ABUNDANCE OF WHITE FLY AND POD BORER ON DIFFERENT VARIETIES OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled **'Abundance of Whitefly and Pod borer on Different Varieties of Mungbean'** 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. Nahian Badsha Nahid**, Registration number: **09-03297** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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DEDICATED

TO

MY BELOVED PARENTS

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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 during the period from October 2014 to February 2015 to study the abundance of white fly and pod borer on different varieties of mungbean. The study comprised with six varieties as treatment and the name of the mungbean varieties are, V_1: BARI Mung-1, V_2: BARI Mung-2, V_3: BARI Mung-3, V_4: BARI Mung-4, V_5: BARI Mung-5 and V_6: BARI Mung-6. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The lowest number of whitefly/10 leaves (2.33) was observed from V_6 and the highest number (7.47) from V_1. The lowest number of pod borer/10 plants (1.27) was found from V_6, while the highest number (3.67) from V_1. At early growing stage, the lowest leaf infestation/plant (3.25%) was recorded from V_6, while the highest (7.48%) from V_1. At mid growing stage, the lowest leaf infestation/plant (3.87%) was recorded from V_6, whereas the highest (9.49%) from V_1. At late growing stage, the lowest leaf infestation/plant (4.01%) was recorded from V_6, whereas the highest (10.21%) from V_1. At early pod development stage, the lowest pod infestation/plant (3.91%) was recorded from V_6, while the highest (8.34%) from V_1. At mid pod development stage, the lowest pod infestation/plant (5.70%) was recorded from V_6, while the highest (9.86%) from V_1. At late pod development stage, the lowest pod infestation/plant (6.16%) was recorded from V_6, while the highest (10.67%) from V_1. The highest yield (1.48 t/ha) was observed from V_6, while the lowest (1.22 t/ha) from V_1. It was revealed that BARI Mung-6 was superior mungbean variety followed by BARI Mung-5 among the studied variety in terms of minimum insect pests infestation and yield contributing characters and yield.

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CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L.) belonging to family Leguminosae and sub-family Papilionaceae, is composed of more than 150 species originating mainly from Africa and Asia where the Asian tropical regions have the greatest magnitude of genetic diversity (USDA-ARS GRIN, 2012). It is an important pulse crop of Bangladesh and ranks the third in protein content and fourth position considering both acreage and production (MoA, 2014). Mungbean is a cheap source of easily digestible dietary protein which complements the staple rice in the country. It's seed contains 24.7% protein, 0.6% fat, 0.9 fiber and 3.7% ash (Potter and Hotchkiss, 1997). Mungbean plays a significant role in sustaining crop productivity by adding nitrogen through rhizobial symbiosis and crop residues (Sharma and Behera, 2009). The total production of mungbean in Bangladesh in 2013-14 was 1.81 lac metric tons from an area of 1.73 lac hectares with an average yield 1.04 t ha^{-1} (MoA, 2014).

According to FAO (2013) recommendation, a minimum intake of pulse by a human should be 80 gm/day, whereas it is 7.92 g in Bangladesh (BBS, 2014). 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, 2014). Mungbean is cultivated with minimum tillage, local varieties with no or minimum fertilizers, pesticides and very early or very late sowing, no practicing of irrigation and drainage facilities etc. with other different stress condition. All these factors are responsible for low yield of mungbean which is incomparable with the yields of developed countries of the world (FAO, 1999). The low yield of mungbean besides other factors may partially be due to lack of knowledge regards to suitable production technology of this crop (Hussain *et al*., 2008). 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 insect 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). Based on the growing season, management practices and crop variety the abundance and infestation level of insect pests of mungbean existed differently. Due to variation in the agro climate and environmental conditions and of different regions insects show vary in trends in their incidence also in nature and extent of damage to the crop (Bourland *et al*., 2003).

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). 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. On the other hand, non-chemical control plays an important role in evolving an ecologically sound and environmentally acceptable method. In that context and for many other factors such as drought, salinity and high moisture content, biological control through use of resistant varieties is recommended (Truong *et al*., 2013).

Varieties can be developed or simply searched for within the existing environmental diversity. In both cases, a good knowledge of the existing varietal diversity and of the agronomic performances is necessary (Ajjapplavara, 2009; Nasbiyera *et al*., 2013). Moreover, better orientation of improvement programs also calls for mastering production constraints and farmers' varietal preference criteria (Zhang *et al*., 2012). In Bangladesh, very few research works have been done mainly on approaches for the assessment of insect pest abundance on different varieties of mungbean, their incidence level and so that the yield contributing characters and yield of mungbean. Under the above perspective the present study has been undertaken with fulfilling the following objectives.

1. To document the seasonal abundance and damage severity of different insect pests on mungbean.

2. To evaluate the available mungbean variety for resistance against different insect pests during the study period..

3. To determine the yield contributing characters and yield of mungbean due to different variety.

CHAPTER II
REVIEW OF LITERATURE

2.1 Abundance of insect pests 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 its 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 obliquae*	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*	Hemiptera
Galerucid beetle	*Madurisia obscurella*	Coleptera
Green semi-lopper	*Plusia signata*	Lepidoptera
Bean lycaenidae	*Euchrysops cnejus*	Lepidoptera

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

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.

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 Varietal performance of mungbean in terms of insect pests

The resistance of mungbean varieties (NM-92, NM-98, NM-121-125, M-1, and NCM-209) was investigated by Khattak *et al.* (2004) against some sucking insect pests of mungbean at the Gram Research Station Kalurkot, Bhakkar. Mungbean varieties, NM-92 and NM-98 showed significantly low mean whitefly population/leaf as compared to the other three tested varieties. Similar trend was also found among the varieties against jassids and thrips; however, the mean population/leaf of jassids and thrips in NM-98 and NM-121-125 were statistically similar. Yield production of NM-92 and NM-98 was significantly higher than the other tested varieties due to low infestation by sucking insect pests.

In order to investigate the effect of sowing time on yield and yield components of different mungbean varieties, a field experiment was conducted by Ali *et al*. (2014) at agronomic research area, University of Agriculture, Faisalabad, Pakistan. The experiment was designed according to randomized complete block design under split plot arrangement in triplicate. Different sowing times (15th June, 25th June, 5th July and 15th July) were assigned to main plots and varieties (NM-2011, NM-2006, AZRI-2006 and NM-98) were allocated to subplots. Results of combined analysis showed that seed yield was significantly affected by sowing dates. Different mungbean varieties also responded significantly towards yield and yield components and NM-2011 variety outperformed in terms of maximum seed yield (1282.87 kg ha^{-1}) than rest of varieties. Overall; sowing of NM-2011 variety on 15th June remained superior combination in terms of all studied attributes.

Field experiments were carried out by Duraimurugan and Tyagi (2014) to explore the change in pest spectra, their status, succession and yield loss in mungbean and urdbean under changing climatic scenario. The pest spectra comprised of 35 species on mungbean and 25 species on urdbean during *kharif* season and 17 species were recorded during summer season in both the crops. Broad mite (*Polyphagotarsonemus latus*), blister beetle (*Mylabris pustulata*) and spotted pod borer (*Maruca vitrata*) has assumed the status of major pests during *kharif* season as compared to earlier report at Kanpur location. Bean flower thrips (*Megalurothrips usitatus*), a major pest during spring/summer seasons has now become major pest in *kharif* season also. The avoidable losses due to pest complex on different varieties of mungbean ranged from 27.03 to 38.06% with an average of 32.97%. The avoidable losses due to pest complex on different varieties of urdbean ranged from 15.62 to 30.96% with an average of 24.03%. Seed treatment with imidacloprid 17.8 SL caused 40.2 to 81.4% reduction in sucking pests. Foliar application of monocrotophos 36 SL @ 0.04% at 35, 45 and 55 days after sowing resulted in mean per cent reduction of 35.6 to 90.3% in insect and mite pests.

It was revealed that there were no significant literatures on abundance of insect pests in mungbean varieties.

2.3 Effects of varieties on plant characters of mungbean

Four mungbean accessions from the Asian Vegetable Research and Development Centre (AVRDC) were grown by Agugo *et al.* (2010). Results showed a significant difference in the yield of the varieties with VC 6372 (45-8-1) producing the highest seed yield of 0.53 t/ha. This was followed by NM 92, 0.48 t/ha; NM 94, 0.40 t/ha; and VC 1163 with 0.37 t/ha. The variety, VC 6372 (45-8-1), also formed good agronomic characters.

Field studies were conducted by Kumar *et al.* (2009) in Haryana, India to determine the growth behaviour of mungbean genotypes sown on different dates under irrigated conditions. The treatments consisted of 2 genotypes (SML 668 and MH 318) and 6 sowing dates starting from 1 March to 19 April, at of 10-day intervals. Results showed that SML 668 had higher plant height than MH 318 and the less height of both the genotypes during summer was due to low average temperature during the initial growth stage. SML 668 accumulated more dry matter than MH 318. The contribution of leaves and stem was more in SML 668, whereas the contribution of pods towards total aboveground biomass at harvest was higher in MH 318.

Quaderi *et al.* (2006) carried out an experiment in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from October 2000 to February 2001 to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) at a concentration of 50 ppm, 100 ppm and 200 ppm on the growth, yield and yield contributing characters of two modern mungbean (*Vigna radiata* L.) varieties viz. BARI moog 4 and BARI moog 5. The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with 3 replications. Among the mungbean varieties, BARI moog 5 performed better than that of BARI moog 4.

To study the nature of association between *Rhizobium phaseoli* and mungbean an experiment was conducted by Muhammad *et al*. (2006). Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains × mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM-209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from March 2002 to June 2002 to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA_3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). Among the mungbean varieties, BINA moog 5 performed better than that of BINA moog 2 and BINA moog 4.

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP/ha in a field experiment conducted in Delhi, India during the kharif season by Tickoo *et al*. (2006).

Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t/ha, respectively) compared to cv. Pusa 105.

To evaluate the effects of crop densities (10, 13, 20 and 40 plants/m^2) on yield and yield components of two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A), a field experiment was conducted by Aghaalikhani *et al*. (2006) at the Seed and Plant Improvement Institute of Karaj, Iran, in the summer of 1998. The results indicated that VC-1973A had the highest grain yield. This line was superior to the other cultivars due to its early and uniform seed maturity and easy mechanized harvest.

Rahman *et al*. (2005) conducted an experiment with mungbean in Jamalpur, Bangladesh, from February to June 1999, involving 2 planting methods, i.e. line sowing and broadcasting; 5 mungbean cultivars, namely Local, BARI moog 2, BARI moog 3, BINA moog 2 and BINA moog 5; and 5 sowing dates. Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of BINA moog 2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

Studies were conducted by Bhati *et al*. (2005) from 2000 to 2003 to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean showed that K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher grain yield and 13.7% higher fodder yield than the local cultivar. The experiment with mothbean showed that RMO-40 gave 34.8-35.2% higher grain yield and 30.2-33.4% higher fodder yield over the local cultivar as well as 11.8% higher grain yield and 9.2% higher fodder yield over RMO-257. The experiment with clusterbean showed that improved cultivars of RGC-936 gave 136.0 and 73.5% higher grain yield and

124.0 and 67.3% higher fodder yield over the local cultivar and Maru Guar, respectively.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen and phosphorus on the productivity of mungbean. K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods plant^{-1}, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit:cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) under Kasetsart mungbean breeding project in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbean cultivars was also conducted in the farmer's field.

Two summer mungbean cultivars, i.e. BINA mung 2 and BINA mung 5, were grown during the kharif-1 season (February-May) of 2001, in Mymensingh, Bangladesh, under no irrigation or with irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by Shamsuzzaman *et al*. (2004). Data were recorded for days to first flowering, days to first leaf senescence, days to pod maturity, flower + pod abscission, root, stem+leaf, pod husk and seed dry matter content, pods plant^{-1}, seeds pod^{-1}, 100-seed weight, seed yield, biological yield and harvest index. The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence, which were significantly delayed under different irrigated frequencies. BINA moog 2 performed slightly better than BINA moog 5 for most of the growth and yield parameters studied.

An experiment was conducted by Abid *et al*. (2004) in Peshawar, Pakistan, during the 2002 summer season to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-1. Data were recorded for days to emergence, emergence/m^2, days to 50% flowering, days to physiological maturity, plant height at maturity and grain yield. Sowing on 15 April took more number of days to emergence but showed maximum plant height. The highest emergence/m^2 and higher mean grain yield was recorded in NM-92 than M-1.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season of 2003 in Uttaranchal, India, to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

To find out the effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mung bean (*Vigna radiata*) cultivars were investigated by Hossain and Solaiman (2004). The mungbean cultivars were BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, BINA mung-2 and BU mung-1. Among the cultivars, BARI mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha. *Rhizobium* strain TAL169 did better than TAL441 in most of the studied parameters. It was concluded that BARI mung 4 in combination with TAL169 performed the best in terms of nodulation, plant growth, seed and stover yields, and seed protein content.

The performance of 20 mungbean cultivars were evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela. Data on plant height, clusters per plant, pods per plant, pod length, seeds per pod, grain yield by plant and yield/ha were recorded. Significant differences in the values of the parameters measured due to cultivar were recorded. The average yield was 1342.58 kg/ha. VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

The effect of sowing rates on the growth and yield of mungbean cultivars NM-92, NARC mung-1 and NM-98 was investigated in Faisalabad, Pakistan during 2002-03 by Riaz *et al*. (2004). NM-98 produced the maximum pod number of 77.30, grain yield of 983.75 kg/ha and harvest index value of 24.91%. NM-92 also produced the highest seed protein content of 24.64%.

Brar *et al*. (2004) introduced SML 668 high yielding variety of summer mungbean selection from AVRDC line NM 94, is a cultivar recommended for general cultivation in irrigated areas of Punjab, India in 2002. This early maturing cultivar flowers in 34 days and matures in 60 days. It has an average plant height of 44.6 cm and bears an average of 16 pods per plant and 10.4 seeds per pod. Seeds are bold with 100-seed weight of 5.7 g and devoid of hard seeds. Protein content is 22.7% and water absorption capacity is high (91%).

Seed treatment with biofertilizers in controlling foot and root rot of mungbean cultivars BINA moog-3 and BINA mung-4 was investigated by Mohammad and Hossain (2003) under field conditions in Pakistan. Treatment of seeds of BINA moog-3 with biofertilizer showed a 5.67% increase in germination over the control, but in case of BINA moog-4 10.81% increase in germination over the control was achieved by treating seeds with biofertilizer. The biofertilizers caused 77.79% reduction of foot and root rot disease incidence over the control along with BINA moog-3 and 76.78% reduction of foot and rot disease in BINA moog-4. Seed treatment with biofertilizer also produced up to 20.83% higher seed yield in BINA moog-3 and 12.79% higher seed yield BINA moog-4 over the control.

Three mungbean cultivars (LGG 407, LGG 450 and LGG 460) and two urd bean [black gram] cultivars (LBG 20 and LBG 623) were sown on 15 June 2001 in Lam, Guntur, Andhra Pradesh, India, by Durga *et al*. (2003) and subjected to severe moisture stress during the first 38 days after sowing (DAS) and only a rainfall of 21.4 mm was received during this period. Mungbean registered higher root length (11.83%), root volume (37.50), root weight (31.43%), lateral roots (81.71%), shoot length (13.04%), shoot weight (84.62%), leaf number (25.75%), leaf weight (122.86%) and leaf area (108.60%) than the urd bean. Mungbean recorded better leaf characters than urd bean, but root and shoot characters were better in the latter. Among the mungbean cultivars, LGG 407 recorded the highest yield. Between the urd bean cultivars, LBG 20 had a higher yield than LBG 623. Among the mung bean cultivars, LGG 407 was the most tolerant, while in urd bean, LBG 20 was more efficient in avoiding early drought stress than LBG 623.

Taj *et al*. (2003) carried out an experiment to find out the effects of sowing rates (10, 20, 30 and 40 kg seed/ha) on the performance of 5 mungbean cultivars (NM-92, NM 19-19, NM 121-125, N/41 and a local cultivar) were studied in Ahmadwala, Pakistan, during the summer season of 1998. Among the cultivars, NM 121-125 recorded the highest average pods per plant (18.18), grains per pod (9.79), 1000-grain weight (28.09 g) and grain yield (1446.07 kg ha^{-1}).

Satish *et al*. (2003) conducted an experiment in Haryana, India in 1999 and 2000 to investigate the response of mung bean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels. Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P ha^{-1}. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851.

The development phases and seed yield were evaluated by Infante *et al*. (2003) in mungbean cultivars ML 267, Acriollado and VC 1973C under the agroecological conditions of Maracay, Venezuela, during May-July 1997. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, pods per plant, seeds per pods and pod length were also studied. The earliest cultivar was ML 267 with 34.87 days to flowering and 61.83 to maturity. There were significant differences for total pod clusters per plant and pods per plant, where ML 267 and Acriollado had the highest values. The total seeds per pod of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg/ha.

Seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with *Rhizobium* strains M-11-85, M-6-84, GR-4 and M-6-65 before sowing in a field experiment conducted by Navgire *et al*. (2001) in Maharashtra, India during the kharif season of 1993-94 and 1995-96. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q/ha) and grain yield (4.79 q/ha) during the experimental years. S-8, BM-4 and BM-86 recorded the highest nodulation, plant biomass and grain yield.

Hamed (1998) carried out two field experiments in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering (15, 22 and 30 days) and 4 fertilizer treatments: inoculation with *Rhizobium* (R) + Azotobacter (A) + 5 (N_1) or 10 kg N/feddan (N_2), and inoculation with R only +5 (N_3) or 10 kg N/feddan (N_4). Kawny 1 surpassed Giza 1 in pod number per plant (24.3) and seed yield (0.970 t/feddan), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t/feddan, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg/feddan), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg/feddan).

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted to study the abundance of white fly and pod borer on different varieties of mungbean during the period from October 2014 to February 2015. 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

Different variety of BARI Mung were used as the test crop of this experiment. The seeds of BARI Mung 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 October 18, 2014. 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 study comprised with six varieties as treatment. The name of the mungbean varieties presented below:

- V_1: BARI Mung-1
- V_2: BARI Mung-2
- V_3: BARI Mung-3
- V_4: BARI Mung-4
- V_5: BARI Mung-5
- V_6: BARI Mung-6

3.9 Experimental layout and design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. An area of 22.50 m × 10.00 m was divided into three equal blocks. Each block was divided into 6 plots, where 6 treatment combinations were allocated at random. There were 18 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 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.

3.11 Crop sampling and data collection

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

3.12 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 -

- Number of whitefly per 10 leaves
- Number of pod borer per 10 plants
- Number of healthy leaves at early, mid and late stage
- Number of infested leaves at early, mid and late stage
- Leaf infestation at early, mid and late stage (%)
- 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
- Number of seeds/pod
- Weight of 1000 seeds (g)
- Pod yield per hectare (ton)

3.13 Determination of leaf infestation by number

All the healthy and infested leaves were counted from 10 randomly selected leaves from middle rows of each plot and examined. The collected data were divided into early, mid and late growing stage. The healthy and infested leaves were counted at early, mid and late stage and the percent leaf infestation was calculated using the following formula:

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

3.14 Determination of pod infestation by number

All the healthy and infested pods were counted from 10 randomly selected plants from middle rows of each plot and examined. The collected data were divided into early, mid and late pod development stage. The healthy and infested pods were counted at early, mid and late stage and the percent pod damage was calculated using the following formula:

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

3.15 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.

3.16 Procedure of data collection

3.16.1 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.

3.16.2 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.

3.16.3 Number of seeds/pod

The number of seeds per pod was recorded randomly from selected pods at the time of harvest. Data were recorded as the average of 10 pods from each plot.

3.16.4 Weight of 1000 seeds

One thousand cleaned, dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and expressed in gram.

3.16.5 Yield per hectare

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

3.17 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 abundance of white fly and pod borer on different varieties of mungbean. Data were recorded on number of whitefly and pod borer during the study period, leaf infestation and pod infestation status in number at early, mid and late growth and pod development stage and also yield contributing characters and yield of different varieties of mungbean. The analysis of variance (ANOVA) of the data on different parameters has been presented in Appendix III-X. The results have been presented with the help of different Tables, Graphs and possible interpretations are given under the following headings and sub-headings:

4.1 Incidence of whitefly and pod borer

4.1.1 Whitefly

Number of whitefly showed statistically significant differences due to different varieties of mungbean during the study period (Appendix III). The lowest number of whitefly/10 leaves (2.33) was observed from V_6 (BARI Mung-6) which was followed (3.60 and 4.13, respectively) by V_5 (BARI Mung-5) and V_2 (BARI Mung-2) and they were statistically similar (Table 1). On the other hand, the highest number of whitefly/10 leaves (7.47) was recorded from V_1 (BARI Mung-1) which was closely followed (6.20 and 5.60) by V_4 (BARI Mung-4) and V_3 (BARI Mung-3) and they were also statistically similar.

4.1.2 Pod borer

Significant variation was recorded in terms of pod borer for different varieties of mungbean during the study period (Appendix III). The lowest number of pod borer/10 plants (1.27) was found from V_6 which was followed (2.73 and 3.07, respectively) by V_5 and V_2 and they were statistically similar, while the highest number of pod borer/10 plants (3.67) was recorded from V_1 which was statistically similar (3.47 and 3.27, respectively) to V_4 and V_3 (Table 1).

Table 1. Incidence of white fly and pod borer during the study period on different varieties of mungbean

Mungbean Variety	Number of whitefly/10 leaves	Pod borer/10 plant
V_1: BARI Mung-1	7.47 a	3.67 a
V_2: BARI Mung-2	4.13 c	3.07 bc
V_3: BARI Mung-3	5.60 b	3.27 ab
V_4: BARI Mung-4	6.20 b	3.47 ab
V_5: BARI Mung-5	3.60 c	2.73 c
V_6: BARI Mung-6	2.33 d	1.27 d
$LSD_{(0.05)}$	0.651	0.474
CV(%)	7.31	8.93

In a column, numeric data represents the mean value of 3 replications

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

4.2 Leaf infestation status

4.2.1 At early growing stage

Number of healthy, infested leaves and percentage of leaf infestation showed statistically significant differences at early growing stage due to different varieties of mungbean (Appendix IV). At early growing stage, the highest number of healthy leaves/plant (25.80) was recorded from V_6 which was statistically similar (25.47, 25.07, 24.60 and 24.40, respectively) to V_5, V_4, V_3 and V_2, respectively, whereas the lowest number of healthy leaves (22.27) was recorded from V_1 (Table 2). The lowest number of infested leaves/plant (0.87) was recorded from V_5 and V_6 which was closely followed (1.20, 1.27 and 1.47, respectively) by V_3, V_4 and V_2, respectively, while the highest number of infested leaves (1.80) was observed from V_1. The lowest leaf infestation/plant (3.25%) was recorded from V_6 which was statistically similar (3.31%) to V_5 and closely followed (4.64%, 4.83% and 5.68%, respectively) by V_3, V_4 and V_2, respectively, while the highest leaf infestation/plant (7.48%) was found from V_1.

4.2.2 At mid growing stage

Different varieties of mungbean varied significantly in terms of number of healthy, infested leaves and percentage of leaf infestation at mid growing stage (Appendix V). At mid growing stage, the highest number of healthy leaves/plant (26.47) was recorded from V_6 which was statistically similar (25.87, 25.60 and 25.07, respectively) to V_5, V_4 and V_3, respectively, whereas the lowest number of healthy leaves (23.47) was recorded from V_1 which was statistically similar (24.67) to V_2 (Table 3). The lowest number of infested leaves/plant (1.07) was recorded from V_6 which was statistically similar (1.20) to V_5 and closely followed (1.67 and 1.87, respectively) by V_3 and V_4, respectively, while the highest number (2.47) was observed from V_1 which was closely followed (2.00) by V_2. The lowest leaf infestation/plant (3.87%) was recorded from V_6 which was statistically similar (4.43%) to V_5 and followed (6.23% and 6.82%, respectively) by V_3 and V_4, respectively, whereas the highest leaf infestation/plant (9.49%) was found from V_1 which was followed (7.50%) by V_2.

Table 2. Incidence of white fly and its damage severity on leaves at early growing stage of different varieties of mungbean

Mungbean Variety	Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
V_1: BARI Mung-1	22.27 b	1.80 a	7.48 a
V_2: BARI Mung-2	24.40 a	1.47 b	5.68 b
V_3: BARI Mung-3	24.60 a	1.20 b	4.64 b
V_4: BARI Mung-4	25.07 a	1.27 b	4.83 b
V_5: BARI Mung-5	25.47 a	0.87 c	3.31 c
V_6: BARI Mung-6	25.80 a	0.87 c	3.25 c
$LSD_{(0.05)}$	2.041	0.293	1.180

CV(%)	4.56	13.01	13.34

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

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

Table 3. Incidence of white fly and its damage severity on leaves at mid growing stage of different varieties of mungbean

Mungbean Variety	Healthy leaves/ Plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
V_1: BARI Mung-1	23.47 c	2.47 a	9.49 a
V_2: BARI Mung-2	24.67 bc	2.00 b	7.50 b
V_3: BARI Mung-3	25.07 ab	1.67 c	6.23 c
V_4: BARI Mung-4	25.60 ab	1.87 bc	6.82 bc
V_5: BARI Mung-5	25.87 ab	1.20 d	4.43 d
V_6: BARI Mung-6	26.47 a	1.07 d	3.87 d
$LSD_{(0.05)}$	1.410	0.310	1.081
CV(%)	3.08	9.93	9.30

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

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

4.2.3 At late growing stage

Statistically significant variation was recorded due to different varieties of mungbean in terms of number of healthy, infested leaves and percentage of leaf infestation at late growing stage (Appendix VI). At late growing stage, the highest number of healthy leaves/plant (27.13) was recorded from V_6 which was statistically similar (26.40, 26.13 and 25.60, respectively) to V_5, V_4 and V_3, respectively, while the lowest number of healthy leaves (24.07) was recorded from V_1 which was statistically similar (25.33) to V_2 (Table 4). The lowest number of infested leaves/plant (1.13) was recorded from V_6 which was statistically similar (1.33) to V_5 and closely followed (2.27) by V_3, whereas the highest number (2.73) was observed from V_1 which was statistically similar (2.67 and 2.60, respectively) to V_2 and V_4, respectively. The lowest leaf infestation/plant (4.01%) was recorded from V_6 which was statistically similar (4.81%) to V_5 and followed (8.14%) by V_3, whereas the highest leaf infestation/plant (10.21%) was found from V_1 which was statistically similar (9.52%) to V_2 and closely followed (9.04%) by V_4.

From the findings it is revealed that mungbean variety BARI Mung-6 produced the highest number of leaves and have the lowest leaf infestation whereas BARI Mung-1 have the highest leaf infestation by the insect pests of mungbean. Due to infestation 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).

Table 4. Incidence of white fly and its damage severity on leaves at late growing stage of different varieties of mungbean

Mungbean Variety	Healthy leaves/ Plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
V_1: BARI Mung-1	24.07 c	2.73 a	10.21 a
V_2: BARI Mung-2	25.33 bc	2.67 a	9.52 ab
V_3: BARI Mung-3	25.60 abc	2.27 b	8.14 c
V_4: BARI Mung-4	26.13 ab	2.60 a	9.04 b
V_5: BARI Mung-5	26.40 ab	1.33 c	4.81 d
V_6: BARI Mung-6	27.13 a	1.13 c	4.01 d
$LSD_{(0.05)}$	1.645	0.244	0.808
CV(%)	3.51	6.36	5.82

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

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

4.3 Pod infestation status

4.3.1 At early pod development stage

Different varieties of mungbean varied significantly in terms of number of healthy, infested pods and percentage of pod infestation at early pod development stage (Appendix VII). At early pod development stage, the highest number of healthy pods/plant (21.33) was recorded from V_6 which was statistically similar (20.47) to V_5, whereas the lowest number (18.33) was found from V_1 which was statistically similar (18.73, 19.47 and 19.53, respectively) to V_4, V_3 and V_2 (Table 5). The lowest number of infested pods/plant (0.87) was recorded from V_6 which was statistically similar (0.93) to V_5 and closely followed (1.27 and 1.33) by V_3 and V_2, respectively, while the highest number (1.67) was observed from V_1 which was statistically similar (1.47) to V_4. The lowest pod infestation/plant (3.91%) was recorded from V_6 which was statistically similar (4.36%) to V_5, while the highest pod infestation/plant (8.34%) was found from V_1 which was statistically similar (7.30%) to V_4 and closely followed (6.39% and 6.13%, respectively) by V_2 and V_3, respectively.

4.3.2 At mid pod development stage

Number of healthy, infested pods and percentage of pod infestation showed statistically significant differences at mid pod development stage due to different varieties of mungbean (Appendix VIII). At mid pod development stage, the highest number of healthy pods/plant (24.27) was recorded from V_6 which was statistically similar (23.73, 23.40, 22.73 and 22.20, respectively) to V_5, V_3, V_2 and V_4, respectively, while the lowest number (20.73) from V_1 (Table 6). The lowest number of infested pods/plant (1.47) was recorded from V_6 which was statistically similar (1.60) to V_5 and closely followed (1.80) by V_3, whereas the highest number (2.27) was observed from V_1 which was followed (2.00 and 1.87, respectively) by V_4 and V_2, respectively. The lowest pod infestation/plant (5.70%) was recorded from V_6 which was statistically similar (6.33%) to V_5, while the highest pod infestation/plant (9.86%) from V_1 which was and closely followed (8.27% and 7.61, respectively) by V_4 and V_2, respectively.

Table 5. Incidence of pod borer and its damage severity on pods at early pod development stage of different varieties of mungbean

Mungbean Variety	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
V_1: BARI Mung-1	18.33 c	1.67 a	8.34 a
V_2: BARI Mung-2	19.53 bc	1.33 b	6.39 b
V_3: BARI Mung-3	19.47 bc	1.27 b	6.13 b
V_4: BARI Mung-4	18.73 c	1.47 ab	7.30 ab
V_5: BARI Mung-5	20.47 ab	0.93 c	4.36 c
V_6: BARI Mung-6	21.33 a	0.87 c	3.91 c
$LSD_{(0.05)}$	1.580	0.215	1.313
CV(%)	4.42	9.50	11.89

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

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

Table 6. Incidence of pod borer and its damage severity on pods at mid pod development stage of different varieties of mungbean

Mungbean Variety	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
V_1: BARI Mung-1	20.73 b	2.27 a	9.86 a
V_2: BARI Mung-2	22.73 ab	1.87 b	7.61 b
V_3: BARI Mung-3	23.40 a	1.80 bc	7.16 bc
V_4: BARI Mung-4	22.20 ab	2.00 b	8.27 b
V_5: BARI Mung-5	23.73 a	1.60 cd	6.33 cd
V_6: BARI Mung-6	24.27 a	1.47 d	5.70 d
$LSD_{(0.05)}$	1.937	0.223	1.133
CV(%)	4.66	6.61	8.32

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

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

4.3.3 At late pod development stage

Number of healthy, infested pods and percentage of pod infestation showed statistically significant differences at late pod development stage due to different varieties of mungbean (Appendix IX). At late pod development stage, the highest number of healthy pods/plant (26.40) was recorded from V_6 which was statistically similar (26.47, 25.73 and 25.40, respectively) to V_5, V_3 and V_2, respectively, while the lowest number of healthy pods (24.00) was recorded from V_1 which was statistically similar (24.53) to V_4 (Table 7). The lowest number of infested pods/plant (1.73) was recorded from V_6 which was statistically similar (1.93) to V_5 and closely followed (2.40) by V_3, whereas the highest number of infested pods/plant (10.67) was observed from V_1 which was closely followed (9.58 and 9.29, respectively) to V_4 and V_2. The lowest pod infestation/plant (6.16%) was recorded from V_6 which was statistically similar (6.81%) to V_5 and closely followed (8.52%) by V_3, while the highest pod infestation/plant (10.67%) was found from V_1 which was closely followed (9.58% and 9.29%, respectively) by V_4 and V_2, respectively.

From the findings it is revealed that mungbean variety BARI Mung-6 produced the highest number of healthy pods/plant and have the lowest pods infestation whereas BARI Mung-1 have the highest pod infestation in number by the insect pests of mungbean. Duraimurugan and Tyagi (2014) reported that avoidable losses due to pest complex on different varieties of mungbean ranged from 27.03 to 38.06% with an average of 32.97%. The avoidable losses due to pest complex on different varieties of urdbean ranged from 15.62 to 30.96% with an average of 24.03%.

Table 7. Influence of different varieties on the damage severity on pods due to pod borer attack on mungbean at late pod development stage

Mungbean Variety	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
V_1: BARI Mung-1	24.00 c	2.87 a	10.67 a
V_2: BARI Mung-2	25.40 abc	2.60 ab	9.29 bc
V_3: BARI Mung-3	25.73 ab	2.40 b	8.52 c
V_4: BARI Mung-4	24.53 bc	2.60 ab	9.58 b
V_5: BARI Mung-5	26.47 a	1.93 c	6.81 d
V_6: BARI Mung-6	26.40 a	1.73 c	6.16 d
$LSD_{(0.05)}$	1.518	0.325	0.904
CV(%)	3.28	7.54	5.84

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

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

4.4 Yield contributing characters and yield of mungbean

4.4.1 Plant height

Plant height showed statistically significant differences due to different varieties of mungbean (Appendix X). The longest plant (64.74 cm) was recorded from V_6 which was statistically similar (63.17 cm and 61.83 cm, respectively) to V_5 and V_2, respectively, while the shorted plant (58.26 cm) was found from V_1 which was statistically similar (58.87 cm and 60.09 cm, respectively) to V_4 and V_3, respectively (Table 8).

4.4.2 Number of pods/plant

Statistically significant variation was recorded in terms of number of pods/plant due to different varieties of mungbean (Appendix X). The maximum number of pods/plant (28.13) was observed from V_6 which was statistically similar (27.00 and 26.80, respectively) to V_5 and V_3, respectively, while the minimum number of pods/plant (24.87) was recorded from V_1 which was statistically similar (26.20 and 26.40, respectively) to V_4 and V_2, respectively (Table 8).

4.4.3 Number of seeds/pods

Different varieties of mungbean showed statistically significant differences in terms of number of seeds/pods (Appendix X). The maximum number of seeds/pod (11.93) was recorded from V_6 which was statistically similar (11.40, 11.20 and 10.80, respectively) to V_5, V_2 and V_3, respectively, whereas the minimum number of pods/plant (10.07) was found from V_1 which was statistically similar (10.40) to V_4 (Table 8).

Table 8. Influence of different varieties on yield contributing characters and yield of mungbean

Mungbean Variety	Plant height (cm)	Number of pods/plant	Number of seeds/pod	Weight of 1000 seeds (g)	Yield (t/ha)
V_1: BARI Mung-1	58.26 c	24.87 c	10.07 c	40.39	1.22 c
V_2: BARI Mung-2	61.83 abc	26.40 bc	11.20 abc	41.22	1.39 ab
V_3: BARI Mung-3	60.09 bc	26.80 ab	10.80 abc	41.05	1.36 abc
V_4: BARI Mung-4	58.87 bc	26.20 bc	10.40 bc	40.82	1.31 bc
V_5: BARI Mung-5	63.17 ab	27.00 ab	11.40 ab	41.84	1.42 ab
V_6: BARI Mung-6	64.74 a	28.13 a	11.93 a	42.47	1.48 a
$LSD_{(0.05)}$	4.062	1.607	1.111	NS	0.141
CV(%)	3.65	4.51	5.57	3.02	5.70

In a column, numeric data represents the mean value of 3 replications

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

4.4.4 Weight of 1000 seeds

Statistically non-significant variation was recorded in terms of weight of 1000 seeds plant due to different varieties of mungbean (Appendix X). The highest weight of 1000 seeds (42.47 g) was observed from V_6, whereas the lowest weight 1000 seeds (40.39 g) was found from V_1 (Table 8).

4.4.5 Yield per hectare

Yield per hectare showed statistically significant variation due to different varieties of mungbean (Appendix X). The highest yield (1.48 t/ha) was observed from V_6 which was statistically similar (1.42 t/ha, 1.39 t/ha and 1.36 t/ha, respectively) to V_5, V_2 and V_3, respectively, while the lowest yield (1.22 t/ha) was found from V_1 which was statistically similar (1.31 t/ha) to V_4 (Table 8).

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 during the period from October 2014 to February 2015 to study the abundance of insect pests on different varieties of mungbean. The study comprised with six varieties as treatment and the name of the mungbean varieties are, V_1: BARI Mung-1, V_2: BARI Mung-2, V_3: BARI Mung-3, V_4: BARI Mung-4, V_5: BARI Mung-5 and V_6: BARI Mung-6. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data was recorded on number of whitefly and pod borer during the study period, leaf infestation and pod infestation status in number at early, mid and late growth and pod development stage and also yield contributing characters and yield of different varieties of mungbean and statistically significant variation was recorded for different parameters.

The lowest number of whitefly/10 leaves (2.33) was observed from V_6 and the highest number of whitefly/10 leaves (7.47) was recorded from V_1. The lowest number of pod borer/10 plants (1.27) was found from V_6, while the highest number of pod borer/10 plants (3.67) was recorded from V_1.

At early growing stage, the highest number of healthy leaves/plant (25.80) was recorded from V_6, whereas the lowest number of healthy leaves (22.27) was recorded from V_1. The lowest number of infested leaves/plant (0.87) was recorded from V_5 and V_6, while the highest number of infested leaves (1.80) was observed from V_1. The lowest leaf infestation/plant (3.25%) was recorded from V_6, while the highest leaf infestation/plant (7.48%) was found from V_1. At mid growing stage, the highest number of healthy leaves/plant (26.47) was recorded from V_6, whereas the lowest number of healthy leaves (23.47) was recorded from V_1. The lowest number of infested leaves/plant (1.07) was recorded from

V_6, while the highest number (2.47) was observed from V_1. The lowest leaf infestation/plant (3.87%) was recorded from V_6, whereas the highest leaf infestation/plant (9.49%) was found from V_1. At late growing stage, the highest number of healthy leaves/plant (27.13) was recorded from V_6, while the lowest number of healthy leaves (24.07) was recorded from V_1. The lowest number of infested leaves/plant (1.13) was recorded from V_6, whereas the highest number (2.73) was observed from V_1. The lowest leaf infestation/plant (4.01%) was recorded from V_6, whereas the highest leaf infestation/plant (10.21%) was found from V_1.

At early pod development stage, the highest number of healthy pods/plant (21.33) was recorded from V_6, whereas the lowest number (18.33) was found from V_1. The lowest number of infested pods/plant (0.87) was recorded from V_6, while the highest number (1.67) was observed from V_1. The lowest pod infestation/plant (3.91%) was recorded from V_6, while the highest pod infestation/plant (8.34%) was found from V_1. At mid pod development stage, the highest number of healthy pods/plant (24.27) was recorded from V_6, while the lowest number (20.73) from V_1. The lowest number of infested pods/plant (1.47) was recorded from V_6, whereas the highest number (2.27) was observed from V_1. The lowest pod infestation/plant (5.70%) was recorded from V_6, while the highest pod infestation/plant (9.86%) from V_1. At late pod development stage, the highest number of healthy pods/plant (26.40) was recorded from V_6, while the lowest number of healthy pods (24.00) was recorded from V_1. The lowest number of infested pods/plant (1.73) was recorded from V_6, whereas the highest number of infested pods/plant (10.67) was observed from V_1. The lowest pod infestation/plant (6.16%) was recorded from V_6, while the highest pod infestation/plant (10.67%) was found from V_1.

The longest plant (64.74 cm) was recorded from V_6, while the shorted plant (58.26 cm) was found from V_1. The maximum number of pods/plant (28.13) was observed from V_6, while the minimum number of pods/plant (24.87) was recorded from V_1. The maximum number of seeds/pod (11.93) was recorded from V_6, whereas the minimum number of pods/plant (10.07) was found from V_1. The highest weight of 1000 seeds (42.47 g) was observed from V_6, whereas the lowest weight 1000 seeds (40.39 g) was found from V_1. The highest yield (1.48 t/ha) was observed from V_6, while the lowest yield (1.22 t/ha) was found from V_1.

Conclusion:

It was revealed that BARI Mung-6 was superior mungbean variety followed by BARI Mung-5 among the studied variety in terms of minimum insect pests infestation and yield contributing characters and yield.

Considering the above results of this experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.

2. Another experiment may be conducted with other variety of mungbean and different pest management practices.

REFERENCES

Abid, H., Khalil, S.K., Sartaj, K. and Haroon, K. (2004). Effect of sowing time and variety on grain yield of mungbean. *Sarhad J. Agric*., **20**(4): 481-484.

Aghaalikhani, M., Ghalavand, A. and Ala, A. (2006). Effect of plant density on yield and yield components of two cultivars and a line of mungbean [*Vigna radiata* (L.) Wilczek] in Karaj Region. *J. Sci, Tech. Agric. Natural Resour*., **9**(4): 111-121.

Agugo B.A.C., Oguike, P.C. and Kanu, B.O. (2010). A preliminary field assessment of mungbean (*Vigna radiata* L. Wilczek) yield in the rain forest zone of southeastern Nigeria. *American Eurasian J. Agril. Env. Sci*., **8**(6): 752-757.

Ajjapplavara, P.S. (2009). Genetic diversity in mungbean (*Vigna radiata* L.). *The Asian J. Hort*., **4**(1): 29-31.

Ali, S., Khaliq, T., Ahmad, A., Rehman, M., Hussain, S., Rehman, K. and Pervez, M.W. (2014). Genotypic variations in mungbean yield and its attributes in response to different sowing times. *Res. J. Agric. Env. Manag*., **3**(5): 255-258.

Anonymous. (1986). Annual report of the pulses improvement programme. 1985/86. Bangladesh Agricultural research Institute (BARI), Joydebpur, Gazipur, Bangladesh.

Anonymous. (1989). Annual Report of Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Anonymous. (1998). Effect of sowing date and insecticides against stemfly and pod borer of blackgram. Annual Report, 1997/1998. Bangladesh Agricultural Research Institute (BARI). Joydebpur, Gazipur, Bangladesh. pp. 104-105.

Apurv, P. and Tewari, S.K. (2004). Yield dynamics of mungbean (*Vigna radiata* L. Wilczek) varieties in poplar based agroforestry system. *Indian J. Agroforest*., **6**(2): 89-91.

Bakr, M.A. (1998). Diseases and insect pests management of mungbean and blackgram. Resource manual-Location-specific technologies for rice based cropping system under irrigated conditions. Thana cereal technology transfer and identification project, Dhaka. pp. 201-205.

Baldev, B. Ramanujam. S. and Jain. H.K. (1988). Pulse crops. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi. pp. 229-258.

BBS. (2014). Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Govt. of the Peoples Republic of Bangladesh, Dhaka. p. 156.

Bhati, T.K., Rathore, S.S. and Gaur, N.K. (2005). Effect of improved varieties and nutrient management in kharif legumes under arid ecosystem in Institution Village Linkage Programme. *J. Arid Leg.*, **2**(2): 227-229.

Bhatnagar, V.S. (1980). A report on research on the *Heliothis* complex at ICRISAT (India) 1974-79. Presented at the all India Workshop on Consolidation of Pest Management Recommendations and Guidelines of Research. April,Udaipur, India. pp. 24-26.

Bhatt, N.J. and Patel, R.K. (200l). Biology of pod borer, *Helicoverpa armigera. Indian J. Entom.*, **63**(3): 255-259.

Bourland, F.M., Hornback, J.M. and Calhun, S.D. (2003). A rating system for leaf pubescence of mungbean. *J. Cotton Sci*., **7**: 8-15.

Boztok, S. (1985). Investigation on the effect of sowing date and verbalisation on seed production in early cauliflower cv. Ege. *Universal Zirrat fakultesi Dergis*., **22**: 89-99.

Brar, J.S., Inderjit, S., Sarvjeet, S. and Bains, T.S. (2004). SML 668: a new early maturing and high yielding variety of summer mungbean. *J. Res. Punjab Agril. Univ*., **41**(1): 174.

Chaisri, P., Kaveeta, L., Chaisri, S. and Kaveeta, R. (2005). Mungbean yield trial for cropping system in Lopburi area. *Proceedings of 43rd Kasetsart University Annual Conference*, Thailand, 1-4 February, 2005: 214-222.

Chaudhary, J.P., Yadav, L.S. Poonia, R.S. and Rastogi, K.B. (1980). Some observation on field populations of *Empoasca kerri* Pruthi, a jasid pest on mungbean crop in Haryana. *Haryana Agric, Univ. J. Res*., **10**(2): 250-252.

Chhabra K. S. and Kooner, B. S. (1985). Problem of flower shedding caused by thrips, *Megalurothrips distalis* (Karny), on summer mungbean, *Vigna radiate* (L) Wilczek, and its control. *Trop. Pest Management*., **31**(3): 186-188.

Dhurve, S.B. and Borle, M.N. (1986). Effect of sowing dates on pod borer damage *Heliothis armigera* (Hubner). *PKV Res. J.*, **10**(1): 70-71.

Duraimurugan, P. and Tyagi, K. (2014). Pest spectra, succession and its yield losses in mungbean and urdbean under changing climatic scenario. *Legume Res.*, **37**(2): 212-222.

Durga, K.K., Rao, M.M., Reddy, M.V. and Rao, Y.K. (2003). Effect of early drought stress on morpho-physiological characters and yield of mungbean and urdbean cultivars. *Indian J. Pulses Res.*, **16**(2): 133-135.

Edris, K.M., Islam, A.T.M.T., Chowdhury, M.S. and Haque, A.K.M.M. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People’s Republic of Bangladesh. P. 118.

FAO (Food and Agriculture Organization). (1999). Production Yearbook. Basic Data Unit. Statistic Division, FAO. Rome, Italy.

FAO (Food and Agriculture Organization). (2013): http://faostat.fao.org.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wilely and Sons. New York p. 182.

Gowda, C.L.L. and Kaul, A.K. (1982). Pulses in Bangladesh. Bangladesh Agricultural Research Institute, Joydebpur, Dhaka and Food & Agricultural Organization of the United Nations. pp. 154-167.

Haider, M.Z. (1996). Effectiveness of some IPM packages for the management of viruse-disseminating whitefly on tomato. M. S. Thesis in Entomology. IPSA. Salna, Gazipur, Bangladesh. pp. 1-65.

Hamed, M.F. (1998). Response of two mungbean varieties under irrigation intervals and certain fertilization treatments. *Ann. Agril. Sci*., **36**(1): 31-42.

Hardwick, D.F. (1965). The corn earworm complex. Memoirs of the Ent. Soc. of Canada 40, Ottawa, Canada. p. 247.

Hirano, K. Budiyanto, E and Winarni, S. (1993). Biological characteristics and forecasting outbreaks of the whitefly *Bemisia tabaci,* a vector of virus diseases in soybean fields. Food and Fertilizer Technology Center. Technical Bulletin. No. 135.

Hossain, D. and Solaiman, A.R.M. (2004). Performances of mungbean varieties as affected by Rhizobium inoculants. *Bulletin of the Inst. Tropic. Agric.*, **27**: 35-43.

Husain, M. (1993). Anistakari Kit-patanga Daman (in Bengali). Bangla Academy. Dhaka, p. 220.

Hussain, M.M., Miah, M.N.A., Rahman, M.A., Islam, M.A. and Islam, M.T. (2008). Effect of salt stress on growth and yield attributes of Mungbean. *Bangladesh Res. Pub. J*., **1**(4): 324-336.

Ibrahim, M. (1980). Biology of *Cricula trifenestrata* (Lepidoptera: Saturnidae). A leaf eating caterpillar. *Bangladesh J. Entom.*, **1**: 19-26.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). (1982). Proceedings of the International Workshop on *Heliothis* Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. P. 418.

Infante, N., Madriz, P. and Gonzalez, T. (2003). Phases of development and yield components of three mungbean cultivars (*Vigna radiata* (L) Wilczek) in Maracay, Aragua state, Venezuela. *Revista Faculty of Agron*., **20**(4): 417-429.

Islam, M.K., Islam, S.M.A., Harun-or-Rashid, M., Hossain, A.F.M.G.F. and Alom, M.M. (2006). Effect of biofertilizer and plant growth regulators on growth of summer mungbean. *Interl. J. Botany*. **2**(1): 36-41.

Jayaraj, S. (1982). Biological and Ecological Studies of *Heliothis*, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). Proceedings of the International Workshop on *Heliothis* Management, 15-20 November 1981. ICRISAT Center, Patancheru, A. P. India.

Kajita, H. and Alam, M.Z. (1996). Whiteflies on guava and vegetables in Bangladesh and their Aphelinid parasitoids. *Appl. Entomol. Zool*., **31**(1): 159-162.

Karim, M.A. and Rahman, M.M. (1991). Status of insect and vertebrate pest management research on pulses. Pp. 135-138. In: Proceedings of the Second National Workshop on Advances in Pulses Research in Bangladesh, 6-8 June 1989, Joydebpur, Bangladesh.

Kay, D.E. (1979). Crop and Product Dighest No. 3-Food Legumes. Tropical Products Institute, London. p. 435.

Khattak, M.K., Ali, S. and Chishti, J.I. (2004). Varietal resistance of mungbean (Vigna radiata L.) against whitefly (Bemisia tabaci Genn.), jassid (Amrasca devastans Dist.), and thrips (Thrips tabaci Lind.) *Pakistan Entomol.*, **26**(1): 9-12.

Kumar, M., Lathwal, O.P. and Kumar, S. (2009). Growth behaviour of mungbean genotypes under varying sowing time during summer season. *Haryana J. Agron.*, **25**(1/2): 79-81.

Lal, S.S. (1985). A review of insect pests of mungbean and their control in India. *Trop. Pest Management.*, **31**(2): 105-114.

Loganathan, M. (1981). Studies on the ecology and effect of host plants on the susceptibility of larvae of *Heliothis armigera* (Hubner) to insecticides. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, India.

Madriz-Isturiz, P.M. and Luciani-Marcano, J.F. (2004). Agronomic characterization of 20 cultivars of mungbean, *Vigna radiata* (L.) Wilczek during three seasons, in Maracay, Aragua state, Venezuela. *Revista Fac. Agron.*, **21**(1): 19-35.

MoA (Ministry of Agriculture). (2014): *Monthly Hand Book of Agricultural Statistics, June.* p. 57.

Mohammad, D. and Hossain, I. (2003). Seed treatment with biofertilizer in controlling foot and root rot of mungbean. *Pakistan J. Plant Patho.*, **2**(2): 91-96.

Muhammad, A., Abdul, R., Muhammad, A. and Zafar, M.I. (2006). Association among Rhizobium phaseoli strains and mungbean genotypes under rainfed conditions. *Sarhad J. Agric.*, **22**(3): 453-457.

Nair, M.R.G.K. (1986). Insects and Mites of Crops in India. Indian Council of Agric. Res. New Delhi. 408p.

Naresh, J.S. and Nene, Y.L. (1980). Host range, host preference for oviposition and development and the dispersal of *Bemisia tabaci* (Genn). A vector of several plant viruses. *Indian J. Agric. Sci*., **50**: 620-623.

Navgire, K.D., Datar, V.V., Asewar, B.V. and Dahiwal, A.L. (2001). Response of mungbean cultivars to different Rhizobium strains under rainfed conditions. *Ann. Plant Physio*., **15**(2): 134-137.

Nsabiyera, V., Logose, M., Ochwo-Ssemakula, M., Sseruwagi, P., Gibson, P., Ojiewo, C.O. (2013). Morphological Characterization of Local and Exotic Hot Pepper (*Capsicum annuum*) Collections in Uganda. *Bioremediation, Biodiversity and Bioavailability*. **7**(1): 22-32.

Poehlman, J.M. (1991). The mungbean. Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi, Bombay and Calcutta, 292p.

Potter, Y.K. and Hotchkiss, M.P. (1997). Nutrient content in mungbean. *Ann. Agril. Sci*. **35**(2): 23-28.

Quaderi, R.S., Islam, S.M.A., Hossain, A.F.M.G.F., Hoque, M.M. and Haque, M.S. (2006). Influence of seed treatment with indole acetic acid on mungbean cultivation. *Interl. J. Botany*. **2**(1): 42-47.

Rahman, M.M. (1987). Evaluation of Sumithion as a component of an integrated pest management program to control insect pests of mungbean. Abstracts of for the Bangladesh Science Conference 12, *Bangladesh Assoc. Adv. Sci*., **1**: 38-39.

Rahman, M.M. and Miah, A.A. (1988). Mungbean in Bangladesh-problem and Prospects. In: Shanmugasundaram, S(ed) Mungbean: Proceedings of the second International Symposium on Mungbean. 16-20 November 1987. Bankok, Thailand. AVRDC, Shanhua, Tainan, Taiwan (ROC). p. 570.

Rahman, M.M. Mannan, M.A. and Islam, M.A. (1981). Pest survey of major summer and winter pulses in Bangladesh. In the proceedings of the National Workshop on Pulses. (eds.) A. K. Kaul. p. 265-273.

Rahman, M.S., Eunus, M. and Awal, M.A. (2005). Dry matter production and partitioning of mungbean (*Vigna radiata* I.) varieties as influenced by sowing date and planting method in summer. *Bangladesh J. Training and Dev.*, **15**(1/2): 193-199.

Raj, S. and Tripathi, K.P. (2005). Productivity and economics of mungbean (*Vigna radiata* L.) as influenced by varieties and nutrient management. *J. Arid Leg*., **2**(2): 223-226.

Rao, V.P. (1974). Biology and breeding techniques for parasites and predators of *Ostrinia.* spp. and *Heliothis* spp. CIBC Field Technical Report, U.S. PL-480 Project, Bangalore, India. P. 86.

Riaz, A., Imran, M., Javed, K. and Bukhari, S.A.H. (2004). Growth and yield response of three mungbean (Vigna radiata L.) cultivars to varying seeding rates. *Internl. J. Agric. Bio*., **6**(3): 538-540.

Roome, R.E. (1975). Activity of adult *Heliothis armigera* with reference to the flowering of sorghum and maize in Botswana. *Bulln. Envirl. Res.*, **65**: 523-530.

Satish, K., Singh, R.C. and Kadian, V.S. (2003). Response of mungbean genotypes to phosphorus application. *Indian J. Pulses Res*., **16**(1): 65-66.

Sehgal, V.K. and Ujagir, R. (1988). Insect and pest management of mungbean in India. Mungbean: Proceedings of the Second International Symposium. Asian Vegetable Research and Development Centre, Shanhua, Taiwan.

Shamsuzzaman, A.M.M., Alam, M.S., Mondal, G. and Ahamed, K.U. (2004). Growth and yield response of summer mungbean to irrigation frequency. *J. Agric. Rural Dev.*, **2**(1): 95-100.

Sharma, A.R. and Behera, U.K. (2009). Nitrogen contribution through *Sesbania* green manure and dual-purpose legumes in maize-wheat cropping system: Agronomic and economic considerations. *Plant Soil*., **325**: 289-304.

Singh, H. and Singh, G. (1975). Biological studies on *Heliothis armigera* (Hub.) in Punjab. *Indian J. Entom*., **37**: 154-164.

Srivastava, K.M. and Singh, L.N. (1976). A review of the pest complex of kharif pulses in Uttar Pradesh (U.P.) *PANS*. **22**(3): 333-335.

Taj, F.H., Muhammad, A. and Kakar, K.M. (2003). Effect of seed rates on mungbean varieties under dryland conditions. *Interl. J. Agric. Biol.*, **5**(2): 160-161.

Tayaraj, K.K. (1982). Preliminary screening of chickpea genotypes for susceptibility to *Heliothis armigera* (Hub.) at Pantnagar, India. *Interl. Chickpea Newsl*. **17**: 14.

Tickoo, J.L., Naresh, C., Gangaiah, B. and Dikshit, H.K. (2006). Performance of mungbean (*Vigna radiata*) varieties at different row spacings and nitrogen-phosphorus fertilizer levels. *Indian J. Agric. Sci.*, **76**(9): 564-565.

Truong, H.T.H., Kim, J.H., Cho, M.C., Chae, S.Y., Lee, H.E. (2013). Identification and development of molecular markers linked to Phytophthora root rot resistance in mungbean. *European J. Plant Pathol*., **135**(2): 289-297.

UNDP. (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. pp. 212, 577.

USDA-ARS, Germplasm resources information network (GRIN). (2012). http://www.ars-grin.gov/cgi bin/npgs/html/tax_search.

Vijayakumar, A. and Jayaraj, S. (1981). Studies on the food plant ecology *of Heliothis armigera* (Hub.) (Lepidoptera, Noctuidae). *Indian J. Agril. Sci*., **51**(2): 105-110.

Zalucki, M.P., G. Daglish, S. Firempong and Twine, P. (1986). The biology and ecology of *Heliothis armigera* (Hubner) and *Heliothis punctigera* Wallengren (Lepidoptera, Noctuidae) in Australia. *Australian J. Zool*., **34**: 779-814.

Zhang, Y., Sun, J., Li, S.H. and Shu, S. and Guo, S.R. (2012). Application of vinegar residue substrate in nursery and cultivation of mungbean. *Acta Hort*., **1037**: 1093-1101.

APPENDICES

Appendix I. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agricultural Botany 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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	6.1
Organic matter (%)	1.13
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

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

Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from October 2014 to February 2015

Month	*Air temperature (ºc)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2014	26.5	19.4	81	22	6.9
November, 2014	25.8	16.0	78	00	6.8
December, 2014	22.4	13.5	74	00	6.3
January, 2015	24.5	12.4	68	00	5.7
February, 2015	27.1	16.7	67	30	6.7

* Monthly average,

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

Appendix III. Analysis of variance of the data on incidence of white fly and pod borer during the study period as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square	
		Number of whitefly/ 10 leaves	Pod borer/ 10 plant
Replication	2	0.042	0.062
Variety (A)	5	10.580**	2.260**
Error	10	0.128	0.068

**: Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on incidences of white fly and its damage severity on leaves at early growing stage as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square		
		At early growing stage		
		Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.427	0.002	0.023
Variety (A)	5	4.736*	0.388**	7.554**
Error	10	1.259	0.026	0.421

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

Appendix V. Analysis of variance of the data on incidences of white fly and its damage severity on leaves at mid growing stage as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square		
		At mid growing stage		
		Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.462	0.069	0.536
Variety (A)	5	3.309**	0.814**	12.755**
Error	10	0.601	0.029	0.353

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on incidences of white fly and its damage severity on leaves at late growing stage as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square		
		At late growing stage		
		Healthy leaves/ plant (No.)	Infested leaves/ plant (No.)	Leaf infestation (%)
Replication	2	0.082	0.016	0.156
Variety (A)	5	3.305*	1.512**	20.138**
Error	10	0.818	0.018	0.197

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

Appendix VII. Analysis of variance of the data on incidences of pod borer and its damage severity on pods at early pod development stage as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square		
		At early pod development stage		
		Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
Replication	2	0.069	0.009	0.346
Variety (A)	5	3.673*	0.285**	8.632**
Error	10	0.754	0.014	0.521

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

Appendix VIII. Analysis of variance of the data on incidences of pod borer and its damage severity on pods at mid pod development stage as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square		
		At mid pod development stage		
		Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
Replication	2	0.062	0.007	0.173
Variety (A)	5	4.804*	0.244**	6.531**
Error	10	1.134	0.015	0.388

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

Appendix IX. Analysis of variance of the data on incidences of pod borer and its damage severity on pods at late pod development stage as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square		
		At late pod development stage		
		Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
Replication	2	0.482	0.002	0.071
Variety (A)	5	2.974*	0.569**	8.909**
Error	10	0.696	0.032	0.247

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

Appendix X. Analysis of variance of the data on yield contributing characters and yield as influenced by different varieties of mungbean

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm)	Number of pods/plant	Number of seeds/pod	Weight of 1000 seeds (g)	Yield (t/ha)
Replication	2	1.168	0.015	0.000	0.655	0.001
Variety (A)	5	19.257*	3.449*	1.401*	1.664	0.025*
Error	10	4.986	0.780	0.373	1.561	0.006

*: Significant at 0.05 level of probability