INSECT PESTS INCIDENCE IN MUNGBEAN AND THEIR MANAGEMENT

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This is to certify that thesis entitled, "Insect Pests Incidence in Mungbean and their Management" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of Master of Science in Entomology, embodies the result of a piece of bona fide research work carried out by Md. Arefur Rahman, Registration No. 06-02070 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.

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ABSTRACT

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study the insect pest incidence in mungbean and their management. BARI Mung-5 was used as the test crop of this experiment. The experiment consists of the following treatments: T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval; T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval; T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval; T_4: Actara @ 0.5 gm/L of water at 15 days interval; T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval; T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval and T_7: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The lowest stemfly infestation (4.50%), lowest stem tunneling (6.22%) and lowest number of stemfly larvae/pupae (0.25) was recorded from T_5 (Marshal 20 EC @ 2.0 ml/L of water), whereas the highest stemfly infestation (22.50%), highest stem tunneling (19.71%) and highest number of stemfly larvae/pupae (2.17) was found from T_7 (untreated control) treatment, respectively. The lowest number of jassid per 10 leaves (1.36), lowest number of whitefly per 10 leaves (1.20), lowest number of hairy caterpillar per plant (1.00), lowest number of thrips per 10 flowers (1.20) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water), while the highest number of jassid per 10 leaves (9.78), highest number of whitefly per 10 leaves (5.67), highest number of hairy caterpillar per plant (4.10) and highest number of thrips per 10 flowers (5.40) was observed from T_7 (untreated control) treatment, respectively. At early, mid and late stage, the highest percent of infested pods plant^{-1} in number (11.86%, 15.02% and 17.02%) was recorded in T_7 (untreated control) treatment again, the lowest infestation percent in number (3.94%, 5.38% and 5.68%) was recorded in T_5 (Marshal 20 EC @ 2.0 ml/L of water) treatment, respectively. The highest yield per hectare (1.78 ton) and highest benefit cost ratio (2.65) was found in T_5 (Marshal 20 EC @ 2.0 ml/L of water) treatment, whereas the lowest yield per hectare (1.33 ton) and lowest benefit cost ratio (1.04) in T_7 (untreated control). Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices for controlling insect pest of mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water.

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CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiate L.* Wilczek) belonging to the family Leguminosae and sub-family Papilionaceae is one of the most important pulse crops in tropical and sub-tropical regions. The area under pulse crops in Bangladesh is 0.406 million hectares with a production of 0.322 million tons where mungbean is cultivated in the area of 0.108 million hectares with production of 0.03 million tons (BBS, 2010). It is considered as a quality pulse in the country but production per unit area is very low (736 kg/ha) as compared to other countries of the world (BBS, 2006). Although, mungbean plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh but the acreage production of mungbean is gradually declining (BBS, 2010).

The global mungbean growing area has increased during the last 20 years at an annual growth rate of 2.5% (Green and King, 1992). The crop has many advantages in cropping system because of its rapid growth and early maturation. It can also fix atmospheric nitrogen through symbiotic relationship with soil bacteria and improve the soil fertility (Yadav *et al*., 1994). It ranks fifth both in acreage and production and contributes 6.5% of the total pulse production in Bangladesh (Anon., 1998). Mungbean is considered as a poor man's meat because it is a good source of protein (Mian, 1976). It contains 51% carbohydrate, 26% protein, 10% water, 4% minerals and 3% vitamins. It is a popular crop in Bangladesh not only as a food crop but also as a fodder crop. Mungbean is one of the least cared crops and cultivated with minimum tillage, local varieties with no or minimum fertilizers, without pest management and very early or very late sowing, no practicing of irrigation and drainage facilities etc. All these factors are responsible for low yield of mungbean which is incomparable with the yields of developed countries of the world (FAO, 1999). A number of agronomic practices have been found to influence the yield of pulse crops (Boztok, 1985). Management of insect pest is one of the most important practices among them.

Many insect pest species attack mungbean throughout the cropping period in a mungbean field and several species of insect pests may be feeding in a plant at the same time for that making it difficult to evaluate the economic importance of individual species. Several insect pests have been reported to infest mungbean and damage the seedlings, leaves, stems, flowers, buds, pods causing considerable losses (Sehgal and Ujagir, 1988; Husain, 1993; Karim and Rahman, 1991). The most damaging inset pests of mungbean recorded so far are stemfly (Rahman, 1987; Lal, 1985), jassid (Baldev, 1988; Chaudhary *et al.,* 1980), whitefly (Rahman *et al*., 1981; Srivastava and Singh, 1976), thrips (Rahman *et al*., 1981; Chhabra and Kooner, 1985), hairy caterpillar (Rahman *et al*., 1981) and pod borer (Nair, 1986; Rahman *et al*., 1981).

Stemfly attack mainly the crop by feeding tender stems at seedling stage, although it may attack at any stage of the crop. In mungbean; upto 97% plants were found to be infested by stemfly (Rahman, 1991). Jassid infests the crop by sucking sap from leaves. With severe infestation the leaves turn brown, curl from the edges and dry leading to the common term for the damage, the hopper burn (Poehlman, 1991). Rahman (1988) reported 43.4% leaf infestation by jassids. The whitefly causes damage to the plants by feeding on the leaf with stylets inserted into the leaf tissue. Whitefly reduces crop yield and act as a vector of viral pathogens (Kajita and Alam, 1996). Thrips is associated mostly with the damage of tender buds and flowers of mungbean (Lal, 1985). Chhabra and Kooner (1985) have reported extensive damage to the summer mungbean due to flower shedding caused by thrips. Another insect pest of mungbean is the hairy caterpillar which feed on green portion of the leaf causing serious damage to the plant (Lal *et al*., 1980). In case of severe attack of caterpillar the plant may die (Nair, 1986). Pod borer damages flower, flower bud and tender or mature pods (Poehlman, 1991). This pest could cause up to 14.33% pod damage (Anon., 1998). In Bangladesh, the pod borers are a chronic and often cause serious problem resulting severe loss of the crop (Bakr, 1998). Pod borer alone has been reported to cause grain losses of 136 kg ha^{-1} (Anon., 1986).

Management of mungbean insect pests, many options such as chemical, cultural, mechanical, biological etc. are available. Chemical control is generally being advocated for the management of insect pests of mungbean. Soil application of Furadan 3G @ 1.5 kg a.i. ha^{-1} just prior to sowing followed by foliar application of Azodrin 40 EC @ 0.07% at 50% flowering protected the crop ensured higher yield (Rahman, 1988). Cypermethrin or Cymbush @ 0.008% applied at flowering and again at podding were effective against pod borer (Rahaman, 1989). Insecticide was also found effective against pod borer of pulses (Reed *et al*., 1989). In controlling stemfly, foliar sprays have been found to be more effective than granular forms of Carbofuran (Sreekanth *et al*., 2004). Studies have been found feasible to manage insect pests of mungbean through non-chemical methods such as use of botanicals (Jayaraj, 1988). Plant products were found to be effective against various pests (Rajasekaran and Kumaraswami, 1985).

Generally the farmers of Bangladesh do not spray chemicals to control insect pest complex of mungbean due to its low profit margin. For this reason, several chemicals for different insect pests may not be acceptable to growers although, they are highly reluctant to follow pest control measure. The use of chemicals led to impose certain well known undesirable side effects including environmental pollution, resurgence, upset, resistance to pesticides, and develop high pesticide residues. On the other hand, non-chemical control plays an important role in evolving an ecologically sound and environmentally acceptable method. Under the above perspective for the effective control mungbean pests the present study has been undertaken with fulfilling the following objectives.

1. To document the abundance and damage severity of stemfly, jassid, whitefly, thrips, hairy caterpillar and pod borer.
2. To find out the relationship between incidence of stemfly, jassid, whitefly, thrips, hairy caterpillar and pod borer with mungbean yield and
3. To find out the most suitable insecticide for the management of insect pests of mungbean.

CHAPTER II

REVIEW OF LITERATURE

2.1 Insect pest incidence in mungbean

Pulses 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 (Kay, 1979). In fact, until today, pulses provide the only high protein component of the average diet of the majority people of Bangladesh (Rahman *et al.*, 1988). Mungbean is one of the most promising pulse crops in Bangladesh and there are many constrains for it's low yield such as varietal aspect, climatic factors, management practices, insect pests and diseases. Among them insect pests is considered the important one. Rahman *et al*. (1981) listed the following insect pests that attack mungbean-

Common name	**Scientific name**	**Order**
Bean stemfly	*Ophiomya phaseoli*	Diptera
Jassid	*Empoasca kerri*	Homoptera
Whitefly	*Bemisia tabaci*	Homoptera
Thrips	*Megalurothrips distalis*	Thysanoptera
Bean aphid	*Aphis Craccivora*	Homoptera
Hairy caterpillar	*Spilarctia oblique*	Lepidoptera
Leaf webber	*Laprosoma indicate*	Lepidoptera
Leaf miner	*Acrocerphos phacospora*	Lepidoptera
Epilachna beetle	*Epilachna spp.*	Coleoptera
Semi-loopers	*Diachrysia orochalcea*	Lepidoptera
Spotted pod borer	*Maruca vitrata*	Lepidoptera
Bruchids	*Callosobruchus chinensis*	Coleoptera
Green bug	*Nezara viridula*	Homoptera
Galerucid beetle	*Madurisia obscurella*	Coleptera
Green semi-lopper	*Plusia signata*	Lepidoptera
Bean lycaenidae	*Euchrysops cnejus*	Lepidoptera

Of the above listed insect pests, stemfly, jassid, whitefly, thrips, hairy caterpillar and pod borer are most damaging (Rahman *et al*., 1981; Gowda and Kaul, 1982).

Stemfly

The stemfly is a serious pest of mungbean at seedling stage (Gupta and Sing, 1984) and has been identified as a major mungbean pest in India (Saxena, 1978). The adult bean fly deposits eggs in punctures of the leaf tissue, the first pair of leaves of bean seedlings being favorite sites for oviposition. The maggot bores into young stem and damages the stem. In young plants the larvae of the fly cause extensive tunneling. The freshly formed tunnels are silvery-white and difficult to locate. The older tunnels are dark brown in colour and contained faeces. Due to the decaying of the surrounding pith area around the zic-zac tunnels, the old tunnels turned into straight ones (Singh and Singh, 1990). They do not make any exit hole (Sehgal *et al*., 1980). Infested seedlings frequently wilt and subsequently die. The growth of older plants become slowly stunted (Prodhan *et al*., 2000).

Jassid

Jassid is a serious pest of mungbean. The female adult insect lays a number egg singly on leaf. Eggs are oviposited into veins and leaf petioles of the mungbean plant (Chaudhary *et al,* 1980). The wingless nymphs feed on the plant while passing through several nymphal stages and later emerge as winged adults. Life cycles are completed in three to four weeks. Nymphs and adults generally feed on the underside of the leaf, sucking out the juice and injecting toxic saliva into the cells causing hopper burn. Infested plants are unthrifty and lack vigor and young plants may be stunted (Chhabra *et al*., 1981).

Whitefly

The adult whitefly is a tiny soft bodied and pale yellow, change to white within a few hours due to deposition of 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 0.2 mm long. One female can lay upto 136 eggs in its life time in mungbean (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. They 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 mungbean (Srivastava and Singh, 1976). The infested plant parts become yellowish, the leaves become wrinkle, curl downwards and eventually they fallen off. This happens mainly due to viral infection where the whitefly acts as a mechanical vector of many viral diseases.

Thrips

Thrips are another important pests in mungbean. They are small, slim-bodied insects with rasping-sucking mouthparts that puncture plant cells and suck out their contents. Thrips feed on flowers, petioles and stigmas; causing deformity of the inflorescence and premature flower shedding. Sachan (1986) has reported widespread thrips damage to mungbean flowers.

Hairy caterpillar

The name of the insect denotes that there are plenty of hairs on the body of the larval stage of the insect. Adult moth is straw colored and the front pair of wings contains black spot. The body of the larvae is orange colored with both ends are black. In about 15 to 20 days, the caterpillar is fully-grown and it measures 2.5 to 4.0 cm (Bakr, 1998). Hairy caterpillar is a widely distributed polyphagous insect pest. The hairy caterpillar attacks the tender leaves of the seedling after hatching and as a result, the growth of the seedling is ceased.

Pod borer

Pod borer is one serious preharvest pest of mungbean in Bangladesh (Rahman *et al.*, 1981), in India (Sehgal and Ujagir, 1988) and other tropical and sub-tropical countries. The adult moth of pod borer is dark brown in color. There is a white half circle spot on the front pair of wings.

Hind pair of wings is grayish white in color and moth having light brown spots on the leaf. The larvae are yellowish in color. They enter into the inflorescence and start feeding the flowers, later they cripple leaves together making nets and nets with leaves, flowers and young pods. They remain inside the nets hiding themselves and eat the young seeds boring the pods. Bakr (1988) reported that the span of larval period may be 10-24 days.

Pod borer is a polyphagous pest, which spreads in wide geographical areas and it extends from Cape Verde Islands in the Atlantic, through Africa, Asia and Autralasia, to the South Pacific Islands and from Germany in the north to New Zealand in the south (Hardwick, 1965). Rao (1974) stated that in India, *H. armigera* is distributed over a wide range and caused serious losses to many crops, including chickpea, particularly in the semi-arid tropics. Ibrahim (1980) observed that *Heliothis* spp. is of considerable economic importance as pests on many Egyptian crops but *H. armigera* is the most abundant species throughout Egypt. Zalucki *et al.*, (1986) reported that *H. armigera* was one of the widest distributions of any agricultural pests, occurring throughout Asia, Australia, New Zealand, Africa, southern Europe and many Pacific islands.
Vijayakumar and Jayaraj (1981) studied the preferred host plants for oviposition by *H. armigera* and found in descending order, pigeonpea > fieldpea > chickpea> tomato> cotton> chillics> mungbean> sorghum.

Mating and oviposition

The eggs were laid singly, late in the evening, mostly after 2100 hr to midnight. On many host plants, the eggs were laid on the lower surface of the leaves, along the midrib. Eggs were also laid on buds, flowers and in between the calyx and fruit.

Roome (1975) studied the mating activity of *H. armlgera* and reported that from 02.00 to 04.00 hr the males flew above the crop while the females were stationary and released a pheromone. During this period males were highly active and assembled around females.

Singh and Singh (1975) found that the pre-oviposition period ranged from 1 to 4 days, oviposition period 2 to 5 days and post-oviposition period 1 to 2 days. Eggs were laid late in the evening, generally after 2100 hours and continued up to midnight. However, maximum numbers of egg were laid between 2100 and 2300 hours. The moths did not oviposit during the daytime. Loganathan (1981) observed peak mating activity at 04.00 hr.

Dhurve and Borle (1986) cited that the pod damage in mungbean by *H. armigera* was the lowest when the crop was sown between 30 October and 4 December. The yield was significantly higher in 30 October and 27 November sowings.

Tayaraj (1982) reported that oviposition usually started in early June, with the on set of pre-monsoon showers, adults possibly emerging from diapausing pupae and also from larvae that had been carried over in low numbers on crops and weeds during the summer. Reproductive moths were recorded throughout the year ovipositing on the host crops and weeds with flowers. The pest multiplied on weeds, early-sown corn, sorghum, mungbean and groundnut before infesting pigeon pea in October-November and chickpea in November-March.

Zalucki *et al.* (1986) reported that females laid eggs singly or in groups of 2 or 3, on flowers, fruiting bodies, growing tips and leaves. During their two weeks life span, females laid approximately 1400 eggs.

Bhatt and Patel (2001) cited that the pre-oviposition period ranged from 2 to 4 days, oviposition period 6 to 9 days and post-oviposition period 0 to 2 days. Moth oviposited 715 to 1230 eggs with an average of 990.70 ± 127.40.

Egg

The eggs of *H. armigera* are nearly spherical, with a flattened base, giving a somewhat dome-shaped appearance, the apical area surrounding the micropyles smooth, the rest of the surface sculptured in the form of longitudinal ribs, The freshly laid eggs are 0.4 to 0.55 mm in diameter, yellow-white, glistening, changing to dark brown before hatching .The incubation period of the eggs is longer in cold weather and shorter in hot weather, being 2 to 8 days in South Africa and 2.5 to 17 days in the United States and 2 to 5 days in India (Singh and Singh, 1975).

Larva

The newly hatched larva is translucent and yellowish white in color, with faint yellowish orange longitudinal lines. The head is reddish brown, thoracic and anal shields and legs brown and the setae dark brown. The full-grown larva is about 35 to 42 mm long; general body color is pale green, with one broken stripe along each side of the body and one line on the dorsal side. Short white hairs are scattered all over the body. Prothorax is slightly more brownish than meso and metathorax. Crochets are arranged in biordinal symmetry on the prolegs. The underside of the larva is uniformly pale. The general color is extremely variable; and the pattern may be in shades of green, straw yellow and pinkish to reddish brown or even black (Singh and Singh, 1975).

Temperature affects the development of the larva considerably. The larval duration varied from 21 to 40 days in California, 18 to 51 days in Ohio, and 8 to 12 days in the Punjab, India (Singh and Singh, 1975) on the same host, tomato. The larval stage lasted for 21 to 28 days on chickpea; 2 to 8 days on maize silk; 33.6 days on sunflower corolla).

There are normally six larval instars in *H. armigera* (Bhatt and Patel, 2001), but exceptionally, during the cold season, when larval development is prolonged, seven instars regularly found in Southern Rhodesia.

Pupa

The pupa is 14 to 18 mm long, mahogany-brown, smooth-surfaced and rounded both anteriorly and posteriorly, with two tapering parallel spines at the posterior tip (Singh and Singh, 1975). The pupa of *H. armigera* undergoes a facultative diapause. The non-diapause pupal period for *H. armigera* was recorded as 14 to 40 days in the Sudan Gezira, 14 to 57 days in Southern Rhodesia, 14 to 37 days in Uganda and 5 to 8 days in India Jayaraj, (1982). According to Bhatt and Patel (2001) the pupal period ranged from 14 to 20 days in Gujarat, India.

Adult

The female *H. armigera* is a stout-bodied moth, 18 to 19 mm long, with a wingspan of 40 mm. The male is smaller, wing span being 35 mm. Forewings are pale brown with marginal series of dots; black kidney shaped mark present on the underside of the forewing; hind wings lighter in color with dark colored patch at the apical end. Tufts of hairs are present on the tip of the abdomen in females (ICRISAT, 1982). The female lived long. The length of life is greatly affected by the availability of food, in the form of nectar or its equivalent; in its absence, the female fat body is rapidly exhausted and the moth dies when only 3 to 6 days old Jayaraj (1982).

The longevity of laboratory reared males and females were 3.13 ± 0.78 and 6.63 ± 0.85 days, respectively (Singh and Singh, 1975). According to Bhatt and Patel (200l), adult period in male ranged from 8 to 11 days with an average of 9.15 ± 0.90 days and in females 10 to 13 days with an average of 11.40 ± 0.91 days.

Generations

Singh and Singh (1975) reported that *H. armigera* passed through four generations in the Punjab, India; one on chickpea during March; two on tomato, from the end of March to May; and one on maize and mungbean in July-August. Bhatnagar (1980) observed that seven to eight generations of *H. armigera* were present each year in Andhra Pradesh, India.

2.2 Management of insect pests of mungbean

The avail 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 and botanical is widely and frequently used. However, very limited research reports on the performance of chemical and botanical on the controlling of major insect pests of mungbean have been done in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect re reviewed under the following headings:

2.2.1 Mungbean insect pests management by using chemical

An experiment was conducted by Dubey (2007) in New Delhi, India to study the efficacy of Trichoderma viride (IARIP-2), Pongamia glabra [P. pinnata] cake and leaf extract and carboxin in different combinations and modes of application in field trials. The resulting yield of mungbean (*Vigna radiata*) was measured. Fifty-four combinations of different treatments were applied through soil, seed and foliar spray. Integration of soil application of P. glabra cake (200 kg/ha), seed treatment with T. viride (2 g/kg seed)+carboxin (1 g/kg seed)+Rhizobium sp. (25 g/kg seed) and foliar spray of P. glabra leaf extract (10%) suppressed disease severity significantly (92.7%). This treatment also increased seed germination (32.4%), improved plant vigour and enhanced production (49.2%). The same combination excluding carboxin was also effective and could be an option for organic production of mungbean. The integration of any two modes of applications of the treatments was superior to any single mode of application.

Field experiments were conducted by Ganapathy and Karuppiah (2004) during summer seasons in Tamil Nadu, India, to determine the efficacy of new insecticides against whitefly, mungbean yellow mosaic virus (MYMV) and urdbean leaf crinkle virus (ULCV) in mungbean cv. CO-4. The treatments comprised: seed treatment with 5 g imidacloprid/kg seed (T_1); seed treatment with 5 g thiamethoxam/kg seed (T_2); 0.25 ml imidacloprid/litre at 15 days after sowing (DAS; T_3); 0.2 g thiamethoxam/litre at 15 DAS (T_4); 0.1 g acetamiprid/litre at 15 DAS (T_5); 0.25 ml fipronil/litre at 15 DAS (T_6); 2 ml dimethoate/litre at 15 DAS (T_7); 0.5 ml cypermethrin/litre at 15 DAS (T_8); 1 ml neem oil/litre at 15 DAS (T_9); water spray (control; T_{10}). Whitefly population was observed at 25, 35 and 50 DAS and found that T_4 effectively decreased whitefly population and gave the highest yield (800 kg/ha).

Rajnish *et al*. (2004) reported that whitefly population was higher in urdbean [*Vigna mungo*] than mungbean [*Vigna radiata*] crop season in Uttar Pradesh, India. Kharif season crop of mungand urdbean were more vulnerable to the attack of whitefly. Peak population of whitefly in both the crops was recorded in first fortnight of May and second fortnight of September. Temperature and sunshine hours were favourable for whitefly as positive correlation was observed. Of the 50 entries tested, 16 entries of urd bean were superior as whitefly population was lower than the standard control (T-9) and its population varied between 0.85 and 8.26 per plant as against 8.46 per plant on standard control.

The efficacy of imidacloprid, thiamethoxam, acetamiprid, fipronil, dimethoate, fenvalerate and azadirachtin in controlling *T. palmi*, the vector of peanut bud necrosis virus (PNBV) infecting mungbean, was determined by Sreekanth *et al*. (2004) in a field experiment. All the insecticides tested reduced *T. palmi* population and PBNV incidence, with imidacloprid treatment resulting in the highest *T. palmi* control (57.47 and 67.41%) and consequently, the lowest PBNV incidence (19.11 and 29.74%) was recorded during the kharif and rabi seasons, respectively.

Management of insect pests of mungbean with insecticides using seed treatment and pre-sowing soil application followed by foliar application was studied by Ram and Singh (1999) at Pantnagar. Seed treatment with carbosulfan, monocrotophos, dimethoate, phosphamidon, methyl-o-demeton, methomyl and chlorpyriphos was evaluated for effect on germination and seedling vigour in the laboratory. Field efficacy of the effective doses of the above insecticides was evaluated, together with the pre-sowing soil application of phorate and carbofuran followed by foliar application of various insecticides at flowering against pests of mungbean. The insecticidal treatments significantly reduced the population of various insect pests in both seasons. Grain yield varied significantly from the lowest value of 214.2 and 353.3 kg/ha in untreated control to the highest value of 583.3 and 524.6 kg/ha in treatments with phorate followed by quinalphos in summer and rainy season, respectively. Seed treatment with monocrotophos, carbosulfan, dimethoate, methyl-o-demeton, chlorpyriphos tested at 40, 40, 120, 100 and 40 g a.i./ha dosages, respectively, followed by sprays at flowering also gave higher grain yield than the untreated control.

The pod borer can also be controlled by Cymhush 10 EC @ 1.0 ml/L 0f water (Bakr, 1998). Applications of 0.3% Dimethoate or 0.4% Monocrotophos at 45 and 60 DAS were found effective in protecting Kharif mungbean against lepidopteran pod borers and other pests attacking the crop at the flowering and fruiting stage (Ahmad *et al*., 1998).

Four granular insecticides (Carbofuran, Phorate, 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) were evaluated by Dhiman *et al*. (1993) in a field experiment for the control of stemfly (*Ophiomyia phaseoli*) of mungbean. All of the tested granular insecticides were found to be more effective for controlling mungbean stemfly than the control condition.

The succession and abundance of insect pests on *Vigna radiata* and *V. mungo* were observed by Raj and Kalra (1995) in Hisar, India, during summer. These crops were attacked by 22 and 16 insect pest species, respectively, at different stages of growth. The most important insect pests were *Empoasca kerri*, *Ophiomyia phaseoli*, *Austroagallia* sp., *Bemisia tabaci* and *Nysius* sp.

The peak populations of *E. kerri* (nymphs and adults), *O. phaseoli*, *Austroagallia* sp., *B. tabaci* and *Nysius* sp. (adults) was 6.40, 0.25, 10.82, 16.65 and 5.60 per plant, respectively on *V. radiata*, and 9.25, 0.75, 7.67, 19.25 and 4.05 insects per plant on *V. mungo*.

Ashfaq *et al*. (1995) reported that mungbean (*Vigna radiata*) suffers heavily due to attack of various pest insects. So far emphasis has been on the control of these insect pests with chemical insecticides. The role of antagonistic microbes like *Arachniotus* sp. and *Trichoderma harzianum* along with other major inputs per recommendations of the Agriculture Department were investigated. The results of the present investigations conducted in Faisalabad, Pakistan showed that the combined treatments of Tamaron 600 SL [methamidophos], Aspergopak (*Arachniotus* sp.), Trichopak (*T. harzianum*) and hoeing gave the highest yield (2.41 kg) and minimum black thrips population (1.80 thrips $leaf^{-1}$).

Rana and Dalal (1995) *P. lilacinus* at 1 or 2 g/kg soil together with seed treatments with carbosulfan at 0.5% w/w were applied to *Vigna radiata* for control of *H. cajanus* in pot trials. All treatments receiving combined applications of nematicide and fungus had significantly lower *H. cajani* populations and significantly higher growth and yield compared to controls.

Different indices for developing an insecticide application schedule against *Euchrysopscnejus* were evaluated in mungbean and Fenitrothion @ 0.1% when egg number reached about 5.2 per meter was found as the best schedule for it (Rahman, 1989). In another trial was conducted on need based application of insecticides against the pod borer in mungbean at Joydebpur and it was found that the spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio (Rahman, 1989).

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 them 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).

Rahman (1987) also reported that Fenitrothion or Sumithion 50 EC @ 2ml/L of water was recommended for the control of pod borer. Ahmad (1987) observed that pre sowing soil application of Carbofuran or Furadan 3G, Aldicarb 10G or Phroate 10 G 1 kg a.i./ha gave significant control of stemfly damage and two applications of Dimethoate or Monocrotophos at 45 and 60 DAS gave effective control of pod borer damage.

Lal (1987) reported that foliar application at flower initiation with Endosulfon0.07%, Dimethoate 0.03%, Phosphamidon 0.03% gave significant control of pod damage against pod borer. Srivastava *et al*. (1987) reported that the synthetic pyrethroids were effective in reducing pod borer damage and did not leave a toxic residue.

Jassid may be controlled by a basal application of a systemic insecticide at the time of sowing, followed by a foliar spray (Catipon, 1986). Cypermethrin (Cymbush) 0.006 percent was found to be highly effective against galerucid beetle, while Dimethoate 0.03 percent against jassid (Chhabra and Kooner, 1985). They also reported that treatments with Aldicarb and Monocrotophos, Dimethoate, Malathion or Endosulfan gave significant control of thrips. For the control of hairy caterpillar of mungbean Diazinon 50 EC or Nuvacron 40 WSC @ 1.5 ml per liter of water can be used. Gupta and Singh (1984) obtained the largest increase in grain yield by controlling stemfly of mungbean with Aldicarb and Disulfoton.

Phorate or Carbofuran granules at the rate of 1 to 2 kg a.i./ha and foliar sprays of Dimethoate, Fenithion, Phosphhamidon were effective in reducing whitefly and jassid population of mungbean (Yadav *et al*., 1979).

2.2.2 Mungbean insect pest management by using botanicals

Field studies were conducted by Korat and Dabhi (2009) during three successive wet seasons (1995-97) in rice fields in Gujarat, India, to determine the efficacy of various concentrations of azadirachtin (Nimbicidine, Neemax, and Neem Gold (all 300 ppm), Econeem (3000 ppm), Neem Azal T/S (10 000 ppm) and Fortune Aza (1500 ppm)) compared to chlorpyrifos for the control of *Cnaphalocrocis medinalis*, *Sogatella furcifera* and *Scirpophaga incertulas*. Results showed that although all neem formulations were effective against pests and resulted in an increased yield none were superior in efficacy to chlorpyrifos.

Visalakshimi *et al*., (2005) reported that application of neem effectively reduced the oviposition of *H. armigera* through out the crop period. Among various IPM components (neem 0.06%, HaNPV 250 L/ha, bird perches one/plot, endosulfan 0.07%), neem and HaNPV found as effective as endosulfan in the terms of reduction larval population and pod damage, further, endosulfan comparatively found toxic to natural enemies present in chickpea eco-system.

Jeyakumar and Gupta (1999) reported neem seed kernel extract (NSKE) reduced the oviposition of *H. armigera* in a dose dependent manner during the exposure periods of 0-24 h and 24-48 h and showed oviposition deterrency effect. Reduction of oviposition was highest (60.9%) with 10% NSKE. The hatchability of the laid eggs was also affected on NSKE treated surface.

Akhauri and Yadav (1999) observed that aqueous extracts of neem seed kernel and green castor leaves each at 5 and 10 per cent concentration, neem and mahua oils and mangraila (*Nigella sativa* L.*)* seed extract in water each at 2 per cent concentration, were effective in controlling Melanagromyza obtusa, Apion clavipes Gerst and *H. armigera*.

Butani and Mittal (1993) studied the efficacy of neem seed kernel suspension and several conventional insecticides against *H. armigera* and reported that all the tested insecticides significantly reduced the pest population and neem seed kernel suspension being equally effective.

Sarode *et al*. (1994) studied the efficacy of different doses of neem seed kernel extract (NSKE) for the management of pod borer. It was found two sprays of NSKE 6% at 7 days interval provided significantly high larval reduction (69.45%) followed by two sprays of NSKE 5% (67.28%) and suggested that it may be used in managing *H. armigera*.

Oils of plant origin such as neem seed oil (Puri *et al*., 1991; Butler *et al*., 1991), soybean oil (Butler *et al*., 1991), cotton seed oil (Butler *et al*., 1991), have been tested against whitefly and the results were encouraging. In a laboratory study, Butler and Rao (1990) reported that 0.5% sprays of 3 commersial neem oil formulation namely Neemguard, Newark, Neempon to single eggplant leaves against whitefly resulted 97% fewer eggs and 87% fewer immature compared to those on untreated leaves. The crude extracts and active principles isolated from number of other plants have anti feedant, insecticidal, hormonal and repellants properties (Jayaraj, 1988).

Plant products play an important role in evolving an ecologically sound and environmentally acceptable pest management system. Grainage *et al*. (1985) reported that neem is the major source of anti feedant principles and the seed contain a number of toxic terpenoids. The ether extract of *Tribulus terrestris* L. had juvenilising effects on cutworm *(Spodoptera litura)* and pod borer (*Heliothts armigera*), respectively (Gunasekaran and Chelliah, 1985). Treatment of Triflumuron, a moult inhibitor against whitefly nymphys or pupae reduced the adult emergence (Radwan, 1985).

Some insect growth inhibitors are also reported to be effective against whitefly. Khalil *et al*., (1979) reported that Dimilin (Diflubenzuron) to be effective against all stages of *Bemisiatabac*i. The aqueous extract from kernels was effective on pod borer as anti feedant.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the insect pest incidence in mungbean and their management during the period from March to June 2012. A brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, data collection and analysis of different parameters under the following headings are presented below:

3.1 Experimental site

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in $23^0 74^/$N latitude and $90^0 35^/$E longitude (Anon., 1989).

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No. 28 and is shallow red brown terrace soil. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and has been presented in Appendix I.

3.3 Climate

The climate of experimental site was subtropical, characterized by 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). Meteorological data related to the temperature, relative humidity and rainfall during the experimental period was collected from Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and has been presented in Appendix II.

3.4 Planting material

BARI Mung-5 was used as the test crop of this experiment. The seeds of BARI Mung-5 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Land preparation

The land was first opened with the tractor drawn disc plough. Then the soil was ploughed and cross ploughed. Ploughed soil was then brought into desirable fine tilth by the operations of ploughing, harrowing and laddering. The stubble and weeds were removed. Experimental land was divided into unit plots following the design of experiment. During land preparation 10 t/ha decomposed cowdung were mixed with soil.

3.6 Manures and fertilizers application

Urea, Triple super phosphate (TSP) and Muriate of potash (MoP) were used as a source of nitrogen, phosphorous and potassium, respectively. Urea, phosphate and potash were applied at the rate of 40, 40 and 50 kg per hectare, respectively following the BARI recommendation. The entire amount of TSP and MP was applied as basal dose at the time of land preparation. Urea was applied as top dressing in three equal splits at vegetative stage and early and mid fruiting stage.

3.7 Sowing of seeds in the field

The seeds of mungbean were sown on March 16, 2012. Before sowing seeds were treated with fungicide Bavistin to control the seed borne disease. The seeds were sown in furrows having a depth of 2-3 cm. Row to row distance was 30 cm.

3.8 Treatments of the experiment

The experiment consists of the following management practices and was applied starting from 5 days after seed germination:

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Untreated control

3.9 Experimental layout and design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 23.00 m × 9.00 m was divided into three equal blocks. Each block was divided into 7 plots, where 7 treatment combinations were allocated at random. There were 21 unit plots altogether in the experiment. The size of the each unit plot was 2.5 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.10 Application of different treatments

Sevin, Dursban, Sumi Alpha, Actara, Marshal and Neem seed kernel extract were sprayed in assigned plots 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 in 15 days interval starting from 5 days after seed germination. 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.

3.11 Intercultural operations

Irrigation was done at 30 and 45 Days after sowing (DAS). The crop field was weeded twice; first weeding was done at 30 DAS and second at 44 DAS.

3.12 Crop sampling and data collection

Five plants from each treatment were randomly marked inside the central row of each plot with the help of sample card.

3.13 Monitoring and data collection

The mungbean plants of different treatments were closely examined at regular intervals commencing from germination to harvest. The following parameters were considered during data collection -

- Stem fly infested plant
- Stem tunneling

- Number of stemfly larvae/pupae per plant
- Number of jassid per 10 leaves
- Number of whitefly per 10 leaves
- Number of hairy caterpillar per 10 leaves
- Number of thrips per 10 flowers
- Number of healthy pods at early, mid and late stage
- Number of infested pods at early, mid and late stage
- Pod infestation in number at early, mid and late stage (%)
- Plant height (cm) at harvest
- Number of pods per plant
- Pod yield per hectare (ton)

3.14 Determination of pod infestation by number and infestation reduction over control

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

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

$$\text{\% Infestation reduction} = \frac{\text{(\% Infestation in control – \% Infestation in the concerned treatment)}}{\text{\% Infestation in control}} \times 100$$

3.15 Determination of stem tunneling

For determination of stem tunneling, 5 randomly selected plants from each plot were uprooted and stems were split opened by a scalpel for recording the extent of stem tunneling by stemfly. The lengths of the stem were measured by a scale. From these data, percentage of stemfly infested plants and percentage of stem tunneling were calculated. Percent stem tunneling was calculated using the following formula:

$$\text{Stem tunneling (\%)} = \frac{\text{Length of stem tunneling}}{\text{Total length of stem}} \times 100$$

3.16 Harvest and post harvest operations

The plants of middle three rows, avoiding border rows, of each plot were harvested. The pods were then threshed; cleaned and dried in bright sunshine. The yield obtained from each plot was converted into yield per hectare.

3.17 Procedure of data collection

3.17.1 Plant height at harvest

The plant heights of 5 randomly selected plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in centimeter (cm). Data were recorded from the inner rows plant of each plot during harvesting period.

3.17.2 Number of pods per plant

Number of total pods of selected plants from each plot was counted and the mean number was expressed on plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.17.3 Fruits yield hectare^{-1}

Fruits per plot were converted into hectare and the weight of fruits per hectare was calculated and expressed in ton.

3.18 Statistical analysis

The data on different parameters as well as yield of mungbean were statistically analyzed to find out the significant differences among the effects of different treatments. The mean values of all the characters were calculated and analyses of variance were performed by the ‘F’ (variance ratio) test. The significance of the differences among the mean values of treatment in respect of different parameters was estimated by the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the insect pests incidence in mungbean and their management. The analysis of variance (ANOVA) of the data on different insect pest, pod infestation, different yield contributing characters and yield are given in Appendix III-VIII. The results have been presented by using different Table & Graphs and discussed with possible interpretations under the following headings and sub headings:

4.1 Intensity of stemfly infestation

Statistically significant variation was recorded for intensity of stemfly infestation of mungbean due to different management practices (Table 1). Data revealed that the lowest stemfly infestation (4.50%) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which was statistically identical (5.00%) with T_2 (Dursban 20 EC @ 2.0 ml/L of water) and T_6 (Neem seed kernel extract @ 20 gm/L of water) and closely followed (7.50% and 9.00%) by T_3 (Sumi Alpha 5 EC @ 1.0 ml/L of water) and T_4 (Actara @ 0.5 gm/L of water), whereas the highest stemfly infestation (22.50%) was observed from T_7 (control condition) which was followed (12.50%) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on stemfly infestation over control, the highest value (80.00%) was recorded for the treatment T_5 and the lowest value (44.44%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices for controlling stemfly infestation which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water. Rahman (1987) reported that the most damaging inset pests of mungbean recorded so far are stemfly. Rahman (1991) reported from earlier study that in mungbean; upto 97% plants were found to be infested by stemfly which was much higher than the findings of this study. Dhiman *et al*. (1993) reported that all of the tested granular insecticides were found to be more effective for controlling mungbean stemfly than the control condition.

Table 1. Effect of different management practices on the damage severity of stemfly by infesting plant and stem tunneling of mungbean

Treatments	Stemfly infested plant (%)	Stem tunneling (%)	Reduction on infestation over control (%)	
			Stemfly infested plant	Stem tunneling
T_1	12.50 b	17.50 a	44.44	11.21
T_2	5.00 d	7.87 de	77.78	60.07
T_3	7.50 c	11.62 bc	66.67	41.05
T_4	9.00 c	13.98 b	60.00	29.07
T_5	4.50 d	6.22 e	80.00	68.44
T_6	5.00 d	9.53 cd	77.78	51.65
T_7	22.50 a	19.71 a	--	--
$LSD_{(0.05)}$	**1.692**	**2.986**	**--**	**--**
CV(%)	**10.09**	**13.59**	**--**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.2 Stem tunneling

Stem tunneling of mungbean showed statistically significant differences for due to different management practices (Table 1). Data revealed that the lowest stem tunneling (6.22%) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which was statistically identical (7.87%) with T_2 (Dursban 20 EC @ 2.0 ml/L of water) and closely followed (9.53%) by T_6 (Neem seed kernel extract @ 20 gm/L of water), while the highest stem tunneling (19.71%) was observed from T_7 (control condition) which was followed (17.50%) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on stem tunneling over control, the highest value (68.44%) was recorded for the treatment T_5 and the lowest value (11.21%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices in terms of stem tunneling in mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water.

4.3 Number of stemfly larvae/pupae per plant

Different management practices showed statistically significant variation for number of stemfly larvae/pupae of mungbean (Table 2). It was found that the lowest number of stemfly larvae/pupae (0.25) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which closely followed (0.45 and 0.50) with T_2 (Dursban 20 EC @ 2.0 ml/L of water) and T_6 (Neem seed kernel extract @ 20 gm/L of water), while the highest number of stemfly larvae/pupae (2.17) was observed from T_7 (control condition) which was followed (0.85) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on number of stemfly larvae/pupae over control, the highest value (88.48%) was recorded for the treatment T_5 and the lowest value (60.83%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices in terms of controlling stemfly larvae/pupae in mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water. Lal, 1985 reported chemical control was significant for stemfly control.

Table 2. Effect of different management practices on the incidence of stemfly larvae/pupae attacking on mungbean

Treatments	Number of stemfly larvae/pupae per plant	Population reduction over control (%)
T_1	0.85 b	60.83
T_2	0.45 d	79.26
T_3	0.65 c	70.05
T_4	0.75 bc	65.44
T_5	0.25 e	88.48
T_6	0.50 d	76.96
T_7	2.17 a	--
$LSD_{(0.05)}$	**0.138**	**--**
CV(%)	**9.81**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.4 Number of jassid per 10 leaves

Significant variation was recorded for number of jassid per 10 leaves of mungbean due to different management practices (Table 3). It was found that the lowest number of jassid per 10 leaves (1.36) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which followed (2.58) by T_2 (Dursban 20 EC @ 2.0 ml/L of water), while the highest number of jassid per 10 leaves (9.78) was observed from T_7 (control condition) which was followed (6.47) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on number of jassid per 10 leaves over control, the highest value (86.09%) was recorded for the treatment T_5 and the lowest value (33.84%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices in terms of controlling jassid which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water. Rahman (1988) reported 43.4% infestation by jassids and controlled by a basal application of systemic insecticide at the time of sowing, followed by a foliar spray (Catipon, 1986).

4.5 Number of whitefly per 10 leaves

Significant variation was recorded for number of whitefly per 10 leaves of mungbean for different management practices (Table 3). Data revealed that the lowest number of whitefly per 10 leaves (1.20) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which closely followed (2.87) by T_2 (Dursban 20 EC @ 2.0 ml/L of water), while the highest number of whitefly per 10 leaves (5.67) was observed from T_7 (control condition) which was followed (3.65) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on number of whitefly per 10 leaves over control, the highest value (78.84%) was recorded for the treatment T_5 and the lowest value (35.63%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices in terms of controlling whitefly in mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water. Kajita and Alam (1996) reported that whitefly reduces crop yield significantly.

Table 3. Effect of different management practices on the incidence of jassid and whitefly attacking on mungbean

Treatments	Number of jassid per 10 leaves	Number of whitefly per 10 leaves	Population reduction over control (%)	
			Jassid	Whitefly
T_1	6.47 b	3.65 b	33.84	35.63
T_2	2.58 f	2.87 d	73.62	49.38
T_3	4.50 d	3.14 cd	53.99	44.62
T_4	5.22 c	3.34 bc	46.63	41.09
T_5	1.36 g	1.20 e	86.09	78.84
T_6	3.35 e	2.95 cd	65.75	47.97
T_7	9.78 a	5.67 a	--	--
$LSD_{(0.05)}$	**0.477**	**0.386**	**--**	**--**
CV(%)	**5.66**	**6.66**	**--**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.6 Number of hairy caterpillar per plant

Statistically significant variation was recorded for number of hairy caterpillar per plant of mungbean due to different management practices (Table 4). Data revealed that the lowest number of hairy caterpillar per plant (1.00) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which closely followed (1.20) by T_2 (Dursban 20 EC @ 2.0 ml/L of water), while the highest number of hairy caterpillar per plant (4.10) was found from T_7 (control condition) which was followed (2.35) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on number of hairy caterpillar per plant over control, the highest value (75.61%) was recorded for treatment T_5 and the lowest value (42.68%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices in terms of controlling hairy caterpillar in mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water. Lal *et al*. (1980) reported that hairy caterpillar feed on green portion of the leaf causing serious damage to the plant.

4.7 Number of thrips per 10 flowers

Statistically significant variation was recorded for number of thrips per 10 flowers of mungbean due to different management practices (Table 4). The lowest number of thrips per 10 flowers (1.20) was found from T_5 (Marshal 20 EC @ 2.0 ml/L of water) which closely followed (1.85) by T_2 (Dursban 20 EC @ 2.0 ml/L of water), while the highest number of thrips per 10 flowers (5.40) was observed from T_7 (control condition) which was followed (3.50) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). In case reduction on number of thrips per 10 flowers over control, the highest value (77.78%) was recorded for the treatment T_5 and the lowest value (35.19%) from T_1 treatment. From the findings it is revealed Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices in terms of controlling thrips in mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water. Chhabra and Kooner (1985) have reported extensive damage to the summer mungbean due to flower shedding caused by thrips.

Table 4. Effect of different management practices on the incidence of hairy caterpillar and thrips attacking on mungbean

Treatments	Number of hairy caterpillar per plant	Number of thrips per 10 flowers	Population reduction over control (%)	
			Hairy caterpillar	Thrips
T_1	2.35 b	3.50 b	42.68	35.19
T_2	1.20 de	1.85 d	70.73	65.74
T_3	1.50 d	2.50 c	63.41	53.70
T_4	1.95 c	3.30 b	52.44	38.89
T_5	1.00 e	1.20 e	75.61	77.78
T_6	1.45 d	2.45 c	64.63	54.63
T_7	4.10 a	5.40 a	--	--
$LSD_{(0.05)}$	**0.303**	**0.474**	**--**	**--**
CV(%)	**8.75**	**9.21**	**--**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.8 Pod bearing status at early fruiting stage

Number of healthy pods, infested pods and percent infestation of mungbean pod showed statistically significant differences at early pod stage for different management practices under the present trial (Table 5). The highest number of healthy pods plant^{-1} (78.73) was recorded in T_5 (Marshal 20 EC @ 2.0 ml/L of water) treatment which was statistically identical (74.10, 72.63 and 71.43) with T_2 (Dursban 20 EC @ 2.0 ml/L of water), T_6 (Neem seed kernel extract @ 20 gm/L of water) and T_3 (Sumi Alpha 5 EC @ 1.0 ml/L of water), respectively. It was followed (67.73) by T_4 (Actara @ 0.5 gm/L of water). On the other hand, the lowest number (61.43) was recorded in T_7 (untreated control) treatment which was statistically similar (64.53) with T_1 (Sevin 85 WP @ 2.5 gm/L of water). The highest number of infested pods plant^{-1} (8.27) was recorded in T_7 treatment, whereas the lowest number (3.23) was recorded in T_2 treatment which was followed (3.83) by T_2. The highest percent of infested pods plant^{-1} in number (11.86%) was recorded in T_7 treatment which was followed (7.94% and 7.14%) by T_1 and T_4, respectively. Again, the lowest infestation percent in number (3.94%) was recorded in T_5 treatment which was statistically similar (4.94%) with T_2 and closely followed (5.84% and 5.47%) by T_3 and T_6. Mungbean pod infestation percentage reduction over control at early pod stage in number was estimated for different management practices and the highest value (66.78%) was recorded for the treatment T_5 and the lowest value (33.05%) from T_1 treatment. From the findings it is revealed that spraying of Marshal 20 EC @ 2.0 ml/L performed maximum healthy pods and minimum infested pods as well as lowest percent of pod infestation in number followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water, while in untreated control treatment gave the minimum healthy pods, maximum infested pods and highest percentage of infestation under the trail followed by Sevin 85 WP @ 2.5 gm/L of water. Lal (1987) reported that the foliar application at flower initiation stage with Endosulfon 0.07%, Dimethoate 0.03%, Phosphamidon 0.03% gave significant control of pod damage against pod borer.

Table 5. Effect of different management practices on the damage severity of pod borer attacking mungbean at early pod stage

Treatments	Healthy pods per plant	Infested pods per plant	% Infestation	Reduction of infestation over control (%)
T_1	64.53 cd	5.53 b	7.94 b	33.05
T_2	74.10 ab	3.83 d	4.94 cd	58.35
T_3	71.43 abc	4.43 c	5.84 c	50.76
T_4	67.73 bcd	5.17 b	7.14 b	39.80
T_5	78.73 a	3.23 e	3.94 d	66.78
T_6	72.63 ab	4.20 cd	5.47 c	53.88
T_7	61.43 d	8.27 a	11.86 a	--
$LSD_{(0.05)}$	**7.441**	**0.560**	**1.149**	**--**
CV(%)	**5.97**	**6.35**	**9.60**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.9 Pod bearing status at mid fruiting stage

Number of healthy pods, infested pods and percent infestation of mungbean pod showed statistically significant differences at mid pod stage for different management practices (Table 6). The highest number of healthy pods plant^{-1} (83.43) was recorded in T_5 (Marshal 20 EC @ 2.0 ml/L of water) treatment which was statistically identical (80.30, 78.77, 75.33 and 75.20) with T_2 (Dursban 20 EC @ 2.0 ml/L of water), T_4 (Actara @ 0.5 gm/L of water), T_6 (Neem seed kernel extract @ 20 gm/L of water) and T_3 (Sumi Alpha 5 EC @ 1.0 ml/L of water), respectively and followed (71.63) by T_1 (Sevin 85 WP @ 2.5 gm/L of water). On the other hand, the lowest number (65.47) was recorded in T_7 (untreated control) treatment which was statistically similar (71.63) with T_1 (Sevin 85 WP @ 2.5 gm/L of water). At mid pod stage the highest number of infested pods plant^{-1} (11.50) was recorded in T_7 treatment, whereas the lowest number (4.73) was recorded in T_5 treatment which was similar (4.97) with T_2. The highest percent of infested pods plant^{-1} in number (15.02%) was recorded in T_7 treatment which was followed (9.51% and 8.14%) by T_1 and T_4, respectively. Again, the lowest infestation percent in number (5.38%) was recorded in T_5 treatment which was statistically similar (5.84%) with T_2 and closely followed (7.19% and 7.58%) by T_6 and T_3. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (64.18%) was recorded for the treatment T_5 and the lowest value (36.68%) from T_1 treatment. From the findings it is revealed that at mid pod stage, spraying of Marshal 20 EC @ 2.0 ml/L performed maximum healthy pods and minimum infested pods as well as lowest percent of pod infestation in number followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water, while in untreated control treatment gave the minimum healthy pods, maximum infested pods and highest percentage of infestation under the trail followed by Sevin 85 WP @ 2.5 gm/L of water.

Table 6. Effect of different management practices on the damage severity of pod borer attacking mungbean at mid pod stage

Treatments	Healthy pods per plant	Infested pods per plant	% Infestation	Reduction of infestation over control (%)
T_1	71.63 bc	7.53 b	9.51 b	36.68
T_2	80.30 ab	4.97 ef	5.84 de	61.12
T_3	75.20 abc	6.17 cd	7.58 cd	49.53
T_4	78.77 ab	6.97 bc	8.14 bc	45.81
T_5	83.43 a	4.73 f	5.38 e	64.18
T_6	75.33 abc	5.83 de	7.19 cd	52.13
T_7	65.47 c	11.50 a	15.02 a	--
$LSD_{(0.05)}$	**9.379**	**0.960**	**1.701**	**--**
CV(%)	**6.96**	**7.92**	**11.40**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.10 Pod bearing status at late fruiting stage

Number of healthy pods, infested pods and percent infestation of mungbean pod showed statistically significant differences at late pod stage for different management practices (Table 7). The highest number of healthy pods plant^{-1} (79.87) was recorded in T_5 (Marshal 20 EC @ 2.0 ml/L of water) treatment which was statistically identical (76.50 and 71.57) with T_2 (Dursban 20 EC @ 2.0 ml/L of water) and T_6 (Neem seed kernel extract @ 20 gm/L of water) and followed (68.47) by T_3 (Sumi Alpha 5 EC @ 1.0 ml/L of water), respectively. On the other hand, the lowest number (59.87) was recorded in T_7 (untreated control) treatment which was statistically similar (61.63) with T_1 (Sevin 85 WP @ 2.5 gm/L of water). At late pod stage the highest number of infested pods plant^{-1} (12.33) was recorded in T_7 treatment, whereas the lowest number (4.77) was recorded in T_5 treatment which was similar (5.43, 5.53 and 6.10) with T_2, T_6 and T_3. The highest percent of infested pods plant^{-1} in number (17.02%) was recorded in T_7 treatment which was followed (10.90% and 9.45%) by T_1 and T_4, respectively. Again, the lowest infestation percent in number (5.68%) was recorded in T_5 treatment which was statistically similar (6.63%) with T_2 and closely followed (7.18% and 8.18%) by T_6 and T_3. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (66.63%) was recorded for the treatment T_5 and the lowest value (35.96%) from T_1 treatment. From the findings it is revealed that at late pod stage, spraying of Marshal 20 EC @ 2.0 ml/L performed maximum healthy pods and minimum infested pods as well as lowest percent of pod infestation in number followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water, while in untreated control treatment gave the minimum healthy pods, maximum infested pods and highest percentage of infestation under the trail followed by Sevin 85 WP @ 2.5 gm/L of water.

Table 7. Effect of different management practices on the damage severity of pod borer attacking mungbean at late pod stage

Treatments	Healthy pods per plant	Infested pods per plant	% Infestation	Reduction of infestation over control (%)
T_1	61.63 d	7.53 b	10.90 b	35.96
T_2	76.50 ab	5.43 cd	6.63 e	61.05
T_3	68.47 bcd	6.10 bcd	8.18 cd	51.94
T_4	63.73 cd	6.63 bc	9.45 bc	44.48
T_5	79.87 a	4.77 d	5.68 e	66.63
T_6	71.57 abc	5.53 cd	7.18 de	57.81
T_7	59.87 d	12.33 a	17.02 a	--
$LSD_{(0.05)}$	**9.068**	**1.510**	**1.472**	**--**
CV(%)	**7.41**	**12.29**	**8.91**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.11 Yield contributing characters and yield of mungbean

4.11.1 Plant height at harvest

Plant height of mungbean at harvest for controlling pod borer by using different management practices showed statistically significant differences (Table 8). The longest plant (63.41 cm) was recorded in T_5 treatment which was statistically identical (61.50 cm, 60.83 cm and 59.09 cm) with T_2, T_6 and T_3, respectively and closely followed (57.87 cm and 57.73 cm) by T_4 and T_1, while the shortest plant (54.78 cm) was recorded in T_7 treatment. Plant height increase over control was estimated for different management practices and the highest value (15.75%) was recorded for the treatment T_5 and the lowest value (5.39%) from T_1 treatment.

4.11.2 Number of pods per plant

Number of pods per plant of mungbean at harvest for controlling pod borer by using different management practices showed statistically significant differences (Table 8). The maximum number of pods/plant (84.63) was recorded in T_5 treatment which was statistically identical (81.93, 77.10 and 74.57) with T_2, T_6 and T_3, while the minimum number of pods per plant (68.20) was recorded in T_7 treatment which was statistically identical (69.17 and 70.37) by T_1 and T_4. Number of pods per plant increase over control was estimated for different management practices and the highest value (24.09%) was recorded for the treatment T_5 and the lowest value (1.42%) from T_1 treatment.

4.11.3 Yield per hectare

For controlling pod borer by using different management practices yield per hectare of mungbean showed significant differences (Table 8). The highest yield per hectare (1.78 ton) was recorded in T_5 treatment which was statistically identical (1.72 ton, 1.69 ton, 1.66 ton and 1.64 ton) with T_2, T_6, T_3 and T_4, respectively and closely followed (1.52 ton) by T_1, whereas the lowest yield (1.33 ton) in T_7 treatment. Yield per hectare of mungban increase over control was estimated for different management practices and the highest value (33.83%) was recorded from T_5 and the lowest value (14.29%) from T_1 treatment.

Table 8. Effect of different management practices on plant height, number of pods/plant and yield per hectare of mungbean

Treatments	Plant height	Number of pods/plant	Yield (t/ha)	Increase over control (%)		
				Plant height	Number of pods/plant	Yield (t/ha)
T_1	57.73 bc	69.17 c	1.52 bc	5.39	1.42	14.29
T_2	61.50 ab	81.93 ab	1.72 ab	12.27	20.13	29.32
T_3	59.09 abc	74.57 abc	1.66 ab	7.87	9.34	24.81
T_4	57.87 bc	70.37 c	1.64 ab	5.64	3.18	23.31
T_5	63.41 a	84.63 a	1.78 a	15.75	24.09	33.83
T_6	60.83 ab	77.10 abc	1.69 ab	11.04	13.05	27.07
T_7	54.78 c	68.20 c	1.33 c	--	--	--
$LSD_{(0.05)}$	**4.631**	**9.630**	**0.195**	**--**	**--**	**--**
CV(%)	**4.39**	**7.15**	**6.84**	**--**	**--**	**--**

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

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.12 Economic analysis

The analysis was done in order to find out the most profitable management practices based on cost and benefit of various components. The results of economic analysis of mungbean cultivation showed that the highest net benefit of Tk. 198,800 ha^{-1} was obtained in T_5 treatment and the second highest was found Tk. 193,000 ha^{-1} in T_2 (Table 9). The highest benefit cost ratio (2.65) was estimated for T_5 treatment and the lowest (1.04) for T_1 treatment under the trial. The highest BCR was found in the treatment T_5 may be due to the minimum pest infestation to the other treatment components and the highest yield of this treatment. Rahman (1989) spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio.

4.13 Relationship between pod infestation at different pod stage and yield per hectare of mungbean

4.13.1 Relationship between pod infestation at early pod stage and yield per hectare

The data on pod infestation by pod borer at early pod stage were regressed against yield per hectare of mungbean and a negative linear relationship was obtained between them. It was evident from the Figure 1 that the equation $y = 2.629x^{-0.26}$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.932$) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the yield decreased with the increased of pod infestation at early pod stage for different insect pests management practices in controlling insect pests in mungbean.

Table 9. Cost of mungbean production for different management practices of insect pests

Treatments	Cost of pest Management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio
T_1	11200	1.52	182400	171200	11600	1.04
T_2	13400	1.72	206400	193000	33400	2.49
T_3	13400	1.66	199200	185800	26200	1.96
T_4	14200	1.64	196800	182600	23000	1.62
T_5	14800	1.78	213600	198800	39200	2.65
T_6	13600	1.69	202800	189200	29600	2.18
T_7	0	1.33	159600	159600	0	

Price of mungbean @ Tk. 50/kg

T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval

T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval

T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval

T_4: Actara @ 0.5 gm/L of water at 15 days interval

T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval

T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval

T_7: Control

4.13.2 Relationship between pod infestation at mid pod stage and yield per hectare

Correlation study was done to established a relationship between pod infestation at mid pod stage and yield per hectare of mungbean. From the study it was revealed that significant correlations existed between the characters. The regression equation $y = 2.899x^{-0.28}$ gave a good fit to the data and the value of the co-efficient of determination ($R^2 = 0.965$). From this it can be concluded that increase the pod infestation decreases the yield (Figure 2).

4.13.3 Relationship between pod infestation at late pod stage and yield per hectare

The data on pod infestation by pod borer at late pod stage were regressed against yield per hectare of mungbean and a negative linear relationship was obtained between them. It was evident from the Figure 3 that the equation $y = 2.854x^{-0.26}$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.963$) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the yield decreased with the increased of pod infestation at late pod stage for different insect pests management practices in controlling insect pests in mungbean.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study the insect pests incidence in mungbean and their management. BARI Mung-5 was used as the test crop of this experiment. The experiment consists of the following treatments- T_1: Sevin 85 WP @ 2.5 gm/L of water at 15 days interval; T_2: Dursban 20 EC @ 2.0 ml/L of water at 15 days interval; T_3: Sumi Alpha 5 EC @ 1.0 ml/L of water at 15 days interval; T_4: Actara @ 0.5 gm/L of water at 15 days interval; T_5: Marshal 20 EC @ 2.0 ml/L of water at 15 days interval; T_6: Neem seed kernel extract @ 20 gm/L of water at 15 days interval and T_7: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Under the present study statistically significant variation was recorded in different parameters.

Data revealed that the lowest stemfly infestation (4.50%) was found from T_5, whereas the highest stemfly infestation (22.50%) from T_7. In case reduction on stemfly infestation over control, the highest value (80.00%) was recorded for the treatment T_5 and the lowest value (44.44%) from T_1. The lowest stem tunneling (6.22%) was found from T_5, while the highest stem tunneling (19.71%) was observed from T_7. In case reduction on stem tunneling over control, the highest value (68.44%) was recorded for the treatment T_5 and the lowest value (11.21%) from T_1 treatment. The lowest number of stemfly larvae/pupae (0.25) was found from T_5, while the highest number of stemfly larvae/pupae (2.17) was observed from T_7. In case reduction on number of stemfly larvae/pupae over control, the highest value (88.48%) was recorded for the treatment T_5 and the lowest value (60.83%) from T_1 treatment. It was found that the lowest number of jassid per 10 leaves (1.36) was found from T_5, while the highest number of jassid per 10 leaves (9.78) was observed from T_7. In case reduction on number of jassid per 10 leaves over control, the highest value (86.09%) was recorded for the treatment T_5 and the lowest value (33.84%) from T_1 treatment. The lowest number of whitefly per 10 leaves (1.20) was found from T_5, while the highest number of whitefly per 10 leaves (5.67) was observed from T_7. In case reduction on number of whitefly per 10 leaves over control, the highest value (78.84%) was recorded for the treatment T_5 and the lowest value (35.63%) from T_1 treatment. The lowest number of hairy caterpillar per plant (1.00) was found from T_5, while the highest number of hairy caterpillar per plant (4.10) was observed from T_7. In case reduction on number of hairy caterpillar per plant over control, the highest value (75.61%) was recorded for the treatment T_5 and the lowest value (42.68%) from T_1 treatment. The lowest number of thrips per 10 flowers (1.20) was found from T_5, while the highest number of thrips per 10 flowers (5.40) was observed from T_7. In case reduction on number of thrips per 10 flowers over control, the highest value (77.78%) was recorded for the treatment T_5 and the lowest value (35.19%) from T_1 treatment.

The highest number of healthy pods plant^{-1} (78.73) was recorded in T_5 and the lowest number (61.43) was recorded in T_7. The highest number of infested pods plant^{-1} (8.27) was recorded in T_7 treatment, whereas the lowest number (3.23) was recorded in T_2 treatment. The highest percent of infested pods plant^{-1} in number (11.86%) was recorded in T_7 treatment again, the lowest infestation percent in number (3.94%) was recorded in T_5 treatment. Mungbean pod infestation percentage reduction over control at early pod stage in number was estimated for different management practices and the highest value (66.78%) was recorded for the treatment T_5 and the lowest value (33.05%) from T_1 treatment. At mid pod stage the highest number of healthy pods plant^{-1} (83.43) was recorded in T_5 and the lowest number (65.47) was recorded in T_7. The highest number of infested pods plant^{-1} (11.50) was recorded in T_7 treatment, whereas the lowest number (4.73) was recorded in T_5 treatment. The highest percent of infested pods plant^{-1} in number (15.02%) was recorded in T_7 treatment again, the lowest infestation percent in number (5.38%) was recorded in T_5 treatment. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (64.18%) was recorded for the treatment T_5 and the lowest value (36.68%) from T_1 treatment. At late stage the highest number of healthy pods plant^{-1} (79.87) was recorded in T_5 and the lowest number (59.87) in T_7. The highest number of infested pods plant^{-1} (12.33) was recorded in T_7 treatment, whereas the lowest number (4.77) in T_2 treatment. The highest percent of infested pods plant^{-1} in number (17.02%) was recorded in T_7 treatment again, the lowest (5.68%) was recorded in T_5 treatment. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (66.63%) was recorded for the treatment T_5 and the lowest (35.96%) from T_1.

The longest plant (63.41 cm) was recorded in T_5 treatment, while the shortest plant (54.78 cm) in T_7 treatment. The maximum number of pods/plant (84.63) was recorded in T_5 treatment, while the minimum number (68.20) was recorded in T_7 treatment. The highest yield per hectare (1.78 ton) was recorded in T_5 treatment, whereas the lowest (1.33 ton) in T_7. The highest benefit cost ratio (2.65) was estimated for T_5 treatment and the lowest (1.04) for T_1 treatment.

Conclusion

From the above findings it was revealed that Marshal 20 EC @ 2.0 ml/L of water was more effective among the management practices for controlling insect pest of mungbean which was followed by Dursban 20 EC @ 2.0 ml/L of water and Neem seed kernel extract @ 20 gm/L of water.

Recommendations

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study needs to be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
2. Using chemical with different concentration may be used for further study.
3. Integrated pest management practices may be introduced for effective control of mungbean pest.

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APPENDICES

Appendix I. Physical characteristics of field soil analyzed in Soil Resources Development Institute (SRDI) laboratory, Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Laboratory field, SAU, Dhaka
AEZ	Madhupur 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

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 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 Resources Development Institute (SRDI)

Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine of the experimental site during the period from March to June 2012

Month (2012	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
March	31.4	19.6	54	11	8.2
April	34.2	23.4	61	112	8.1
May	34.7	25.9	70	185	7.8
June	35.4	28.6	75	242	7.5

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on stemfly infested plant, stem tunneling and number of stemfly larvae/pupae per plant of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Stemfly infested plant (%)	Stem tunneling (%)	Number of stemfly larvae/pupae per plant
Replication	2	0.571	0.076	0.004
Treatment	6	123.857**	74.743**	1.205**
Error	12	0.905	2.817	0.006

**: Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on number of jassid, number of white fly, number of hairy caterpillar and number of thrips per 10 flowers of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square			
		Number of jassid per 10 leaves	Number of whitefly per 10 leaves	Number of hairy caterpillar per plant	Number of thrips per 10 flowers
Replication	2	0.002	0.001	0.023	0.001
Treatment	6	23.347**	5.228**	3.349**	5.562**
Error	12	0.072	0.047	0.029	0.071

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on healthy and infested pods and percent infestation at early pod stage of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Early pod stage		
		Healthy pods	Infested pods	% Infestation
Replication	2	3.784	0.006	0.014
Treatment	6	105.214**	8.205**	20.656**
Error	12	17.496	0.009	0.417

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on healthy and infested pods and percent infestation at mid pod stage of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Mid pod stage		
		Healthy pods	Infested pods	% Infestation
Replication	2	2.215	0.634	1.520
Treatment	6	106.002*	15.811**	31.470**
Error	12	27.794	0.291	0.914

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on healthy and infested pods and percent infestation at late pod stage of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Late pod stage		
		Healthy pods	Infested pods	% Infestation
Replication	2	4.500	0.080	0.011
Treatment	6	173.182**	19.602**	44.057**
Error	12	25.980	0.720	0.685

**: Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data on plant height, number of pods/plant and yield per hectare of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Late pod stage		
		Plant height	Number of pods/plant	Yield (t/ha)
Replication	2	4.005	5.522	0.004
Treatment	6	24.541*	102.641*	0.069**
Error	12	6.776	29.301	0.012

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability