed yield (1300 kg/ha) was obtained from Diazinon 60 EC treated plots, followed by hand picking+neem seed extract treated plot (1280 kg/ha). The highest BCR (3.00) was obtained from the hand picking technique plots followed by Diazinon 60 EC treated plots (2.66). Santhosh (2008) recorded highest larval mortality of *S. litura* (73.33%) at 72 hrs after treatment with 5 per cent neem seed kernel extract (NSKE).

The contact toxicity of the ethyl alcohol, acetone, methanol and ethyl acetate extracts of *Dodonaea viscosa* (L.) leaf was tested on 3rd instar larvae of *S. litura* under laboratory conditions. The ethyl alcohol extract showed the highest mortality of 73 per cent and the others exhibited 66, 53 and 13 per cent mortality, respectively at 1 per cent concentration as reported by Deepa and Ramadevi (2007).

Choudhary and Shrivastava (2007) conducted a field experiment at Zonal Agricultural Station (JNKVV), Powarkheda, Madhya Pradesh, on soybean during kharif 2004 and 2005. Six neem-based products and quinalphos (0.04%) were evaluated to assess the efficacy and economics of managing *S. litura* in soybean. Among the neem-based products, application of neem seed kernel extract (NSKE) at 5% + neem leaf extract (NLE) at 10% reduced the maximum larval population (51.59%) and recorded a seed yield of 987.66 kg/ha. However, the ICBR showed that the application of NSKE at 5% (2.44) proved economically most viable amongst the neem-based treatments, followed by NLE at 5% (2.20).

Perumal *et al.* (2004) studied the larvicidal properties of *V. negundo*, *Argemone mexicana* L., *Datura metel* L., *A. squamosa* and *Lantana camara* L. against *S.litura*. Out of the five plants screened, the petroleum ether extract of *V. negundo, A. mexicana*, *D. metel* and *A. squamosa* showed significant larvicidal activities at different concentrations.

Under field condition the combination of cow urine, pongamia, NSKE and aloe registered a maximum groundnut yield (13.54 q/ha) which was at par with vitex + aloe (12.42 q/ha) and found significantly superior over untreated check in controlling *S. litura* larvae (Barapatre and Lingappa, 2003).

Sahayaraj and Paulraj (1998) recorded highest mortality of *S. litura* at 96 hr after treatment with 10 percent extract of *Citrus sinensis* (L.) Osbeck (90%) followed by *V. negundo* (83%), *A. indica* (80%) and *Zingiber officinale* Rosc. (70%). Six percent crude extracts of *C. gigentia, A. indica* and *P. pinnata* L. caused 75.72 and 63 percent mortality of *Aproaerema modicella* Dev., respectively after exposure for 96 hr. The calculated LC_{50} values of neem, calotropis and pongamia were 1.22, 2.43 and 2.94 percent respectively. Ginger extract as natural pesticide, alone and in combination with other plant products like chilli, garlic and cow urine was found effective against *H. armigera* (Vijayalakshmi, *et al*., 1997).

Soil application of phorate plus three sprays of endosulfan (0.07%) were effective against stemfly and leaf miner (*A. modicella*) followed by Neem oil (2%) against stem fly. Neem seed extract (3%) was also effective against leaf miner (Anon., 1991). Devaprasad *et al*. (1990) reported metholic fraction of *Allium sativum* L., *Ocimum sancteum* L., *Acorus calamus* L., neem seed kernel and ethanol extracts of *Tribulus terrestris* L. resulted in morphological deformities in *S. litura*. Efficacy of plant extract (5%) and their readily available formulations were evaluated against *Amsacta moorei* Butler. Among them *Calotrois* sp., *Argenoma maxicana* L., *Catharanthus* sp. and *Datura* sp. gave higher larval mortality than *A. indica*, after 24 hrs of treatment as reported by Patel *et al*. (1990).

A laboratory study carried out using acetone extracts of *V. negundo* resulted in complete mortality of third instar larvae of *S. litura* at 500-ppm concentration (Bai and Kundaswamy, 1985). The toxicity of aqueous and alcohol extracts of 10 plant species to larvae of *S. litura* were evaluated in the laboratory (each at one, two, three and four per cent concentration).

The extracts of *lpomea carnea* (Jacq) and *V. negundo* were most detrimental particularly at higher concentrations after 48th week of treatment (More *et al*., 1989).

Grainge *et al*. (1985) listed 1,005 species of plants having biological properties against insects including 384 species as antifeedants, 297 as repellents, 97 as attractants and 31 as growth inhibitors. The use of neem is well known in India and documented in the earliest Sanskrit medical writings (Watt, 1972 and Abdul Kareem, 1980).

Ahmed (1984) listed 2,121 plant species possessing pesticidal properties, these included neem, sweet flag, cashew, custard apple, sugar apple, derris, lantana, Indian privet, agave, crow plant etc. Sayed (1983) evaluated the effect of neem seed suspension on eggs and larvae of *S. litura* in the laboratory. When first instar or fifth day larvae were treated at 0.2 to 0.5 percent, suspension, cent per mortality was observed by the end of larval stage.

Deshmukh and Borle (1976) reported insecticidal activity of suspensions and extracts of parts of 20 plants on larvae of *S. litura* and adults of *Uroleucon carthemi* (H.R.L.). Aphids were more succeptable to plant extracts than *S. litura*. The active principle responsible for mortality in the extracts of *Vitex negundo* (L.) were found to be 1-9- pinene carrphane terpenyl acetate and diteropone alcohol.

Puttarudraiah and Bhatta (1955) reported insecticidal property of 45 plants occurring in Karnataka. According to them none of them were effective as stomach poisons.

Dust and cold alcohol extracts of *Derris elliptica* Benth, *Tephrosia candida* (Robx), *T. villos, Madhuca* sp. and *A. squamosa* L. caused more than 80 per cent mortality of *S. litura, Crocidolmia binotalis* Zeen. and *Bruchus chinensis* L.

CHAPTER III

MATERIALS AND METHODS

Two experiments were carried out separately during July 2012 to June 2013 at the farm of Sher-e-Bangla Agricultural University. This chapter deals with a brief description of the experimental site, land preparation, intercultural operations, design, treatments, data recording and procedure of statistical analysis.

3.1 Monitoring of pest incidence and evaluation of some botanicals and chemicals against major insect pests

3.1.1 Location and site

The location of the experimental site is $23^0 74^{'}$N latitude and $90^0 35^{'}$E longitude and an elevation of 8.2 meters from sea level (Anon., 1989). The plot no. was 33 and it is numbered by the authority of Sher-e-Bangla Agricultural University Farm. The location of the experimental site is presented in Appendix I.

3.1.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under Agro Ecological Zone No. 28 and was dark grey terrace soil. The selected plot was medium high land, the soil series was Tejgaon and the soil was Non-calcarious dark grey (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and presented in Appendix II.

3.1.3 Climate

The climatic condition of experimental site is under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon period or hot season from March to April and the

monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka.

3.1.4 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The whole experimental field was divided into three equal blocks having 1.0m space between them. Each block was again subdivided into 9 plots (3.0m × 2.0m) with 1.0m distance between the plots. The experimental plot is shown in Plate I.

Plate I: Showing the experimental plot at SAU farm

3.1.5 Planting material

The seeds of BARI Soybean 5 were used for the study. This variety was developed by Oilseed Research Center, Bangladesh Agricultural Research Institute (BARI) in the year of 2002. The variety takes 90-115 days to mature and yields 1.6-2.0 tons per hectare (BARI, 2006).

3.1.6 Land preparation

The experimental field was opened with a power tiller and later on, the land was ploughed and cross-ploughed three times followed by laddering to obtain the desirable tilth. The corners of the land were spaded. All kinds of weeds and stubbles were removed from the field and the land was made ready. The whole experimental land was divided into sub plots as per experimental design.

3.1.7 Fertilizer application

Manures and Fertilizers were applied as per recommendation for soybean (Mondal and Wahhab, 2001). Standard doses of fertilizers for optimum production comprising of N, P and K @ 8 kg, 10 kg and 20 kg per hectare in the form of Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP), respectively were applied during preparation of field (BARC, 2005). The whole amount of TSP and MP were applied as basal dose at the time of seed sowing. Total Urea was applied as side dressing two times during seedlings and vegetative stage.

3.1.8 Sowing of seeds

The seeds were sown in each plot in rows with spacing of 30 cm between rows and 15 cm between plants.

3.1.9 Treatments

The treatments and the control thus included in the study were as follows:

T_1 = Neem leaf extract @ 30.0 g/L of water
T_2 = Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder
T_3 = Tobacco leaf extract @ 2.0 g/L of water
T_4 = Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water
T_5 = Dursban (Clorpyriphos) 20EC @ 2.0 ml/L of water
T_6 = Ripcord (Cypermethrin) 10EC @ 1.0 ml/L of water
T_7 = Fiter (Lambdacyhalothrin) 2.5EC @ 1.0 ml/L of water
T_8= Actara (Thiamehoxam) 25WG @ 0.5 g/L of water
T_9 = Control

3.1.10 Intercultural operations

After sowing seeds light irrigation was applied to each plot for proper germination of seed. Supplementary irrigation was given as and when needed. Weeding and mulching was done to keep the plot free from weeds and to break the soil crust. Fungicide was applied during seedling stage to control wilting and fruit root disease.

3.1.11 Application of botanicals and insecticides

Fresh neem leaves were collected from SAU campus and weighed by an electronic balance then washed thoroughly with running tap water followed by chopping with a knife. About 400 ml water was added with chopped leaves. Then it was ground well by a blender to make it a solution. It was kept undisturbed overnight and filtered through the fine cloth and poured into a volumetric flask and water was added to make 1.0 liter volume. Similarly tobacco leaf extract was prepared by mixing dry leaf powder with water.

Neem oil and detergent were mixed with water and solution was prepared. Insecticides were directly mixed with water and solution was made. Plant extracts and insecticides were sprayed with the help of knapsack sprayer having a pressure of 4.5 kg/cm^2. Mixture of insecticides or plant extracts in the sprayer was shaken well during spraying. Spraying was done at 11:00 am to avoid drift with moisture of leaves. First application was done 20 days after germination of seeds and it was continued at 10 days interval up to final harvest. Only water was sprayed for control plot.

3.1.12 Sampling and data collection

Observation on species of insect pests with their population per plant was recorded from seedling to matured stage of the crop from 10 randomly selected samples of the plants in each plot. The nature of damage and feeding behavior of the insects were carefully observed and their photographs were taken in the crop fields and in the laboratory. The recordings of data were included visual observations, hand nets, and hand picking of insects from the standing crops during 7:00-10:00 am and 4:00-6:00 pm at weekly intervals. Some insects were also collected by aspirators for laboratory studies. The collected insects were preserved in the insect box and vial having 75% ethyl alcohol for identification. Relative population of insect was counted as suggested by Biswas *et al.* (2001).

From these data the average number of insect pests was calculated and the percent decrease of population for each treatment was determined by the following formula:

$$\% \text{ Reduction of population over control} = \frac{\text{No. of insects in treatments - No. of insect in control}}{\text{No. of insect in control}} \times 100$$

3.1.13 Yield data

After harvest the plants were sundried and seeds were separated from the fruits by beating with bamboo stick. After separation the weight of grain was measured separately from each plot. From these data yield per plot was calculated and percent increase of yield over untreated control plot was determined by the following formula:

$$\% \text{ Increase of yield over control} = \frac{\text{Yield in treatments - Yield in control}}{\text{Yield in control}} \times 100$$

3.1.14 Statistical analysis

The data were compiled and tabulated in proper form and were subjected to statistical analysis. The percentage data were subjected to ArcSine transformation. Analysis of variance was done following the computer package MSTAT-C program. The mean differences among the treatments were adjudged by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

3.2 Development of integrated pest management techniques for the management of soybean insect pests

Materials and methods were similar of Experiment 1 but treatments were different.

The treatment combinations for this experiment are given below:

T_1 = Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water

T_2 = Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder

T_3 = Plant Revitalization Hormone (PRH) @ 10.0 ml/L of water

T_4 = Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)

T_5 = Neem oil + Plant Revitalization Hormone (PRH)

T_6 = Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)

T_7 = Control

In case of T_1, T_2 and T_3 only Marshal, neem oil and PRH were applied at 10 days interval. In case of T_4, T_5 and T_6 Marshal 20EC, neem oil and PRH were sprayed alternatively at 10 days interval.

CHAPTER IV
RESULTS AND DISCUSSION

Two experiments were conducted to study the pest incidence on soybean and management of major insect pests. The analysis of variance (ANOVA) of the data on incidence of different pests, pod infestation, different yield contributing characters and yield were done. The results have been presented by using different tables and graphs and discussed with possible interpretations under the following headings and sub headings:

4.1 Pest complex of soybean

Nineteen species of insect pests belonging to sixteen families under six orders were found to infest at the different growth stages of soybean crop at SAU experimental field during 2012-13 (Table 1). Most of the insect pests were under three major orders (Lepidoptera, Homoptera and Coleoptera, leaf feeding and sucking insect pests were dominant. Of these, five species namely, leaf beetle (*Monolepta signata* Olv.), semilooper (*Plusia orichalcea* [Fab.]), aphid (*Aphis craccivora* [Koch]), jassid (*Amrasca biguttula biguttula* [Ishida]) and whitefly (*Bemisia tabaci* Genn.) respectively caused 90-100%, 40-50%, 85-100%, 70-100% and 90-100% plant infestation (Table 2). The population density of leaf beetle, semilooper, aphid, jassid and whitefly were 0.60-1.40, 0.40-0.90, 12.40-15.00, 5.40-6.50 and 10.90-13.10 per plant, respectively. Among those insect pests leaf beetle attacked seedling to pod formation stage of soybean but other four insect pests attacked vegetative to pod formation stage. Adult leaf beetle and larva of semilooper fed on leaves of soybean but nymph and adult of aphid, jassid and whitefly sucked cell sap from different parts of the plant (Table 1).

Table 1. Insect pests recorded from soybean crop ecosystem during 2012-2013 at SAU experimental field

Sl. No.	Common Name	Scientific name	Order	Family	Feeding behavior
01.	Hairy caterpillar	*Spilarctia obliqua* (Walker)	Lepidoptera	Arctiidae	Larvae feed on leaves
02.	Tobacco caterpillar	*Spodoptera litura* Fab.	Lepidoptera	Noctuidae	Larvae cut and feed on leaves
03.	Semilooper	*Plusia orichalcea* (Fab.)	Lepidoptera	Noctuidae	Larvae feed on leaves
04.	Pod borer	*Helicoverpa armigera* (Hub.)	Lepidoptera	Noctuidae	Larvae bore pod
05.	Leaf roller	*Lamprosema indicata* F.	Lepidoptera	Pyralidae	Larvae roll and feed on leaves
06.	Leaf miner	*Stomopteryx* spp.	Lepidoptera	Gelechiidae	Larvae mine and feed on leaves
07.	Whitefly	*Bemisia tabaci Genn.*	Homoptera	Aleyrodidae	Nymph and adult suck cell sap
08.	Jassid	*Amrasca biguttula biguttula* (Ishida)	Homoptera	Jassidae	Nymph and adult suck cell sap
09.	Aphid	*Aphis craccivora* (Koch)	Homoptera	Aphididae	Nymph and adult suck cell sap
10.	Mealybug	*Pseudococcus filamentosus*	Homoptera	Pseucoccidae	Nymph and adult suck cell sap
11.	Green stink bug	*Nezara viridula* L.	Hemiptera	Pentatomidae	Nymph and adult suck cell sap
12.	Grey weevil	*Myllocerus discolor* Boh.	Coleoptera	Curculionidae	Adult feed on leaves
13.	Pumpkin beetle	*Aulacophora* spp.	Coleoptera	Chrysomelidae	Adult feed on leaves
14.	Leaf beetle	*Monolepta signata* Olv.	Coleoptera	Chrysomelidae	Adult and larvae feed on leaves
15.	Epilachna beetle	*Epilachna* spp.	Coleoptera	Coccinellidae	Larvae and adult feed on leaves
16.	Green grass hopper	*Attractomorpha crenulata* F.	Orthoptera	Acrididae	Nymph and adult feed on leaves
17.	Long horned grass hopper	*Phaneroptera gracilli* Bur.	Orthoptera	Tettigoniidae	Nymph and adult feed on leaves
18.	Stem fly	*Ophiomyia phaseoli* (Tryon.)	Diptera	Agromyzidae	Larvae bore stem
19.	Flower thrips	*Frankliniella schultzei* Trybom	Thysanoptera	Thripidae	Nymph and adult suck cell sap

Table 2. Incidence of some important soybean insect pests and their infestation level in control plot during 2012-2013 at SAU experimental field

Name of insects	% plant infestation	No. of insect plant^{-1}	Stage of infestation
Leaf beetle	90-100	0.6-1.40	Seedling - Pod formation
Semilooper	40-50	0.40-0.90	Vegetative - Pod formation
Aphid	85-100	12.40-15.00	Vegetative - Pod formation
Jassid	70-100	5.40-6.50	Vegetative - Pod formation
Whitefly	90-100	10.90-13.10	Vegetative - Pod formation

Data were recorded from 10 soybean plants in each replication.

The result partially contradicts with the findings of Biswas (2013) who recorded 39 species of insect pests attacking soybean in Noakhali region. Biswas (2008) reported that green stink bug (*Nezara viridula* L.), semilooper (*Plusia orichalcea* Fab.), black cutworm (*Agrotis ipsilon* (Hufn.), leaf miner (*Stomopteryx* spp.), green grasshopper (*Attractomorpha crenulata* F.), pod bug (*Eusarcocoris* sp.) and aphid (*Aphis cracraccivora*) became occasionally important and caused serious damage to the soybean crop. In another report Biswas *et al.* (2001) observed that leaf roller (*L. indicata*) and hairy caterpillar (*S. obliqua*) were the major pests of soybean and about 80% plant and about 60% leaf were infested by the attack of these pests. Netam *et al*. (2013) recorded girdle beetle (*Obereopsis brevis*), tobacco caterpillar (*Spodoptera litura*), green semilooper (*Chryrodecxis acuta*), jassids (*Empoasca kerri*) and white fly (*Bemisia tabaci*) as the major pests on soybean. Das (1998) recorded two major pests namely, hairy caterpillar and stem fly that causes most damage in soybean. From the survey report of Ali (1988) in the northern Bangladesh observed 47 species of insect pests from different stages of soybean crop.

4.2 Incidence of leaf beetle, semilooper, aphid, jassid and whitefly

The population trends of five major insect pests in relation to environmental temperature and relative humidity and age of the crop have been presented in graphs. Figure 1 illustrated that leaf beetle population increased with the increasing of temperature, relative humidity and the age of the crop. It was reached in peak during 40-50 days after sowing and then declined although temperature was not decreased. Similar trend was observed for semilooper (Figure 2), aphid (Figure 3) and jassid (Figure 4). In case of whitefly, peak population was observed at 40 days after sowing (Figure 5) and it was declined with age of the crop. Thus temperature, humidity and age of the crop had great influence on incidence of the insect pests on soybean.

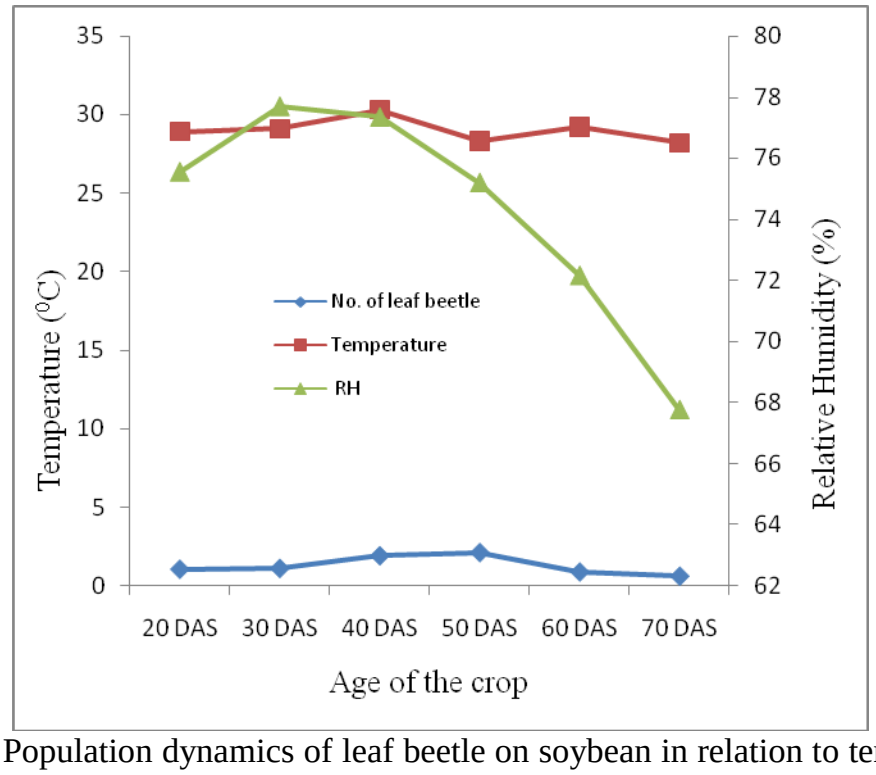

Figure 1: Population dynamics of leaf beetle on soybean in relation to temperature, relative humidity and age of the crop.

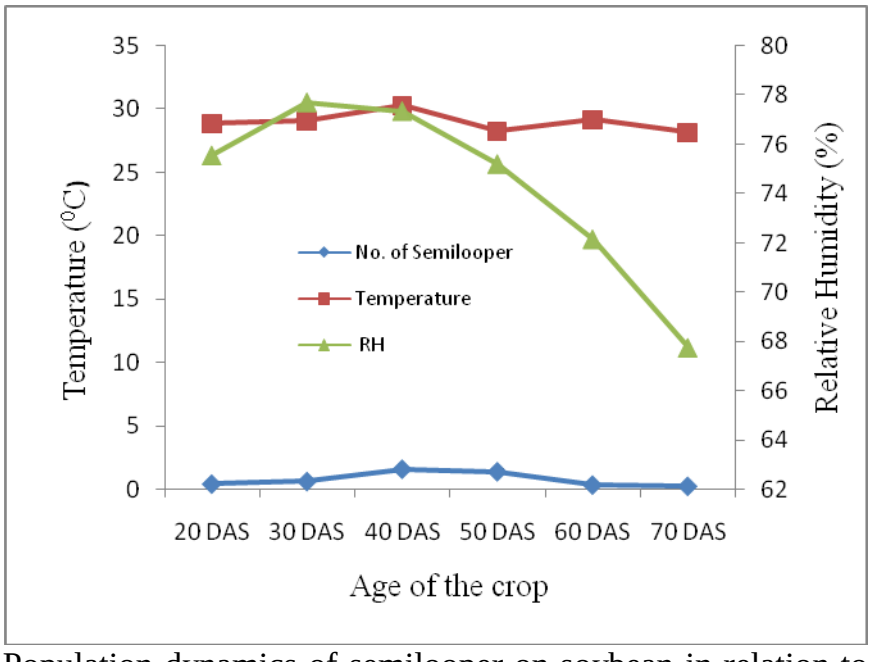

Figure 2: Population dynamics of semilooper on soybean in relation to temperature, relative humidity and age of the crop.

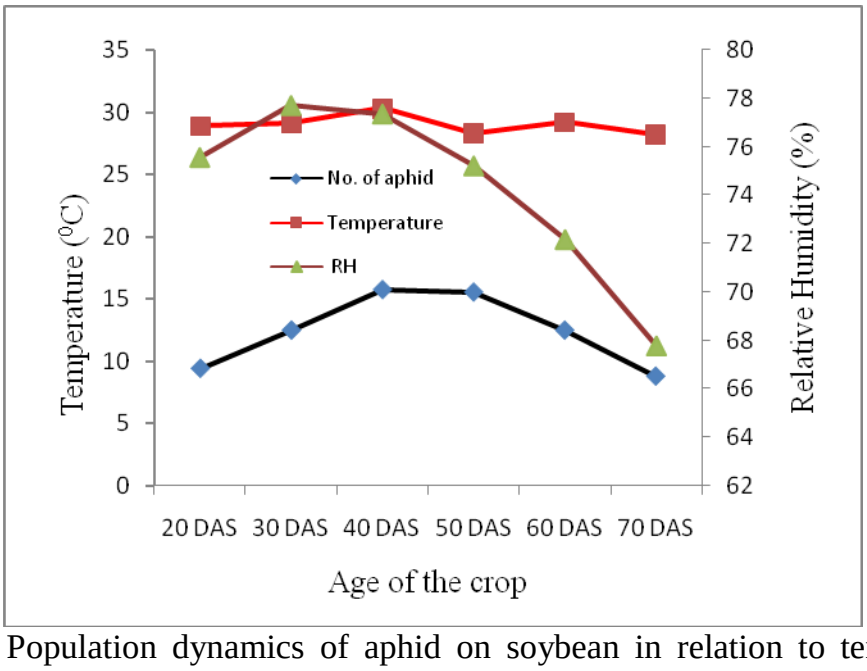

Figure 3: Population dynamics of aphid on soybean in relation to temperature, relative humidity and age of the crop.

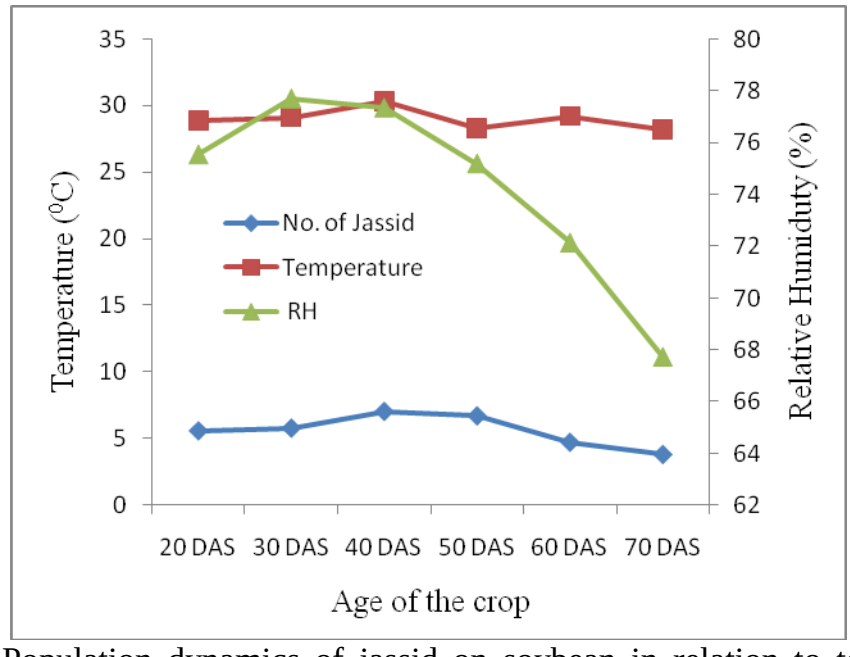

Figure 4: Population dynamics of jassid on soybean in relation to temperature, relative humidity and age of the crop.

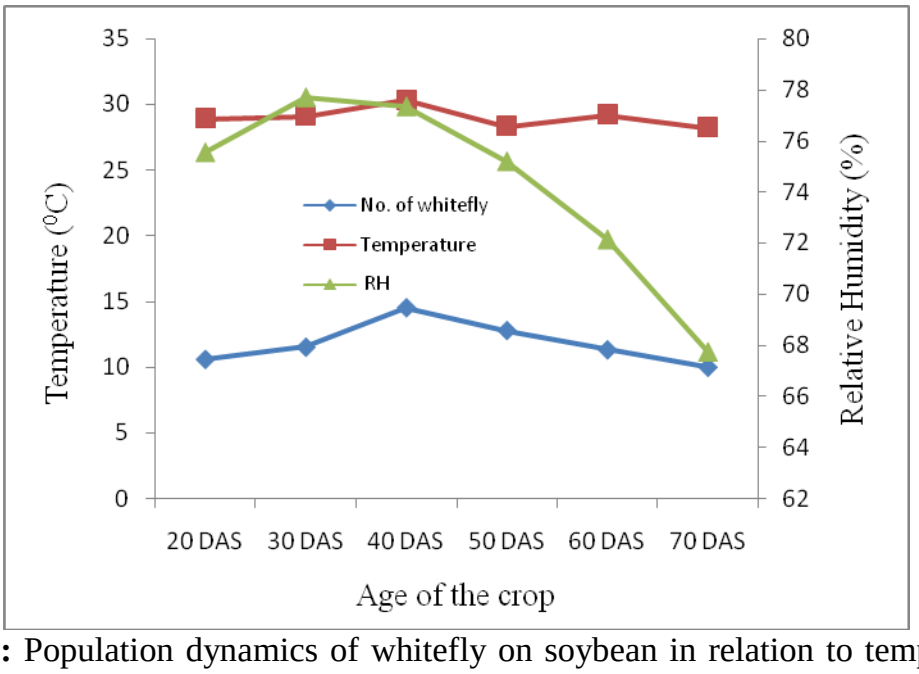

Figure 5: Population dynamics of whitefly on soybean in relation to temperature, relative humidity and age of the crop.

4.3 Effect of some plant extracts and chemical insecticides on insect pests and grain yield of soybean

Spraying of plant extracts and chemical insecticides significantly reduced insect pests incidence and increased grain yield of soybean. The data in Table 3 indicate that the lowest number of leaf beetle (0.60/plant) and semilooper (0.33/plant) was observed in Carbosulfan treated plots having no significant difference with Thiamethoxam treated plots. These two insecticides reduced more than 50% population of leaf beetle and semilooper. All the plant extracts reduced more than 30% population of these two insect pests but best result was found in case of neem oil which reduced 37.26% leaf beetle and 36.53% semilooper population over control (Table 3). Therefore, spraying of plant extracts and chemical insecticides significantly reduced the leaf feeding insect pests and neem oil was the best plant material and Carbosulfan was the most effective chemical insecticide against leaf beetle and semilooper of soybean. Choudhury and Shrivastava (2007) found that application of NSKE (5%) + NLE (10%) reduced 51.59% of lavarl population of *S. litura*.

Plant extracts and chemical insecticides spraying also significantly reduced three major sucking insects such as aphid jassid and whitefly. The lowest number of aphid (7.67/plant), jassid (3.79/plant) and whitefly (5.63/plant) was recorded from Carbosulfan treated plots as against the highest in control plot. But no significant difference was found between Carbosulfan and Thiamethoxam regarding number of aphid, jassid and whitefly (Table 4). These two insecticides reduced more than 40% aphid and 50% jassid and whitefly population over control. It was also observed that Chlorpyriphos, Cypermethrin and Lambdacyhalothrin reduced more than 40% population of the jassid and whitefly which were significantly lower than

Carbosulfan and Thiamethoxam. Among the plant materials, neem oil gave the best result by reducing 35.62% aphid, 37.67% jassid and 41.42% whitefly population over control which was significantly lower than all chemical insecticides treated plots (Table 4). Thus neem oil was the most effective plant material and Carbosulfan was the best chemical insecticide against sucking insect pest of soybean.

Table 3. Incidence of leaf beetle and semilooper in some plant extracts and chemical insecticides treated plots

Treatments	No. of leaf beetle/plant	% decrease over control	No. of semilooper/plant	% decrease over control
Neem leaf	0.87 b	31.93 b	0.52 b	31.53 c
Neem oil	0.80 bc	37.26 bc	0.48 b	36.53 bc
Tobacco leaf	0.83 b	34.40 c	0.51 b	32.56 bc
Carbosulfan	0.60 d	52.68 a	0.33 c	54.92 a
Chlorpyriphos	0.73 c	42.35 b	0.45 b	40.91 b
Cypermethrin	0.82 b	35.79 c	0.48 b	36.44 bc
Lambda-cyhalothrin	0.83 b	34.56 c	0.47 b	38.26 bc
Thiamethoxam	0.62 d	51.46 a	0.37 c	50.76 a
Control	1.25 a	-	0.76 a	-
CD $_{(0.05)}$	**0.78**	**5.73**	**0.78**	**8.14**
CV	**4.85%**	**8.17%**	**8.15%**	**11.56%**

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Table 4. Incidence of aphid, jassid and whitefly in some plant extracts and chemical insecticides treated plots

Treatments	No. of aphid/plant	% decrease over control	No. of jassid/plant	% decrease over control	No. of Whitefly/plant	% decrease over control
Neem leaf	9.92 b	31.27 e	5.64 b	31.52 e	8.65 b	29.07 g
Neem oil	9.30 c	35.62 d	5.13 c	37.67 d	7.15 d	41.42 e
Tobacco leaf	9.78 b	32.28 e	5.63 b	31.76 e	7.95 c	34.95 f
Carbosulfan	7.67 f	46.87 a	3.79 f	54.17 a	5.63 f	53.84 a
Chlorpyriphos	8.40 de	41.85 bc	4.59 e	44.35 b	6.03 ef	50.53 b
Cypermethrin	8.60 d	40.41 c	4.77 de	42.05 c	6.38 e	47.72 c
Lambda-cyhalothrin	8.77 d	39.38 c	4.84 d	41.18 c	6.54 e	46.30 d
Thiamethoxam	8.03 ef	44.43 ab	3.86 f	53.27 a	5.67 f	53.43 a
Control	14.42 a	-	8.22 a	-	12.22 a	-
CD $_{(0.05)}$	**0.42**	**3.24**	**0.20**	**1.41**	**0.55**	**1.51**
CV	**2.56 %**	**4.75 %**	**2.31 %**	**1.91%**	**4.35 %**	**1.47%**

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Schedule spraying of plant materials and chemicals also had significant effect on grain yield of soybean. The highest grain yield (1.51 t/ha) was obtained from Carbosulfan treated plots as against the lowest (1.01 t/ha) in control plot. Carbosulfan increased 50.27% yield of soybean over control. But no significant difference was observed among Carbosulfan, Thiamethoxam and Chlorpyriphos regarding grain yield of soybean (Table 5). Cypermethrin, Lambdacyhalothrin, neem oil and tobacco leaf extract treatment gave the statistically similar result in production of soybean (Choudhury and Shrivastava, 2007). Application of plant extracts and chemical insecticides at 10 days interval reduced population of leaf feeding and sucking insects of soybean and increased grain yield.

Among the plant extracts neem oil gave the best effectiveness and Carbosulfan showed the best performance in reducing leaf feeding and sucking insect pests of soybean and increasing grain yield over control.

Table 5. Effect of some plant extracts and chemical insecticides on grain yield of soybean

Treatments	**Grain yield (t ha^{-1})**	**% increase of grain yield over control**
Neem leaf	1.19 c	17.68 c
Neem oil	1.29 b	28.24 b
Tobacco leaf	1.22 bc	21.27 bc
Carbosulfan	1.51 a	50.27 a
Chlorpyriphos	1.43 a	42.02 a
Cypermethrin	1.29 b	27.91 b
Lambdacyhalothrin	1.25 bc	24.25 bc
Thiamethoxam	1.50 a	48.84 a
Control	1.01 d	-
CD $_{(0.05)}$	**0.08**	**8.83**
CV	**3.35%**	**15.49%**

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

4.4 Effectiveness of some integrated pest management (IPM) techniques on pest population and grain yield of soybean

Integrated or individual use of neem oil, Carbosulfan and Plant Revitalization Hormone (PRH) reduced leaf feeding and sucking insect pests of soybean and increased yield over control. The data in Table 6 revealed that the lowest number of leaf beetle (0.48/plant) and semilooper (0.13/plant) was recorded from T_3 (PRH alone) treated plot which was significantly different from all other treatments. It decreased 62.56% leaf beetle and 82.33% semilooper population over control. However, individual use of neem oil/ Carbosulfan/ PRH gave better result than integrated use of Carbosulfan and PRH or neem oil + PRH or Carbosulfan + neem oil + PRH.

Table 6. Effect of some integrated pest management techniques on incidence of leaf beetle and semilooper in soybean

Treatments	No. of leaf beetle/plant	% decrease over control	No. of semilooper/plant	% decrease over control
T_1	0.76 c	41.27 b	0.40 d	46.52 b
T_2	0.92 b	29.40 c	0.43 cd	41.71 c
T_3	0.48 d	62.56 a	0.13 e	82.33 a
T_4	0.76 c	41.83 b	0.47 c	37.58 c
T_5	0.73 c	43.46 b	0.58 b	22.08 d
T_6	0.91 b	30.00 c	0.45 cd	39.75 c
T_7	1.30 a	-	0.75 a	-
$CD_{(0.05)}$	**0.10**	**5.35**	**0.06**	**4.56**
CV	**6.12 %**	**7.10 %**	**6.83 %**	**5.57 %**

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water
T_2 = Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder
T_3 = Plant Revitalization Hormone (PRH) @ 10.0 ml/L of water
T_4 = Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)
T_5 = Neem oil + Plant Revitalization Hormone (PRH)
T_6 = Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)
T_7 = Control

Population of sucking insect pest varied significantly in different treatments but lowest number of aphid, jassid and whitefly was recorded from PRH treated plots (T_3). No significant difference was found in T_1 (Carbosufan), T_2 (neem oil) and T_3 (PRH) in case of jassid incidence and percent reduction of jassid population over control (Table 7). For reducing whitefly, T_3 (PRH) and T_1 (Carbosufan) showed similar performance but PRH gave the best result in reducing aphid population over control. Combined use of neem oil, Carbosulfan and PRH did not give satisfactory result against sucking insect pests of soybean.

Table 7. Effect of some integrated pest management techniques on incidence of aphid, jassid and whitefly in soybean

Treatments	No. of aphid/plant	% decrease over control	No. of jassid/plant	% decrease over control	No. of Whitefly/plant	% decrease over control
T_1	7.47 c	45.54 b	1.82 d	67.66 a	7.43 d	36.99 a
T_2	7.87 c	42.65 b	1.92 cd	65.96 ab	8.13 c	30.99 b
T_3	6.42 d	53.22 a	1.77 d	68.54 a	7.43 d	36.91 a
T_4	7.67 c	44.14 b	2.10 bc	62.77 bc	9.25 b	21.66 c
T_5	9.28 b	32.36 c	2.37 b	57.98 d	9.40 b	20.16 c
T_6	9.00 b	34.41 c	2.20 b	60.78 cd	9.12 b	22.60 c
T_7	13.73 a	-	5.62 a	-	11.80 a	-
$CD_{(0.05)}$	**0.54**	**3.72**	**0.27**	**3.96**	**0.49**	**3.40**
CV	**3.47 %**	**4.86 %**	**6.01 %**	**3.40 %**	**3.06 %**	**6.62 %**

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water
T_2 = Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder
T_3 = Plant Revitalization Hormone (PRH) @ 10.0 ml/L of water
T_4 = Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)
T_5 = Neem oil + Plant Revitalization Hormone (PRH)
T_6 = Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)
T_7 = Control

Grain yield of soybean was obtained highest (1.41 t/ha) from T_3 (PRH) treated plots followed by 1.34 t/ha and 1.28 t/ha from T_1 (Carbosulfan) and T_2 (neem oil) treated plots, respectively having significant difference among them. PRH treatment also increased 43.75% grain yield of soybean over control (Table 8). Individual use of neem oil/ Carbosulfan/ PRH gave better result than integrated use of Carbosulfan and PRH or neem oil + PRH or Carbosulfan + neem oil + PRH.

Table 8. Effect of some integrated pest management techniques on grain yield of soybean

Treatments	Grain yield (t ha^{-1})	% increase of grain yield over control
T_1	1.34 b	36.15 b
T_2	1.28 c	30.09 c
T_3	1.41 a	43.75 a
T_4	1.20 e	21.62 e
T_5	1.18 f	19.82 f
T_6	1.22 d	23.68 d
T_7	0.98 g	-
SEm	**0.006**	**0.44**
CD $_{(0.05)}$	**0.018**	**1.38**
CV (%)	**1.10**	**2.60**

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water
T_2 = Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder
T_3 = Plant Revitalization Hormone (PRH) @ 10.0 ml/L of water
T_4 = Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)
T_5 = Neem oil + Plant Revitalization Hormone (PRH)
T_6 = Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)
T_7 = Control

CHAPTER V
SUMMARY AND CONCLUSION

SUMMARY

Two experiments were carried out separately during July 2012 to June 2013 at the farm of Sher-e-Bangla Agricultural University to study the insect pests of soybean, their pest status and to develop integrated management practices against major insect pests of soybean based on plant products and hormone. Seeds of soybean variety BARI Soybean-5 were collected from Bangladesh Agricultural Research Institute, Dhaka used as a test crop for the study.

The first experiment was to monitor the pest incidence and evaluation of some botanicals and chemicals against major insect pests on soybean. The experiment consists of 9 (nine) treatments as T_1: Neem leaf extract @ 30.0 g/L of water, T_2: Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder, T_3: Tobacco leaf extract @ 2.0 g/L of water, T_4: Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water, T_5: Dursban (Clorpyriphos) 20EC @ 2.0 ml/L of water, T_6: Ripcord (Cypermethrin) 10EC @ 1.0 ml/L of water, T_7: Fiter (Lambdacyhalothrin) 2.5EC @ 1.0 ml/L of water, T_8: Actara (Thiamehoxam) 25WG @ 0.5 g/L of water T_9: Control. The second experiment was for the development of integrated pest management techniques for the management of soybean insect pests. In this experiment 7 (seven) treatments were used as T_1: Marshal (Carbosulfan) 20EC @ 2.0 ml/L of water, T_2: Neem oil @ 10.0 ml/L of water + 0.5 g detergent powder, T_3: T Plant Revitalization Hormone (PRH) @ 10.0 ml/L of water, T_4: Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH), T_5: Neem oil + Plant Revitalization Hormone (PRH), T_6: Marshal (Carbosulfan) 20EC + Neem oil + Plant

Revitalization Hormone (PRH) and T_7: Control. Both the experiments were laid out in Randomized Complete Block Design (RCBD) with 3 (Three) replications.

Nineteen (19) species of insect pests belonging to sixteen (16) families under six (6) orders were found to infest at the different growth stages of soybean crop. Leaf feeding and sucking insect pests were dominant. Of these, five species namely, leaf beetle, semilooper, aphid, jassid and whitefly respectively caused 90-100%, 40-50%, 85-100%, 70-100% and 90-100% plant infestation. Among those insect pests leaf beetle attacked seedling to pod formation stage of soybean but other four insect pests attacked vegetative to pod formation stage. Temperature, humidity and age of the crop had great influence on incidence of the insect pests on soybean. Leaf beetle population increased with temperature and relative humidity and also with the age of the crop. Semilooper, aphid and jassid showed similar trend but in case of whitefly peak population was observed at 40 DAS and it was also declined with age of the crop.

Spraying of plant extracts and chemical insecticides significantly reduced insect pests incidence and increased grain yield of soybean. Schedule spraying of plant materials and chemicals also had significant effect on grain yield of soybean. The highest grain yield (1.51 t/ha) was obtained from Carbosulfan treated plots as against the lowest (1.01 t/ha) in control plot. Among the plant extracts neem oil gave the best effectiveness and Carbosulfan showed the best performance in reducing leaf feeding and sucking insect pests of soybean and increasing grain yield over control.

Integrated or individual use of neem oil, Carbosulfan and Plant Revitalization Hormone (PRH) reduced leaf feeding and sucking insect pests of soybean and increased yield over control. Population of sucking insect pest varied significantly in different treatments but lowest number of aphid, jassid and whitefly was recorded from PRH treated plots. Combined use of neem oil, Carbosulfan and PRH did not give satisfactory result against sucking insect pests of soybean. Individual use of neem oil/ Carbosulfan/ PRH gave better grain yield than integrated use of Carbosulfan and PRH or neem oil + PRH or Carbosulfan + neem oil + PRH

CONCLUSION

The overall results of the present study indicate that rapid growth, soft and succulent foliage of soybean attracts many insect pests and provide unlimited source of food, space and shelter. Nineteen insect pests of sixteen families under six order attacked soybean in experimental field. Most of them were under the Order Lepidoptera, Homoptera and Coleoptera. Leaf beetle and semilooper were found as major leaf feeding and aphid, jassid and whitefly were major sucking insect pests of soybean. Population of these insect pests increased with increasing of temperature, humidity and age of the crop and reached in peak at 40-50 days after sowing and then declined with age of the crop. Among the plant materials neem oil showed the best performance against all insect pests and produced highest yield. Carbosulfan gave the best result in reducing insect pests of and increasing yield of soybean over control. Among the IPM techniques, Plant Revitalization Hormone (PRH) alone showed the better performance in reducing insect pests and increasing yield of soybean than Carbosulfan, neem oil and/or combined use of them.

RECOMMENDATIONS

Based on the above results following recommendations may be made:

- Carbosulfan (Marshal) 20EC @ 2.0 ml/L water at 10 days interval may be applied for the management of soybean insect pests.
- Considering environmental safety and health hazard neem oil @ 10.0 ml/L water at 10 days interval may be used as IPM component for the management of soybean insect pests.
- Plant Revitalization Hormone (PRH) may be included as IPM component in controlling soybean insect pest but it needs further trial to determine the appropriate dose and large scale effectiveness

CHAPTER VI
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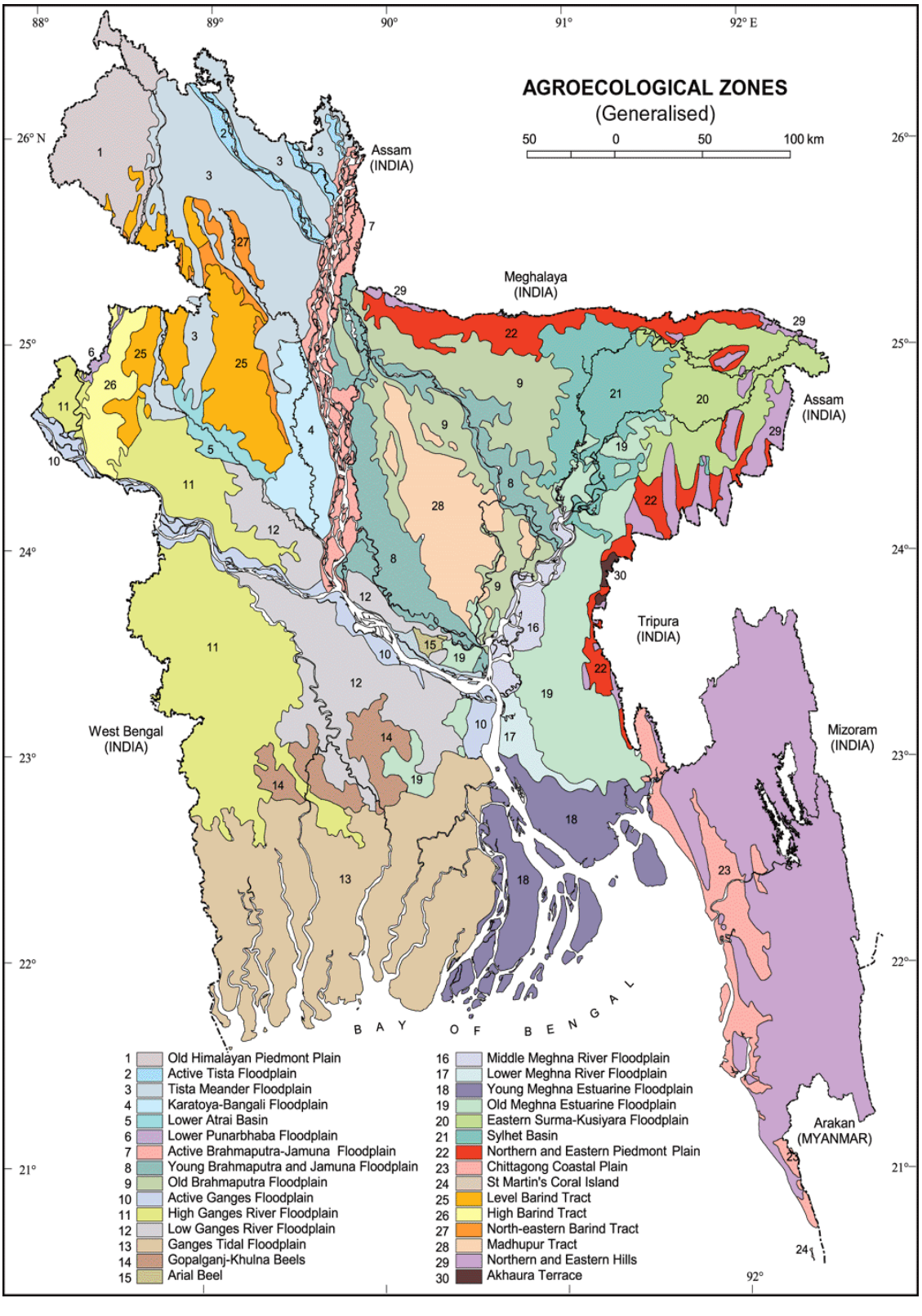
APPENDICES

Appendix I. The location of the experimental site



28 Location of experimental field

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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central 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	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45