EFFECT OF SOWING DATES AND MICRONUTRIENTS ON INCIDENCE OF MAJOR INSECT PESTS OF MUNGBEAN

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EFFECT OF SOWING DATES AND MICRONUTRIENTS ON INCIDENCE OF MAJOR INSECT PESTS OF MUNGBEAN

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CERTIFICATE

This is to certify that thesis entitled **"Effect of Sowing Dates and Micronutrients on Incidence of Major Insect Pests of Mungbean"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), 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 bonafide research work carried out by **Most. Mahmuda Akter, Registration no. 07-2433** 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 duly been acknowledged.

Dated: JUNE, 2014
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LIST OF ABBREVIATIONS

AEZ	:	Agro-Ecological Zone
et al.	:	And associates
BBS	:	Bangladesh Bureau of Statistics
CV	:	Coefficient of variation
DAS	:	Days After Sowing
DMRT	:	Duncan's Multiple Range Test
d.f	:	Degrees of freedom
etc.	:	Et cetera
FAO	:	Food and Agriculture Organization
g	:	Gram
ha	:	Hactre
J.	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
MS	:	Mean sum of square
MP	:	Murate of Potash
no.	:	Number
%	:	Percent
SAU	:	Sher-e-Bangla Agricultural University
m^2	:	Square meter
t	:	Ton
TSP	:	Triple Super Phosphate

EFFECT OF SOWING DATES AND MICRONUTRIENTS ON INCIDENCE OF MAJOR INSECT PESTS OF MUNGBEAN

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ABSTRACT

The experiment was conducted at the farm of Sher -e- Bangla Agricultural University, Sher-e Bangla Nagar, Dhaka, Bangladesh to evaluate the effect of sowing dates and different micronutrients on incidence of insect pests of mungbean (*Vigna radiata* (L.) Wilezek) during kharif-II season (August to December) of 2013. The experiment comprised two factors, viz., factor A: Sowing date (two levels) – S_1: Sowing on 24 August, 2013; S_2: Sowing on 23 September , 2013 and factor B: Micronutrient treatments (five levels) – F_0: {Recommended doses (R) Urea (45 kg/ha), TSP (100 kg/ha), MP (58 kg/ha)}; F_1: {R + Boron (1.0 kg/ha)}; F_2: {R + Boron (2.0 kg/ha)}; F_3: { R + Zinc (8.5 kg/ha)} and F_4: { R + Zinc (17.0 kg/ha)}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Incidence of insect pests was recorded during the entire cropping season. Whitefly, jassid, thrips and pod borer were observed as important pests. Considering the sowing times, the lowest number of whitefly (1.13), jassid (1.40) and pod infestation (24.10%) of pod borer was observed in S_2 and the highest population of those was found in S_1. The lowest (3.93) and highest (5.36) number of thrips was observed in S_1 and S_2. In case of micronutrient treatments, the lowest number of whitefly (0.83), jassid (1.33), thrips (3.83) and pod infestation (19.98%) of pod borer was found in F_0, F_3, F_0 and F_4 respectively. On the other hand, the highest number of whitefly (1.48), jassid (2.33), thrips (5.30) and pod infestation (26.44%) of pod borer was found F_1, F_2 , F_3 and F_3 respectively. Considering the combined effect, the lowest number of whitefly (0.57) was found in S_1F_0, S_2F_1 and S_2F_3 while jassid (1.00), thrips (0.20) and pod infestation (19.10%) of pod borer was found in S_2F_3, S_1F_4 and S_1F_4 respectively. Contrary, the highest number of whitefly (2.40), jassid (3.00), thrips (10.20) and pod infestation (28.59%) of pod borer was found in S_1F_1, S_1F_2, S_1F_3 and S_1F_3 respectively. In case of yield effect, there was strong negative correlation between yield with insect infestation. But there was a negative relationship between yield and jassid infestation.

INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilezek] is one of the most important pulse crop of global economic importance. It belongs to the family Fabaceae and sub-family Papilionaceae. It is originated in the South and Southeast Asia (India, Mayanmar, Thailand) (Poehlman, 1991a). It is widely grown in India, Pakistan, Bangladesh, Mayanmar, Thailand, Philippinnes, China and Indonesia (FAO, 2005). It contains high graded vegetable proteins, satisfactory minerals and vitamins. Due to good taste, easy digestibility, better palatability and acceptable market price mungbean may be the first choice of farmers. In Bangladesh, among the pulses cultivated area only 8.10% lands are used for the cultivation of mungbean. According to World Health Organization (WHO) report, per capita requirement of pulse is 45 g. But in Bangladesh, only 12 g of pulse is available per capita per day. About 6.01 million metric tons of pulse will be required to meet the present per capita requirement of Bangladesh. There has been a continuous decline in production of pulses in Bangladesh during the last decade. In farmer's level, the average yield of mungbean is very low due to lack of knowledge of selecting and planting the suitable variety, inappropriate agronomic practices and infestation of insects and other pests.

The relative abundance of different species of mungbean insect pest is not identical in all seasons. The severity of damage is related with the abundance of different insects and environmental conditions. Several insect pests have been reported to infest mungbean crops during seedlings on leaves, stems, flowers, buds and pods causing considerable losses (Husain, 1993; Karim and Rahman, 1991; Litsinger *et al.*, 1988;

Rahman and Miah 1988; Sehgal and Ujagir, 1988). More than twelve species of insect pests were found to infest mungbean in Bangladesh (Anonymous, 1998). Among them jassid (Baldev *et al.*, 1988), whitefly (Rahman *et al.*, 1981), thrips (Hossain *et al.*, 2004; Rahman *et al.*, 1981), and pod borers (Hossain *et al.*, 2004; Rahman *et al.*, 1981) are important. Whitefly (*Bemisia tabaci* Genn.) is one of the most serious pest of mungbean. Both adults and nymphs of it suck plant sap from the underside of the leaves. They also secrete honeydew, which later helps the growth of sooty mould fungus reducing the photosynthetic area. The infested plants became weakened because of sucking the plant sap from the leaves and reduction of photosynthesis. Although white fly inflicts direct damage however it causes heavy damage by transmitt of viral diseases to mungbean. Many researchers reported that whitefly is responsible for transmission of viral diseases of mungbean (Yadav and Dahiya, 2004; Aftab *et al*., 1992; Bakar, 1991). Among them, yellow mosaic virus is the major one which reduced plant height, fresh shoot weight and up to 66% yield (Varma and Subrahmanym, 1986). Mungbean yellow mosaic virus disease spreads rapidly with increasing of whitefly population (Aftab *et al*., 1992). Moreover, there was significant effect of existing temperature and relative humidity on population of whitefly (Pimple and Summanwar, 1986).

Jassid have also been identified as major pests of mungbean (Yadav and Dahiya, 2000; Devesthali and Saran, 1998) causing serious damage of the plant. In case of severe attack the plant may die (Chhabra and Kooner, 1993). Thrips is associated mostly with the damage of tender buds and flowers of mungbean. Extensive damage of thrips to summer mungbean (kharif- I season) resulted flower shedding and significant yield loss (Chhabra and Kooner, 1985; Lal, 1985). Pod borer damages flowers, flower buds and developing or mature pods (Poehlman, 1991). Pod borer alone has been reported to cause grain yield loss of 136 kg/ha (Anon. 1986).

Pest appearance, population fluctuation, infestation rate and crop yield are very much dependent on sowing time. Most of the farmers usually sow mungbean just after harvesting the rabi crops without considering optimum sowing dates (Hossain *et al*., 2000). If they get free land early then they sow early or if it is late they sow late. As a result crops growth affected by unfavorable prevailing climatic conditions and also crop faced higher pest infestation thus yields become reduced. Information regarding insect pests appearance, infestation and its severity of damage in relation to sowing time is scanty in Bangladesh specially for mungbean crops. These insect pests not only reduce the vigor of the plant by sucking the sap but also transmit diseases and affect photosynthesis as well (Sachan and Kathi,1994) and ultimately cause yield losses.

Nutrient deficiency in soil is the key challenge for poor productivity of pulses. The soils of different parts of Bangladesh are more or less deficient in boron and Zinc. However, there is a great possibility to increase its production by cultivating HYV with balanced fertilization including micronutrient. Micronutrients play an important role in increasing yield of pulses and legumes through their effects on the plant itself. Deficiencies of those nutrients have been very pronounced under multiple cropping systems due to excess removal by HYV of crops and hence their exogenous supplies are urgently required. Zinc and Boron deficiency is widespread in the country; much observed in wetland rice soils, light textured soils and calcareous soils (Islam *et al.*, 1997; Rahman *et al.*, 1993; Jahiruddin *et al.*, 1992). Zinc is involved in auxin formation; activation of dehydrogenase enzymes; stabilization of ribosomal fractions (Obata *et al.,* 1999). Boron is very important in cell division and in pod and seed formation (Vitosh *et al.*, 1997). Rate of water adsorption and carbohydrate translocation restricted due to boron deficiency. It ranks third place among micronutrients, its concentration in seed and stem as well as its total amount after zinc (Robinson, 1973). Boron influences the absorption of N, P, K, and its deficiency changed the equilibrium of optimum of those three macronutrients. Inadequate supply of B decreased the economic yield of legume (Raj, 1985). The N and B concentrations of grain for mungbean were markedly influenced by B treatment indicating that the B had a positive role on protein synthesis. lqtidar and Rahman (1984) found that essential amino acid increased with increasing B supply. The critical level of boron with reference to crops in general was reported to a range from 0.3 to 0.8 ppm depending on soil types (Shorrocks, 1984). Therefore, applications of micronutrients in addition to essential major elements have gained practical significance.

Keeping these in view, the present study was undertaken with the following objectives:

1. To find out the incidence of major insect pests on mungbean at different sowing times.
2. To assess the effect of micronutrients on population of major insect pests of mungbean.

REVIEW OF LITERATURE

Pulses play a pivotal role in the diet of the common people of Bangladesh. Nutritionally, they are two to three times higher in protein content than cereals and have remained the least expensive source of protein for people since the dawn of civilization (Kay, 1979). In fact, until today, pulses provide the only high protein component of the average diet of the vast majority of the people of Banglaesh (Rahman and Rahman, 1988). About 73 million hectares of land are used in pulse production, which is 5.3% of the total cropped area of Bangladesh. Mungbean is one of the most promising pulse crops in Bangladesh and it is the only pulse crop grown during the entire year in the three main seasons under existing cropping patterns. It is sensitive to cloudy weather and can not tolerate frost (Gowda and Kaul, 1982). The average yield of mungbean is 617.50 kg/ ha in Bangladesh, which is far low as compared to the potential yield of this crop and to the average yields of other pulse growing countries (Anon. 1998) . There are many constrain responsible for the low yield of mungbean. The poor yield is due to varietal aspect, climatic factors, management practices, insect pests and diseases (Rahman *et al*., 1981). Among the constraints of mungbean culvitation, the attack of insect pests is considered the important one. Rahman *et al* (1981) listed the 16 insect pests that attack mungbean. These are bean stemfly (*Ophiomya phaseoli*), jassid (*Empoasca kerri*), whitefly (*Bemisia tabaci*), thrips (*Megalurothrips distalis*), bean aphid (*Aphis craccivora*), hairy caterpiller (*Diacrisia obliqua*), leaf webber (*Laprosoma indica*), leaf miner (*Acrocerphos phacospora*), epilachna beetle (*Epilachna* spp), semi- loopers

(*Diachrysia orochalcea),* spotted pod borer (*Maruca testulalis*), bruchids *(Callosobruchus chinensis)*, green bug (*Nezara viridula*), galerucid beetle (*Madurisia obscurella*), green semi-looper (*Plusia signata*), bean lycaenid (*Euchrysops cnejus*).

Green jassids, bean stemfly, whitefly, hairy caterpillar, galerucid beetle and aphids infest the crop at the seedling stage, vegetative stage and continue to flowering, stage while spotted pod borer damage flower buds, flowers and pods of mungbean (Rahman, 1991). Of these insect pests, whitefly, jassid, thrips and pod borer are most damaging (Gowda and Kaul, 1982; Rahman *et al*., 1981). For better understanding efforts have been made to review the available literature related to this pest distribution, their nature of damage and yield loss caused by this insect pests. However, some of the important and informative works regarding the sowing date and micronutrient so far been done at home and abroad on this crop and their findings regarding the growth and yield of this crop have been reviewed in this chapter under the following headings-

2.1 Abundance of insect pests of mungbean

Altaf *et al.* (2006) was conducted an experiment at Pulses Research Center, Ishurdi, Pabna, Bangladesh during Kharif-I to find out the insect pests attacking mungbean crop sowing at different dates to determine the optimum date(s) of sowing. It was seen 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 sowing (mid April to onward) crops received higher pest infestation than the mid sown (March 13 to April 10) crops. The highest yield (1548 kg/ha) obtained from March 27 sowing crop. The second highest yield (1279 kg/ ha) obtained from March 13 sowing which was statistically identical to March 20, April 03 and April 10. Again, the delayed sowings after mid April to onward provide yield of 717 kg/ha which were very poor. Hence, for ensuring higher yield and less insect pests infestation, mungbean should be sown within the period of March 13 to April 10 and the best date of sowing should be March 27.

Tajbakhsh and Saeid (2006) carried out a field study trial during 2005-2006 growing season to compare winter and spring sowing dates and studied the effect of plant density on the yield, yield components and some quality of morphological traits of one local cultivar chickpea (ghazvin). The study comprised of three sowing dates viz., mid November, mid March and mid April, four planting densities viz., 30 x 7.5, 30 x 10, 30 x15 and 30 x 20 cm that representing 45, 34, 23 and 17 plant m^{-2}. The experiment was laid out in a split plot design, based on the completely randomized blocks. Results indicated that early sowing (mid November and mid March) crops produce higher yield as compared to mid April and plant density did not significantly affect the yield.

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 to 66.5 The white traps caught the highest number of thrip (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.

Sreekant *et al.* (2004) conducted field experiments in kharif seasons on mungbean cv. K-85 I 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 virus and mosaic 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.

Yuchenque Chi *et al.* (2003) conducted an experiment in Kagoshima, Japan to study the seasonal variation is legume pod borer abundance in four legumes species by cowpea, (*Vigna unguiculata*), odzuki (*V. angularis*) Soybean *(Glycine max*) and ned kidney bean *(Phaseolus vulgaris*). The infestation peaked in mid July, when more than 90% of cowpea and adzuki flowers were infested.

Huang *et al.* (2003) reported that the bean pod borer infested *Sesbania cannabiba* 30-90 days after sowing especially during 48-62 UAS. Although bean pod borers are not strong fliers when dispersing, it is recommended that mungbean should be planted 45m away from Sesbania cannabina to minimize infestation by the bean pod borer.

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

Bashar (2002) suggested that crop sown by early March enabled to escape the infestation of stemfly, whitefly, hairy caterpiller and pod borer resulting higher yield.

Rathore and Tiwari (1999) studied the distribution pattern of *Megalothrips distalis* (karny) on mungbean, urdbean and cowpea foliage separately and reported that the distribution behaviour of thrips on foliage as initially found to be random and as the densities increased it became aggregated However, in flowers, the distribution was aggregate. Unfavorable seasons adversely affected population growth which was reflected in distribution patterns.

Mungbean sown by 15 and 22 February produced significantly higher yield and had lower percentage of pod borer and higher shootfly infestation (Anon., 1999). The percentage of pod borer infestation was the highest in the mungbean while sowing on 15 March (Anon., 2000b) and the highest healthy pods obtained from crops sowing on

15 February whereas 22 February sowing gave the highest yield by lower pest infestation (Anon., 1997a).

Oghiakhe (1996) studied the effect of cultivar, plant part and phonological growth stages of *V. unguiculata* on oviposition behavior of *M. testulalis* (pod borer) in free-choice and no-choice tests in screen cage. The 3 growth stages viz pre-flowering, flowering and podding respectively. The oviposition pattern by *N. virata* (pod borer) gravid females was similar among the 3 cultivars, and all the various plant parts were oviposited upon at different growth stages cv. TWNu 72 was the least preferred for oviposition while cv. IT820-716 was the most preferred.

Ekesi (1996) investigated the relationship between planting dates and damage by the pyralid, *Maruca testulalis* (pod borer) on *V. unguiculata* (cowpea) in Nigeria during July to August 1993 and 1994. The population tended to build up in the course of the sowing period in both years. The number of flower and pods infested were greater in cowpea planted in August than in July in both years. Grain yield also decreased significantly in late planted crops than in early planted cowpea within the 1^{st} and 2^{nd} weeks of July would reduce damage by the pest.

Nath (1994) studied the relationship between disease incidence and population size of *Bemisia tabaci* on mungbean. He observed a positive correlation between incidence and population size of *Bemisia tabaci*.

Akhgauri *et al*. (1994) showed that the pod borer community remained active from January to March, with their collective larval population being more during end of February until third week of March. Among all the pod borers *Melanagromyza obtuse* predominated throughout the reproductive phase of the pigeon pea.

Chhabra and Kooner (1994) evaluated 35 *I. radiata*, genotypes for their reaction to thrips in the field and reported that SM 112 and SM 103 were rated resistant and had the least inflorescence deformity.

Gupta and Singh (1993) studied the population dynamics of insect pests associated with greengram and reported that in summer, thrips and stemfly appeared first followed by galerucid beetle and white fly while in rainy season (kharif) thrips, stem fly and other insect pests were noticed. The populations of all the insect pests except thrips continued to build up till vegetative growth i.e. 7 or 8 weeks of sowing the crop. Most of the insect pests attained their peaks by 7th or 8th weeks of sowing. Correlations between population of insect pests and various a biotic factors revealed that thrips and whiefly in dry conditions are more favourable than rainy conditions For galerucid beetle, jassids, leaf-miner and leaf-eating caterpillars, the rainy conditions are more favourable.

Zandiglacomo (1992) reported that the major pests of mungbean are whitefly, *Bemisia tabaci*; jassids, *Empoasca kerri*, thrips *Megalurothrips distalis*, GLH, leaf roller, mungbean hairy caterpillar, stinkbug, semilooper, white leafhopper etc.

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

Begum *et al*. (1992) reported from an experiment conducted in Bangladesh on sowing dates had significant influence on *H. Armigera* in chickpea. They observed that chickpea sown on 15 November and 1 December suffered significantly less pod damage than those sown on 15 and 31 December.

Talekar *et al.* (1991) observed that early November sowing of gram (*Cicer arietinum*) had the lowest number of eggs and larvae of *H. Armigera* as compared with the sowing made 2 and 4 weeks later.

The virus spreads on mungbean or blackgram through all seasons, but spreads faster with the onset monsoon (end of June onwards) along with the build up vector population (Varma *et al.*, 1991).

Brunt *et al*. (1990) found that the virus was observed to be transmitted in nature by an insect vector belonging to the family Aleyrodidae: *Bemisia tabaci* in non-persistent manner. Helper virus was not apparently required for transmission. Non-vector transmission was apparently not mechanical inoculation, not by seed and also not by pollen.

Jayaramiah and Babu (1990) reported rainfall as the influencing factor of pod borer moth emergence as well as higher pod borer infestation.

Sahoo *et al*. (1989) evaluated the varietal susceptibility in 60 *V. radiata*, and 50 *V. mungo* cultivars against leaf beetles and pod borer complex in the field. Most of the cultivars tested were resistant or tolerant of both types of pest, with high resistance shown by *V. mungo* cultivar B 3-8-8 and *V. radiata* cultivars PDM 54-146, ML -131 and ML-372.

Rajapakse and Jayasena (1989) conducted a field experiment on the species composition, distribution and control of insect pests of mungbean and reported that the major pests were *0. phaseoli*, *M. testulalis* and *B. tabaci*. The mungbean selections VC 42281-B, VC-422-B, VC-4290 and V-6083 showed less than 10% infestation of *0. phaseoli* under low and high nitrogen regimes.

The attack of pod borer, *Euchrysops cnejus* on mungbean can be minimized by careful selection of a suitable sowing time (Husain and Begum, 1988).

Phookan and Saharia (1987) observed the effects of infestation by legume pod borer *(M. testulalis)* on yield of 3 varieties of green gram in the field. No clear relationship between larval density and yield loss was established. Of the 3 varieties, Kopergaon and T-44 showed greater yield losses than K-85.

Whitefly density is usually the highest between April-June with temperature 29-34^0 C and July-September with temperature 24-25^0 C and relative humidity 66-99% (Pimple and Summanwar, 1986). The whitefly population on plants varies at different periods of the day. In mungbean, the lowest number of *B. tabaci* are found at noon when the light intensity was maximum, and the highest number during early morning or late evening hours as reported by Varma and Subrahmnayan (1986).

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

Prasad *et al.* (1985) conducted an experiment on the incidence of the noctuid *H. armigera* on chickpea at Bihar, India in 1979-81. The lowest pod damage, 8.7 and 11.3% as well as the highest yields, 15.3 and 14.0 kg/ha respectively were recorded in the plot sown in both the years.

Yadav *et al.* (1983) suggested that early sowing of chickpea or the use of early maturing varieties could significantly reduce the damage caused by *H. armigera*, because pod setting and maturation were completed during the period when larval population was low.

Park *et al.* (1978) found that the mungbean pod borer *Euchrysops ivinesuns* Fab., is the most devasting to the pods in the Republic of Korea.

Annonymous (1973) presented on elaborate survey of insects pests associated with various stage of mungbean crop and found the following insect pests such as whitefly, jassids, semilooper, mungbean hairy caterpillar, black and white thrips, brown thrips, black beetle and pea stern fly. It has been also reported that some of the varieties are able to tolerate the attack of' whitefly, *Bemisia tabaci*.

Alam et al. (1964) recorded three different insect pests of mungbean such as whitefly *(Bemisia tabaci*), jassid (*Empoasca kerri*), mungbean leaf roller (*Lamprosema indicata*). He found that whitefly and jassid are major, they suck the sap from leaf and appeared in March to June.

2.2 Nature of damage of mungbean insect pests

2.2.1 Whitefly

Eggs are laid and immature stages of whitefly developed the undersides of the leaves on most crops. Adults congregate on younger leaves in most crops and oviposition is heaviest on these leaves. The location on the plant of the various stages of the whitefly follows the development of the plant. Eggs and early instar nymphs are found on the young leaves and larger nymphs are usually more numerous on older leaves (Gill. I992).

Adults congregate, fed, and mate on the undersurfaces of the leaves of the host plant. This can occur in such numbers as to create “clouds” when disturbed. They appear to be more active during the sunny day light periods and do not fly as readily during early morning, late evening or night hours. The nymphal stages are sedentary, with the exception of the crawler, which after hatching moves a very short distance. Once a feeding site is selected the nymphs do not move. They suck juices from the plant with their piercing sucking mouthparts. The nymphs are located on the undersides of the leaves and can become so numerous that they almost cover the entire undersurface area.

Direct crop damage occurs when whiteflies feed in plant phloem, remove plant sap and reduce plant vigor. Heavily attacked plants may die. Whiteflies also excrete honeydew, which promotes sooty mold that interferes normal photosynthesis and may lower harvest quality. In cotton, the sugars excreted during whitely feeding make the cotton fibers sticky and can promote growth of sooty mold, both of which reduce quality. In some hosts, damage can result from whitefly feeding toxins that cause plant disorders such as silver leaf of squash and irregular ripening of brinjal. Plant viruses also can be transmitted by whiteflies, such as the gernaniviruses in tomatoes.

Plant disorders and virus transmission are of particular concern because they can occur even when a whitefly population is small. In general, the older the plant when infected with virus or the later the onset of plant disorders, the less damage to the crop, so preventative action is critical. Prevention is also crucial in managing whiteflies in highly cosmetic crops such as ornamental plants, where even low number of whiteflies can affect marketability.

The sweet potato whitefly currently is known to attack over 500 species of plants representing 74 plant families (Arnal et al. 1993). They cause particular problem on members of the squash family (Squash, melons. cucumbers, pumpkins), tomato family (tomato, eggplant, potato), cotton family (cotton, okra), bean family (beans, soybean, peanuts), silvia, poinsettia and many other ornamental plants. The poinsettia is a favoured host and suffers color loss as well as leaf damage.

2.2.2 Jassid

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

Nair (1986) reported that the nymhs and adults of *A. devastans* could attack host leaves at all stages of development. The adults and nymphs feeding on the sap and injected saliva into the tissues, which causes toxemia, cause injury of the leaves. The edges of the infested leave turn pale-green, then yellow and finally brick red or brown in color. The color changes are accompanied by severe crinkling and leaf surface, young leaflets appear pale and slightly distorted and if held to the light, small translucent markings are obvious. On beans, leaves may appear shiny and speckled with sooty black markings. The underside of bean leaves develop a rusty discoloration.

2.2.3 Thrips

Thrips are deep black coloured measuring about 1.65 mm in length. Antenna is eight segmented. Both the nymphs and adults feed on stigma inside the flower, the flower sheds before opening and there is elongation of terminal shoot. In case of severe incidence, the plants attain a bushy growth and the crop looks dark green in colour, bearing few pods with shriveled grains.

M. distalis usually occurs on flowers, in the case of fabaceae in the keel of the flower, and causes damage to anthers and stigma. In certain cases it is reported on leaves also. It causes curling of the pods by feeding in the flowers when the pods are forming;

russeting by feeding on pods approaching maturity; malformation of the young plant by feeding in the growing point and curling of leaves by feeding on the undersides. If growing conditions are good, the plants may almost completely recover, but if not they remain unproductive. Late sowing plants are usually more severely injured than early ones.

Thrips (Thysanoptera) and their predators were investigated from 2005-2007 on a wide range of vegetables grown mostly in the winter period in Cukurova region of Turkey. A total of 2989 adult thrips and 406 thrips larvae were extracted from the vegetables. The adults belonged to 14 thrips species of which *Melanthrips* spp. were the most dominant species. The dominance of the commonly found pests *Thrips tabaci* and *Frankliniella occidentalis* differed greatly. *F. occidentalis* was the predominant thrips infesting broad bean, lettuce and parsley, while *T. Tabaci* was more abundant on leek, onion and pea. The most thrips were collected from flowers or heads of vegetables in early spring. Numbers of predatory insects dwelling on the sampled vegetables were lower in comparison to total numbers of thrips obtained in the years 2006 and 2007 (Atkan, 2008).

Lal *et al*. (1987) reported that *M distalis* attacks pigeon pea (*Cajanus cajan*), mung bean (*Vigna radiata*) and cowpea. The nymphs and adults rasp the ventral or dorsal surfaces of the tender leaves, flowers and suck the oozing cell sap. Infested leaves show silvery-white shiny patches with curly tops. Brownish adults and whitish translucent larvae are present on both sides of the leaves. Severity increases with the prolongation of dry weather.

Olowe *et al*. (1987) reported that *M. distalis* punctures plant cells and sucks out their contents; plant tissue around feeding sites becomes discolored, subsequently turning brown and dying.

Chhabra and kooner (1985a) reported the cumulative damage caused by the three insect pests of the summer season mung bean crop, *Ophiomyia phaseoli* at seedling stage, *Acherontia styx* at vegetative stage and *M. distalis* at the flowering stage, as up to 54.3%, *M. distalis* was the most serious pest, causing heavy damage to the fruiting bodies.

Ananthakrishnan (1971) reported that some species of thrips act as vectors of bacterial, fungal and virus diseases. In addition, they form galls which are caused by the reaction of plant tissues with salivary toxins during feeding. Instances of bacterial disease transmission have not so far been reported in India, although the possibility of transmission of pod twist disease of beans, caused by *Pseudomonas flectens,* cannot be overlooked. Transmission of this bacterial disease has been reported from Australia, the natural source of infection being the common fabaceous plant *Phaseolus lathyroides*.

2.2.4 Pod borer

Pod borer is highly devasting to pods. Pod borer damage starts from pod initiation to pod maturation stage. But the infestation is higher at pod initiation and pod filling stage. After hatching, the larvae search for food. Larva bores into the flower buds and pods. Larvae bore the pods at the base and enter into the pods. The larvae remain inside the pod and feed on the seed sometimes larvae role the leaves and shill to pods. Infested pods show exit holes along with excreta. The larvae nest in a cell of the pods. The full grown larvae comes out through the infested pods and drop on the ground for pupation in the soil and plant debris.

Panicker *et al.* (2002) investigated the interrelationship of flower, pod and seed damages by *Maruca virata* and identified damage criteria to be considered for damage based resistance evaluation. A positive correlation was observed between pod and seed damage. Flower damage, however, was independent of pod damage. Thus, damage to both flowers and pods should be considered when damage based screening for pod borer resistance is conducted for *V. unguiculata*.

Vidya and Oomen (2001) conducted an experiment to evaluate legume pod borer resistance in 50 accessions of yard long bean (*Vigna unguiculata*) and reported significant differences ($P<0.05$) for flower and pod damage among the cultivars. Correlation between flower and pod damages was not significant ($P>0.05$) differences. Plant resistance evaluation based on simultaneous consideration of flower and pod damages indicated that accession Vs 5 was the most resistance one among the cultivars evaluated.

Hussain and Shaharia (1994) studied the feeding response by *Riptorus lineari*s, *N. viridula* and *M. testulalis* on greengram in the field and reported a linear relationship between pod borer infestation and seed loss, with the rate of seed loss being greater for *R. litorus* and *N. viridula* than *M. testutalis.*

Ogunwolu (1990) conducted an experiment to quantify the damage to cowpea (*V. unguiculata*) by different densities of the pyralid (*M. testlalis*) and reported that larval damage to the flowers and pods increased with percent infestation and reduced the yield to 72.1%.

Qu and Kogan (1984) reported that the mungbean pod borer is wide spread in the tropics and subtropics and is most damaging pod borer in Asia. After hatching the insect spins a small web and then bore through the pod and feed on the developing seeds. A spot of dead tissue at the point of the insect exit and a large exit aperture clearly visible on damaged pods.

2.3 Yield loss caused by insect pests

Variability in pest infestation was created by growing *E. belat* (an erect cowpea cultivar) in two locations over three seasons and under different insecticide spray schedules. Stepwise regression for individual locations and seasons data indicated that most of the variation in cowpea grain yields was caused by thrips. We estimated that to the total variation in cowpea grain yields, on average, the major pests contribute 51-69% in Pallisa and 24-48% in Kumi. Thrips alone contribute 35-41% and 13-19% at these two sites, respectively (Kyamanywa, 2009).

Yigitoglu (2006) reported that highest seed yield of chickpea was obtained in early winter sowing and high plant density (45 plant m^{-2}). Planting density depends to environmental conditions, seed size, plant type and method of sowing.

Maruca testulalis G. is one of the important insect pests of French bean. Studies at the Sokoine University of Agriculture (Morogoro, Tanzania) have indicated that uncontrolled populations of pod borers, particularly *M. testulalis*, decreased the seed yield by 20-50% in some local cultivars. In Kenya, studies have revealed that *Maruca testulalis* G. is the most important pest of cowpea, reducing yields by up to 80% (Karel, 2004).

Patnaik (2004) carried out a field trial on the effects of sowing date (30 October, 15 November, 30 November or 15 December) and row spacing (30 or 45 cm) on the incidence of *H. armigera* and yield of chickpea cultivars Annigeri-1, K 850 and H 208 in Keonjhar, Orissa, India. The sowing date had greater effects on pod damage and grain yield than the genotype. Crops sown on 30 October and 30 November had high grain yields (11.8-15.2 and 15.6-20.7 quintal/ha) despite the high levels of pod damage (4.6-11.1 and 14.5-16.7%) caused by *H. armigera*. However, based on yield and pod damage, sowing on 30 October was considered optimum. Closer spacing (30 cm) resulted in a higher mean number of eggs (5.0) and larvae (8.2) per plant irrespective of sowing date and cultivar. Pod damage and grain yield did not significantly vary with the row spacing and cultivar.

Singh *et al*. (2002) conducted on trial in Gurdaspur, Punjab, India, during 1999 and 2000 on chickpea cultivars PBG-1 and GL-769 to determine the effect of sowing dates (10 October, 20 October, 30 0ctober, 10 November and 20 November) on incidence of *H. armigera*. GL-769 showed the highest pod infestation (13.08 and 12.70% in 1999 and 2000, respectively), while PBG-1 showed the highest grain yield (1410.66 kg/ha in 1999 and 1414.27 kg/ha in 2000).

The pod borers inflicted heavy crop losses from seedling to maturity. But the losses reached at its peak when the pods appeared (Deka *et al*. 1989; Mehto and Singh 1983). Lal (1996) reported that the seed yield losses due to *H. armigera* were 75-90% and in some places the losses were up to 100%. The yield loss in chickpea due to pod borer was reported as 10 to 60 percent in normal weather conditions, while it was 50 to 100 percent in favorable weather conditions, particularly in the state where frequent rain and cloudy weather is prevailing during the crop season (Patel 1979). These losses can be reduced by the application of insecticides (Balasubramanian *et al*., 2001; Rakesh *et al*., 1996; Singh *et al.*, 1987; sinha *et al*., 1983;). In favourable conditions pod borer may cause 90-95 percent pod damage (Sachan and Kathi, 1994).

Gill (1999) conducted an experiment on the effect of mungbean yellow mosaic virus transmitted by *Bemisia tabaci* on yield components of the mungbean cultivar ML-267 in Punjab, India. They briefly reported that infection in the early growth stages reduced yields significantly more than that of infection at the flowering stage.

Yield losses due to infestation by jassid was agreement with several other workers. (Hassan, *et al.*, 1998). They reported that population of jassid showed comparatively higher yield loss (18.31%).

Aftab *et al.* (1992) reported that a crop of *Vigna* (*unguiculata* subsp.) *sesqupedalis* was found to be infected by mungbean yellow mosaic bigeminivirus during 1990 at Islamabad, Pakistan. Symptoms included pale to yellow spots mixed with green areas on the leaves. The disease spread rapidly with increase in the whitefly (*Bemisia tabaci*) population. Plant height, number of pods, seeds and yield/plant were reduced by 10.3, 50.5, 44.7 and 49.2% respectively while the effect on nodulation was non-significant.

Ganwar and Ahmed (1991) evaluated 10 mungbean varieties for seed yield and productivity, days to maturity, percentage pod damage due to pod borer *M. testulalis* and reported that mean seed yield was greatest in ADT2 (899 kg/ha), followed by ML6S CO1. P 104 and P l05. ML6S had the highest seed productivity (11.7 kg/ha per day). Pod damage was relatively high which 29.9% in S8 and 39.2% in CO_3.

Bakar (1991) described yellow mosaic virus as the most serious limiting factor in mungbean and blackgram cultivation. He also stated that the disease can attack the crop at any stage of growth but losses are severe when it attacks at an early stage. Total loss had been reported when the crop was infected within 1-2 weeks after germination, 63% at three weeks and around 20-30% in plants, which were infected at the age of 4-7 weeks of mungbean.

Pod damaged by pod borer varied significantly due to different sowing dates. The lowest pod damage (9.25%) was observed in March 27 sowing crops which was statistically identical to February 14, February 21 and March 13 sowing crop. The highest pod damage (38.54%) was observed in May 01 sowing crops which was statistically identical to April 17 and April 24 sowing crops. It is seen that in February and March sowing crop pod borer damage was comparatively low than that of April and May sowing crops. This might be due to higher rainfall in April-May sowings favouring pod borer population increase caused higher pod infestation.

Sehgal and Ujagir (1985, 86) reported that pod borer damage to mungbean without protection at Pantnagar varied from 8 to 11% during 1985 and 1986. Pod borer alone were reported to grain losses of 136 kg/ha in mungbean, 191 kg/ha in cowpea (Annon. 1986) and 400 kg/ha in chickpea (Rahman, 1989).

The legume pod borer is one of the largest yield reducing factors in food legumes. Its serious pest status has mainly been attributed to the high fecundity, extensive polyphagy, strong dispersal ability and a facultative diapause. The larval preference for feeding on plant parts rich in nitrogen such as reproductive structures and growing tips results in extensive crop losses (Fitt, 1989).

Rahman (1987), Taylor (1978) reported that pod borer infestation may cause great reduction of yields of the infested crops.

The plant pathology divisions of the Bangladesh Agricultural Research Institute (BARI) and Bangladesh Agricultural University (BAU) had estimated yield losses for a few diseases in the pulse crops. Yellow mosaic caused 16% yield loss in mungbean and 10% loss in Blackgram (Anon., 1988; Fakir, 1983). Reduced plant height and fresh shoot weight were also reported along with yield loss of up to 66% (Chanda and Varma *et al.*, 1983).

Chhabra and kooner (1985b) reported that *M. distalis* infests flowers causing flower drop, deformation of pods, in some cases reaching 100%.

Pod borer is every important pest of the bean. In recent study, *Maruca testulalis* G was found to cause maximum damage in pigeon pea in Bangladesh (Rahman, 1989). As an important pest of leguminous vegetables, substantial works have been done on *Maruca testulalis* G. was studied at the Regional Agricultural Research Station, Jamalpur. Out of 32 genotypes, the highest percentage of infestation was found in Bata (Mirsharai) (16.81+1.21%) but the lowest percentage of infestation in sword bean (0.74+0.05%) (Kabir *et al.*, 1983).

Singh *et al.* (1982) carried out an experiment to study yield losses in mungbean due to mungbean yellow mosaic virus and observed that early infected plants had more severe symptoms than the late infected ones. They also established that chlorosis, stunting and reduced branching contributed to yield loss.

Rahman *et. al*., (1981) found the insect to cause as high as 100% infestation of black gram leaves, the effect of infestation at such high levels are likely to be profound on yield of the crop. He also reported that bean pod borers could cause as high as 38% reduction of the yields of pigeon peas in Bangladesh. Ohno and Alam (1989) found that pod borer damage in cowpea was 54.4% at harvest.

Singh and Allen (1980) reviewed the infestation of pod borers in field and horticultural crops across Africa, Asia, South Central America and Australia and concluded that the insect can cause 20-60% damage to host crops.

Gangrade *et al*. (1975) reported that upto 85 insect species were found feeding on mungbean at Jabalpur in indica (at latitude similar to Bangladesh). Not all of them were important pets but a few caused severe economic losses.

MATERIALS AND METHODS

The experiment was conducted to know the effect of sowing dates and different micronutrients on incidence of major insect pests of mungbean during the period from August to December 2013. The details materials and methods of this experiment are given below:

3.1 Location and Time

The research work was conducted at plot no: 27 in Sher-e- Bangla Agricultural University farm, Dhaka 1207; during kharif-II season (August to December) of 2013.

3.2 Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the general soil type is Shallow Red Brown Terrace soils. Upper level soils were clay loam in texture, olive-gray through common fine to medium distinct dark yellowish brown mottles. The selected plot was above flood level and sufficient sunshine was also available there. Irrigation and drainage system was developed during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources and Development Institute (SRDI), Dhaka. The experimental plot was also high land, fertile, well drained and having pH 5.8. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix 1.

3.3 Climate and weather

The experimental area was situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year (Biswas, 1987). The Rabi season (October to March) is characterised by comparatively low temperature and dazzling sunshine from November to February. Meteorological data in respect of temperature, relative humidity and total rainfall recorded by the Sher-e-Bangla Agricultural University Farm, Dhaka during the study period and has been presented in Appendix II.

3.4 Experimental design and layout

Factorial experiment was conducted in Randomized Complete Block Design with three replications. There was two factors; Factor A**-** sowing times (two sowing times) and Factor B- micronutrient treatments (5 levels). A total of 30 experimental plots was maintained for this experiment. The experiment was carried out during August to December, 2013.

3.4.1. Total Area: 200 m^2

3.4.2. Total Plot: 30

3.4.3. Plot Size: 3.0 m X 2.0 m

3.4.4. Plot to Plot distance**:** 0**.**5 m

3.5 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. The plots were spaded one day before planting and the whole amount of fertilizers were incorporated throughly before planting according to fertilizer recommendation guide (BARI, 2006).

3.6 Manures and fertilizers

The calculated entire amount of all manures and fertilizers were applied during final field preparation. The applied manures were mixed properly with the soil in the plot using a spade. Urea, TSP and MP fertilizers were applied as recommended by Annon. (1997) for mungbean cultivation @ 45 kg urea, 100 kg TSP and 58 kg MP, respectively per hectare during land preparation.

The whole field was divided into two equal blocks having 0.5m space between the block and each block was again sub-divided into 30 plots (3m X 2m) as treatment plot with 0.5m space between them. The spacing was 30 cm between rows and 10 cm between plants. As it was factorial experiments fertilizers such as Urea, TSP and MP was given at the rate of 13.5g, 30g and 17.4g per plot corresponding to 45, 100 and 58 kg per hectare, respectively. 13.5g urea, 30g TSP and 17.4g MP was measured as recommended dose and expressed as F_0. In case of F_1 recommended dose and 1.76 g boric acid was given per plot. In case of F_2 recommended dose and 3.52 g boric acid was given per plot. In case of F_3 recommended dose and 7.15 g $ZnS0_4.H_20$ per plot. Recommended dose and 14.3 g $ZnS0_4.H_20$ was given per plot in case of F_4.

3.7 Treatments

The treatment consists of two factors.

Factor A

Sowing dates (2 levels)

S_1= Sowing on 24 August, 2013

S_2= Sowing on 23 September, 2013

Factor B

Micronutrients (5 levels)

F_0 = Recommended doses (R)

Urea (45 kg/ha), TSP (100 kg/ha), MP (58 kg/ha)

F_1 = R + Boron (1.0 kg/ha)

F_2 = R + Boron (2.0 kg/ha)

F_3 = R + Zinc (8.5 kg/ha)

F_4 = R + Zinc (17.0 kg/ha)

3.8 Seed treatments

Before planting, seeds were treated with Vitavax-200 @ 0.25% to prevent seeds from the attack of soil borne diseases. Furadan 5G @ 1.2 kg ha^{-1} was also used against wireworm and mole cricket.

3.9 Sowing of seeds

There were two sowing dates. First sowing was done on 24 August, 2013 while second at 23 September, 2013. Treated mature 4-5 seeds of mungbean were sown in each hole by hand. The row to row and plant to plant distances were maintained 25 and 10 cm, respectively. Seeds were placed about 6-7 cm depth from the soil surface. Few seedlings were grown in the border of the plots as stock for gap filling subsequently.

3.10 Intercultural operations

3.10.1 Thinning

As the seeds were sown continuously, so there were so many seedlings which need thinning. Seedling was emergence after 5 days of sowing. Over crowded seedlings of first sowing was thinning out 15 days after sowing. Emergence of seedling of second sowing was completed within 3 days after sowing. Over crowded seedlings of second sowing was thinning 30 days after sowing which was done on priority based of unhealthy and lineless seedlings.

3.10.2 Gap filling

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

3.10.3 Weeding

There were some common weeds found in the experimental field. First weeding was done at 10 days after first sowing. Second weeding was done at 20 days after first sowing. Third weeding was done at 30 days after second sowing. After third weeding, the plots were weeding once in a week to ensure aeration.

3.10.4 Irrigation and drainage

The first irrigation was done after first weeding. Subsequent irrigation was given when needed. Proper drainage system was also maintained for draining out of excess water.

3.11 Collection of Data

Data were recorded on the incidence and infestation of different insect pests such as whitefly, jassid, thrips and pod borer. Data were recorded by direct counting and collected at early in the morning (6.30 a.m.-9.00 a.m.) once in a week. According to Anon. (1984) and Ohnesorge and Rapp (1986) sampling of the sedentary immature stages gives more reliable estimates of the absolute population density. The accuracy of the estimates depends on the choice of leaves to be sampled and the manner in which the individual are to be assessed. Within plants, eggs and young nymphs occur on the upermost and young leaves, while older nymphs and pupae are found on older leaves. Based on their findings, nymphs on lower, mid and upper leaves were counted visually.

3.11.1 Whitefly

Plate 1. Adult whitefly

Plate 2. Infested leaf with whitefly

Whitefly was counted from five fully unfolded top leaves of the plant. Data were collected once in a week. Whitefly were collected at early in the morning (6.30 a.m.-9.00 a.m.). Accordingly, direct counting were done early in the morning when the adults (whitefly) are least mobile (Gerling and Horowitz, 1984; Hill, 1968; Seif, 1981). Whitefly nymphs were counted by using magnifying glass and recorded.

- Whitefly adult direct counting by visual method/10 plants.
- Whitefly nymph direct counting on lower, mid and upper leaf by using magnifying glass/10 plants.

3.11.2 Jassid

Plate 3. Jassid

Jassid was also counted from five fully unfolded top leaves of the plant. Data were collected once in a week. Jassid were collected at early in the morning (6.30 a.m.-9.00 a.m.).

- Number of jassid/10 plants.

3.11.3 Thrips

Plate 4. Thirps

Thrips was counted from five flowers per plant. Data were collected once in a week and commencing from first incidence. Thrips were collected at early in the morning (6.30 a.m.-9.00 a.m.).

- Number of thrips/5 flowers / plant

3.11.4 Pod borer

Plate: 5. Infested pod with pod borer

Plate: 6. Infested plant with pod borer

Plate: 7. Healthy pod

Healthy and infested pods were counted due to infestation of pod borer. Those were counted ten days before harvesting and at harvest.

- Number of healthy pod /5 plants.
- Number of infested pod/ 5 plants.
- **Percent pod infestation**

The number of infested pod was counted for each sample plant. The infested pods were identified by recognizing the bored pod caused by the pod borer after emerging adult from the pods. Magnifying lens and simple microscope were also used in that purpose whenever needed. The percent grain infestation was then calculated from the data on number of infested and total pods observed by using the following formula:

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

3.12 Yield

First harvest of first sowing was done after 64 (DAS), second and third harvest of first sowing was done after 72 (DAS) and 82 (DAS), respectively. First harvest of second sowing was done after 68 (DAS) and second harvest of second sowing was done after 77 (DAS). The harvested pods were dried, threshed cleaned and weighed with the help of a digital balance.

3.13 Statistical analysis

The recorded data was compiled and tabulated for statistical analysis. Analysis of variance was done with the help of MSTAT-C software. The treatment means were separated by Duncan**'s** Multiple Range Test (DMRT) and Least Significant Difference (LSD) when necessary.

RESULTS AND DISCUSSION

The study was conducted to evaluate the effect of sowing dates and different micro nutrients on incidence of insect pests of mungbean. The results are presented under the following headings:

4.1. Effect of sowing dates on pest incidence

Incidence of insect pests for the entire cropping season viz. whitefly, jassid, thrips and pod borer was observed. Incidence of insect pests were counted and presented as follows:-

4.1.1. Whitefly

Infestation by whitefly on two sowing dates are shown in Fig. 1. The figure indicated that the lowest number of whitefly (1.13/plant) was found in S_2 (Sowing on 23 September, 2013). On the other hand, maximum number of whitefly (1.27/plant) was found in S_1 (Sowing on 24 August, 2013) but they are statistically insignificant. As temperature was initially high, the whitefly population was also high in case of first sowing. After rainfall the whitefly population was subsequently decreased.

Butani and Jotwani (1984) also reported that the activity of this pest decreased with the on set of rain.

No. of white fly/plant

Sowing date

Fig. 1: Average infestation by whitefly on two sowing dates.

4.1.2. Jassid

Infestation on two sowing dates by jassid are shown in Fig. 2. The figure expressed that the lowest (1.40/plant) number of jassid was found in S_2 (Sowing on 23 September, 2013). On the other hand, maximum (2.07/plant) number of jassid was found in S_1 (Sowing on 24 August, 2013) but they are statistically insignificant. It also reveal that initially temperature was high and higher number of population was observed in case of first sowing. But in case of second sowing, due to rainfall and temperature fluctuation, the lower number of population was found.

Yein and Singh (1980) observed that temperature and rainfall had significant influence on number of jassid population.

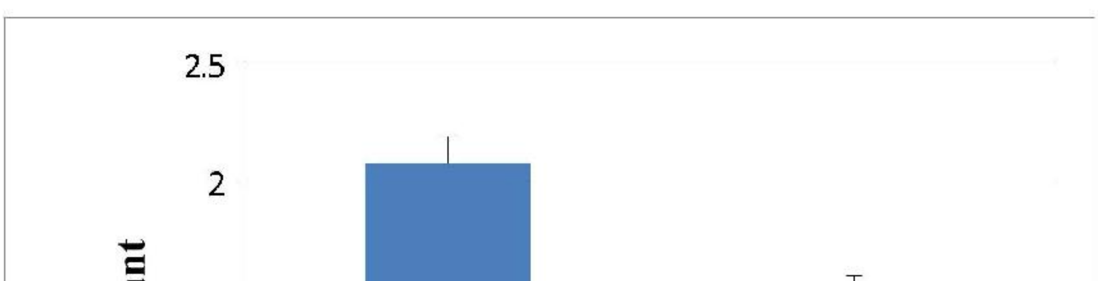


Fig. 2 : Average infestation by jassid on two sowing dates.

4.1.3. Thrips

Infestation on two sowing dates by thrips are shown in Fig. 3. The figure expressed that the lowest (3.93/plant) number of thrips was found in S_1 (Sowing on 24 August, 2013) while maximum (5.36/plant) number of thrips was found in S_2 (Sowing on 23 September, 2013) but they are statistically insignificant. This figure also indicated that initially there was less number of flower in the plant and thrips population was also lower. But when second sowing was done, there were huge number of flowers in the field and thrips population was also increased.

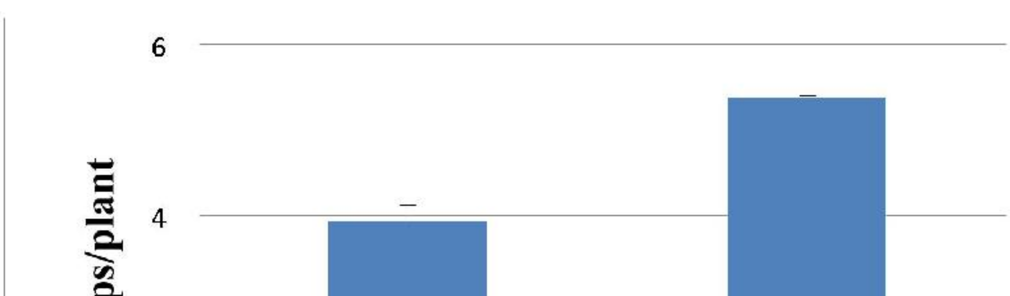
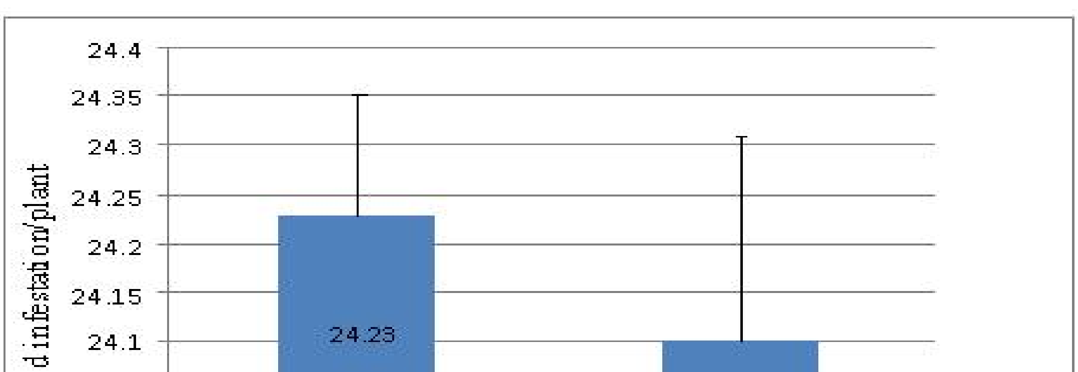


Fig. 3 : Average infestation by thrips on two sowing dates.

4.1.4. Pod borer

Percent pod infestation on two sowing dates by pod borer are shown in Fig. 4. The figure expressed that the lowest (24.10%) pod infestation per plant was found in S_2 (Sowing on 23 September, 2013) and maximum (24.23%) pod infestation was found in S_1 (Sowing on 24 August, 2013) but they are statistically insignificant.



Sowing date

Fig. 4 : Average infestation by pod borer on two sowing dates.

4.2. Effect of Micronutrients on pest incidence

The effect of different micronutrients and incidence of whitefly, jassid and thrips are shown in table 1. The data indicated that the lowest number of whitefly (0.83/plant) was found in F_0 (without micronutrients) and the second lowest (1.17/plant) was found in F_4 {R + Zinc (17.0 kg/ha)}. On the other contrary the highest number of whitefly (1.48/plant) was found in F_1{R + Boron (1.0 kg/ha)} which significantly higher than all other treatments.

In case of jassid, the lowest number of population (1.33/plant) was found in F_3 {R + Zinc (8.5 kg/ha)} and the second lowest result (1.50/plant) was found in F_4 {R + Zinc (17.0 kg/ha)}. On the other hand, the highest (2.33/plant) number of jassid was observed in F_2{R + Boron (2.0 kg/ha)} but they are statistically insignificant.

In case of thrips, the lowest number of population (3.83/plant) was found in F_0 (no micronutrients) followed by F_1{R + Boron (1.0 kg/ha)} which were statistically similar. On the other hand, the highest (5.30/plant) number of thrips was found in F_3{R + Zinc (8.5 kg/ha)} followed by (5.07/plant) F_2 {R + Boron (2.0 kg/ha)} and (4.83/plant) F_4{R + Zinc (17.0 kg/ha)}, respectively which are statistically similar.

Table1.Effect of different micronutrients on number of whitefly, jassid and thrips

Micronutrient Treatments	Number of sucking insects plant^{-1}		
	Whitefly	**Jassid**	**Thrips**
F_0	0.83 d	1.67	3.83 b
F_1	1.48 a	1.83	4.20 b
F_2	1.20 bc	2.33	5.07 a
F_3	1.32 b	1.33	5.30 a
F_4	1.17 c	1.50	4.83 a
$LSD_{(0.05)}$	**0.13**	**NS**	**0.52**
CV (%)	**9.20**		**9.19**

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.

NS= Non-significant

F_0 = Recommended doses

F_1 = R + Boron (1.0 kg/ha)

F_2 = R + Boron (2.0 kg/ha)

F_3 = R + Zinc (8.5 kg/ha)

F_4 = R + Zinc (17.0 kg/ha)

4.2.1. Whitefly

Population trend of whitefly due to treatments of different micronutrients are shown in Fig. 5. The figure expressed that the maximum number of population was observed in F_1 {R + Boron (1.0 kg/ha)}. Contrary, the minimum number of whitefly was observed in F_4 {R + Zinc (17.0 kg/ha)}. This figure also revealed that initially the whitefly population was maximum due to high temperature which was found in F_1. Again, the population decreased due to rainfall.

Alam (2001) reported that temperature had positive effect on the abundance of whitefly population.

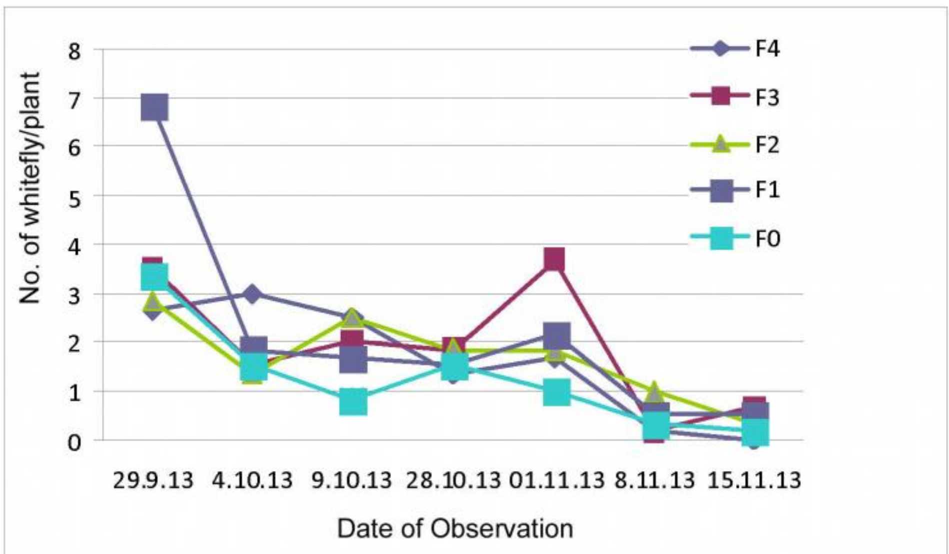


Fig. 5: Population trend of whitefly on different micronutrient treatments

4.2.2. Jassid

Population trend of jassid on different micronutrient treatments are shown in Fig. 6. The fig expressed that the maximum number of jassid was observed in F_2 {R + Boron (2.0 kg/ha)}. Quite the opposite, the minimum number of jassid was observed in F_3 {R + Zinc (8.5 kg/ha)} and F_4 {R +Zinc (17.0 kg/ha)}. This figure also revealed that initially temperature was high and higher population was observed. Then population fluctuated due to rainfall.

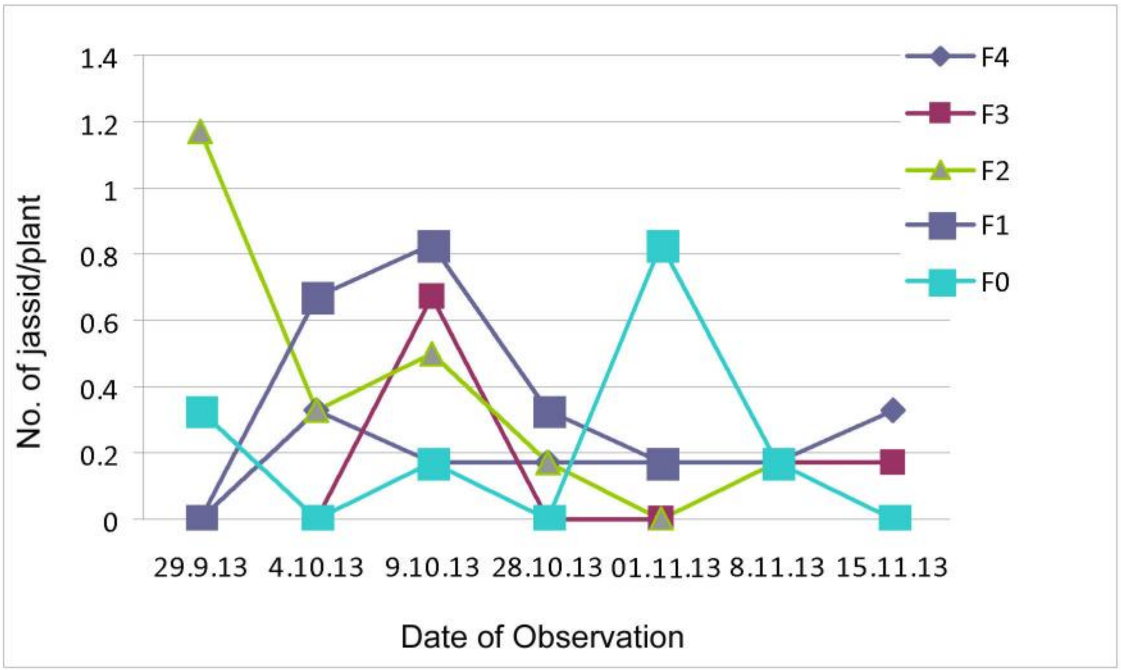


Fig. 6: Population trend of jassid on different micronutrient treatments.

4.2.3. Thrips

Population trend of thrips on different micronutrient treatments are shown in Fig. 7. The figure revealed that the maximum population was found in F_4 {R + Zinc (17.0 kg/ha)} but the minimum population was found in F_2 {R + Boron (2.0 kg/ha)}. This figure also revealed that initially the number of flower in the plant was lower and therefore thrips population was also low. As the fower increased day by day thrips population was also increased.

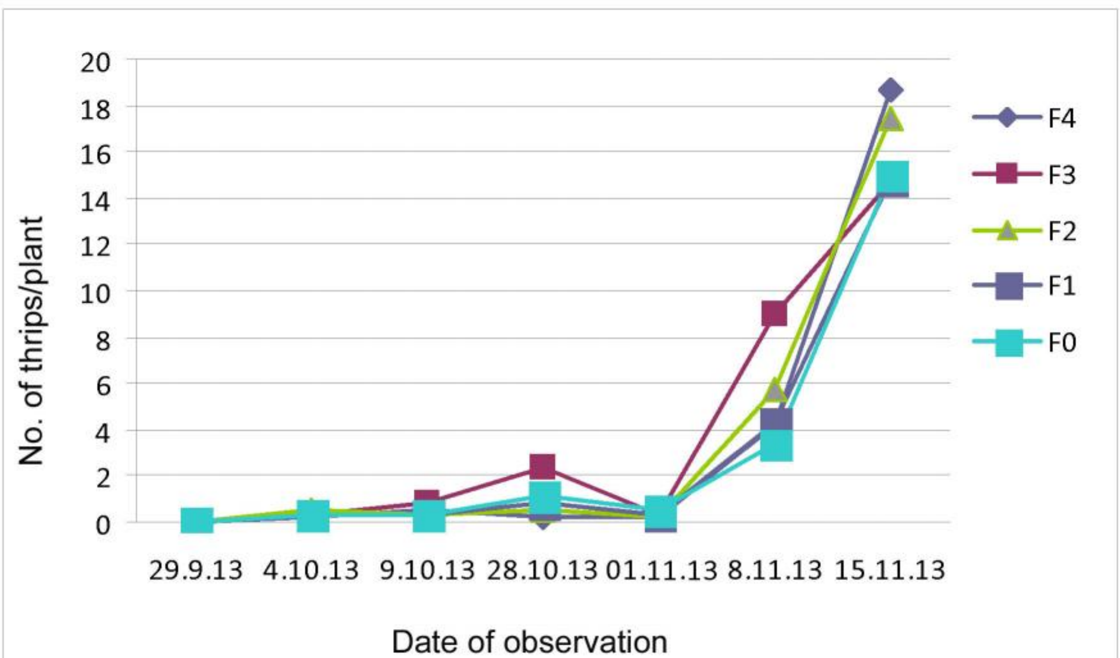


Fig. 7: Population trend of thrips on different micronutrient treatments.

4.2.4. Pod borer

The effect of different micronutrient treatments on pod infestation by pod borer are shown in table 2. Data revealed that the lowest number of pod infestation was found in F_4 (19.98%).On the other hand maximum infestation was recorded in F_3 (26.44%) which was significantly different from all other treatments.

Table 2. Effect of different micronutrient treatments on percent pod infestation

Micronutrient treatments	pod infestation (%)
F_0	24.62 b
F_1	24.30 b
F_2	25.48 ab
F_3	26.44 a
F_4	19.98 c
$LSD_{(0.05)}$	1.23
Significance level	**0.05**
CV (%)	**4.20**

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

NS=Non-significant

F_0 = Recommended doses (R)

F_1 = R + Boron (1.0 kg/ha)

F_2 = R + Boron (2.0 kg/ha)

F_3 = R + Zinc (8.5 kg/ha)

F_4 = R + Zinc (17.0 kg/ha)

Population trend of pod borer on treatments of different micronutrient are shown in Fig. 8. The figure indicated that maximum number of population was found F_3 (R + Zinc (8.5 kg/ha)). On the other hand, minimum number of population was found in F_1 {R + Boron (1.0 kg/ha)}.

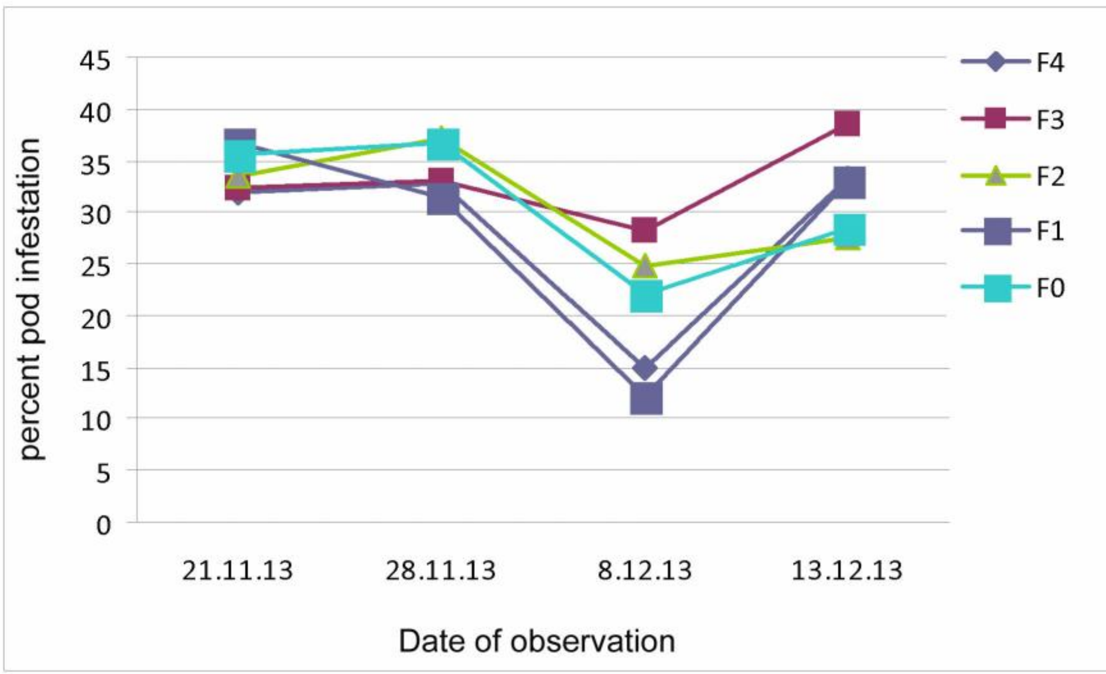


Fig. 8: Population trend of pod borer on different micronutrient treatments.

4.3. Combined effects of sowing dates and different micronutrients on pest incidence

4.3.1. Whitefly, Jassid and Thrips

The combined effect of sowing dates and different micronutrients on incidence of whitefly, jassid and thrips are shown in table 3. Data revealed that the lowest number of whitefly (0.57/plant) were found in S_1F_0, S_2F_1 and S_2F_3 which statistically similar. On the other hand, maximum number of whitefly (2.40/plant) was found in S_1F_1 which was significantly higher than all other combined treatments.

In case of jassid, the lowest number of population (1.00/plant) was found in S_2F_3 but the maximum number of population was found in S_1F_2 (3.00/plant) and S_1F_1 (2.33/plant) which were statistically insignificant.

In case of thrips, the lowest number of insect was found in S_1F_4 (.20/plant) followed by S_1F_0 (0.27/plant) and S_2F_1 which are statistically similar. On the other hand, the maximum number of insect (10.20/plant) was found in S_1F_3 which significantly higher than all other combined treatment effects.

Table 3. Combined effect of sowing dates and different micronutrients on population of whitefly, jassid and thirps

Sowing dates x Micronutrient treatments	Number of sucking insects plant^{-1}		
	Whitefly	**Jassid**	**Thrips**
$S_1 F_0$	0.57 e	2.00	0.27 e
$S_1 F_1$	2.40 a	2.33	8.13 c
$S_1 F_2$	0.63 e	3.00	0.87 e
$S_1 F_3$	2.07 b	1.67	10.20 a
$S_1 F_4$	0.67 e	1.33	0.20 e
$S_2 F_0$	1.10 d	1.33	7.40 d
$S_2 F_1$	0.57 e	1.33	0.27 e
$S_2 F_2$	1.77 c	1.67	9.27 b
$S_2 F_3$	0.57 e	1.00	0.40 e
$S_2 F_4$	1.67 c	1.67	9.47 b
$LSD_{(0.05)}$	**0.13**	**NS**	**0.52**
CV (%)	**9.20**		**9.19**

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.

NS = Non-significant

F_0 = Recommended doses (R)

S_1=Sowing on 24 August, 2013

F_1 = R + Boron (1.0 kg/ha)

F_2 = R + Boron (2.0 kg/ha)

F_3 = R + Zinc (8.5 kg/ha)

F_4 = R + Zinc (17.0 kg/ha)

S_2=Sowing on 23 September, 2013

4.3.2. Pod borer

The combined effects of sowing dates and different micronutrients on percent pod infestation by pod borer are shown in table 4. Data revealed that the lowest pod infestation (19.10%) was found in S_1F_4 followed by S_2F_4 (20.86%). Contrary, maximum infestation (28.59%) was found in S_1F_3 which significantly higher than all other combined effect treatments.

The present results supported the findings of Jayaramiah and Babu (1990) who claimed that pod damaged by pod borer varied significantly due to different sowing dates.

Table 4. Combined effects of sowing dates and different micronutrients on percent pod infestation

Sowing dates x Micronutrient treatments	pod infestation (%)
S_1 F_0	22.98 cd

$S_1 F_1$	26.28 b
$S_1 F_2$	24.19 c
$S_1 F_3$	28.59 a
$S_1 F_4$	19.10 f
$S_2 F_0$	26.26 b
$S_2 F_1$	22.31 de
$S_2 F_2$	26.77 b
$S_2 F_3$	24.30 c
$S_2 F_4$	20.86 e
$LSD_{(0.05)}$	**1.739**
CV (%)	**4.20**

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

NS=Non-significant

F_0 = Recommended doses (R) S_1=Sowing on 24 August, 2013

F_1 = R + Boron (1.0 kg/ha) S_2=Sowing on 23 September, 2013

F_2 = R + Boron (2.0 kg/ha)

F_3 = R + Zinc (8.5 kg/ha)

F_4 = R + Zinc (17.0 kg/ha)

4.4. Effect of insect population on yield of mungbean

Different insect population has different effects on yield of mungbean. Mungbean yield has been gradually decreased in terms of increasing of insect population in the field.

4.4.1. Whitefly

Seasonal fluctuation of whitefly population throughout the growing season was observed in mungbean field with various treatments effects. In response to various micronutrients and two sowing times, the yield of mungbean was highly affected due to the change of whitefly population in the field with the progress of time.

The relationship between whitefly infestation and yield of mungbean are shown in Fig. 9. The figure revealed that at the primary infested condition of whitefly, the yield of mungbean was maximum but with the increasing of population that become gradually declined. There was a strong negative correlation (R^2=0.424 when, y= -42.14x+237.2) between whitefly infestation (x) and yield (y).

Whitefly excretes honeydew, which promotes sooty mold that interferes normal photosynthesis and ultimately reduced yield (Gill, 1999; Jain *et al*., 1995; Bakar 1991; Bisht *et al*., 1988).

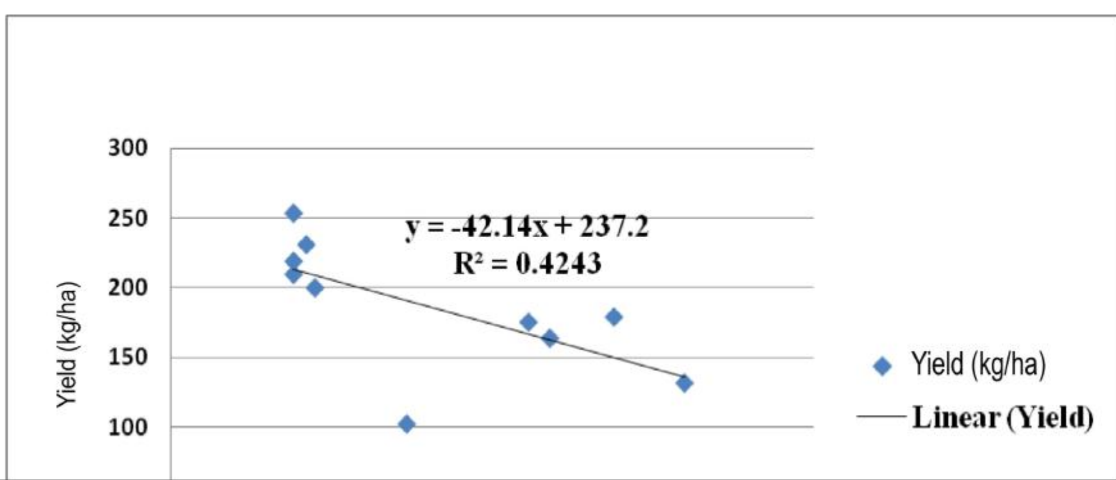


Fig. 9: Relationship between whitefly infestation and yield (kg/ha).

4.4.2. Jassid

Seasonal fluctuation of jassid population throughout the growing season observed in mungbean field with various treatments effects.

The relationship between jassid infestation and yield of mungbean are shown in Fig .10. The figure reveal that there was a linear correlation (R^2=0.0004 when, y = 1.6117x+183.76) between jassid infestation (x) and yield (y).

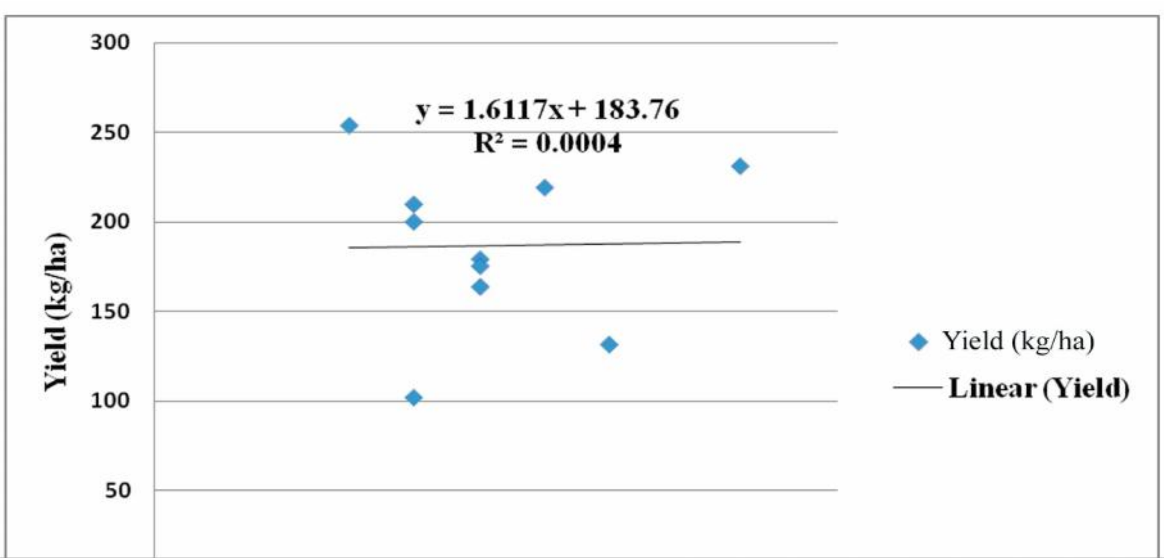


Fig. 10: Relationship between jassid infestation and yield (kg/ha).

4.4.3. Thrips

Seasonal fluctuation of thrips population throughout the growing season also observed in mungbean field with various treatments effects. In response to various micronutrients and two sowing times, the yield of mungbean was highly affected due to the change of thrips population in the field with the progress of time.

The relationship between thrips infestation and yield of mungbean are shown in Fig.11. The figure revealed that at the primary infested condition of thrips, the yield contribution of mungbean was maximum but with the increasing of population that become gradually decreased. There was a strong negative correlation (R^2=0.5379 when, y=-7.429x +221.08) between thrips infestation (x) and yield (y).

Chhabra and kooner (1985b) reported that *M. distalis* infested flowers causing flower drop, deformation of pods, in some cases reaching upto 100% and ultimately reduced yield.

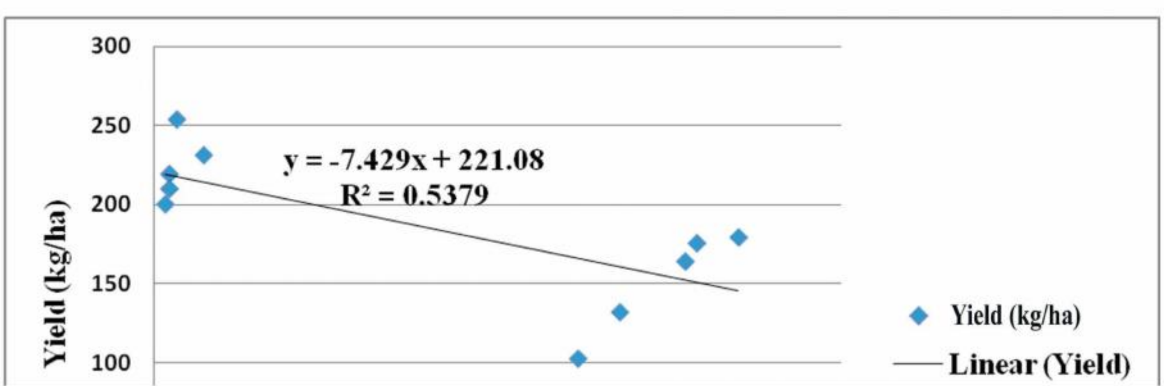


Fig. 11: Relationship between thrips infestation and yield (kg/ha).

4.4.4 Pod borer

Seasonal fluctuation of pod borer infestation throughout the growing season observed in mungbean field with various treatments effects. In response to various micronutrients and two sowing times, the yield of mungbean was highly affected due to the change of pod borer population in the field with the progress of time.

The relationship between pod borer infestation and yield of mungbean are shown in Fig. 12. The figure revealed that at the primary infested condition of pod borer, the yield of mungbean was maximum but with the increasing of population that become gradually decreased. There was a strong negative correlation (R^2=0.1625 when, y= -6.353x +340.08) between pod borer infestation (x) and yield (y).

Rahman (1987), Singh and Taylor (1978) reported that pod borer infestation may cause great reduction of yields of the infested crops. Pod borer alone were reported to grain losses of 136 kg/ha in mungbean {Sehgal and Ujagir (1985, 86)}.

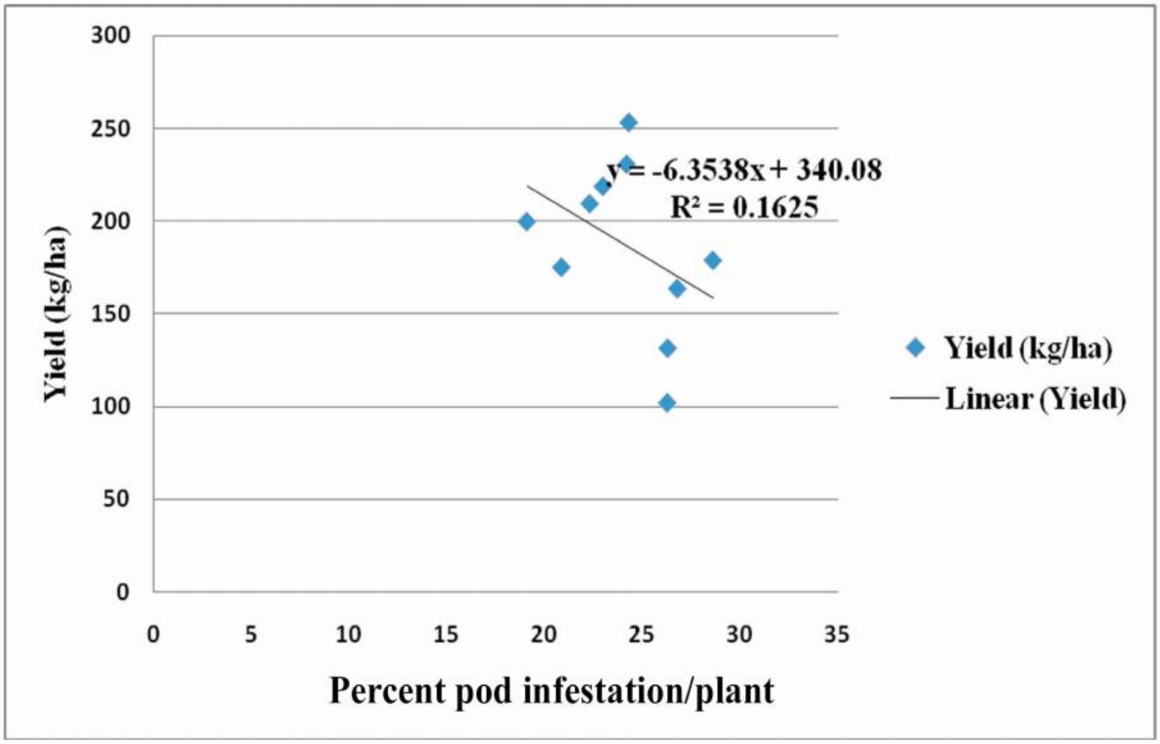


Fig. 12: Relationship between pod borer infestation and yield (kg/ha).

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SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher -e- Bangla Agricultural University, Sher-e Bangla Nagar, Dhaka, Bangladesh to find out the effect of sowing dates and different micronutrients on incidence of insect pests of mungbean (*Vigna radiata* (L.) Wilezek) during kharif-II season (August to December) of 2013. The experiment comprised two factors, viz., factor A: Sowing date (two levels) – S_1: Sowing on 24 August, 2013; S_2: Sowing on 23 September, 2013 and factor B: Micronutrient treatments (five levels) – F_0: {Recommended doses (R) Urea (45 kg/ha), TSP (100 kg/ha), MP (58 kg/ha)}; F_1: {R + Boron (1.0 kg/ha)}; F_2: {R + Boron (2.0 kg/ha)}; F_3: {R + Zinc (8.5 kg/ha)} and F_4: { R + Zinc (17.0 kg/ha)}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on incidence of insect pests were recorded and the collected data were analyzed statistically and the mean differences were adjusted by Duncan' s Multiple Range Test (DMRT).

Incidence of insect pests recorded for the entire cropping season and whitefly, jassid, thrips and pod borer were observed. Considering two sowing dates, the lowest number of whitefly (1.13), jassid (1.40) and pod infestation (24.10%) was observed in S_2 but the highest population of whitefly (1.27), jassid (2.07) and pod infestation (24.23%) was found in S_1. And for thrips, the lowest (3.93) and highest (5.36) number of population was observed in S_1 and S_2. In case of micronutrient treatments, the lowest number of whitefly (0.83), jassid (1.33), thrips (3.83) and pod infestation

(19.98%) was found in F_0, F_3, F_0 and F_4 respectively. On the other hand, the highest number of whitefly (1.48), jassid (2.33), thrips (5.30) and pod infestation (26.44%) was found F_1, F_2 , F_3 and F_3 respectively. Considering the combined effect, the lowest number of whitefly (0.57) was found in S_1F_0, S_2F_1 and S_2F_3 while jassid (1.00), thrips (0.20) and pod infestation (19.10%) was found in S_2F_3, S_1F_4 and S_1F_4 respectively. Contrary, the highest number of whitefly (2.40), jassid (3.00), thrips (10.20) and pod infestation (28.59%) was found in S_1F_1, S_1F_2, S_1F_3 and S_1F_3 respectively.

In case of yield effect, there was strong negative correlation between yield with whitefly, thrips and pod borer infestation. And there was a negative relationship between yield and jassid infestation.

It is concluded that the incidence and population of insect pests of mungbean was very much dependent on the sowing dates and micronutrients. Hence, for ensuring less insect pests infestation, the second sowing (23 September) and micronutrient treatment F_1{R + Boron (1.0 kg/ha)} may be good.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptibility;

2. Other sowing times and micronutrients may be included in the future study.