VARIETAL SCREENING OF MUNGBEAN AGAINST WHITEFLY AND APHID

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CERTIFICATE

This is to certify that the thesis entitled **'Varietal Screening of Mungbean Against Whitefly and Aphid'** 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 *bonafide* research work carried out by **Mohammad Abdullah-Al-Rahad**, Registration number: **09-03402** 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.

Dated: June, 2016
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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from March to June, 2016 with a view to screening of mungbean varieties against whitefly and aphid. Different mungbean varieties i.e. BARI Mung-1, BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and BARI Mung-6 were tested as treatments for this study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different parameters were recorded and statistically analysed. In case of whitefly population, the lowest number of whitefly per plant was found from BARI Mung-6, while the highest number from BARI Mung-1. At early fruiting stage, the lowest infestation (3.26%) was found in BARI Mung-6, whereas the highest infestation (9.35%) in BARI Mung-1. At mid fruiting stage, the lowest infestation (4.53%) was found in BARI Mung-6 but the highest infestation (10.04%) in BARI Mung-1 At late fruiting stage, the lowest infestation (3.24%) was observed in BARI Mung-6, while the highest infestation (10.98%) in BARI Mung-1. In case of aphid population, the lowest number of aphid per plant was recorded in BARI Mung-6 and the highest number from BARI Mung-1. At early fruiting stage, the lowest infestation (3.15%) was found in BARI Mung-6, whereas the highest infestation (10.01%) in BARI Mung-1. At mid fruiting stage, the lowest infestation (4.63%) was attained in BARI Mung-6, while the highest infestation (8.58%) in BARI Mung-1. At late fruiting stage, the lowest infestation (4.70%) was observed in BARI Mung-6, while the highest infestation (11.64%) in BARI Mung-1. The highest seed yield (1.82 t/ha) was recorded in BARI Mung-6, while the lowest (1.30 t/ha) in BARI Mung-4. Among the mungbean varieties BARI Mung-6 were superior in terms of lowest whitefly and aphid infestation and also highest yield.

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CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L.) is an important pulse crop (Family: Leguminosae) ranks fourth position considering both acreage and production in Bangladesh (MoA, 2014). It is originated mainly from Africa and Asia and the Asian tropical regions and composed of more than 150 cultivated species with the greatest magnitude of genetic diversity (USDA-ARS GRIN, 2012). It grows well all over the country except Rangamati district (BBS, 2013). The total production of mungbean in Bangladesh in 2013-14 was 1.81 lac metric tons from 1.73 lac hectares of land and an average yield 1.04 t ha^{-1} (MoA, 2014). It plays a significant role in sustaining crop productivity by adding nitrogen through rhizobial symbiosis and crop residues (Sharma and Behera, 2009). Mungbean contains 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, 132 mg calcium and 367 mg phosphorus in 100 grams of $seed^{-1}$, respectively (Frauque *et al*., 2000).

According to FAO (2013) recommendation, a minimum intake of pulse by a human should be 80 gm day^{-1}, whereas it is 24.19 g in Bangladesh. Mungbean plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, although the land for it cultivation and acreage production is gradually declining (BBS, 2013). 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). Mungbean is considered as a poor man’s meat because it is a good source of protein (Mian, 1976). It is a popular crop in Bangladesh not only as a food crop but also as a fodder crop. Generally, mungbean is cultivated after harvesting of Rabi crops and due to its short duration, it can fit in as a cash crop between major cropping seasons.

Mungbean is cultivated with minimum tillage, use of local varieties with no or minimum fertilizers especially nitrogen, no pesticides or insecticides 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). The low yield of mungbean besides other factors may partially be due to lack of knowledge regards to suitable production technology (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.

Insect pests damage mungbean seedlings, leaves, stems, flowers, buds and pods (Husain, 1993; Karim and Rahman, 1991). The most damaging inset pests of mungbean recorded so far are whitefly (Srivastava and Singh, 1976), stemfly (Rahman, 1987), jassid (Baldev, 1988; Chaudhary *et al.,* 1980), aphid (Morrison and Peairs, 1998), thrips (Chhabra and Kooner, 1985), hairy caterpillar (Rahman *et al*., 1981) and pod borer (Nair, 1986). Among these whitefly and aphids have the major importance (Khattak *et al*., 2004). The whitefly causes damage by feeding on the leaf with stylets inserted into the leaf tissue. It also reduces crop yield and act as a vector of viral pathogens (Kajita and Alam, 1996). Whiteflies play a key role in the spread of mungbean yellow mosaic virus which is a serious disease of this crop (Akhtar *et al.*, 2012). Heavy attack of whitefly cause severe loss of cell sap of plants, make plants weakened and sickly black appearance to plants due to injection of body toxins of whitefly. Aphids can also produce large quantities of sticky exudates known as honeydew, which often turns black with the growth of a sooty mold fungus. Some aphid species inject a toxin into plants, which causes leaves to curl and further distorts growth and a few species cause gall formations (Cannon, 2008).

Variety plays an important role in producing high yield of mungbean because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. Worldwide, a total of 43,027 mungbean accessions are available at core collections or Gene Bank at different stations of the World. Up to date, over 110 mungbean cultivars have been released by AVRDC in South and Southeast Asia and around the world (Ali and Gupta, 2012). Variety is the most important factor in mungbean production. The growth process of mungbean plants under a given agro-climatic condition differs with variety. Selection of potential variety can play an important role in increasing yield and national income. Yield components are directly related to the variety and neighboring environments in which it grows. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have released different varieties of mungbean. There were no definite and conclusive screening work has been done on the comparative efficacy of those varieties against different insect pests.

Under the above mention context and situation, the present study has been undertaken with fulfilling the following objectives.

1. To find out the resistance of the variety against whitefly and aphids;
2. To evaluate the incidence of whitefly and aphids as a sucking pest during the cultivation period; and
3. To assess the damage of mungbean causes by whitefly and aphids.

CHAPTER II

REVIEW OF LITERATURE

2.1 Insect pest of mungbean

The insect pests of mungbean are causes great reduction in yield, which is considered as an important obstacle for mungbean production. Mungbean is one of the important pulse crop although there are many constrains for attaining highest yield among them insect pests is one of the important factor. The insect pests that attack mungbean which was listed by Rahman *et al*. (1981) and presented below:

Common name	Scientific name	Order
Whitefly	*Bemisia tabaci*	Homoptera
Aphid	*Aphis spp.*	Homoptera
Bean stemfly	*Ophiomya phaseoli*	Diptera
Jassid	*Empoasca kerri*	Homoptera
Thrips	*Megalurothrips distalis*	Thysanoptera
Bean aphid	*Aphis Craccivora*	Homoptera
Hairy caterpillar	*Spilarctia oblique*	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

Whitefly and aphid are most damaging sucking pests of mungbean Of the above listed insect pests (Rahman *et al*., 1981; Gowda and Kaul, 1982).

2.1.1 Whitefly

Whiteflies cause damage to plant by three means as (i) large population of nymphs and adults suck sap directly from plant greatly reduce yield, (ii) heavy colonization of whitefly can cause serious damage to some crops due to honeydew excreted by all stages, particularly the late nymphal instars which encourages growth of "sooty mould" that affect yield both in quantity and quality and (iii) they also reduce crop yield through transmission of viral diseases from crop to crop (Kajita and Alam, 1996).

The whitefly, *B. tabaci* is an important pest worldwide for many vegetable crops as well as mungbeam. The whiteflies are very small, fragile and active insects, jump from plant to plant with very slight disturbance and because of this there is great difficulty in handling them and also management. Eggs are laid indiscriminately almost always on the under surface of the young leaves and stem. The adult of whitefly is soft and pale yellow, change to white within few hours due to deposition of wax on the body and wings (Haider, 1996).

Eggs are laid indiscriminately almost always on the under surface of the young leaves (Hirano *et al*., 1993). 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). 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.

Brown and Bird (1992) have pointed out the increased prevalence as well as expanded distribution of whitefly borne viruses during the last decade and resulting devastating impact on crop growth and yield. Yield loss range from 20-

100 per cent, depending on the crop, season, vector prevalence and other factors during the growing season. The whitefly acts as a mechanical vector of many viral diseases for different vegetable crops (Butani and Jotwani, 1984). Young plant may even die in case of severe infestation. The pest is active during the dry season and its activity decreases with the on set of rains. As a result of their feeding the affected parts become yellowish, the leaves become wrinkle, and curl downwards and eventually fallen off. This happens mainly due to viral infection. Yield loss due to *Bean golden mosaic virus* (BGMV) varied from 40-100 %, depending on age, species/genotypes/varieties.

2.1.2 Aphids

There are commonly six species of aphids and these species are *Rhopalosiphum padi, Schizaphis graminurn, Sitobion avenae, Metopoliphiurn dirhodum, R. maidis* and *Diuraphis noxia.* Two of those species commonly known as Bird Cherry-Oat Aphid (*Rhopalosiphum padi*) and Russian Wheat Aphid (*Diuraphis noxia*) and are considered notorious for their direct and indirect losses. The RWA was first reported in South Africa in 1978 (Morrison and Peairs, 1998).

Climatic conditions and temperature in particular, plays a significant role in population dynamics of the aphids. A warmer temperature can potentially accelerate the aphid's growth both in terms of number and size, yet, the extreme temperatures can possibly reduce the survival and spread. RWA is known to be present in its three different morphological types: immature wingless females, mature wingless females and mature winged females. Winged mature females or adults spread the population and infection to the surrounding host plants whereas the wingless types or apterous cause damage by curling and sucking the young leaves. Heavily infested plants may typically look prostrated and/or stunted with yellow or whitish streaks on leaves. The most obvious symptoms due to heavy infestations can be reduced leaf area, loss in dry weight, and poor cholorophyll concentration. Plant growth losses could be attributed mainly due to reduced photosynthetic activity to plants RWA infestation (Morrison and Peairs, 1998).

2.2 Incidence and influence of insect pests on mungbean

Nadeem *et al.* (2014) carried out an experiment to examine the resistance in eight advance mungbean genotypes in comparison with two check varieties against sucking insect pests at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. Findings of the trial showed that none of the tested genotypes have complete resistance against sucking pests i.e., whiteflies, thrips and jassids. Comparison of resistance among the tested genotypes against whitefly showed that the lowest number of whiteflies per leaf (3.7±1.20) was observed in MH 3153, lower than those of both checks, whereas, the highest (11±1.53) was observed in MH 34143. Number of thrips per leaf was observed the lowest (4±1.00) and the highest (12.3±0.67) in cultivar MH 3153 and MH 34143, respectively. Among all the tested cultivars, MH 3153 gave the highest yield (438.7 g/plot) with 129 and 161% increase over check 1 and check 2, respectively. Therefore, genotypes which showed the highest resistance against the sucking pests and tied with high grain yield could be used for direct release as variety or may be used in cross breeding program to get improved resistant germplasm against sucking insects.

A field surveys was conducted by Srivastava and Prajapati (2012) to find out the influence of weather factors and their association with white fly population and Mungbean Yellow Mosaic Virus (MYMV) incidence in Black gram during kharif seasons in Tikamgarh district of Bundelkhand Agro-climatic zone. Maximum temperature, mean relative humidity and rainfall play an important role in white fly population built-up and significantly related to its peak population. A regression model was developed utilizing these three variables and it was found that the model explained 65 per cent variability of the MYVY outbreak. MYMV outbreak may be estimated through minimum temperature and white fly population of the 34-37th SMW and rainfall of 37-39th SMW.

Hossain (2010) was conducted an experiment at the research field of Sher-e Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to manage the sucking insects of mungbean and observe its impact on incidence of mosaic disease and reported that whitefly, jassid, aphid and white leaf hooper were found as sucking insects and whitefly was the most abundant in mungbean field.

An experiment was carried out by Hossain *et al.* (2009) at Pulses Research Center, Ishurdi, Pabna, Bangladesh during kharif-I and observed that the incidence and population fluctuation of various insect pests was very much dependent on the prevailed climatic conditions of the cropping season. The early (February 14 to March 06) and late sown (mid April to onward) crops received higher pest infestation than the mid sown (March 13 to April 10) crops.

Lal (2008) reviewed the various insect pests that infesting mungbean or green gram, *Vigna radiate* (L) Wilczeck, in India and recorded a total number of 64 species of insects reported to attack mungbean in the field have been tabulated. Information on distribution, biology, ecology, natural enemies, cultural, varietal and chemical methods of control etc. of whitefly, *Bemisia tabaci* Genn, leaf hopper, *Empoasca kerri* Pruthi, black aphid, *Aphis craccivora* Koch, Bihar hairy caterpillar, *Diacrisia obliqua* (WIK), galerucid beetle, *Madurasia obscurella* Jacoby, stem fly, *Ophiomyia (Melanagromyza) phaseoli* (Tryon), lycaenid borer, *Euchrysops cnezus* Fabr, and spotted caterpillar, *Maruca testulalis* Geyer, is included.

Islam *et al*. (2008) conducted an experiment with seven recommend varieties of mungbean viz. Barimung 2, Barimung 3, Barimung 4, Barimung 5, Barimung 6, Binamoog 2 and Binamoog 5 to know the population dynamics of whitefly under existing environmental conditions and its impact on incidence of mungbean yellow mosaic virus (MYMV) disease and yield. The lowest population of whitefly (adult and nymph) was found in Barimung 6 as against the highest in Binamoog 2. The population of whitefly was gradually increased with environmental temperature and relative humidity. However, the peak population was found at 32^0C and 80% relative humidity. The lowest percent of MYMV infected plant was found in Barimung 6 and a positive relationship was found between whitefly population and incidence of MYMV disease. The highest yield of mungbean was obtained from Barimung 6 and there was a strong negative relationship between the MYMV infection and yield of mungbean.

Shad *et al.* (2005) reported that the lowest population of whitefly (adult and nymph) was found in Barimung 6 as against the highest in Binamoog 2. The population of whitefly was gradually increased with environmental temperature and relative humidity. However, the peak population was found at 320C and 80% relative humidity. The lowest percent of MYMV infected plant was found in Barimung 6 and a positive relationship was found between whitefly population and incidence of MYMV disease. The highest yield of mungbean was obtained from Barimung 6 and there was a strong negative relationship between the MYMV infection and yield of mungbean. MYMV a member of family Geminiviridae, belong to genus Begomovirus was identified in 1955 and it was observed that vector, whitefly (*Bemisia tabaci* Genn) is responsible for its transmission. This virus cannot be transmitted through sap, seed, soil or mechanically but Thailand strain of this virus can be transmitted by mechanical inoculation.

Sreekant *et al*. (2004) carried out a field experiments in kharif seasons on mungbean cv. K-851 to determine the effect of intercropping on the incidence of thrips. The treatments comprised intercropping mungbean with pigeon pea, maize, sorghum, pearl millet, castor bean and cotton, sole cropping of mungbean. The reduction in thrips was observed with pearl millet intercrop during both the seasons.

Sharma *et al*. (2004) conducted and experiment with eighteen promising varieties of mungbean for resistance to white fly (*Bemisia tabaci*) and yellow mosaic virus and reported that the cultivar IPU-95-13 showed high tolerance of yellow mosaic virus. Among the 4 control cultivars, PU-35 performed well. T-9, a popular cultivar of the area was highly susceptible to whitefly and yellow mosaic virus.

Hossain *et al*. (2004) reported that mungbean (*Vigna radiata* L) is one of the important pulse crops in Bangladesh. Due to its short lifespan gradually farmers are becoming more interested to cultivate this valuable crop after harvesting of rabi crops. Several insect pests have been reported to infest mungbean damaging the crops during seedlings, leaves, stems, flowers, buds and pods causing considerable losses. More than twelve species of insect pests were found to infest mungbean in Bangladesh, aphid and whitefly, thrips and pod borers are important.

Massod *et al*. (2004) observed the resistance of mungbean varieties (NM-92, NM-98, NM-121-125, M-1, and NCM-209) was investigated 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.

Khattak *et al*. (2004) were investigated the resistance of mungbean cultivars (NM-92, NM-98, NM-121-125, M-1 and NCM- 209) against some sucking insect pests was evaluated in Kalurkot, Bhakkar, Pakistan. NM-92 and NM-98 showed significantly low mean whitefly population per leaf than the other cultivars. A similar trend was observed among the cultivars against jassids (A. devastans [A. biguttula biguttula]) and thrips, except that the mean populations of jassids and thrips per leaf in NM-98 and NM-121-125 did not significantly vary. The yields of NM-92 and NM-98 were significantly higher than the other cultivars due to low infestation by sucking insect pests.

Babu *et al*. (2004) conducted an experiment in the field against thrips population. They showed that during kharif season, the thrips catching ranged from 21.2-66.5. The white traps caught the highest number of thrips (297.4) followed by blue traps (227.6). In general, thrips infestation appeared from the first week of the crop, which progressively and significantly increased in successive crop stages up to 6 weeks.

Yadav and Dahiya (2000) evaluated 30 genotyeps of mungbean under field conditions for resistance of whitefly *Bemisia tabaci*, jassids *Empoasca kerri* and YMV. There were no significant differences among the genotypes MI-5, ML-803, DP91-249 and PMB-5. However, the genotypes were good sources of resistance against whitefly, jassids and YMV and might be used as donor parents in breeding program.

Pal (1996) stated that several factors are responsible for low production of mungbean. Among them, insects attack plays an important role. The most important insects observed in the field, in order of their intensity, were caterpillar, white fly, and pod borer. The farmers' perception of losses due to insect infestation matched with higher pesticide use on modern varieties. The perceived losses due to disease were found to be minimal at about 4-6%, depending upon variety.

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*.

2.3 Influence of variety on yield attributes and yield of mungbean

Tripathi *et al*. (2012) conducted an experiment to find out the effect of rhizobial strains and sulphur (S) on mungbean cultivars (SML-668, Pusa Vishal, and HUM-1). Cultivar HUM-1 and application of 45 kg S ha^{-1} recorded higher plant height, primary branches, green trifoliates, leaf area index, dry matter accumulation, nodule numbers and nodule dry weight, increased days to maturity, number of pod and higher grain and straw yield as compared to cultivars Pusa Vishal and SML-668.

A field trial was conducted to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan by Rasul *et al*. (2012). Three mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacings respectively. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1}, while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3.

Agugo *et al*. (2010) carried out an experiment with four mungbean accessions collected from the Asian Vegetable Research and Development Centre (AVRDC) and reported 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^{-1}. This was followed by NM 92, 0.48 t ha^{-1}; NM 94, 0.40 t ha^{-1}; and VC 1163 with 0.37 t ha^{-1}. The variety, VC 6372 (45-8-1), also formed good agronomic characters.

A field experiment was 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. 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) conducted an experiment to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) on the growth, yield and yield contributing characters of two modern mungbean (*Vigna radiata* L.) varieties viz. BARI moog 4 and BARI moog 5 in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. They reported that among the mungbean varieties, BARI mung 5 performed better than that of BARI mung 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 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. 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-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 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.) at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh and reported that among the mungbean varieties, Binamoog-5 performed better than that of Binamoog 2 and Binamoog 4.

Tickoo *et al*. (2006) conducted an experiment with 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^{-1} in a field experiment conducted in Delhi, India during the kharif season. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105.

A field experiment was conducted by Aghaalikhani *et al*. (2006) at the Seed and Plant Improvement Institute of Karaj, Iran, to evaluate the effects of crop densities on yield and yield components of two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A). 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) carried out an experiment with mungbean in Jamalpur, Bangladesh, involving 2 planting methods, and 5 mungbean cultivars, namely Local, BARI mung 2, BARI mung 3, Binamoog 2 and BINA moog 5. Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of Binamoog 2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

Bhati *et al*. (2005) conducted an experiment to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes 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.

Raj and Tripathi (2005) conducted an experiment to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen and phosphorus on the productivity of mungbean in Jodhpur, Rajasthan, India, during the kharif seasons,. 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.

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. 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 moog 2 and BINA moog 5, were grown by Shamsuzzaman *et al*. (2004) during the kharif-1 season, 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. 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. BINA moog 2 performed slightly better than BINA moog 5 for most of the growth and yield parameters studied.

Abid *et al*. (2004) conducted an experiment to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-1in Peshawar, Pakistan. 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) 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) during kharif season in Uttaranchal, India and reported that Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

Hossain and Solaiman (2004) conducted an experiment 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. The mungbean cultivars were BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, Binamoog-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^{-1}. *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.

Madriz-Isturiz and Luciani-Marcano (2004) evaluated the performance of 20 mungbean cultivars in a field experiment conducted in Venezuela. Data on plant height, clusters $plant^{-1}$, pods $plant^{-1}$, pod length, seeds pod^{-1}, grain yield by plant and yield ha^{-1} were recorded. Significant differences in the values of the parameters measured due to cultivar were recorded. The average yield was 1342.58 kg ha^{-1}. VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

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. 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 $plant^{-1}$ and 10.4 seeds pod^{-1}. 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%).

Three mungbean cultivars (LGG 407, LGG 450 and LGG 460) and two urd bean [black gram] cultivars were sown 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. 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 mungbean 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 in Ahmadwala, Pakistan, during the summer season to find out the effects of sowing rates (10, 20, 30 and 40 kg seed ha^{-1}) on the performance of 5 mungbean cultivars (NM-92, NM 19-19, NM 121-125, N/41 and a local cultivar) were studied. Among the cultivars, NM 121-125 recorded the highest average pods $plant^{-1}$ (18.18), grains pod^{-1} (9.79), 1000-grain weight (28.09 g) and grain yield (1446.07 kg ha^{-1}).

Satish *et al*. (2003) carried out an experiment in Haryana, India 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. MH 97-2 and Asha produced significantly more number of pods and branches $plant^{-1}$ compared to MH 85-111 and K 851.

Hamed (1998) carried out two field experiments in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals and 4 fertilizer treatments. Kawny 1 surpassed Giza 1 in pod number $plant^{-1}$ (24.3) and seed yield (0.970 t ha^{-1}), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t ha^{-1}, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg ha^{-1}), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg ha^{-1}).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted for varietal screening of mungbean against whitefly and aphid. The details of the materials and methods for this experiment have been presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the time period from March to June, 2016.

3.1.2 Experimental location

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka was located in 24.09^0N latitude and 90.26^0E longitudes. As per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207 the altitude of the location was 8 m from the sea level.

3.1.3 Characteristics of soil

The general soil type of the experimental field is Shallow Red Brown Terrace soil and the soil belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28). A composite sample of the experimental field was made by collecting soil from several spots of the field at a depth of 0-15 cm before initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 5.7 and 1.13%, respectively. The results showed that the soil of experimental filed composed of 27% sand, 43% silt and 30% clay. The details have been presented in Appendix I.

3.1.4 Climatic condition

The climatic condition of experimental site is subtropical and characterized by three distinct seasons, the *Rabi* from November to February and the *Kharif-I*, pre-monsoon period or hot season from March to April and the *Kharif-II* monsoon period from May to October. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department and presented in Appendix II. During the experimental period the maximum temperature (35.4^{0}C), highest relative humidity (80%) and highest rainfall (227 mm) was recorded in the month of June 2016, whereas the minimum temperature (19.5^{0}C), minimum relative humidity (65%) and minimum rainfall (25 mm) was recorded for the month of March 2016.

3.2 Experimental details

3.2.1 Treatments of the experiment

Six mungbean varieties were tested for this experiment. Varieties were BARI Mung-1, BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and BARI Mung-6 and they were selected as treatment for this study.

3.2.2 Planting material

BARI mung varieties were used as the test crop of this experiment. The seeds of these mungbean varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.2.3 Land preparation

The land was opened on the 13th March, 2016 with the tractor drawn disc plough. Ploughed the field soil again and again to brought into desirable tilth by cross-ploughing, harrowing and laddering. The stubble and weeds were removed from the tilth soil. The first ploughing and the final land preparation were done on the 21th and 27nd March, 2016, respectively. Experimental land was divided into unit plots following the experimental design of this experiment.

Plate 01: Experimental mungbean field during the study period

3.2.4 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), Gypsum and Boric acid were used as a source of Nitrogen (N), Phosphorous (P), Potassium (K), Sulphur (S) and Boron (B), respectively. Urea, TSP, MoP, Gypsum and Boric acid were applied at the rate of 120, 133, 62, 90 and 1 kg/ha, respectively following the Bangladesh Agricultural Research Institute (BARI) recommended dose. All of the fertilizers were applied during final land preparation.

3.2.5 Experimental layout and design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 16.50 m × 11.50 m was divided into three equal blocks. Each block was divided into 6 plots, where 6 mungbean varieties 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.

3.3 Growing of crops

3.3.1 Sowing of seeds in the field

The seeds of mungbean were sown on March 27, 2016 in solid rows in the furrows having a depth of 2-3 cm with maintaining row to row distance 30 cm and plant to plant 10 cm.

3.3.2 Intercultural operations

3.3.2.1 Thinning

Seeds started germination of 4 Days after sowing (DAS). Thinning was done two times; first thinning was done at 10 DAS and second was done at 18 DAS to maintain optimum plant population in each plot.

3.3.2.2 Irrigation, drainage and weeding

Irrigation was provided before 15 and 30 DAS for optimizing the vegetative growth of mungbean for the all experimental plots equally. Proper drain also made for drained out excess water from irrigation and also rainfall. The crop field was weeded at 15 and 30 DAS by hand weeding.

3.3.2.3 Plant protection measures

At early growing stage of the crops few worms (*Agrotis ipsilon*) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Ripcord 10 EC was sprayed at the rate of 1 ml with 1 litre water to 5 decimal lands for two times at 15 days interval after seedlings germination to control the insects. Before sowing seeds were treated with Bavistin 50 WP to protect seed borne disease.

3.4 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 white fly at vegetative, flowering and fruiting stages
- Plant infestation by white fly at early, mid and late vegetative stages
- Plant infestation by white fly at early, mid and late fruiting stages
- Number of aphid at vegetative, flowering and fruiting stages
- Plant infestation by aphid at early, mid and late vegetative stages
- Plant infestation by aphid at early, mid and late fruiting stages

- Pod infestation by aphid at early, mid and late fruiting stages
- Number of pods per plant
- Pod length (cm)
- Seeds/pod (No.)
- Weight of 1000 seeds
- Pod yield per hectare (ton)

3.5 Determination of plant infestation by number and infestation reduction over control

All the healthy and infested plants were counted from 1 m^2 land from middle rows of each plot and examined. The collected data were divided into early, mid and late stage. The healthy and infested plants were counted at early, mid and late stage and the percent plant infestation was calculated using the following formula:

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

In the same way pod infestation was calculated.

3.6 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.

3.7 Procedure of data collection

3.7.1 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.

Plate 02: Mungbean plants with health fruits during study period

Plate 03: Infested Mungbean leaves due to cell sap sucking insect pest of Aphid

3.7.2 Pod length

Pod length was taken from randomly selected 10 pods at harvest and calculated and the mean pod length was expressed on per pod basis.

3.7.3 Number of seeds/pod

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

3.7.4 Weight of 1000-seeds

One thousand cleaned, dried seeds were counted randomly at harvest and average was calculated and weighed by using a digital electric balance and expressed in gram (g).

3.7.5 Seeds yield/hectare

The pods were collected from central 3 lines at each plot at harvest and sun dried properly. The weight of seeds was taken and converted the yield in t/ha.

3.8 Statistical analysis

The data on different parameters of mungbean were statistically analyzed to find out the significant differences among the different mungbean varieties. The mean values of all the characters were calculated and analyses of variance were performed by the ‘F’ (variance ratio) test by using MSTAT-C software. 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 for varietal screening of mungbean against sucking insect pests whitefly and aphid. The results have been presented and possible interpretations given under the following headings:

4.1 Whitefly population

Number of whitefly population per plant at early, mid and late vegetative, flowering and fruiting stage showed statistically significant differences due to different mungbean varieties (Table 1).

4.1.1 At vegetative stage

At early vegetative stage, the lowest number of whitefly per plant (0.63) were observed from BARI Mung-6 which was statistically similar (1.03) to BARI Mung-4 and closely followed (1.70) by BARI Mung-5, while the highest number of whitefly (2.73) was recorded from BARI Mung-1 which was statistically similar (2.33) to BARI Mung-2 and closely followed (2.17) by BARI Mung-3 (Table 1). At mid vegetative stage, the lowest number of whitefly per plant (6.43) were found from BARI Mung-6 which was statistically similar (7.56) to BARI Mung-5 and closely followed (8.91) by BARI Mung-4, whereas the highest number of whitefly (12.13) was recorded from BARI Mung-1 which was closely followed (10.67 and 10.24) by BARI Mung-2 and BARI Mung-3 and they were statistically similar. At late vegetative stage, the lowest number of whitefly per plant (3.72) were found from BARI Mung-6 which was statistically similar (4.12) to BARI Mung-5 and closely followed (4.96) by BARI Mung-4, while the highest number of whitefly (7.60) was recorded from BARI Mung-1 which was statistically similar (7.30) to BARI Mung-2 and closely followed (6.00) by BARI Mung-3. Raj and Kalra (1995) reported that hese crops were attacked by 22 and 16 insect pest species at different stages of growth. Hossain (2010) reported that whitefly, jassid, aphid and white leaf hooper were found as sucking insects and whitefly was the most abundant in mungbean field.

Table 1. White fly populations per plant at early, mid and late flowering and fruiting stages due to different mungbean varieties

Treatments	Number of whitefly/plant at the stage of								
	Vegetative			Flowering			Fruiting		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
BARI Mung-1	2.73 a	12.13 a	7.60 a	5.23 a	4.90 a	4.43 a	4.13 a	3.90 a	2.73 a
BARI Mung-2	2.33 ab	10.67 b	7.30 a	4.73 a	4.30 a	4.13 a	3.33 b	3.30 b	2.33 b
BARI Mung-3	2.17 b	10.24 b	6.00 b	4.03 b	3.87 b	3.67 b	3.10 b	3.00 b	2.17 b
BARI Mung-4	1.03 d	8.91 c	4.96 c	3.33 c	3.03 c	2.27 d	2.17 d	1.93 d	1.03 d
BARI Mung-5	1.70 c	7.56 d	4.12 d	3.83 bc	3.63 bc	3.07 c	2.60 c	2.30 c	1.70 c
BARI Mung-6	0.63 d	6.43 d	3.72 d	2.60 d	2.20 d	1.77 e	2.00 d	1.33 e	0.63 e
$LSD_{(0.05)}$	0.413	1.206	0.873	0.613	0.824	0.382	0.411	0.503	0.316
Level of significance	0.05	0.01	0.05	0.01	0.01	0.01	0.05	0.01	0.01
CV(%)	4.68	5.59	7.55	4.22	3.89	5.33	6.02	7.15	5.11

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 selected 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

4.1.2 At flowering stage

At early flowering stage, the lowest number of whitefly per plant (2.60) were found from BARI Mung-6 which was closely followed (3.33 and 3.83) by BARI Mung-4 and BARI Mung-5 and they were statistically similar, whereas the highest number of whitefly (5.23) was recorded from BARI Mung-1 which was statistically similar (4.73) to BARI Mung-2 and followed (4.03) by BARI Mung-3 (Table 1). At mid flowering stage, the lowest number of whitefly per plant (2.20) were found from BARI Mung-6 which was closely followed (3.03 and 3.63) by BARI Mung-4 and BARI Mung-5 and they were statistically similar, whereas the highest number of whitefly (4.90) from BARI Mung-1 which was statistically similar (4.30) to BARI Mung-2 and followed (3.87) by BARI Mung-3. At late flowering stage, the lowest number of whitefly per plant (1.77) were found from BARI Mung-6 which was closely followed (2.27) by BARI Mung-4, while the highest number (4.43) from BARI Mung-1 which was statistically similar (4.13) to BARI Mung-2 and closely followed (3.67) by BARI Mung-3.

4.1.3 At fruiting stage

At early fruiting stage, the lowest number of whitefly per plant (2.00) were recorded in BARI Mung-6 which was statistically similar (2.17) to BARI Mung-4 and closely followed (2.60) by BARI Mung-5, while the highest number of whitefly (4.13) was recorded from BARI Mung-1 which was followed (3.33 and 3.10) to BARI Mung-2 and BARI Mung-3 and they were statistically similar (Table 1). At mid fruiting stage, the lowest number of whitefly per plant (1.33) were found from BARI Mung-6 which was closely followed (1.93) by BARI Mung-4, while the highest number of whitefly (3.90) in BARI Mung-1 which was closely followed (3.30 and 3.00) by BARI Mung-2 and BARI Mung-3 and they were statistically similar. At late fruiting stage, the lowest number of whitefly per plant (0.63) were found from BARI Mung-6 which was closely followed (1.03) by BARI Mung-4, whereas the highest number of whitefly (2.73) was recorded from BARI Mung-1 which was followed (2.33 and 2.17) by BARI Mung-2 and BARI Mung-3 and they were statistically similar.

4.2 Whitefly infested mungbean plants and pods

4.2.1 Plant infestation at vegetative stage by whitefly

Number of healthy plants, infested plants and per cent infestation of plant by whitefly showed statistically significant differences at early, mid and late vegetative stage for different mungbean varieties (Table 2).

4.2.1.1 At early stage

At early vegetative stage, the highest number of healthy plants/m^2 (29.67) was recorded in BARI Mung-6 which was statistically similar with other varieties except BARI Mung-1, while the lowest number of healthy plants/m^2 (28.00) was found in BARI Mung-1 (Table 2). The lowest number of infested plant/m^2 (3.33) was recorded in BARI Mung-6, whereas the highest number (6.00) was observed in BARI Mung-1 which was statistically similar (5.67) to BARI Mung-2 and closely followed (5.00) by BARI Mung-4. The lowest infestation (10.09%) was attained in BARI Mung-6 which was followed (12.86%) by BARI Mung-3, whereas the highest infestation (17.65%) was recorded in BARI Mung-1 which was statistically similar (16.68%) to BARI Mung-2 and closely followed (14.71% and 13.74%) by BARI Mung-4 and BARI Mung-5.

4.2.1.2 At mid stage

At mid vegetative stage, the highest number of healthy plants/m^2 (30.00) was recorded in BARI Mung-6 which was statistically similar (28.67) to BARI Mung-5 and closely followed (28.33) by BARI Mung-4, whereas the lowest number of healthy plants/m^2 (27.33) was found in BARI Mung-1 (Table 2) which was statistically similar (27.36 and 27.67) to BARI Mung-3 and BARI Mung-2 and they were statistically similar. The lowest number of infested plant/m^2 (4.00) was recorded in BARI Mung-6 which was closely followed (5.33 5.64 and 5.67) by BARI Mung-5, BARI Mung-3 and BARI Mung-4 and they were statistically similar, whereas the highest number (6.67) was observed in BARI Mung-1 which was statistically similar (6.33) to BARI Mung-2. The lowest infestation (11.76%) was attained in BARI Mung-6 which was followed

Table 2. Plant infestation by white fly at early, mid and late vegetative stages due to different mungbean varieties

Treatments	Early vegetative stage			Mid vegetative stage			Late vegetative stage		
	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)
BARI Mung-1	28.00 b	6.00 a	17.65 a	27.33 c	6.67 a	19.62 a	27.00 b	7.00 a	20.59 a
BARI Mung-2	28.33 ab	5.67 a	16.68 a	27.67 bc	6.33 a	18.62 a	27.00 b	7.00 a	20.59 a
BARI Mung-3	29.33 a	4.33 c	12.86 c	27.36 c	5.64 b	17.09 b	27.67 ab	5.33 b	16.15 b
BARI Mung-4	29.00 a	5.00 bc	14.71 b	28.33 b	5.67 b	16.68 b	28.00 a	6.00 b	17.65 b
BARI Mung-5	29.33 a	4.67 c	13.74 b	28.67 ab	5.33 b	15.68 bc	28.33 a	4.67 bc	14.15 c
BARI Mung-6	29.67 a	3.33 d	10.09 d	30.00 a	4.00 c	11.76 d	28.67 a	4.33 c	13.12 c
$LSD_{(0.05)}$	0.893	0.534	1.231	1.452	0.503	1.231	0.714	0.684	1.562
Level of significance	0.05	0.05	0.01	0.05	0.05	0.01	0.05	0.01	0.01
CV(%)	6.33	4.28	5.98	7.01	4.89	6.22	4.76	5.05	6.44

In a column, numeric data represents the mean value of 3 replications; each replication is derived from $1m^2$ selected areas as 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

(15.68%) by BARI Mung-5, whereas the highest infestation (19.62%) was recorded in BARI Mung-1 which was statistically similar (18.62%) to BARI Mung-2 and closely followed (17.09% and 16.68%) by BARI Mung-3 and BARI Mung-4 and they were statistically similar.

4.2.1.3 At late stage

At late vegetative stage, the highest number of healthy plants/m^2 (28.67) was recorded in BARI Mung-6 which was statistically similar with other varieties except BARI Mung-1 and BARI Mung-2, while the lowest number of healthy plants/m^2 (27.00) was found in BARI Mung-1 and BARI Mung-2 (Table 2). The lowest number of infested plant/m^2 (4.33) was recorded in BARI Mung-6 which was statistically similar (4.67) to BARI Mung-5, whereas the highest number (7.00) was observed in BARI Mung-1 and BARI Mung-2 and closely followed (6.00 and 5.33) by BARI Mung-4 and BARI Mung-3 and they were statistically similar. The lowest infestation (13.12%) was attained in BARI Mung-6 which was statistically similar (14.15%) by BARI Mung-5, whereas the highest infestation (20.59%) was recorded in BARI Mung-1 and BARI Mung-2 and closely followed (17.65% and 16.15%) by BARI Mung-4 and BARI Mung-3.

4.2.2 Plant infestation at flowering stage by whitefly

Number of healthy plants, infested plants and per cent infestation of plant by whitefly showed statistically significant differences at early, mid and late flowering stage for different mungbean varieties (Table 3).

4.2.2.1 At early stage

At early flowering stage, the highest number of healthy plants/m^2 (28.33) was recorded in BARI Mung-6 and BARI Mung-5 which was statistically similar with other varieties except BARI Mung-1, while the lowest number of healthy plants/m^2 (27.00) was found in BARI Mung-1 (Table 3). The lowest number of infested plant/m^2 (1.33) was recorded in BARI Mung-6 which was statistically similar (1.67 and 2.00) to BARI Mung-5 and BARI Mung-4, whereas the highest number (3.00) was observed in BARI Mung-1 which was closely followed

Table 3. Plant infestation by white fly at early, mid and late flowering stages due to different mungbean varieties

Treatments	Early flowering stage			Mid flowering stage			Late flowering stage		
	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)
BARI Mung-1	27.00 b	3.00 a	10.00 a	26.33 c	3.67 a	12.23 a	26.33 c	3.67 a	12.23 a
BARI Mung-2	27.67 ab	2.33 b	7.77 b	26.67 c	3.33 ab	11.10 b	26.67 bc	3.33 b	11.10 b
BARI Mung-3	27.67 ab	2.33 b	7.77 b	27.00 bc	3.00 b	10.00 c	27.00 b	3.00 c	10.00 c
BARI Mung-4	28.00 a	2.00 bc	6.67 c	27.33 ab	2.67 bc	8.90 d	27.33 ab	2.67 d	8.90 d
BARI Mung-5	28.33 a	1.67 bc	5.57 d	27.67 a	2.33 c	7.77 e	27.67 a	2.33 e	7.77 e
BARI Mung-6	28.33 a	1.33 c	4.48 e	28.00 a	2.00 c	6.67 f	28.33 a	2.33 e	7.60 e
$LSD_{(0.05)}$	0.892	0.562	0.943	0.615	0.351	1.012	1.121	0.281	1.003
Level of significance	0.05	0.01	0.01	0.05	0.01	0.01	0.05	0.01	0.01
CV(%)	7.11	4.17	5.46	6.33	5.48	7.03	8.13	3.78	5.64

In a column, numeric data represents the mean value of 3 replications; each replication is derived from $1m^2$ selected areas as 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

(2.33) by BARI Mung-2 and BARI Mung-3 and they were statistically similar. The lowest infestation (4.48%) was attained in BARI Mung-6 which was followed (5.57%) by BARI Mung-5, whereas the highest infestation (10.00%) was recorded in BARI Mung-1 which was closely followed (7.77%) by BARI Mung-2 and BARI Mung-3.

4.2.2.2 At mid stage

At mid flowering stage, the highest number of healthy plants/m^2 (28.00) was recorded in BARI Mung-6 which was statistically similar (27.67 and 27.33) to BARI Mung-5 and BARI Mung-4, whereas the lowest number of healthy plants/m^2 (26.33) was found in BARI Mung-1 which was statistically similar (26.67 and 27.00) to BARI Mung-2 and BARI Mung-3 and they were statistically similar (Table 3). The lowest number of infested plant/m^2 (2.00) was recorded in BARI Mung-6 which was statistically similar (2.33 and 2.67) to BARI Mung-5 and BARI Mung-4, whereas the highest number (3.67) was observed in BARI Mung-1 which was statistically similar (3.33) to BARI Mung-2 and followed (3.00) by BARI Mung-3. The lowest infestation (6.67%) was attained in BARI Mung-6 which was followed (7.77%) by BARI Mung-5, whereas the highest infestation (12.23%) was recorded in BARI Mung-1 which was followed (11.10%) by BARI Mung-2.

4.2.2.3 At late stage

At late flowering stage, the highest number of healthy plants/m^2 (28.33) was recorded in BARI Mung-6 which was statistically similar (27.67 and 27.33) with BARI Mung-5 and BARI Mung-4, while the lowest number of healthy plants/m^2 (26.33) was found in BARI Mung-1 which was statistically similar (26.67) to BARI Mung-2 (Table 3). The lowest number of infested plant/m^2 (2.33) was recorded in BARI Mung-6 and BARI Mung-5, whereas the highest number (3.67) was observed in BARI Mung-1 which was closely followed (3.33) by BARI Mung-2. The lowest infestation (7.60%) was attained in BARI Mung-6 which was statistically similar (7.77%) by BARI Mung-5, whereas the highest infestation (12.23%) was recorded in BARI Mung-1 and closely followed (11.10%) by BARI Mung-2.

4.2.3 Pod infestation at fruiting stage by whitefly

Number of healthy pods, infested pods and per cent infestation of pod by whitefly showed statistically significant differences at early, mid and late fruiting stage due to different mungbean varieties (Table 4).

4.2.3.1 At early stage

At early fruiting stage, the highest number of healthy pods/m^2 (34.73) was recorded in BARI Mung-6 which was closely followed (32.63 and 32.10) by BARI Mung-5 and BARI Mung-4 and they were statistically similar, whereas the lowest number of healthy pods/m^2 (24.53) was found in BARI Mung-1 which was followed (27.73) by BARI Mung-2 (Table 4). The lowest number of infested pod/m^2 (1.17) was recorded in BARI Mung-6 which was statistically similar (1.20) to BARI Mung-5, while the highest number (2.53) was observed in BARI Mung-1 which was closely followed (2.17, 2.00 and 1.83) by BARI Mung-2, BARI Mung-3 and BARI Mung-4 and they were statistically similar. The lowest infestation (3.26%) was found in BARI Mung-6 which was statistically similar (3.55%) by BARI Mung-5, whereas the highest infestation (9.35%) was recorded in BARI Mung-1 which was closely followed (7.26%) by BARI Mung-2.

4.2.3.2 At mid stage

At mid fruiting stage, the highest number of healthy pods/m^2 (36.43) was recorded in BARI Mung-6 which was statistically similar (36.33 and 35.30) to BARI Mung-5 and BARI Mung-4, whereas the lowest number of healthy pods/m^2 (31.63) was found in BARI Mung-1 which was closely followed (33.77) by BARI Mung-2 (Table 4). The lowest number of infested pod/m^2 (1.73) was recorded in BARI Mung-6 which was statistically similar (1.83) to BARI Mung-5, whereas the highest number (3.53) was observed in BARI Mung-1 which was followed (2.97 and 2.17) by BARI Mung-2 and BARI

Table 4. Pod infestation by white fly at early, mid and late fruiting stages due to different mungbean varieties

Treatments	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)	Healthy pods (No.)	Infested pods (No.)	% pod infestation	Healthy pods (No.)	Infested pods (No.)	% pod infestation
BARI Mung-1	24.53 e	2.53 a	9.35 a	31.63 d	3.53 a	10.04 a	28.63 e	3.53 a	10.98 a
BARI Mung-2	27.73 d	2.17 b	7.26 b	33.77 c	2.97 b	8.08 b	30.73 d	2.63 b	7.88 b
BARI Mung-3	31.43 c	2.00 b	5.98 c	34.20 b	2.17 bc	5.97 c	32.47 c	2.10 c	6.07 c
BARI Mung-4	32.10 b	1.83 b	5.39 c	35.30 ab	1.97 c	5.29 c	34.50 b	1.43 d	3.98 d
BARI Mung-5	32.63 b	1.20 c	3.55 d	36.33 a	1.83 cd	4.80 cd	34.57 b	1.53 d	4.24 d
BARI Mung-6	34.73 a	1.17 c	3.26 d	36.43 a	1.73 d	4.53 d	35.87 a	1.20 e	3.24 e
$LSD_{(0.05)}$	1.451	0.342	0.856	1.241	0.214	1.045	1.217	0.242	0.341
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.09	4.89	5.34	6.76	4.45	6.22	7.15	5.55	7.05

In a column, numeric data represents the mean value of 3 replications; each replication is derived from $1m^2$ selected areas as 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

Mung-3. The lowest infestation (4.53%) was attained in BARI Mung-6 which was statistically similar (4.80%) by BARI Mung-5, whereas the highest infestation (10.04%) was recorded in BARI Mung-1 which was followed (8.08%) by BARI Mung-2.

4.2.3.3 At late stage

At late fruiting stage, the highest number of healthy pods/m^2 (35.87) was recorded in BARI Mung-6 which was followed (34.57 and 34.50) with BARI Mung-5 and BARI Mung-4, while the lowest number of healthy pods/m^2 (28.63) was found in BARI Mung-1 which was followed (30.73) by BARI Mung-2 (Table 4). The lowest number of infested pod/m^2 (1.20) was recorded in BARI Mung-6 which was closely followed (1.43 and 1.53) by BARI Mung-4 and BARI Mung-5, while the highest number (3.53) was observed in BARI Mung-1 which was closely followed (2.63) by BARI Mung-2. The lowest infestation (3.24%) was observed in BARI Mung-6 which was followed (4.24%) by BARI Mung-5, while the highest infestation (10.98%) was recorded in BARI Mung-1 and closely followed (7.88%) by BARI Mung-2.

4.3 Aphid population

Number of aphid population per plant at early, mid and late vegetative, flowering and fruiting stage showed statistically significant differences due to different mungbean varieties (Table 5).

4.3.1 At vegetative stage

At early vegetative stage, the lowest number of aphid per plant (2.63) were recorded in BARI Mung-6 which followed (3.03) by BARI Mung-4, whereas the highest number of aphid (4.37) was recorded from BARI Mung-1 which was statistically similar (4.33 and 4.17) to BARI Mung-2 and BARI Mung-3 (Table 5). At mid vegetative stage, the lowest number of aphid per plant (5.43) were found from BARI Mung-6 which was followed (7.43) by BARI Mung-5, while the highest number of aphid (12.31) was found from BARI Mung-1 which was closely followed (11.46) by BARI Mung-2. At late vegetative stage, the lowest

Table 5. Aphid populations per plant at early, mid and late vegetative, flowering and fruiting stages due to different mungbean varieties

Treatments	Number of aphids/plant at the stages of								
	Vegetative			Flowering			Fruiting		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
BARI Mung-1	4.37 a	12.31 a	7. 26 a	3.67 a	3.77 a	4.47 a	4.83 a	4.27 a	3.07 a
BARI Mung-2	4.33 a	11.46 b	7.73 a	3.17 b	3.63 a	4.37 a	4.77 a	3.90 a	2.37 b
BARI Mung-3	4.17 a	10.45 c	6.45 b	2.97 b	3.67 a	4.00 b	4.67 a	3.80 a	2.43 b
BARI Mung-4	3.03 c	8.98 d	5.96 b	2.87 b	3.33 bc	3.77 c	3.87 b	3.27 b	2.37 b
BARI Mung-5	3.70 b	7.43 e	5.12 c	2.93 b	3.20 bc	3.07 d	4.40 ab	3.60 ab	2.17 c
BARI Mung-6	2.63 d	5.43 f	5.72 b	2.23 c	3.00 c	3.00 d	3.73 b	3.27 b	2.10 c
$LSD_{(0.05)}$	0.341	0.741	0.541	0.455	0.281	0.246	0.362	0.474	0.196
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	4.24	7.91	5.61	6.23	3.41	5.04	4.38	6.00	4.22

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 10 selected 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

number of aphid per plant (5.72) were found from BARI Mung-6 which was followed (5.12) by BARI Mung-5, whereas the highest number of aphid (7.26) was recorded from BARI Mung-1 which was statistically similar (7.73) to BARI Mung-2 and closely followed (6.45 and 5.96) by BARI Mung-3 and BARI Mung-4. Hossain *et al.* (2004) reported than twelve species of insect pests were found to infest mungbean in Bangladesh, aphid and whitefly, thrips and pod borers are important.

4.3.2 At flowering stage

At early flowering stage, the lowest number of aphid per plant (2.23) were found from BARI Mung-6 which was closely followed (2.87 and 2.93) by BARI Mung-4 and BARI Mung-5 and they were statistically similar, whereas the highest number of aphid (3.63) was recorded from BARI Mung-1 which was followed by other variety except BARI Mung-6 (Table 5). At mid flowering stage, the lowest number of aphid per plant (3.00) were found from BARI Mung-6 which was statistically similar (3.20 and 3.33) to BARI Mung-4 and BARI Mung-5, whereas the highest number of aphid (3.77) from BARI Mung-1 which was statistically similar (3.63 and 3.67) to BARI Mung-2 and BARI Mung-3. At late flowering stage, the lowest number of aphid per plant (3.00) were found from BARI Mung-6 which was statistically similar (3.07) by BARI Mung-5, whereas the highest number (4.47) from BARI Mung-1 which was statistically similar (4.37) to BARI Mung-2 and closely followed (4.00) by BARI Mung-3.

4.3.3 At fruiting stage

At early fruiting stage, the lowest number of aphid per plant (3.73) were recorded in BARI Mung-6 which was statistically similar (3.87) to BARI Mung-4 and, while the highest number of aphid (4.83) was recorded from BARI Mung-1 which was statistically similar (4.77, 4.67 and 4.40) to BARI Mung-2, BARI Mung-3 and BARI Mung-5 (Table 5). At mid fruiting stage, the lowest number of aphid per plant (3.27) were found from BARI Mung-6 which was statistically similar (3.27) to BARI Mung-4, while the highest number of aphid (4.27) in BARI Mung-1 which was statistically similar (3.90, 3.80 and 3.60) by BARI Mung-2, BARI Mung-3 and BARI Mung-5. At late fruiting stage, the lowest number of aphid per plant (2.10) were found from BARI Mung-6 which was statistically similar (2.17) by BARI Mung-5, whereas the highest number of aphid (3.07) was recorded from BARI Mung-1 which was followed (2.43 and 2.37) by BARI Mung-3, BARI Mung-2 and BARI Mung-4 and they were statistically similar.

4.4 Aphid infested mungbean plant and pods

4.4.1 Plant infestation at vegetative stage by aphid

Number of healthy plants, infested plants and per cent infestation of plant by aphid showed statistically significant differences at early, mid and late vegetative stage for different mungbean varieties (Table 6).

4.4.1.1 At early stage

At early vegetative stage, the highest number of healthy plants/m^2 (29.33) was observed in BARI Mung-6 which was statistically similar with other varieties except BARI Mung-1 and BARI Mung-2, whereas the lowest number of healthy plants/m^2 (28.00) was found in BARI Mung-1 which was statistically similar (28.33) to BARI Mung-2 (Table 6). The lowest number of infested plant/m^2 (0.67) was recorded in BARI Mung-6 which was followed (1.33) by BARI Mung-5, while the highest number (2.33) was found in BARI Mung-1 which was followed (2.00) by BARI Mung-2. The lowest infestation (2.23%) was attained in BARI Mung-6 which was followed (3.30%) by BARI Mung-4, whereas the highest infestation (7.68%) was recorded in BARI Mung-1 which was followed (6.59%) by BARI Mung-2. Hossain *et al.* (2009) reported that the incidence and population fluctuation of various insect pests was very much dependent on the prevailed climatic conditions of the cropping season as well as crop genotypes.

Table 6. Plant infestation by aphid at early, mid and late vegetative stages due to different mungbean varieties

Treatments	Early vegetative stage			Mid vegetative stage			Late vegetative stage		
	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)
BARI Mung-1	28.00 b	2.33 a	7.68 a	27.33 b	3.33 a	10.86 a	27.00 b	3.67 a	11.97 a
BARI Mung-2	28.33 b	2.00 b	6.59 b	27.67 b	2.67 b	8.80 b	27.00 b	3.00 b	10.00 b
BARI Mung-3	28.67 ab	1.67 c	5.50 c	28.00 ab	2.33 c	7.68 c	27.67 ab	2.67 c	8.80 c
BARI Mung-4	29.33 a	1.00 e	3.30 e	28.33 a	1.67 d	5.57 d	28.00 a	2.33 d	7.68 d
BARI Mung-5	29.00 a	1.33 d	4.39 d	28.67 a	1.33 e	4.43 e	28.33 a	2.00 e	6.59 e
BARI Mung-6	29.33 a	0.67 f	2.23 f	29.00 a	1.00 f	3.33 f	28.67 a	1.67 f	5.50 f
$LSD_{(0.05)}$	0.512	0.263	0.693	0.363	0.271	0.962	0.793	0.254	0.803
Level of significance	0.05	0.01	0.01	0.05	0.01	0.01	0.05	0.01	0.01
CV(%)	5.03	3.75	6.34	4.88	6.06	4.09	6.89	3.95	6.11

In a column, numeric data represents the mean value of 3 replications; each replication is derived from $1m^2$ selected areas as 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

4.4.1.2 At mid stage

At mid vegetative stage, the highest number of healthy plants/plot (29.00) was recorded in BARI Mung-6 which was statistically similar with other variety except BARI Mung-1 and BARI Mung-2, whereas the lowest number of healthy plants/m^2 (27.33) was found in BARI Mung-1 which was statistically similar (27.67) to BARI Mung-2 (Table 6). The lowest number of infested plant/m^2 (1.00) was recorded in BARI Mung-6 which was closely followed (1.33) by BARI Mung-5, whereas the highest number (3.33) was observed in BARI Mung-1 which was followed (2.67) by BARI Mung-2. The lowest infestation (3.33%) was attained in BARI Mung-6 which was followed (4.43%) by BARI Mung-5, whereas the highest infestation (10.86%) was recorded in BARI Mung-1 which was closely followed (8.80%) by BARI Mung-2.

4.4.1.3 At late stage

At late vegetative stage, the highest number of healthy plants/m^2 (28.67) was recorded in BARI Mung-6 which was statistically similar with other varieties except BARI Mung-1 and BARI Mung-2, while the lowest number of healthy plants/m^2 (27.00) was found in BARI Mung-1 and BARI Mung-2 (Table 6). The lowest number of infested plant/m^2 (1.67) was recorded in BARI Mung-6 which was followed (2.00) by BARI Mung-5, whereas the highest number (3.67) was observed in BARI Mung-1 which was followed (3.00) by BARI Mung-2. The lowest infestation (5.50%) was attained in BARI Mung-6 which was followed (6.59%) by BARI Mung-5, while the highest infestation (11.97%) was recorded in BARI Mung-1 which was followed (10.00%) by BARI Mung-2. Pal (1996) stated that the most important insects observed in the field, in order of their intensity, were caterpillar, white fly, and pod borer. The farmers' perception of losses due to insect infestation matched with higher pesticide use on modern varieties. The perceived losses due to disease were found to be minimal at about 4-6%, depending upon variety.

4.4.2 Plant infestation at flowering stage by aphid

Number of healthy plants, infested plants and per cent infestation of plant by aphid showed statistically significant differences at early, mid and late flowering stage for different mungbean varieties (Table 7).

4.4.2.1 At early stage

At early flowering stage, the highest number of healthy plants/m^2 (28.33) was recorded in BARI Mung-6 and BARI Mung-5 which was statistically similar with other varieties except BARI Mung-1, while the lowest number of healthy plants/m^2 (27.00) was found in BARI Mung-1 (Table 7). The lowest number of infested plant/m^2 (1.67) was recorded in BARI Mung-6 which was statistically similar (2.00) to BARI Mung-5, while the highest number (3.67) was found in BARI Mung-1 which was closely followed (2.67 and 2.33) by BARI Mung-2 and BARI Mung-3 and they were statistically similar. The lowest infestation (5.57%) was attained in BARI Mung-6 which was followed (6.59%) by BARI Mung-5, whereas the highest infestation (11.97%) was recorded in BARI Mung-1 which was closely followed (8.80%) by BARI Mung-2.

4.4.2.2 At mid stage

At mid flowering stage, the highest number of healthy plants/m^2 (28.00) was recorded in BARI Mung-6 which was statistically similar with other mungbean variety except BARI Mung-1 and BARI Mung-2, while the lowest number of healthy plants/m^2 (26.33) was found in BARI Mung-1 which was statistically similar (26.67 and 27.00) to BARI Mung-2 and BARI Mung-3 and they were statistically similar (Table 7). The lowest number of infested plant/m^2 (2.00) was recorded in BARI Mung-6 which was statistically similar (2.67) to BARI Mung-4 and BARI Mung-5, whereas the highest number (4.33) was observed in BARI Mung-1 which was followed (3.67) by BARI Mung-2. The lowest infestation (6.67%) was attained in BARI Mung-6 which was followed (8.80 and 8.90%) by BARI Mung-5 and BARI Mung-4, whereas the highest infestation (14.12%) was recorded in BARI Mung-1 which was followed (12.10%) by BARI Mung-2.

Table 7. Plant infestation by aphid at early, mid and late flowering stages due to different mungbean varieties

Treatments	Early flowering stage			Mid flowering stage			Late flowering stage		
	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)	Healthy plants (No.)	Infested plants (No.)	Plant infestation (%)
BARI Mung-1	27.00 b	3.67 a	11.97 a	26.33 b	4.33 a	14.12 a	26.33 b	4.67 a	15.06 a
BARI Mung-2	27.67 ab	2.67 b	8.80 b	26.67 b	3.67 b	12.10 b	26.67 b	3.67 b	12.10 b
BARI Mung-3	27.67 ab	2.33 b	7.77 c	27.00 ab	3.33 c	10.98 c	27.00 ab	3.33 b	10.98 c
BARI Mung-4	28.00 a	2.33 b	7.68 c	27.33 a	2.67 d	8.90 d	27.33 a	2.67 c	8.90 d
BARI Mung-5	28.33 a	2.00 bc	6.59 d	27.67 a	2.67 d	8.80 d	27.67 a	2.33 cd	7.77 e
BARI Mung-6	28.33 a	1.67 c	5.57 e	28.00 a	2.00 e	6.67 e	27.67 a	2.00 d	6.74 f
$LSD_{(0.05)}$	0.682	0.382	0.894	0.672	0.312	1.134	0.678	0.372	0.896
Level of significance	0.05	0.01	0.01	0.05	0.01	0.01	0.05	0.01	0.01
CV(%)	7.04	5.47	6.35	4.88	6.24	5.98	5.89	4.56	6.22

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 1m^2 selected areas as 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

4.4.2.3 At late stage

At late flowering stage, the highest number of healthy plants/plot (27.67) was recorded in BARI Mung-6 which was statistically similar with other variety except BARI Mung-1 and BARI Mung-2, while the lowest number of healthy plants/m^2 (26.33) was found in BARI Mung-1 which was statistically similar (26.67) to BARI Mung-2 (Table 7). The lowest number of infested plant/m^2 (2.00) was recorded in BARI Mung-6, whereas the highest number (4.67) was observed in BARI Mung-1 which was closely followed (3.67 and 3.33) by BARI Mung-2 and BARI Mung-3. The lowest infestation (6.74%) was found in BARI Mung-6 which was followed (7.77%) by BARI Mung-5, whereas the highest infestation (15.06%) was recorded in BARI Mung-1 and closely followed (12.10%) by BARI Mung-2.

4.4.3 Pod infestation at fruiting stage by aphid

Number of healthy pods, infested pods and per cent infestation of pod by aphid showed statistically significant differences at early, mid and late fruiting stage due to different mungbean varieties (Table 8).

4.4.3.1 At early stage

At early fruiting stage, the highest number of healthy pods/plot (34.73) was recorded in BARI Mung-6 which was closely followed (32.63 and 32.10) by BARI Mung-5 and BARI Mung-4 and they were statistically similar, whereas the lowest number of healthy pods/m^2 (24.53) was found in BARI Mung-1 which was followed (27.73) by BARI Mung-2 (Table 8). The lowest number of infested pod/m^2 (1.13) was recorded in BARI Mung-6 which was followed (1.43) by BARI Mung-5, while the highest number (2.73) was found in BARI Mung-1 which was closely followed (2.47) by BARI Mung-2. The lowest infestation (3.15%) was found in BARI Mung-6 which was followed (4.20%) by BARI Mung-5, whereas the highest infestation (10.01%) in BARI Mung-1 which was closely followed (8.18%) by BARI Mung-2. Pal (1996) stated that the most important insects observed in order of their intensity were pod borer.

Table 8. Pod infestation by aphid at early, mid and late fruiting stages due to different mungbean varieties

Treatments	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)	Healthy pods (No.)	Infested pods (No.)	Pod infestation (%)
BARI Mung-1	24.53 e	2.73 a	10.01 a	31.63 d	2.97 a	8.58 a	28.63 e	3.77 a	11.64 a
BARI Mung-2	27.73 d	2.47 b	8.18 b	33.77 c	2.83 a	7.73 b	30.73 d	2.97 b	8.81 b
BARI Mung-3	31.43 c	2.13 c	6.35 c	34.20 b	2.63 a	7.14 b	32.47 c	2.43 c	6.96 c
BARI Mung-4	32.10 b	1.97 c	5.78 d	35.30 ab	1.97 b	5.29 c	34.50 b	2.13 d	5.81 d
BARI Mung-5	32.63 b	1.43 d	4.20 e	36.33 a	1.97 b	5.14 c	34.57 b	2.00 d	5.47 d
BARI Mung-6	34.73 a	1.13 e	3.15 f	36.43 a	1.77 b	4.63 d	35.87 a	1.77 e	4.70 e
$LSD_{(0.05)}$	1.451	0.263	0.794	1.241	0.481	0.304	1.217	0.254	0.782
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.09	4.10	6.13	6.76	5.34	6.22	7.15	3.69	6.02

In a column, numeric data represents the mean value of 3 replications; each replication is derived from $1m^2$ selected areas as 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

4.4.3.2 At mid stage

At mid fruiting stage, the highest number of healthy pods/m^2 (36.43) was recorded in BARI Mung-6 which was statistically similar (36.33 and 35.30) to BARI Mung-5 and BARI Mung-4, whereas the lowest number of healthy pods/m^2 (31.63) was found in BARI Mung-1 which was closely followed (33.77) by BARI Mung-2 (Table 8). The lowest number of infested pod/m^2 (1.77) was recorded in BARI Mung-6 which was statistically similar (1.97) to BARI Mung-5 and BARI Mung-4, whereas the highest number (2.97) was observed in BARI Mung-1 which statistically similar (2.83 and 2.63) by BARI Mung-2 and BARI Mung-3. The lowest infestation (4.63%) was attained in BARI Mung-6 which was statistically similar (5.14 and 5.29%) by BARI Mung-5 and BARI Mung-4, while the highest infestation (8.58%) was recorded in BARI Mung-1 which was followed (7.73%) by BARI Mung-2.

4.4.3.3 At late stage

At late fruiting stage, the highest number of healthy pods/m^2 (35.87) was recorded in BARI Mung-6 which was followed (34.57 and 34.50) with BARI Mung-5 and BARI Mung-4, while the lowest number of healthy pods/m^2 (28.63) was found in BARI Mung-1 which was followed (30.73) by BARI Mung-2 (Table 8). The lowest number of infested pod/m^2 (1.77) was recorded in BARI Mung-6 which was closely followed (2.00 and 2.13) by BARI Mung-4 and BARI Mung-5, while the highest number (3.77) was observed in BARI Mung-1 which was closely followed (2.97) by BARI Mung-2. The lowest infestation (4.70%) was observed in BARI Mung-6 which was followed (5.47% and 5.81%) by BARI Mung-5 and BARI Mung-4, while the highest infestation (11.64%) was recorded in BARI Mung-1 and closely followed (8.81%) by BARI Mung-2. Pal (1996) stated that the most important insects observed in the field, in order of their intensity, were caterpillar, white fly, and pod borer. The farmers' perception of losses due to insect infestation matched with higher pesticide use on modern varieties. The perceived losses due to disease were found to be minimal at about 4-6%, depending upon variety.

4.5 Yield attributes and yield of mungbean

Different yield attributes and yield of mungbean showed statistically significant differences due to different varieties (Table 9).

4.5.1 Number of pods/plant

The highest number of pods/plant (35.53) was recorded in BARI Mung-6 which was followed (33.53) by BARI Mung-5, whereas the lowest number (32.00) was recorded in BARI Mung-1 which was followed (33.60 and 33.87) by BARI Mung-3 and BARI Mung-2 and they were statistically similar (Table 9). Nadeem *et al.* (2014) reported that genotypes of mungbean which showed the highest resistance against the sucking pests and tied with high number of pods/plant as well as highest grain yield could be used for direct release as variety or may be used in cross breeding program to get improved resistant germplasm against sucking insects.

4.5.2 Pod length

The longest pod (8.48 cm) was recorded in BARI Mung-6 which was statistically similar (8.46 cm) to BARI Mung-5, while the shortest pod (7.73 cm) was recorded in BARI Mung-1 which was closely followed (7.85 cm and 7.90 cm) by BARI Mung-3 and BARI Mung-2 and they were statistically similar (Table 9).

4.5.3 Number of seeds/pod

The highest number of seeds/pod (11.30) was recorded in BARI Mung-6 which was followed (10.83) by BARI Mung-2 and BARI Mung-5, while the lowest number (10.07) was recorded in BARI Mung-4 which was followed (10.23) by BARI Mung-1 (Table 9). Islam *et al*. (2006) reported that Binamoog-5 performed better than that of Binamoog 2 and Binamoog 4 in terms of yield contributing characters.

Table 9. Yield and yield contributing characters of different mungbean varieties

Treatments	Number of pods/plant	Pod length (cm)	Number of seeds/ pod	Weight of 1000 seeds (g)	Seed yield (t/ha)
BARI Mung-1	32.00 c	7.73 c	10.23 c	35.50 e	1.50 b
BARI Mung-2	33.87 b	7.90 bc	10.83 b	40.53 b	1.67 ab
BARI Mung-3	33.60 b	7.85 bc	10.50 bc	39.78 c	1.61 b
BARI Mung-4	29.33 d	7.42 c	10.07 cd	37.41 d	1.30 c
BARI Mung-5	33.53 b	8.46 a	10.83 b	40.78 ab	1.75 a
BARI Mung-6	35.53 a	8.48 a	11.30 a	41.10 a	1.82 a
$LSD_{(0.05)}$	1.421	0.352	0.402	0.386	0.124
Level of significance	0.05	0.05	0.05	0.01	0.01
CV(%)	5.44	6.03	4.22	4.89	5.04

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

4.5.4 Weight of 1000-seeds

The highest weight of 1000-seeds (41.10 g) was recorded in BARI Mung-6 which similar (40.78 g) by BARI Mung-5, whereas the lowest weight (35.50 g) was recorded in BARI Mung-1 which was followed (37.41 g) by BARI Mung-4 (Table 9). Shamsuzzaman *et al*. (2004) reported that BINA moog 2 performed slightly better than BINA moog 5 for most of the growth and yield parameters.

4.5.5 Seed yield per hectare

The highest seed yield (1.82 t/ha) was recorded in BARI Mung-6 which was similar (1.75 t/ha and 1.67 t/ha) to BARI Mung-5 and BARI Mung-2, while the lowest yield per hectare (1.30 t/ha) was recorded in BARI Mung-4 which was followed (1.50 t/ha and 1.61 t/ha) by BARI Mung-1 and BARI Mung-3 and they were statistically similar (Table 9). Nadeem *et al.* (2014) earlier reported that genotypes which showed the highest resistance against the sucking pests and tied with highest grain yield could be used for direct release as variety or may be used in cross breeding program to get improved resistant germplasm against sucking insects.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from March to June, 2016for varietal screening of mungbean against whitefly and aphid. Different mungbean varieties i.e. BARI Mung-1, BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and BARI Mung-6 were tested. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different parameters were recoded and statistically analysed.

In case of whitefly population, at early vegetative stage, the lowest number of whitefly per plant (0.63) were observed from BARI Mung-6, while the highest number of whitefly (2.73) was recorded from BARI Mung-1. At mid vegetative stage, the lowest number of whitefly per plant (6.43) were found from BARI Mung-6, whereas the highest number of whitefly (12.13) was recorded from BARI Mung-1. At late vegetative stage, the lowest number of whitefly per plant (3.72) were found from BARI Mung-6, while the highest number of whitefly (7.60) was recorded from BARI Mung-1. At early flowering stage, the lowest number of whitefly per plant (2.60) were found from BARI Mung-6, whereas the highest number of whitefly (5.23) was recorded from BARI Mung-1. At mid flowering stage, the lowest number of whitefly per plant (2.20) were found from BARI Mung-6, whereas the highest number of whitefly (4.90) from BARI Mung-1. At late flowering stage, the lowest number of whitefly per plant (1.77) were found from BARI Mung-6, while the highest number (4.43) from BARI Mung-1. At early fruiting stage, the lowest number of whitefly per plant (2.00) were recorded in BARI Mung-6, while the highest number of whitefly (4.13) was recorded from BARI Mung-1. At mid fruiting stage, the lowest number of whitefly per plant (1.33) were found from BARI Mung-6, while the highest number of whitefly (3.90) in BARI Mung-1 At late fruiting stage, the lowest number of whitefly per plant (0.63) were found from BARI Mung-6, whereas the highest number of whitefly (2.73) was recorded from BARI Mung-1.

In plant infestation at vegetative stage by whitefly, the lowest infestation (10.09%) was attained in BARI Mung-6, whereas the highest infestation (17.65%) was recorded in BARI Mung-1. At mid vegetative stage, the lowest infestation (11.76%) was attained in BARI Mung-6, whereas the highest infestation (19.62%) was recorded in BARI Mung-1. At late vegetative stage, the lowest infestation (13.12%) was attained in BARI Mung-6, whereas the highest infestation (20.59%) was recorded in BARI Mung-1 and BARI Mung-2.

At early flowering stage, the lowest infestation (4.48%) was attained in BARI Mung-6, whereas the highest infestation (10.00%) was recorded in BARI Mung-1. At mid flowering stage, the lowest infestation (6.67%) was attained in BARI Mung-6, whereas the highest infestation (12.23%) was recorded in BARI Mung-1. At late flowering stage, the lowest infestation (7.60%) was attained in BARI Mung-6, whereas the highest infestation (12.23%) was recorded in BARI Mung-1. At early fruiting stage, the lowest infestation (3.26%) was found in BARI Mung-6, whereas the highest infestation (9.35%) was recorded in BARI Mung-1. At mid fruiting stage, the lowest infestation (4.53%) was attained in BARI Mung-6 which, whereas the highest infestation (10.04%) was recorded in BARI Mung-1 At late fruiting stage, the lowest infestation (3.24%) was observed in BARI Mung-6, while the highest infestation (10.98%) was recorded in BARI Mung-1.

In case of aphid population, at early vegetative stage, the lowest number of aphid per plant (2.63) were recorded in BARI Mung-6, whereas the highest number of aphid (4.37) was recorded from BARI Mung-1. At mid vegetative stage, the lowest number of aphid per plant (5.43) were found from BARI Mung-6, while the highest number of aphid (12.31) was found from BARI Mung-1. At late vegetative stage, the lowest number of aphid per plant (5.72) were found from BARI Mung-6, whereas the highest number of aphid (7.26) was recorded from

BARI Mung-1. At early flowering stage, the lowest number of aphid per plant (2.23) were found from BARI Mung-6, whereas the highest number of aphid (3.63) was recorded from BARI Mung-1. At mid flowering stage, the lowest number of aphid per plant (3.00) were found from BARI Mung-6, whereas the highest number of aphid (3.77) from BARI Mung-1. At late flowering stage, the lowest number of aphid per plant (3.00) were found from BARI Mung-6, whereas the highest number (4.47) from BARI Mung-1. At early fruiting stage, the lowest number of aphid per plant (3.73) were recorded in BARI Mung-6, while the highest number of aphid (4.83) was recorded from BARI Mung-1. At mid fruiting stage, the lowest number of aphid per plant (3.27) were found from BARI Mung-6, while the highest number of aphid (4.27) in BARI Mung-1 At late fruiting stage, the lowest number of aphid per plant (2.10) were found from BARI Mung-6, whereas the highest number of aphid (3.07) was recorded from BARI Mung-1.

At early vegetative stage, the lowest infestation (2.23%) was attained in BARI Mung-6, whereas the highest infestation (7.68%) was recorded in BARI Mung-1. At mid vegetative stage, the lowest infestation (3.33%) was attained in BARI Mung-6, whereas the highest infestation (10.86%) was recorded in BARI Mung-1. At late vegetative stage, the lowest infestation (5.50%) was attained in BARI Mung-6, while the highest infestation (11.97%) was recorded in BARI Mung-1. At early flowering stage, the lowest infestation (5.57%) was attained in BARI Mung-6, whereas the highest infestation (11.97%) was recorded in BARI Mung-1. At mid flowering stage, the lowest infestation (6.67%) was attained in BARI Mung-6 which was followed (8.80 and 8.90%) by BARI Mung-5 and BARI Mung-4, whereas the highest infestation (14.12%) was recorded in BARI Mung-1. At late flowering stage, lowest infestation (6.74%) was found in BARI Mung-6, whereas the highest infestation (15.06%) was recorded in BARI Mung-1.

At early fruiting stage, the lowest infestation (3.15%) was found in BARI Mung-6, whereas the highest infestation (10.01%) was recorded in BARI Mung-1. At mid fruiting stage, the highest number of healthy pods/m^2 (36.43) was recorded in BARI Mung-6, whereas the lowest infestation (4.63%) was attained in BARI Mung-6, while the highest infestation (8.58%) was recorded in BARI Mung-1. At late fruiting stage, the lowest infestation (4.70%) was observed in BARI Mung-6, while the highest infestation (11.64%) was recorded in BARI Mung-1.

The longest plant (49.59 cm) was recorded in BARI Mung-6, while the shortest plant (40.82 cm) was recorded in BARI Mung-1. The highest number of pods/plant (35.53) was recorded in BARI Mung-6, whereas the lowest number (32.00) was recorded in BARI Mung-1. The longest pod (8.48 cm) was recorded in BARI Mung-6, while the shortest pod (7.73 cm) was recorded in BARI Mung-1. The highest number of seeds/pod (11.30) was recorded in BARI Mung-6, while the lowest number (10.07) was recorded in BARI Mung-4. The highest weight of 1000-seeds (41.10 g) was recorded in BARI Mung-6, whereas the lowest weight (35.50 g) was recorded in BARI Mung-1. The highest seed yield (1.82 t/ha) was recorded in BARI Mung-6, while the lowest yield per hectare (1.30 t/ha) was recorded in BARI Mung-4.

Among the mungbean varieties BARI Mung-6 were superior in terms of lowest whitefly and aphid infestation and also highest yield.

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APPENDICES

Appendix I. Characteristics of the soil of experimental field

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.7
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 average air temperature, relative humidity and total rainfall of the experimental site during the period from March to June, 2016

Month (2016)	*Air temperature (^{o}C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
March	31.7	19.5	65	25
April	33.4	23.2	67	78
May	34.7	25.9	70	185
June	35.4	22.5	80	277

* Monthly average

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