MANAGEMENT OF WHITEFLY AND THRIPS IN MUNGBEAN WITH SOME SELECTED INSECTICIDES

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CERTIFICATE

This is to certify that thesis entitled, "MANAGEMENT OF WHITEFLY AND THRIPS IN MUNGBEAN WITH SOME SELECTED INSECTICIDES" 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 (M.S.) IN ENTOMOLOGY****, embodies the result of a piece of bona fide research work carried out by Md. Shah Alam, Registration No.:* ***08-03127*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2014
Place: Dhaka, Bangladesh

(Dr. Mohammed Ali)
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Dedicated to

My

Honourable Teachers

LIST OF ABBREVIATIONS

%	: Percentage
^0C	: Degree Celcius
BARI	: Bangladesh Agricultural Research Institute
BBS	: Bangladesh Bureau of Statistics
BRRI	: Bangladesh Rice Research Institute
CRD	: Completely Randomized Design
cv.	: Cultivar
DMRT	: Duncans Multiple Range Test
e.g.	: Exempli gratia (by way of example)
et al	: And others
FAO	: Food and Agriculture Organization
Fig.	: Figure
g	: Gram
GA3	: Gibberellic acid
HCl	: Hydrochloric acid
$HgCl_2$	: Mercuric Chloride
i.e.	: ed est (means That is)
IRRI	: International Rice Research Institute
mgL^{-1}	: Milligram per litre
pH	: Negative logarithm of hydrogen ion
RARS	: Regional Agricultural Research Station
spp.	: Species (plural number)
var.	: Variety
Viz.	: Namely
µM	: Micro mol

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SAU, Dhaka ***The Author***

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ABSTRACT

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period of March to May, 2014 to study the whitefly and thrips incidence in mungbean and their management. BARI Mung-5 was used as the test crop of this experiment. The experiment consists of the following treatments: T_1: Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2: Casper 5SG (Emamectin Benzoate) @ 2gm/L of water at 10 days interval; T_3: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4: Tapnor 40EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval; T_5: Allion 2.5EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6: Admire 200SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval and T_7: Control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The lowest number of whitefly infestation per plant at vegetative (4.18) and reproductive stage (2.13) was recorded from T_6 while the highest number of whitefly infestation per plant at vegetative (14.44) and reproductive (8.10) stage was recorded from T_7 (Control) treatment. The lowest number of thrips infestation per 10 flower (1.88) was recorded from T_6, while the highest number of thrips infestation per 10 flower (6.32) was recorded from T_7 (control) treatment. The highest yield per hectare (1.53 ton) in T_6 and highest benefit cost ratio (12.81) was found in T_3 treatment, while the lowest yield per hectare (1.27 ton) in T_7 (Control) and lowest benefit cost ratio (4.16) in T_5 treatment. Admire 200SL (Imidacloprid) was the best effective among the management practices for controlling whitefly and thrips of mungbean which was followed by Voliam Flexi (Thiamethoxam + Chlorantraniliprole).

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiate L.* Wilczek) belonging to the family Fabaceae (Leguminosae) and sub-family Papilionaceae is one of the most important pulse crops in tropical and sub-tropical regions. The area under pulse crops in Bangladesh is 0.406 million hectares with a production of 0.322 million tons where mungbean is cultivated in the area of 0.108 million hectares with production of 0.03 million tons (BBS, 2010). It is considered as a quality pulse in the country but production per unit area is very low (736 kg/ha) as compared to other countries of the world (BBS, 2006). Although, mungbean plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh but the acreage production of mungbean is gradually declining (BBS, 2010). It ranks fifth both in acreage and production and contributes 6.5% of the total pulse production in Bangladesh (Anon., 1998). Mungbean is considered as a poor man's meat because it is a good source of protein (Mian, 1976). It contains 51% carbohydrate, 26% protein, 10% water, 4% minerals and 3% vitamins. It is a popular crop in Bangladesh not only as a food crop but also as a fodder crop. A number of agronomic practices have been found to influence the yield of pulse crops (Boztok, 1985). Management of insect pest is one of the most important practices among them.

Many insect pest species attack mungbean throughout the cropping period in a mungbean field and several species of insect pests may be feeding in a plant at the same time for that making it difficult to evaluate the economic importance of individual species. Several insect pests have been reported to infest mungbean and damage the seedlings, leaves, stems, flowers, buds, pods causing considerable losses (Sehgal and Ujagir, 1988; Husain, 1993; Karim and Rahman, 1991). The most damaging insect pests of mungbean recorded so far are stemfly (Rahman, 1987; Lal, 1985), jassid (Baldev, 1988; Chaudhary *et al.*, 1980), whitefly (Rahman *et al*., 1981; Srivastava and Singh, 1976), thrips (Rahman *et al*., 1981; Chhabra and Kooner, 1985), hairy caterpillar (Rahman *et al*., 1981) and pod borer (Nair, 1986; Rahman *et al*., 1981). Stemfly attack mainly the crop by feeding tender stems at seedling stage, although it may attack at any stage of the crop. In mungbean; up to 97% plants were found to be infested by stemfly (Rahman, 1991). Jassid infests the crop by sucking sap from leaves. With severe infestation the leaves turn brown, curl from the edges and dry leading to the common term for the damage, the hopper burn (Poehlman, 1991). Rahman (1988) reported 43.4% leaf infestation by jassids.

The whitefly causes damage to the plants by feeding on the leaf with stylets inserted into the leaf tissue. Whitefly reduces crop yield and act as a vector of viral pathogens (Kajita and Alam, 1996).

Thrips is associated mostly with the damage of tender buds and flowers of mungbean (Lal, 1985). Chhabra and Kooner (1985) have reported extensive damage to the summer mungbean due to flower shedding caused by thrips. Another insect pest of mungbean is the hairy caterpillar which feed on green portion of the leaf causing serious damage to the plant (Lal *et al*., 1980).

Management of mungbean insect pests, many options such as chemical, cultural, mechanical, biological etc. are available. Chemical control is generally being advocated for the management of insect pests of mungbean. Soil application of Furadan 3G @ 1.5 kg a.i. ha^{-1} just prior to sowing followed by foliar application of Azodrin 40EC @ 0.07% at 50% flowering protected the crop ensured higher yield (Rahman, 1988). Cypermethrin or Cymbush @ 0.008% applied at flowering and again at podding were effective against pod borer (Rahaman, 1989). Insecticide was also found effective against pod borer of pulses (Reed *et al*., 1989). In controlling stemfly, foliar sprays have been found to be more effective than granular forms of Carbofuran (Sreekanth *et al*., 2004). Studies have been found feasible to manage insect pests of mungbean through non-chemical methods such as use of botanicals (Jayaraj, 1988). Plant products were found to be effective against various pests (Rajasekaran and Kumaraswami, 1985). Generally the farmers of Bangladesh do not spray chemicals to control insect pest complex of mungbean due to its low profit margin. For this reason, several chemicals for different insect pests may not be acceptable to growers although, they are highly reluctant to follow pest control measure. The use of chemicals led to impose certain well-known undesirable side effects including environmental pollution, resurgence, upset, resistance to pesticides, and develop high pesticide residues. Under the above perspective for the effective control of mungbean pests the present study was undertaken to fulfill the following objectives:

1. To document the abundance and damage severity of whitefly and thrips.
2. To find out the relationship between incidence of whitefly and thrips with mungbean yield and
3. To find out the most suitable insecticide for the management of whitefly and thrips of mungbean.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

2.1 Insect pest incidence in mungbean

Pulses are two to three times richer in protein than cereal grains and have remained the least expensive source of protein for people since the dawn of civilization. In fact, until today, pulses provide the only high protein component of the average diet of the majority people of Bangladesh (Rahman *et al.*, 1988). Mungbean is one of the most promising pulse crops in Bangladesh and there are many constrains for its low yield such as varietal aspect, climatic factors, management practices, insect pests and diseases. Among them insect pests is considered the important one. Rahman *et al*. (1981) listed the following insect pests that attack mungbean-

Common name	**Scientific name**	**Order**
Whitefly	*Bemisia tabaci*	Homoptera
Thrips	*Megalurothrips distalis*	Thysanoptera
Bean stemfly	*Ophiomya phaseoli*	Diptera
Jassid	*Empoasca kerri*	Homoptera
Bean aphid	*Aphis craccivora*	Homoptera
Hairy caterpillar	*Spilarctia oblique*	Lepidoptera
Leaf webber	*Laprosoma indicate*	Lepidoptera
Leaf miner	*Acrocerphos phacospora*	Lepidoptera
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

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

2.1.1 Whitefly incidence in mungbean

The adult whitefly is a tiny soft bodied and pale yellow, change to white within a few hours due to deposition of wax on the body and wings (Haider, 1996). Eggs are laid indiscriminately almost always on the under surface of the young leaves (Hirano *et al*., 1993). Eggs are pear shaped and 0.2 mm long. One female can lay upto 136 eggs in its life time in mungbean (Baldev, 1988). The nymphs are pale, translucent white, oval, with convex dorsum and flat elongated ventral side.

The whitefly adults and nymphs feed on the plant sap from the underside of the leaves. They secrete honeydew, which later helps the growth of sooty mould fungus thus reducing the photosynthetic area. The infested plants became weakened due to sucking of the plant sap from the leaves and also due to the reduction of photosynthesis of the infested plant parts (Naresh and Nene, 1980). Young plant may even be killed in case of severe whitefly infestation in mungbean (Srivastava and Singh, 1986). 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.

2.1.2 Thrips incidence in mungbean

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

2.2 Management of sucking insect pests of mungbean

The available techniques for controlling insect pests are conveniently categorized in order of complexity as cultural, mechanical, physical, biological, chemical, genetic, regulatory and biotechnological methods. Among these techniques, chemical method and botanical is widely and frequently used. However, very limited research reports on the performance of chemical and botanical on the controlling of major insect pests of mungbean have been done in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect are reviewed under the following headings:

2.2.1 Mungbean sucking insect pest management by using chemical

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

Sunil and Singh (2010) were conducted a field experiment to management of yellow mosaic (Mungbean Yellow Mosaic Virus) and cercospora leaf spots (*Cercospora canescens* and *Pseudocercospora cruenta*) of mungbean. Insecticides and fungicides as seed dressings, with or without foliar sprays, were evaluated.

Amongst the treatments, a combination of seed treatment with thiamethoxam (Cruiser^{TM}) at 4 g /Land carbendazim (Bavistin^{TM}) TMTD (Thiram^{TM}) at 2.5g/L (1:1 ratio) followed by foliar applications of thiamethoxam (Actara^{TM}) 0.02% and carbendazim 0.05% at 21 and 35 d, respectively after sowing produced the highest seedling establishment, shoot and root lengths, number of pods, plant biomass, 1000-seed weight, and grain yield in mungbean with the lowest intensity of cercospora leaf spots and mungbean yellow mosaic. Vector (whitefly) populations were also the lowest in this treatment during all stages of the crop. This treatment was cost-effective, as it provided the highest return per Rupee of input.

Sucking insects not only reduce the vigor of the plant by sucking the sap but also transmit disease and affect the photosynthetic activity that is the main source of producing more number of pods plant^{-1} (Sethuraman *et al*., 2001). He also reported that the minimum 1000 seed weight (41.7 gm) was observed in case of plots where no pesticide was applied to control sucking insect pest complex.

Mustafa (2000) found that Mospilan, polo and confidor resulted almost 72.76% mortality of whitefly. They also investigated the increased susceptibility of whitefly to confidor. The finding of the study disagree the results of Latif *et al.* (2001) who underestimated the efficacy of Confider than Asmido. Mohan and Katiray (2000) stated that confidor was the most effective in suppressing the whitefly population and its continuous use resulted in increased whitefly population. They also showed better control of jassid by Confidor 200SL.

Ganapathy and Karuppiah (2004) recorded a reduction in whitefly population and incidence of MYMV in mungbean with the application of thiamethoxam either as a seed treatment or as a spray.

Lal (2008) reviews the studies of various insect pests infesting mungbean or green gram, *Vigna radiate* (L) Wilczeck, in India. A total 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 oblique* (WIK), galerucid beetle, *Madurasia obscurella* Jacoby, stemfly, *Ophiomyia (Melanagromyza) phaseoli* (Tryon), lycaenid borer, *Euchryso pscnezus* Fabr, and spotted caterpillar, *Maruca testulalis* Geyer, is included.

The sucking insects and can be controlled by spraying the following insecticides: Malathion 50EC (malathion) 950 ml or Rogor 30EC (dimethoate) 625 ml or Metasystox 25EC (oxydemeion methyl) 625 ml in 200 litres of Water. The vector of this disease is whitefly (*Bemisia tabaci).* It is a very devastating disease due to which leaves become pale yellow and even infected pods turn yellow and produce shriveled grains. Rogue out MYMV affected plains at early crop growth stage and bury them. Grow MYMV resistant varieties like SML 668 and ML 818. Follow control measures as given in insect pest control for whitefly (Sekhon *et al*., 2004).

Khattak *et al*. (2004) conducted an experiment at Agriculture Research Station, Kalurkot, Bhakkar to evaluate the efficacy of Mospilan 20SP, Actara 25WG, polo 500EC, Tamaron 60SI and confidor 200SL against whitefly, jassids, and thrips in mungbean. All the tested insecticides reduced the mean percent population of whiteflies even at 240 hours after spray. Similar trend of insecticides efficacy at 240 hours after spray. Similar trend of insecticides efficacy was also noticed against thrips, but Atari 25WG lost its efficacy at 240 hours after spray. Against jassids, Misplay 20SP, Polo 500EC, and Confider 200SL at 120 hours and 240 hours after spray were completely ineffective. Variation in the mean percent population of the test insects by insecticides, especially, a sudden drop in the efficacy of insecticides at 72 hours after spray almost against the tested insect pests could be because of the special temporary changes in the environmental conditions.

Rajnish *et al*. (2004) reported that whitefly population was higher in urdbean [*Vigna mungo*] than mungbean [*Vigna radiata*] crop season in Uttar Pradesh, India. Kharif season crop of mung and urdbean were more vulnerable to the attack of whitefly.

Peak population of whitefly in both the crops was recorded in first fortnight of May and second fortnight of September. Temperature and sunshine hours were favourable for whitefly as positive correlation was observed. Of the 50 entries tested, 16 entries of urd bean were superior as whitefly population was lower than the standard control (T-9) and its population varied between 0.85 and 8.26 per plant as against 8.46 per plant on standard control. The efficacy of imidacloprid, thiamethoxam, acetamiprid, fipronil, dimethoate, fenvalerate and azadirachtin in controlling *T. palmi*, the vector of peanut bud necrosis virus (PNBV) infecting mungbean, was determined by Sreekanth *et al*. (2004) in a field experiment. All the insecticides tested reduced *T. palmi* population and PBNV incidence, with imidacloprid treatment resulting in the highest *T. palmi* control (57.47 and 67.41%) and consequently, the lowest PBNV incidence (19.11 and 29.74%) was recorded during the kharif and rabi seasons, respectively.

Islam *et al*. (2008) were studied on seven recommend varieties of mungbean viz. Barimung 2, Barimung 3, Barimung 4, Barimung 5, Barimung 6, Binamoog 2 and Binamoog 5 were tested 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 experiment was conducted at the farm of Sher-e-Bangla Agricultural University (SAU) Dhaka during the kharif-I season (April to June) in 2006.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. MYMV a member of family Gemini viridae, belong to genus Begomo virus 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 (Shad *et al.*, 2005). Thiamethoxam was reported to be the best insecticide for controlling sucking pests such as jassid and aphid in okra (Mishra, 2002) and whitefly in mungbean (Ganapathy and Karuppiah, 2004).

Foliar sprays of carbendazim were effective against cercospora leaf spot of groundnut and green gram (Khunti *et al*., 2002; Chand *et al*., 2003). Sreekant *et al*. (2004) conducted 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) studied 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. Mungbean (*V. radiate* 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 (kharif-I season). 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 (Hossain *et al.,* 2004) are important.

Massod *et al*. (2004) reported that 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 investigate the resistance of mung bean 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.

Yaqoob *et al*. (2005) identified some resistance lines of mothbean in available land races. Sachan *et al*. (1994) found a drastic reduction in the infection of YMV when whitefly attack was reasonably controlled. The yellow mosaic virus caused 30-70% yield loss (Marimuthu *et al*., 1981).

Chamder and Singh (1991) noticed a significant reduction in the attack of whitefly and infection of YMV in Mungbean when 0.04% monocrotophos, 0.03% dimethoate, and 0.05% chlorvinphos 55 days after sowing were applied.

Gupta and Singh (1984) obtained the largest increase in grain yield by controlling stemfly of mungbean with Aldicarb and Disulfoton. Phorate or Carbofuran granules at the rate of 1 to 2 kg a.i./ha and foliar sprays of Dimethoate, Fenithion, Phosphhamidon were effective in reducing whitefly and jassid population of mungbean (Yadav *et al*., 1979).

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

Cypermethrin (Cymbush) 0.006 percent was found to be highly effective against galerucid beetle, while Dimethoate 0.03 percent against jassid (Chhabra and Kooner, 1985). They also reported that treatments with Aldicarb and Monocrotophos, Dimethoate, Malathion or Endosulfan gave significant control of thrips. For the control of hairy caterpillar of mungbean Diazinon 50EC or Nuvacron 40WSC @ 1.5 ml per liter of water can be used.

Field study was carried out at Bangladesh Agricultural Research Institute (BARI) farm during March to August, 2005 to find out the most appropriate management practices against thrips of mungbean. The experiment consisted of seven treatments of various management practices. The incidence of this pest was first noticed during vegetative and flowering stage. The infestation rate was highest in reproductive stage. Application of Furadan 5G as a seed treatment gave the maximum yield (950.05 kg ha^{-1}). On the other hand, minimum yield was found in control treatment. Two times application of Shobicron 425EC also gave the satisfactory result but it was not economically viable. Neem oil with Trix gave the significant result in comparison with other treatments and it may be environmentally friendly (Kyamanywa, 2009).

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

Management of insect pests of mungbean with insecticides using seed treatment and pre-sowing soil application followed by foliar application was studied by Ram and Singh (1999) at Pantnagar. Seed treatment with carbosulfan, monocrotophos, dimethoate, phosphamidon, methyl-o-demeton, methomyl and chlorpyriphos was evaluated for effect on germination and seedling vigour in the laboratory. Field efficacy of the effective doses of the above insecticides was evaluated, together with the pre-sowing soil application of phorate and carbofuran followed by foliar application of various insecticides at flowering against pests of mungbean. The insecticidal treatments significantly reduced the population of various insect pests in both seasons. Grain yield varied significantly from the lowest value of 214.2 and 353.3 kg/ha in untreated control to the highest value of 583.3 and 524.6 kg/ha in treatments with phorate followed by quinalphos in summer and rainy season, respectively. Seed treatment with monocrotophos, carbosulfan, dimethoate, methyl-o-demeton, chlorpyriphos tested at 40, 40, 120, 100 and 40 g a.i./ ha dosages, respectively, followed by sprays at flowering also gave higher grain yield than the untreated control. The pod borer can also be controlled by Cymhush 10EC @ 1.0 ml/L 0f water (Bakr, 1998). Applications of 0.3% Dimethoate or 0.4% Monocrotophos at 45 and 60 DAS were found effective in protecting Kharif mungbean against lepidopteran pod borers and other pests attacking the crop at the flowering and fruiting stage (Ahmad *et al*., 1998). Four granular insecticides (Carbofuran, Phorate, Quinalphos applied at 0.75 and 1.0 kg a.i. ha^{-1} each, and Cartap hydrochloride applied at 0.75, 1.0 and 1.5 kg a.i./ha) were evaluated by Dhiman *et al*. (1993) in a field experiment for the control of stemfly (*Ophiomyia phaseoli*) of mungbean. All of the tested granular insecticides were found to be more effective for controlling mungbean stemfly than the control condition.

The succession and abundance of insect pests on *Vigna radiate* 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*.

Rana and Dalal (1995) *P. lilacinus*at 1 or 2 g/kg soil together with seed treatments with carbosulfan at 0.5% w/w were applied to *Vigna radiata* for control of *H. cajanus* in pot trials. All treatments receiving combined applications of nematicide and fungus had significantly lower *H. cajani* populations and significantly higher growth and yield compared to controls. Different indices for developing an insecticide application schedule against *Euchrysop scnejus* were evaluated in mungbean and Fenitrothion @ 0.1% when egg number reached about 5.2 per meter was found as the best schedule for it (Rahman, 1989). In another trial was conducted on need based application of insecticides against the pod borer in mungbean at Joydebpur and it was found that the spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio (Rahman, 1989).

Chemical control is one of the widely practiced methods of controlling insect pests. Modern insecticides are both effective and reliable and almost all the countries of the world are relying to them more and more for the solution of insect problem. But their excessive and indiscriminate use has resulted in the development of insecticide resistance against the pests and causing environmental pollution (Babu, 1988). Rahman (1987) also reported that Fenitrothion or Sumithion 50EC @ 2ml/L of water was recommended for the control of pod borer.

Ahmad (1987) observed that pre sowing soil application of Carbofuran or Furadan 3G, Aldicarb 10G or Phroate 10G 1 kg a.i./ha gave significant control of stemfly damage and two applications of Dimethoate or Monocrotophos at 45 and 60 DAS gave effective control of pod borer damage.

Lal (1987) reported that foliar application at flower initiation with Endosulfon 0.07%, Dimethoate 0.03%, Phosphamidon 0.03% gave significant control of pod damage against pod borer.

Srivastava *et al*. (1987) reported that the synthetic pyrethroids were effective in reducing pod borer damage and did not leave a toxic residue. Jassid may be controlled by a basal application of a systemic insecticide at the time of sowing, followed by a foliar spray (Catipon, 1986).

2.2.2 Mungbean insect pest management by using botanicals

Botanical pesticides are the most cost effective and environmentally safe inputs in integrated pest management (IPM) strategies. There are about 3000 plants and trees with insecticidal and repellant properties in the world, and India is home to about 70% of this floral wealth (Nazrussalam *et al.*, 2008). Nazrussalam has chronicled the use of more than 450 botanical derivatives used in traditional agricultural systems and neem is one of the well-documented trees, and almost all the parts of the tree have been found to have insecticidal value. The neem seed kernel extracts, neem oil, extracts from the leaves and barks have all been used since ancient times to keep scores of insect pests away. A number of commercial neem-based insecticides are now available and they have displaced several toxic chemical insecticides. The extracts are of particular value in controlling the sucking and chewing pests.

Gupta and Pathak (2009) reported that the efficacy of some indigenous neem products, insecticides and their admistures were tested at Research Farm of College of Agriculture, Tikamgarh during kharif 2003-2005. The results indicated that admixture treatments, neem seed kernel extract (NSKE) (in cow urine), 3% + dimethoate, 0.03% and neem oil, 0.5% + dimethoate, 0.03% not only reduced the incidence of whitefly and yellow mosaic but also of pod borer. These treatments gave maximum grain yield of 935 and 902 kg ha^{-1}, net profit of Rs 3934 and Rs 3320 ha^{-1} with incremental cost benefit ratio of 11.2 and 10.9, respectively.

In a laboratory study, Butler and Rao (1990) reported that 0.5% sprays of 3 commercial neem oil formulation namely Neemguard, Newark, Neempon to single eggplant leaves against whitefly resulted 97% fewer eggs and 87% fewer immature compared to those on untreated leaves. The crude extracts and active principles isolated from number of other plants have anti feedant, insecticidal, hormonal and repellants properties (Jayaraj, 1988). Plant products play an important role in evolving an ecologically sound and environmentally acceptable pest management system.

Grainage *et al*. (1985) reported that neem is the major source of anti feedant principles and the seed contain a number of toxic terpenoids. The ether extract of *Tribulus terrestris* L. had juvenilising effects on cutworm *(Spodoptera litura)* and pod borer (*Heliothis armigera*), respectively (Gunasekaran and Chelliah, 1985). Treatment of Triflumuron, a moult inhibitor against whitefly nymphys or pupae reduced the adult emergence (Radwan *et al*., 1985).

Chandrasekharan and Balasubramanian (2002) evaluated the efficacy of botanicals and insecticides against sucking pests, *viz*., aphid, *Aphis craccivora* Koch. and whitefly, *Bemisia tabaci* Genn. on green gram. They reported that among the treatments, acephate 75SP @ 0.075 per cent and TNAU neem oil (C) 60EC at 3.0 per cent were found significantly superior by recording higher percentage of reduction in aphid population and yellow mosaic virus (YMV) incidence due to whitefly and also with grain yield recording 8.5 and 7.4 q/ha, respectively.

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

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

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

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

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

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

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

Oils of plant origin such as neem seed oil (Puri *et al*., 1991; Butler *et al*., 1991), soybean oil (Butler *et al*., 1991), cotton seed oil (Butler *et al*., 1991), have been tested against whitefly and the results were encouraging.

Prodhan *et al*. (2008) conducted an experiment was at the field of Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Ishurdi, Pabna, during March to June 2008 to develop integrated management approaches against insect pest complex of mungbean. The management approaches tested in the study were T_1= Seed treatment with Imidachlorpid (5g/kg seeds) + Poultry manure (3t/ha) + Sequential release of bio-control agent (*Trichograma chilonis* + *Bracon habetor*) + Detergent @ 2g/l of water, T_2= Seed treatment with Imidachlorpid (5g/kg seeds) + Poultry manure (3t/ha) + Sequential release of biocontrol agent (*Trichograma chilonis* + *Bracon habetor*) +Neem seed karnel extract @ 50g/l of water, T_3= Seed treatment with Imidachlorpid (5g/kg seeds) + Poultry manure (3t/ha) + Spray with Quinalphos @ 1ml /l of water and T_4 = Control. All the treatments significantly reduced insect's infestation (except thrips) and produced higher yield compared to control. It was found that the highest yield was obtained from the treatment T_3 (1316 kg/ha) which was statistically similar to T_2 (1316 kg/ha) and T_1 (1283 kg/ha). In case of Benefit Cost Ratio (BCR), the highest value was obtained from the treatment T_3 (1.84), which was followed by T_1 (1.55) and T_2 (1.31).

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The details of the materials and methods of the recent research work have been described in this chapter as experimental materials, site, climate and weather, land preparation, experimental design, lay out, data collection on whitefly and thrips incidence, grain yield etc within a period. Overall discussion about experiment was carried out to study on the management of whitefly and thrips on mungbean under the following headings and sub-headings:

3.1 Description of the experimental site

3.1.1 Location and time

The present research was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from March to May, 2014. The experimental area is located at 23.74^0 N latitude and 90.35^0 E longitude with an elevation of 8.2 m from the sea level (Khan *et al.*, 1997).

3.1.2 Soil

The soil of the experimental area is the general soil type series of shallow red brown terrace soils under Tejgaon series. Upper level soils are clay loam in texture, olive-gray through common fine to medium distinct dark yellowish brown mottles under the Agro-ecological Zone (AEZ- 28) and belong to the Madhupur Tract (UNDP, 1988; FAO, 1988). The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental plot is also high land, fertile, well drained with pH 5.8. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix II.

3.1.3 Climate and weather

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of March to May (Kharif Season). The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February. The detailed meteorological data in respect of temperature, relative humidity and total rainfall were recorded by the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka during the study period have been presented in Appendix III.

3.2 Crop Cultivation

3.2.1 Variety

Mungbean variety BARI mung 5 was used as experimental materials for the study and the seed of the variety for this experiment was collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.2.2 Treatments

The experiment comprised with seven treatments including an untreated control. The details of the treatments are given below:

T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval;

T_2= Casper 5SG (Emamectin Benzoate) @ 2gm/L of water at 10 days interval;

T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval;

T_4= Tapnor 40EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;

T_5= Allion 2.5EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval;

T_6= Admire 200SL (Imidachorpid) @ 0.5 ml/L of water at 10 days interval and

T_7= Control

3.3 Experimental design and layout

The experiment consist of BARI mung 5 and was laid out in a Randomized Complete Block Design (RCBD) with three replications which were divided into seven equal blocks. Thus there were 21 (3 × 7) unit plots altogether in the experiment. The size of each unit plot was 3 m × 3 m. Block to Block and plot to plot distances were 1 m and 0.5 m, respectively. The treatments of the experiment randomly distributed into the experimental plot. Details layout of the experimental plot were presented in Appendix IV.

3.4 Land preparation

Power tiller was used for the preparation of the experimental field. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of this crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field.

3.5 Fertilizers

The fertilizers were applied as per fertilizers recommendation guide (BARI, 2006). The applied manures were mixed properly with the soil in the plot using a spade. The dose and method of application of fertilizers are shown in below:

Fertilizers	**Dose (kg ha^{-1})**
Urea	30
TSP	70
MP	35

3.6 Seed treatments

Before planting seeds were treated with Vitavex-200 @ 0.25% to prevent seeds from the attack of soil borne disease. Furadan @1.2 kg ha^{-1} was also used as per treatment against wireworm and mole cricket.

3.7 Seed sowing

Treated mature 4-5 seeds of mungbean were sown in each hole by hand. Seeds were sown on 13th March, 2014. The row to row and plant to plant distances were 30 and 6 cm, respectively. Seeds were placed at about 5 cm depth from the soil surface. Three seeds were sown in each hole.

3.8 Intercultural operations

3.8.1 Thinning out

As the seeds were sown continuously into the line, so there were so many seedlings which need thinning. Emergence of seedling was completed within 10 days after sowing. Overcrowded seedlings were thinned out two times. First thinning was done after 15 days of sowing which is done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning.

3.8.2 Gap filling

Seedlings were transferred to fill in the gaps where seeds failed to germinate. The gaps were filled in within two weeks after germination of seeds.

3.8.3 Weeding

There were some common weeds found in the mungbean field. First weeding was done at 30 DAS and then once a week to keep the plots free from weeds and to keep the soil loose and aerated.

3.8.4 Irrigation and drainage

The irrigation was done at after first weeding. Irrigation was used as and when irrigation needed. Proper drainage system was also developed for draining out excess water.

3.8.5 Pest management

The experimental crop was infected with sucking pests and diseases and no fungicide was used. They attacked at the early growing stages of seedlings to harvest period. Various chemical spray as water solution 8 times at 10 days interval as a treatment from germination to harvest period to control these sucking pests and diseases.

3.8.6 Procedure of spray application

The actual amount of each chemical insecticide was taken in knapsack sprayer having pressure of 4-5 kg cm^{-2} and thoroughly mixed with water and sprayed in the respective plot. Each treatment was repeated at 10 days interval and 8 sprays were applied in the field.

3.9 Data collection and calculation

3.9.1 Number of whitefly and thrips and reduction percentage

Number of whitefly and thrips were recorded at vegetative and reproductive stage. Randomly 10 (ten) plants were selected for the collection of data. Data on number of insects were recorded at an interval of 10 days commencing from first incidence and continued up to the 13 weeks (8 times). Reduction percentage was also recorded on the basis of control treated plant where the maximum number of whitefly and thrips attacked. The following formula were used for taking the reduction percentage:

$$\text{\% Infestation reduction} = \frac{\text{(\% Infestation in control – \% Infestation in the concerned treatment)}}{\text{\% Infestation in control}} \text{ X100}$$

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

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

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

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

3.9.3 Plant height at harvest

Plant height was measured in centimeter by a meter scale at harvest and their average data were recorded per replication. Data were also recorded as the average of randomly selected 10 plants from the inner rows of each plot. Plant height of the ground surface to the top of the main shoot and the mean height were expressed in cm.

3.9.4 Number of branches plant^{-1}

Number of branches per plant^{-1} data was also recorded from the randomly selected 10 (ten) plants of inner rows of each plot.

3.9.5 Number of leaves plant^{-1}

Number of leaves per plant^{-1} data was also recorded at before and after flowering from the randomly selected 10 (ten) plants of inner rows of each plot.

3.9.6 Number of pods plant^{-1}

All pods were separated from 10 sample plants and the total number of pods were counted and recorded. Average number of pods per plant was calculated.

3.9.7 1000-grain weight (g)

One thousand grains were randomly counted and selected from the stock seed and weighed in gram by digital electric balance. It was expressed as 1000-seed weight in gram (g).

3.9.8 Yield plot^{-1} (kg)

Seed yield were recorded from randomly selected fives pods. After harvesting the plant was sun-dried and threshed. Seed were properly sun-dried and their weights recorded. Seed yield was then converted to kg plot^{-1}.

3.9.9 Fruits yield hectare^{-1}(ton)

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

3.9.10 Statistical analysis

The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values for all the parameters were calculated and the analysis of variance for the characters was accomplished by Duncan's Multiple Range Test (DMRT) and the significance of difference between pair of means was tested by the Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984). Benefit cost ratio was also calculated.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Net return}}{\text{Cost of pest management}}$$

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Effect of different management practices on incidence of whitefly on mungbean

The population incidence of whitefly at vegetative and reproductive stage of mungbean under different treatments has been shown in Table 1. The data (Table 1) shows that the lowest number of whitefly (4.18/plant at vegetative and 2.13/plant at reproductive stage) was observed in T_6 (Admire 200SL) treated plot followed by T_3 (Voliam Flexi) treated plot (5.22/plant at vegetative and 3.90/plant at reproductive stage) having significant difference between them. Other insecticides have intermediate number of whitefly. The highest number of whitefly (14.44/plant at vegetative and 8.10/plant at reproductive stage) was found in control plot which significantly higher than all other treated plots. Similarly Admire 200SL showed the best performance in reduction of whitefly population over control followed by Voliam Flexi. Others showed intermediate results in reducing whitefly population over control.

In case reduction on number of whitefly per plant over control, the highest value in vegetative (71.05%) and reproductive (73.70%) was recorded for the treatment T_6 and the lowest value in vegetative (34.07%) and reproductive (18.52%) from T_1 treatment.

The results of the study reveal that all the insecticides significantly reduced whitefly population infesting mungbean. However, Admire 200SL was the most effective insecticide against whitefly and Voliam Flexi was second effective insecticides but Tapnor 40EC, Allion 2.5EC, Casper 5SG and Nitro 505EC were less effective insecticides in field condition. The order of effectiveness is Admire 200SL> Voliam Flexi> Tapnor 40EC> Allion 2.5EC> Casper 5SG> Nitro 505EC. The result of the present study was in accordance with the findings of other scientist like Mustafa (2000), Sreekanth *et al*. (2004) and Ganapathy and Karuppiah (2004). According to them insecticides application like imidaclorpid and thiamethoxam reduce whitefly on mungbean and increase yield.

Table 1. Population incidence of whitefly on mungbean under different management practices at vegetative and reproductive stage

Treatments	Vegetative stage		Reproductive stage	
	No. of whitefly Plant^{-1}	Population reduction over control (%)	No. of whitefly Plant^{-1}	Population reduction over control (%)
T_1	9.52 b	34.07	6.60 ab	18.52
T_2	9.02 b	37.53	6.10 bc	24.69
T_3	5.22 de	63.85	3.90 cd	51.85
T_4	6.68 cd	53.74	4.45 bcd	45.06
T_5	8.31 bc	42.45	5.90 bc	27.16
T_6	4.18 e	71.05	2.13 d	73.70
T_7 (Control)	14.44 a	--	8.10 a	--
$LSD_{(0.05)}$	2.075	--	1.91	--
CV (%)	14.23	--	17.43	--

In a column, means having different letter(s) are significantly different at 1% level of probability.

[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

4.2 Number of thrips per 10 flowers

Statistically significant variation was recorded for number of thrips per 10 flowers of mungbean due to different management practices (Table 2). The lowest number of thrips per 10 flowers (1.88) was found from T_6 (Admire 200SL) which was followed (2.98) by T_3 (Voliam Flexi), while the highest number of thrips per 10 flowers (6.32) was observed from T_7 (control condition) which was followed (4.34) by T_1 (Nitro 505EC). In case reduction on number of thrips per 10 flowers over control, the highest value (70.25%) was recorded for the treatment T_6 and the lowest value (31.33%) from T_1 treatment. From the findings it is revealed Admire 200SL was more effective among the management practices in terms of controlling thrips in mungbean which was followed by Voliam Flexi.

Table 2. Effect of different management practices on the incidence of thrips attacking on mungbean

Treatments	Number of thrips per 10 flowers	Population reduction over control (%)
T_1	4.34 b	31.33
T_2	4.12 b	34.81
T_3	2.98 bc	52.85
T_4	3.32 b	47.47
T_5	3.88 b	38.61
T_6	1.88 c	70.25
T_7 (Control)	6.32 a	--
$LSD_{(0.05)}$	1.378	--
CV (%)	18.20	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5 SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40 EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5 EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

The order of effectiveness is Admire 200SL > Voliam Flexi > Tapnor 40EC > Allion 2.5EC > Casper 5SG > Nitro 505EC. The result of the present study was in accordance with the findings of other scientist like Mohan and Katiray (2000), Sreekanth *et al*. (2004). According to them insecticides application like imidaclorpid and thiamethoxam reduce thrips on mungbean and increase yield.

4.3 Pod bearing status at early fruiting stage

Number of healthy pods, infested pods and percent infestation of mungbean pod showed statistically significant differences at early pod stage for different management practices under the present trial (Table 3). The highest number of healthy pods plant^{-1} (22.83) was recorded in T_6 (Admire 200SL) treatment which was statistically identical (19.01) with T_3 (Voliam Flexi). On the other hand, the lowest number (14.14) was recorded in T_7 (Control) treatment which was statistically similar (15.43) with T_1 (Nitro 505EC). The highest number of infested pods plant^{-1} (7.20) was recorded in T_7 treatment followed by T_1 (5.40) whereas the lowest number (2.40) was recorded in T_6 treatment which was followed (3.00) by T_3. The highest percent of infested pods plant^{-1} in number (33.81%) was recorded in T_7 treatment which was followed (25.98%) by T_1. Again, the lowest infestation percent in number (9.58%) was recorded in T_6. Mungbean pod infestation percentage reduction over control at early pod stage in number was estimated for different management practices and the highest value (71.67%) was recorded for the treatment T_6 and the lowest value (23.16%) from T_1 treatment. From the findings it is revealed that spraying of Admire 200SL (Imidachorpid) performed maximum healthy pods and minimum infested pods as well as lowest percent of pod infestation in number followed by Voliam Flexi, while in Control treatment gave the minimum healthy pods, maximum infested pods and highest percentage of infestation under the trail followed by Nitro 505EC. Ganapathy and Karuppiah (2004), Mustafa (2000), Sreekanth *et al.* (2004) are also agree with the experiment. They showed significant increase of pod yield by controlling whitefly and thrips population.

Table 3. Effect of different management practices on the damage severity of mungbean pod at early fruiting stage

Treatments	Healthy pods per plant	Infested pods per plant	% Infestation	Reduction of infestation over control (%)
T_1	15.43 bc	5.40 b	25.98	23.16
T_2	15.68 bc	4.80 bc	23.51	30.46
T_3	19.01 ab	3.00 de	13.71	59.45
T_4	18.08 b	3.60 cde	16.69	50.64
T_5	17.24 b	4.20 bcd	19.67	41.82
T_6	22.83 a	2.40 e	9.58	71.67
T_7(Control)	14.14 c	7.20 a	33.81	--
$LSD_{(0.05)}$	2.95	1.58	--	--
CV (%)	18.56	10.40	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5 SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40 EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5 EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

4.4 Pod bearing status at mid fruiting stage

Number of healthy pods, infested pods and percent infestation of mungbean pod showed statistically significant differences at mid pod stage for different management practices (Table 4). The highest number of healthy pods plant^{-1} (24.76) was recorded in T_6 (Admire 200SL) treatment which was statistically identical (21.36) with T_3 (Voliam Flexi). On the other hand, the lowest number (13.83) was recorded in T_7 (Control) treatment which was followed (16.29) by T_1 (Nitro 505EC). At mid pod stage the highest number of infested pods plant^{-1} (7.40) was recorded in T_7 treatment, whereas the lowest number (2.80) was recorded in T_6 treatment followed (3.40) by T_3. The highest percent of infested pods plant^{-1} in number (34.97%) was recorded in T_7 treatment which was followed (26.34%) by T_1. Again, the lowest infestation percent in number (10.25%) was recorded in T_6 treatment which was followed (13.81%) by T_3. Pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (70.69%) was recorded for the treatment T_6 and the lowest value (24.68%) from T_1 treatment. From the findings it is revealed that at mid pod stage, spraying of Admire 200SL (Imidachorpid) of water performed maximum healthy pods and minimum infested pods as well as lowest percent of pod infestation in number followed by Voliam Flexi (Thiamethoxam + Chlorantraniliprole), while in Control treatment gave the minimum healthy pods, maximum infested pods and highest percentage of infestation under the trail followed by Nitro 505EC (Chloropyrifos + Cypermethrin). Ganapathy and Karuppiah (2004), Mustafa (2000), Sreekanth *et al*. (2004) are also agree with the experiment. They showed significant increase of pod yield by controlling whitefly and thrips population.

Table 4. Effect of different management practices on the damage severity of mungbean pod at mid fruiting stage

Treatments	Healthy pods per plant	Infested pods per plant	% Infestation	Reduction of infestation over control (%)
T_1	16.29 bc	5.80 b	26.34	24.68
T_2	17.08 bc	5.20 bc	23.43	33.99
T_3	21.36 ab	3.40 de	13.81	60.51
T_4	19.90 b	4.00 cde	16.83	51.87
T_5	18.10 b	4.60 bcd	20.34	41.84
T_6	24.76 a	2.80 e	10.25	70.69
T_7 (Control)	13.83 c	7.40 a	34.97	--
$LSD_{(0.05)}$	3.89	1.26	--	--
CV (%)	12.19	14.99	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5 SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40 EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5 EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

4.5 Pod bearing status at late fruiting stage

Number of healthy pods, infested pods and percent infestation of mungbean pod showed statistically significant differences at late pod stage for different management practices (Table 5). The highest number of healthy pods plant^{-1} (21.04) was recorded in T_6 (Admire 200SL) treatment which was followed (19.22) by T_3 (Voliam Flexi). On the other hand, the lowest number (12.74) was recorded in T_7 (Control) treatment which was followed (61.63) by T_1 (Nitro 505EC). At late pod stage the highest number of infested pods plant^{-1}

(7.83) was recorded in T_7 treatment followed by T_1 (Nitro 505EC) whereas the lowest number (2.03) was recorded in T_6 treatment which was followed (2.50) by T_3. The highest percent of infested pods plant^{-1} in number (38.16%) was recorded in T_7 treatment which was followed (27.07%) by T_1. Again, the lowest infestation percent in number (8.87%) was recorded in T_6 treatment which was followed (11.59%) with T_3. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (76.76%) was recorded for the treatment T_6 and the lowest value (29.06%) from T_1 treatment.

Table 5. Effect of different management practices on the damage severity of mungbean pod at late fruiting stage

Treatments	Healthy pods per plant	Infested pods per plant	% Infestation	Reduction of infestation over control (%)
T_1	13.52 de	5.00 b	27.07	29.06
T_2	14.97 cde	4.40 bc	22.79	40.28
T_3	19.22 ab	2.50 de	11.59	69.63
T_4	18.19 bc	3.40 cde	15.83	58.52
T_5	16.87 bcd	3.80 bcd	18.46	51.62
T_6	21.04 a	2.03 e	8.87	76.76
T_7 (Control)	12.74 e	7.83 a	38.16	--
$LSD_{(0.05)}$	2.78	1.55	--	--
CV (%)	12.22	11.07	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

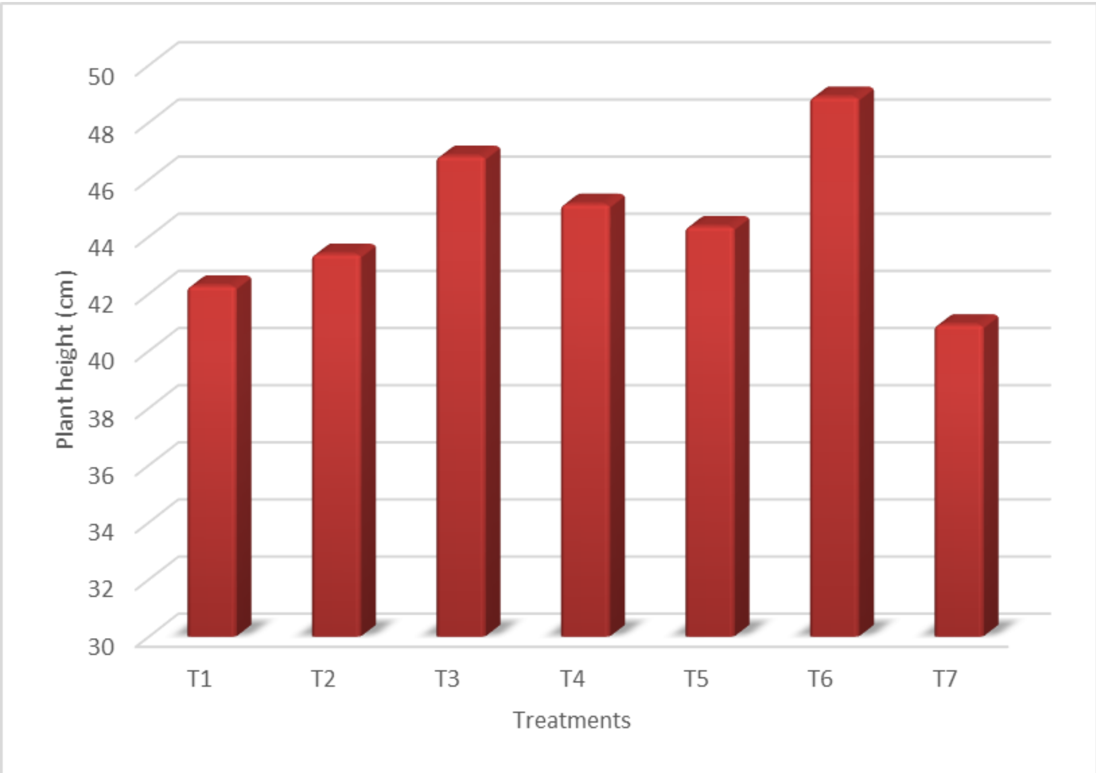
[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5 SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40 EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5 EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

From the findings it is revealed that at late pod stage, spraying of Admire 200SL (Imidachorpid) performed maximum healthy pods and minimum infested pods as well as lowest percent of pod infestation in number followed by Voliam Flexi (Thiamethoxam + Chlorantraniliprole), while in Control treatment gave the minimum healthy pods, maximum infested pods and highest percentage of infestation under the trail followed by Nitro 505EC (Chloropyrifos + Cypermethrin). Ganapathy and Karuppiah (2004), Mustafa (2000), Sreekanth *et al.* (2004) are also agree with the experiment. They showed significant increase of pod yield by controlling whitefly and thrips population.

4.6 Effect of different management practices on growth of mungbean

4.6.1 Plant height at harvest

Plant height of mungbean at harvest for controlling whitefly and thrips by using different management practices showed statistically significant differences (Fig. 1). The longest plant (48.89 cm) was recorded in T_6 treatment which was followed (46.82 cm) by T_3, while the shortest plant (40.92 cm) was recorded in T_7 treatment. Plant height increase over control was estimated for different management practices and the highest value (19.48%) was recorded for the treatment T_6 and the lowest value (3.32%) from T_1 treatment.



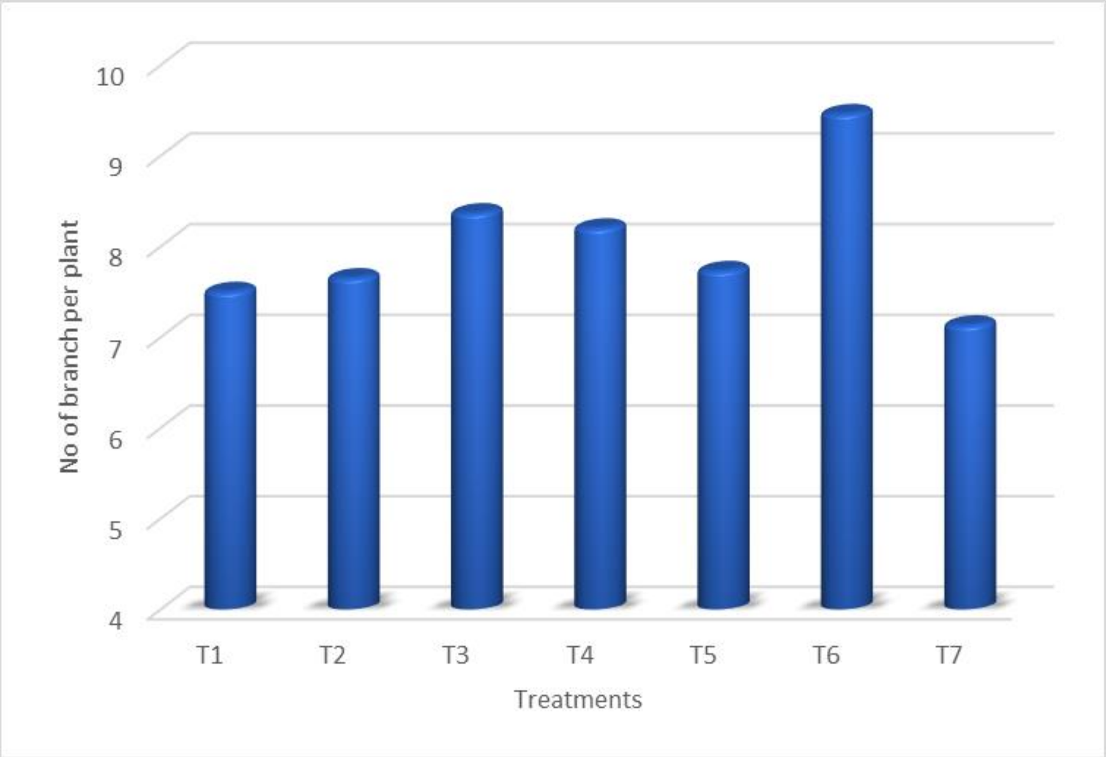
T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 1. Effect of different management practices on height of mungbean plant at harvest

4.6.2 Number of branches plant^{-1}

Branches plant^{-1} was significantly affected by different treatment. Among the treatments, the maximum number of branch (9.46) was found from the treatment Admire 200SL @ 0.25 ml/L of water because minimum number and more reduction of sucking insect pests was recorded which was closely followed (8.37) by Voliam Flexi. On the other hand the minimum number of branch (7.13) was recorded from control treatment where maximum number of sucking insect pests was found (Fig. 2).

The result indicates that application of chemical insecticides reduced the pest infestation in mungbean although their performance was different. Admire 200SL showed the best performance and Voliam Flexi was second effective insecticides. The application of insecticides reduced the population of sucking insects of mungbean and thus number of branch is increases.

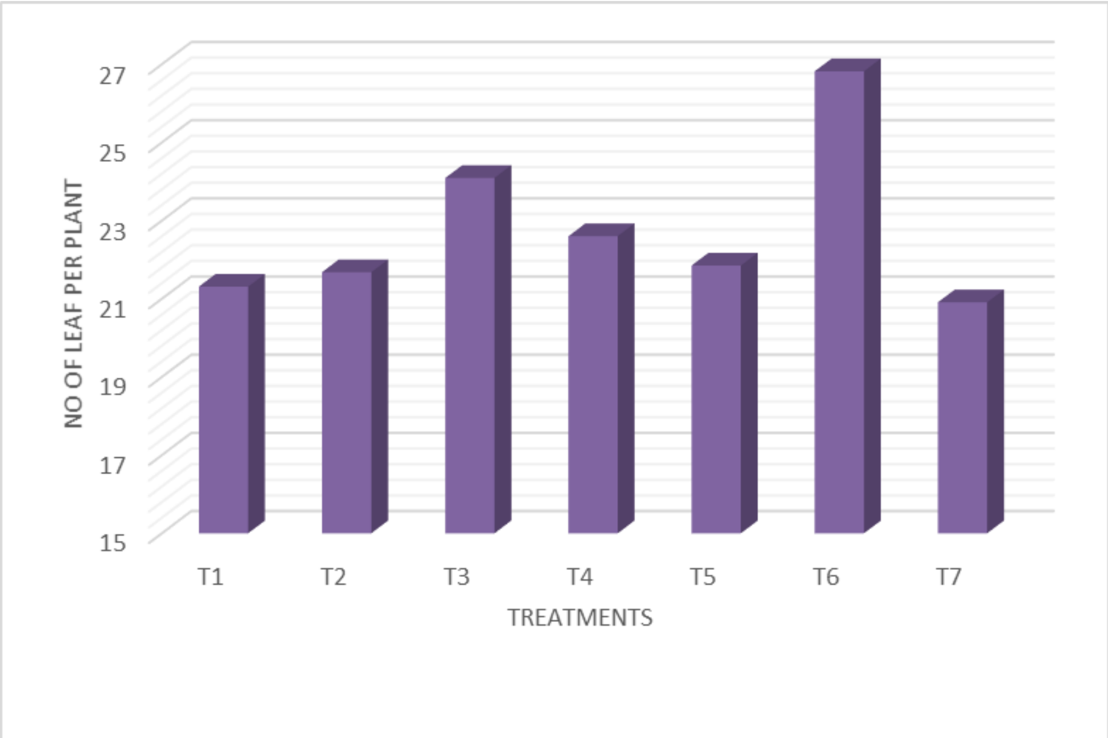


T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 2. Effect of different management practices on branch of mungbean plant

4.6.3 Number of leaves plant^{-1}

Leaves plant^{-1} was significantly affected by the application of chemical insecticides and botanical extracts. Among the treatments, the maximum number of leaves (26.82) was found from the treatment Admire 200SL because minimum number and more reduction of sucking insect pests was recorded which was closely followed by Voliam Flexi (24.09). On the other hand, the minimum number of leaves (20.91) was recorded from control treatment where maximum number of sucking insect pests was found (Fig. 3).The result indicates that application of chemical insecticides reduces the pest infestation in mungbean although their performance was different. Admire 200SL showed the best performance and Voliam Flexi was second effective insecticides. The application of insecticides reduced the population of sucking insects of mungbean and thus number of leaves is increase.



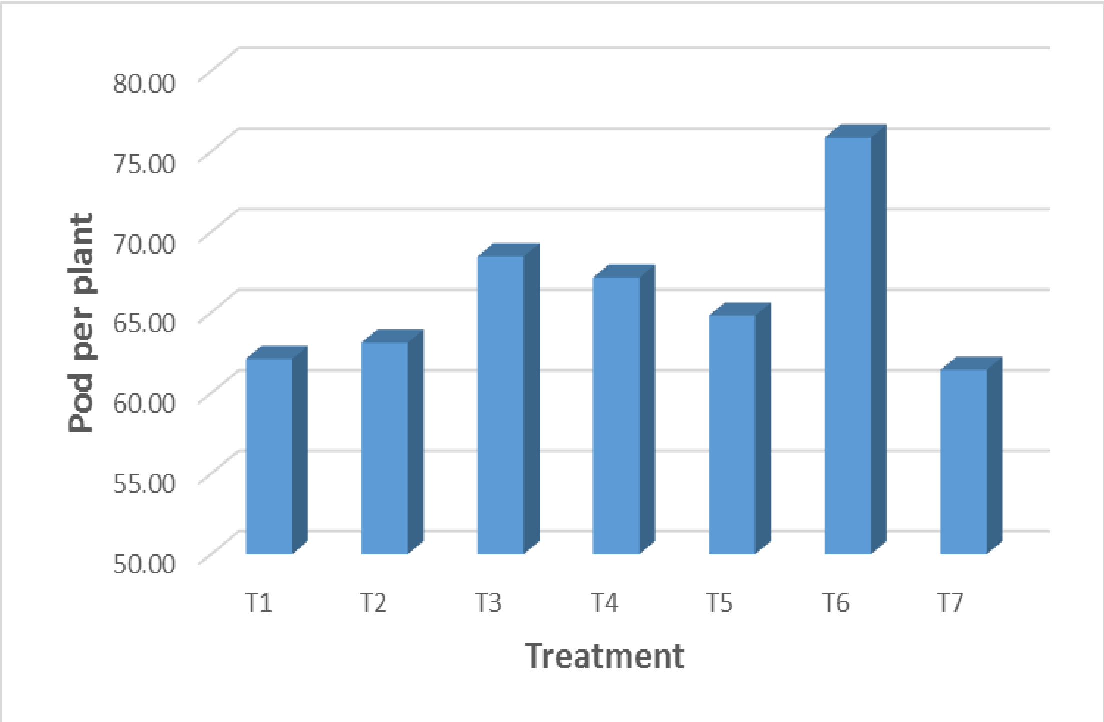
T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 3. Effect of different management practices on number of leaves of mungbean plant

4.7 Effect of different management practices on yield of mungbean

4.7.1 Number of pods plant^{-1}

Number of pods plant^{-1} was significantly influenced by the effect of various insecticides. Whereas, treatment Admire 200SL produced the maximum number of pods plant^{-1} (75.86) and it was followed by Voliam Flexi (68.49) where the maximum reduction of sucking insects was taken. Among the other treatments, the minimum number of pods plant^{-1} (61.44) was recorded in untreated or control treatment (Fig. 4). These results agree with the reports of several researchers Jahangir Shah *et al*. (2007) who reported that pods/plant and seed yield kg ha^{-1} varied significantly among different insecticides. Out of all the insecticides used in this study, Imidacloprid treated plots had significantly the highest yield of (1563 kg ha^{-1}) while the lowest seed yield of (1056 kg/ha) was obtained from the control plots where no insecticide was applied.

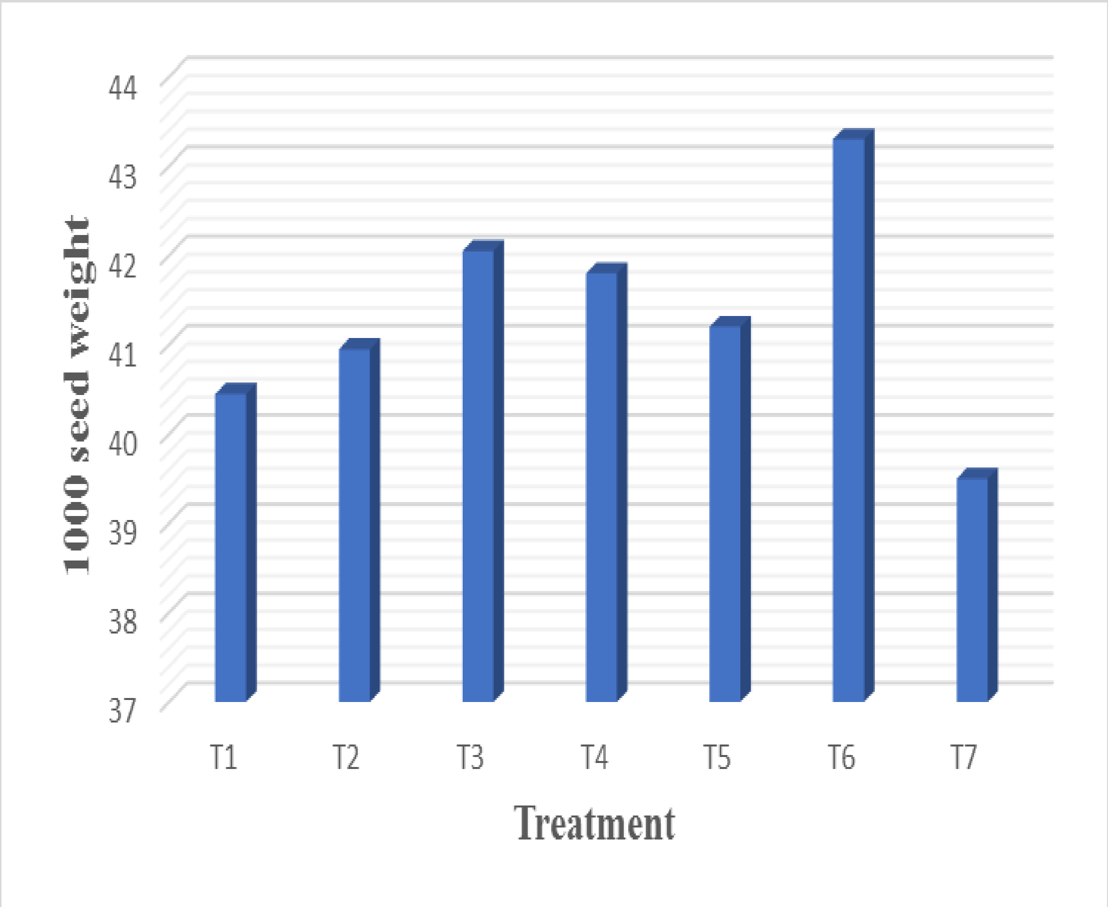


T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 4. Effect of different management practices on number pod per plant

4.7.2 1000-seed weight (g)

Effect of chemical insecticides and botanical extract showed significant variation in respect of 1000-seed weight. Among the treatments, Admire 200SL produced the highest reduction of sucking insects as well as the highest weight of 1000- seeds (43.30 g) and it was followed by the second highest (42.05 g) at Voliam Flexi. Maximum sucking pest reduced the yield because of the lowest 1000-seeds weight (38.5 g) was recorded in control treatment where the minimum reduction of sucking pests was obtained (Fig. 5).

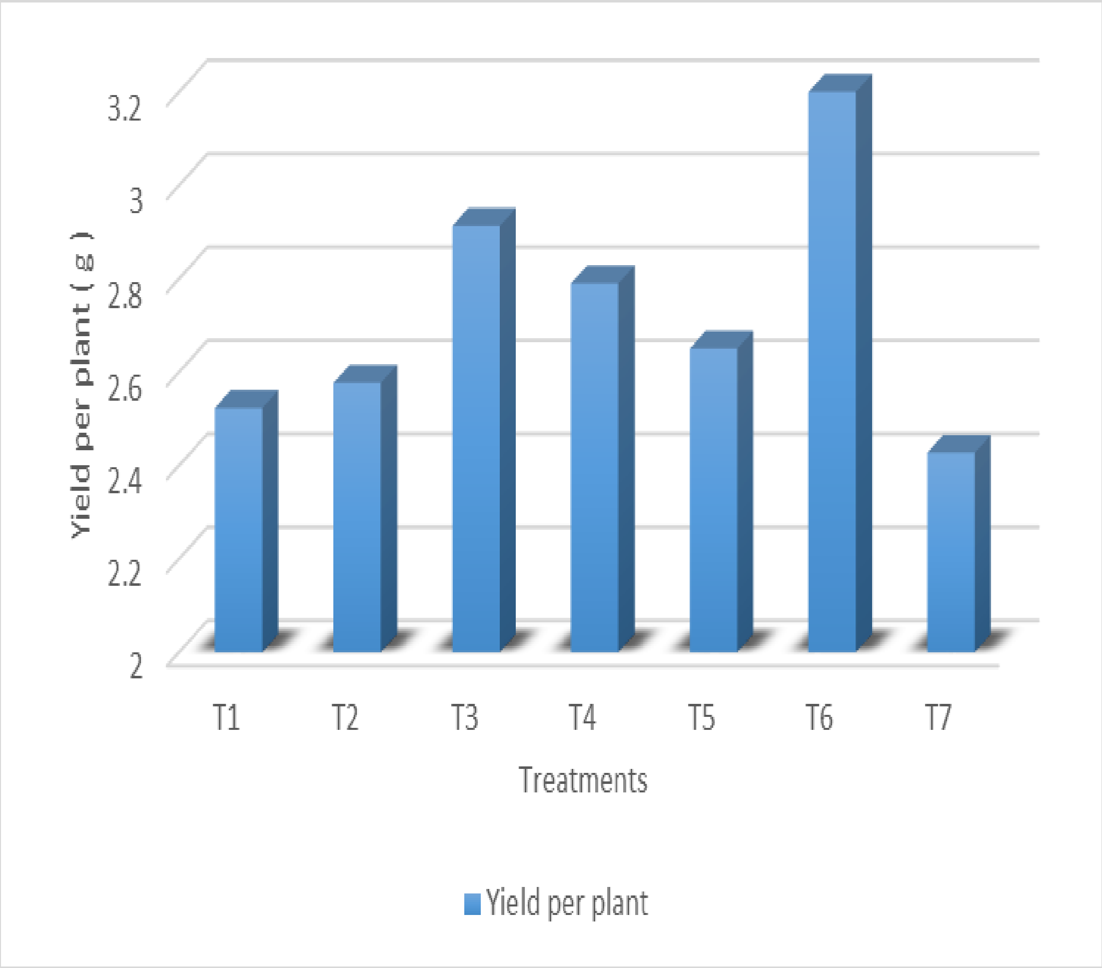


T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 5. Effect of different management practices on 1000 seed weight of mungbean

4.7.3 Yield per plant

To control whitefly and thrips by using different management practices yield per plant of mungbean showed significant differences (Fig. 6). The highest yield per plant (3.20 g) was recorded in T_6 treatment which was followed (2.91g) by T_3, whereas the lowest yield (2.43g) in T_7 treatment followed by T_1 (2.52g).

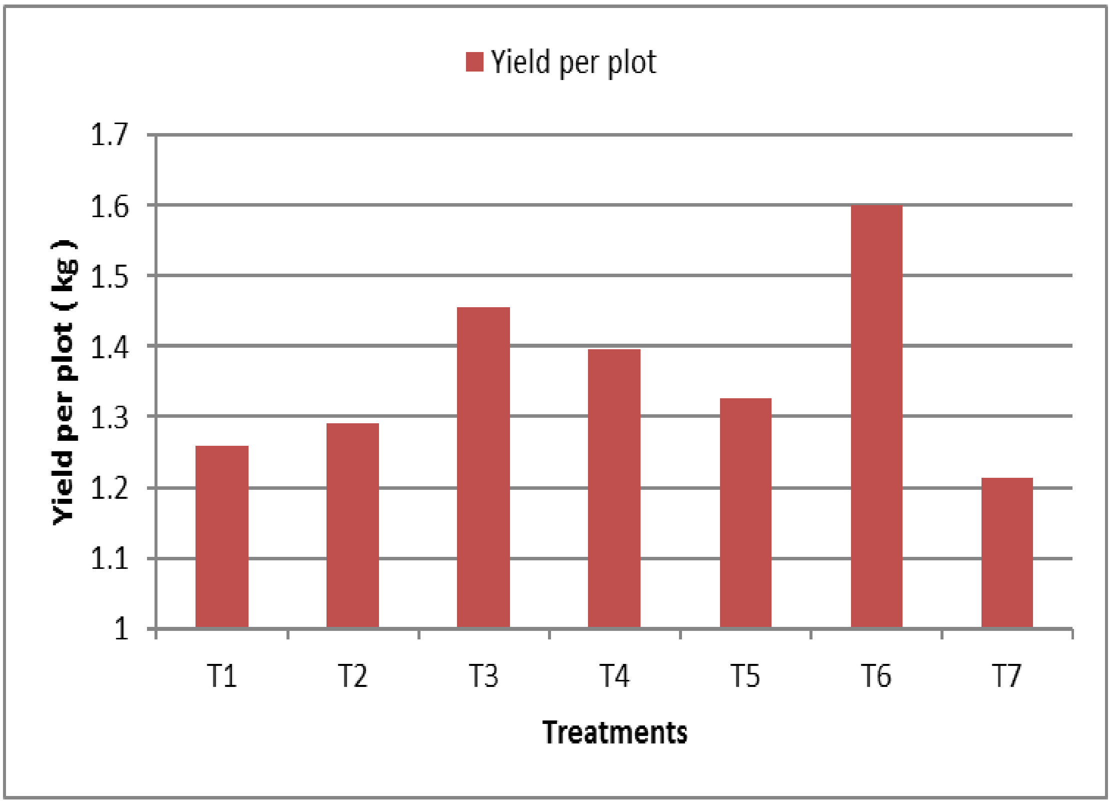


T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 6. Effect of different management practices on yield per plant

4.7.4 Yield per plot

To control whitefly and thrips by using different management practices yield per plot of mungbean showed significant differences (Fig. 7). The highest yield per plot (1.60 kg) was recorded in T_6 treatment which was followed (1.46 kg) by T_3, whereas the lowest yield (1.21 kg) in T_7 treatment followed by T_1 (1.26kg).



T_1= Nitro 505EC; T_2= Casper 5SG; T_3= Voliam Flexi; T_4= Tapnor 40EC; T_5= Allion 2.5EC; T_6= Admire 200SL; T_7= Control

Figure 7. Effect of different management practices on yield per plant

4.7.5 Yield per hectare

To control whitefly and thrips by using different management practices yield per hectare of mungbean showed significant differences (Table 6). The highest yield per hectare (1.91 ton) was recorded in T_6 treatment which was followed (1.75 ton) by T_3, while the lowest yield (1.27 ton) in T_7 treatment. Yield per hectare of mungban increase over control was estimated for different management practices and the highest value (50.39%) was recorded from T_6 and the lowest value (16.54%) from T_1 treatment.

Table 6. Effect of different management practices on plant height, number of pods/plant and yield per hectare of mungbean

Treatments	Plant height	Number of pods/plant	Yield (t/ha)	Increase over control (%)		
				Plant height	Number of pods/plant	Yield (t/ha)
T_1	42.28 bc	62.12 c	1.48 d	3.32	1.11	16.54
T_2	43.39 bc	63.14 c	1.50 d	6.04	2.77	18.11
T_3	46.82 ab	68.49 a	1.74 b	14.41	11.48	37.01
T_4	45.14 b	67.17 b	1.61 c	10.31	9.32	26.77
T_5	44.36 b	64.81 b	1.47 d	8.41	5.48	15.75
T_6	48.89 a	75.86 a	1.91 a	19.48	23.44	50.39
T_7	40.92 c	61.44 d	1.27 e	--	--	--
$LSD_{(0.05)}$	2.96	0.55	5.02	--	--	--
CV (%)	5.59	10.55		--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5 SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40 EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5 EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

4.8 Economic analysis

The analysis was done in order to find out the most profitable management practices based on cost and benefit of various components. The results of economic analysis of mungbean cultivation showed that the highest net benefit was obtained in T_5 treatment and the second highest was found in T_6 (Table 7).

Table 7. Cost of mungbean production for different management practices of insect pests

Treatments	Cost of pest Management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net Return (Tk.)	Benefit cost ratio
T_1	18480	1.48	100800	82320	4.45
T_2	20160	1.50	105000	84840	4.21
T_3	8820	1.74	121800	112980	12.81
T_4	13440	1.61	112700	99260	7.39
T_5	21280	1.57	109900	88620	4.16
T_6	10080	1.91	133700	123620	12.26
T_7	0	1.27	101500	88900	

Price of mungbean @ Tk. 70/kg

[T_1= Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2= Casper 5 SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3= Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4= Tapnor 40 EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval;T_5= Allion 2.5 EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6= Admire 200SL (Imidachoprid) @ 0.5 ml/L of water at 10 days interval and T_7= Control]

The highest benefit cost ratio (12.81) was estimated for T_3 treatment and the lowest (4.16) for T_5 treatment under the trial. The highest BCR was found in the treatment T_5 may be due to the minimum pest infestation to the other treatment components and the highest yield of this treatment. Rahman (1989) spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio.

Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to study whitefly and thrips incidence in mungbean and their management. BARI Mung-5 was used as the test crop of this experiment. The experiment consists of the following treatments- T_1: Nitro 505EC (Chloropyrifos + Cypermethrin) @ 2 ml/L of water at 10 days interval; T_2: Casper 5SG (Emamectin Benzoate) @ 2 gm/L of water at 10 days interval; T_3: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1.0 ml/L of water at 10 days interval; T_4: Tapnor 40EC (Dimethoate) @ 2.0 ml/L of water at 10 days interval; T_5: Allion 2.5EC (Lamda-Cyhalothrin) @ 1.0 ml/L of water at 10 days interval; T_6: Admire 200SL (Imidachorpid) @ 0.5 ml/L of water at 10 days interval and T_7: Control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Under the present study statistically significant variation was recorded in different parameters.

Data revealed that the lowest number of whitefly per planting vegetative (4.18) and reproductive (2.13) stage was found from T_6, while the highest number of whitefly per plant in vegetative (14.44) and reproductive (8.10) stage was observed from T_7. In case reduction on number of whitefly per plant over control, the highest value in vegetative (71.05%) and reproductive (73.70) stage was recorded for the treatment T_6 and the lowest value in vegetative (34.07%) and reproductive (18.52) stage from T_1 treatment. The lowest number of thrips per 10 flowers (1.88) was found from T_6, while the highest number of thrips per 10 flowers (6.32) was observed from T_7. In case reduction on number of thrips per 10 flowers over control, the highest value (70.25%) was recorded for the treatment T_6 and the lowest value (31.33%) from T_1 treatment.

In early stage the highest number of healthy pod plant^{-1} (22.83) was recorded in T_6 and the lowest number (14.44) was recorded in T_7. The highest number of infested pods plant^{-1} (7.20) was recorded in T_7 treatment, whereas the lowest number (2.40) was recorded in T_6 treatment. The highest percent of infested pods plant^{-1} in number (33.81%) was recorded in T_7 treatment again, the lowest infestation percent in number (9.58%) was recorded in T_6 treatment. Mungbean pod infestation percentage reduction over control at early pod stage in number was estimated for different management practices and the highest value (71.67%) was recorded for the treatment T_6 and the lowest value (23.16%) from T_1 treatment. At mid pod stage the highest number of healthy pods plant^{-1} (24.76) was recorded in T_6 and the lowest number (13.83) was recorded in T_7. The highest number of infested pods plant^{-1} (7.40) was recorded in T_7 treatment, whereas the lowest number (2.80) was recorded in T_6 treatment. The highest percent of infested pods plant^{-1} in number (34.37%) was recorded in T_7 treatment again, the lowest infestation percent in number (10.25%) was recorded in T_6 treatment. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (70.69%) was recorded for the treatment T_6 and the lowest value (24.68%) from T_1 treatment. At late stage the highest number of healthy pods plant^{-1}(21.04) was recorded in T_6 and the lowest number (12.74) in T_7. The highest number of infested pods plant^{-1} (7.83) was recorded in T_7 treatment, whereas the lowest number (2.03) in T_1 treatment. The highest percent of infested pods plant^{-1} in number (38.16%) was recorded in T_7 treatment again, the lowest (8.87%) was recorded in T_6 treatment. Mungbean pod infestation percentage reduction over control at mid pod stage in number was estimated for different management practices and the highest value (76.76%) was recorded for the treatment T_6 and the lowest (29.06%) from T_1. The tallest plant (48.89 cm) was recorded in T_6 treatment, while the shortest plant (40.92 cm) in T_7 treatment. The maximum number of pods/plant (25.59) was recorded in T_6 treatment, while the minimum number (18.04) was recorded in T_7

treatment. The highest yield per hectare (1.91 ton) was recorded in T_6 treatment, whereas the lowest (1.27 ton) in T_7. The highest benefit cost ratio (12.81) was estimated for T_3 treatment and the lowest (4.16) for T_5 treatment.

Conclusion

From the above findings it was revealed that Admire 200SL (Imidachoprid) @ 0.5 ml/L of water was more effective among the management practices for controlling whitefly and thrips of mungbean which was followed by Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water .

Recommendations

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

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

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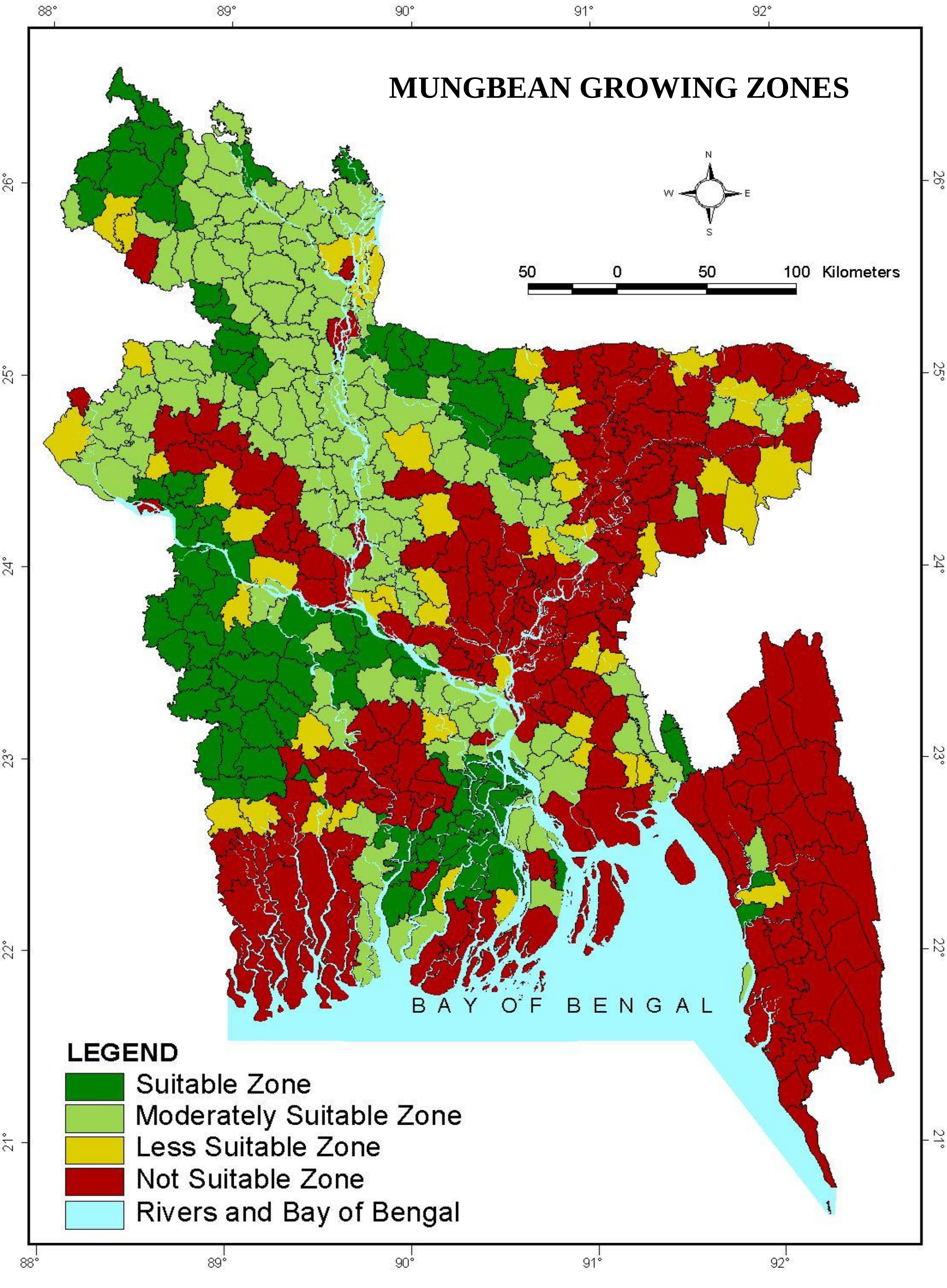
Appendices

APPENDICES

Appendix I. Mungbean growing zones of Bangladesh



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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Laboratory field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

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

Source: Soil Resources Development Institute (SRDI)

Appendix III. Monthly record of air temperature, relative humidity, rainfall, and sunshine of the experimental site during the period from March to June 2014

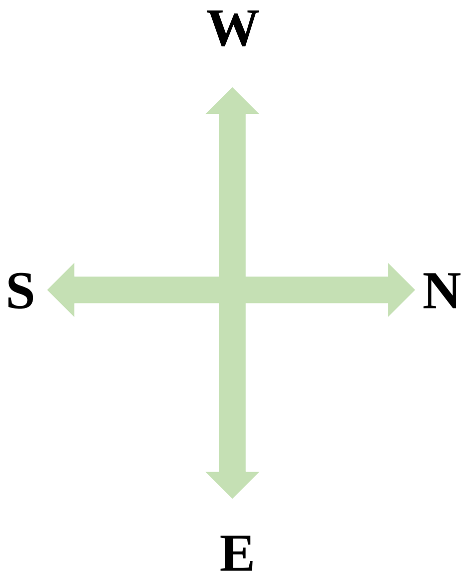
Month (2012)	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
March	31.4	19.6	54	11	8.2
April	34.2	23.4	61	112	8.1
May	34.7	25.9	70	185	7.8
June	35.4	28.6	75	242	7.5

* Monthly average,

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

Appendix IV. Lay out of the experiment

T_3	T_1	T_2
T_5	T_7	T_4
T_1	T_6	T_5
T_2	T_4	T_3
T_6	T_2	T_1
T_4	T_3	T_7
T_7	T_5	T_6
R_1	R_2	R_3



Appendix V. Analysis of variance of the data on number of number of whitefly at vegetative and reproductive stage and number of thrips per 10 flowers of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Number of whitefly per plant at vegetative stage	Number of whitefly per plant at reproductive stage	Number of thrips per 10 flowers
Replication	2	0.36	0.82	0.20
Treatment	6	34.39**	11.62**	5.67**
Error	12	1.36	2.12	0.60

**: Significant at 0.01 level of probability

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

Source of variation	Degrees of freedom	Mean square					
		Early pod stage		Mid pod stage		Late pod stage	
		Healthy pods	Infested pods	Healthy pods	Infested pods	Healthy pods	Infested pods
Replication	2	7.61	0.75	1.18	0.68	1.08	1.77
Treatment	6	25.05*	7.82**	38.85*	7.27**	28.09**	11.12**
Error	12	5.54	0.80	8.32	0.51	4.14	0.76

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

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

Source of variation	Degrees of freedom	Mean square						
		Plant height	Branch/ plant	Leaf/ plant	Number of pods / plant	Yield/ plant	Yield/ plot	Yield/ ha
Replication	2	9.80	1.28	4.57	3.52	3.516	0.012	0.005
Treatment	6	22.01*	1.75*	12.90*	8.34*	8.382*	0.053**	0.085**
Error	12	6.92	0.68	3.88	2.41	2.406	0.007	0.002

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