EFFECT OF DIFFERENT MANAGEMENT PRACTICES ON THE GROWTH AND YIELD OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Different Management Practices on the Growth and Yield of Mungbean"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of *bona fide* research work carried out by **Md. Shobuj Chowdhury**, Registration number: **05-01669** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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EFFECT OF DIFFERENT MANAGEMENT PRACTICES ON THE GROWTH AND YIELD OF MUNGBEAN

ABSTRACT

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from September to December 2012 to study the effect of different management practices on the growth and yield of mungbean. The variety BARI mung-5 was used as the test crops. The experiment consisted of the 12 treatments as- T_1: All management; T_2: All management but sowing in broadcast; T_3: All management but using 20% more seed rate; T_4: All management but no fertilizers; T_5: All management but no irrigation; T_6: All management but no weeding; T_7: All management but no thinning; T_8: All management but no fungicide; T_9: All management but no insecticide; T_{10}: All management but no mulching; T_{11}: All management but no seed treatment and T_{12}: All management but no pre-sowing irrigation. Results revealed that T_1, T_2, T_5, T_8, T_{10} and T_{11} showed identical but significantly higher seed yield (1.54-1.75 t ha^{-1}) than other treatments. So mungbean could be grown under broadcast sowing using no irrigation, no fungicides, no insecticide and no seed treatment provided that the seeds are quality ones, there is no soil moisture deficit and also there is minimum incidence of pests.

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CHAPTER I

INTRODUCTION

Grasspea, lentil, mungbean, blackgram, chickpea, fieldpea and cowpea are common pulses in Bangladesh. Among them mungbean [*Vigna radiata* (L.) R. Wilczek] is one of the most important pulse crops of Bangladesh and belongs to the family Fabaceae and sub-family Faboideae. The area under pulse crops in Bangladesh is 0.406 million hectares with a production of 0.322 million tones 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^{-1}) as compared to other countries of the world (BBS, 2006). Mungbean ranks the fifth position considering both acreage and production.

The pulse crop is an important food crop because it provides a cheap source of easily digestible dietary protein which complements the staple rice in the country. According to FAO (1999), per capita requirement of pulse by human should be 80 g, whereas it is only about 10 g in Bangladesh (BBS, 2007) thus the ideal cereal of pulse ratio (10:1) is not maintained which is now 30:1. This is fact that national production of the pulses is not adequate to meet the population demand. 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). However, it is one of the least cared crops. Mungbean is cultivated with minimum tillage, local varieties with no or minimum fertilizers, pesticides and very early or very late sowing, no practicing of irrigation and drainage facilities etc. All these factors are responsible for low yield of mungbean which is incomparable with the yields of developed countries of the world (FAO, 1999). The low yield of mungbean besides other factors may partially be due to lack of knowledge regarding the providing essential plant nutrients with following modern production technology (Hussain *et al*., 2008).

Moreover, lack of attention on fertilizer application in proper way with appropriate amount is also managerial factors in lowering mungbean yields (Mansoor, 2007). Being leguminous in nature, mungbean needs low nitrogen but require optimum doses of other major nutrients as recommended with the application of suitable time and methods. The management of fertilizer especially nitrogen is the important factor that greatly affects the growth, development and yield of this crop.

Pulses although fix nitrogen from the atmosphere and there is evident that application of nitrogenous fertilizers becomes helpful in increasing the yield (Patel *et al.,* 1984). Nitrogen is most useful for pulse crops because it is the component of protein (BARC, 2005). An adequate supply of nitrogen is essential for vegetative growth and desirable yield. Phosphorus is also one of the important essential macro elements for the normal growth and development of plant. The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). Phosphorus shortage restricted the plant growth and remains immature (Hossain, 1990). Mungbean is a short duration crop, for that easily soluble fertilizer like as phosphorus should be applied in the field. Potassium as an inorganic fertilizer plays a vital role for proper growth and development of mungbean. Pulse crops showed yield benefits from potassium application. Improved potassium supply also enhances biological nitrogen fixation and protein content of pulse grains (Srinivasarao *et al*., 2003). The supply of potassium to leguminous crops is necessary especially at the flowering and pod setting stages (Zahran *et al*., 1998). Potassium also plays a vital role as macronutrient in plant growth and sustainable crop production (Mrschner and Baligar, 2001). It maintains turgor pressure of cell which is necessary for cell expansion. It helps in osmo-regulation of plant cell, assists in opening and closing of stomata. It plays a key role in activation of more than 60 enzymes (Bushkh *et al*., 2011). Soil fertility was improved significantly with farmyard manure used either alone or in combination with NPK over that of initial soil status (Singh *et al*., 2001).

Traditionally, pulse is being grown following diversified methods of cultivation. It is generally broadcasted in the low lying areas, immediately after aman rice harvest as a rainfed crop. Water deficiency had adverse effects on plant growth, average yield and crude protein in legume crops. The flowering stage is the most vulnerable stage for water stress and mungbean is somewhat tolerant to deficit water but susceptible to excess water (Hamid *et al*., 1991; Miah *et al*., 1991). Adequate supply of irrigation, water among with chemical fertilizer is essential for normal growth and yield of a crop (Ayallew and Tabbada, 1987; Kumar *et al*., 1995).

Weed is one of the most important factors responsible for low yield (Islam *et al*., 1989). Although mungbean is competitive against weed control is essential for pulse production (Moody, 1978). Yield losses due to uncontrolled weed growth in pulse ranges from 27 to 100% (Madrid and Vega, 1971). All crops have a stage during their life cycle when they are particularly sensitive to weed competition. In general, it ranges up to first 25 to 50% of the life time of crops. The first 30-60 days are considered critical for crop weed competition. Critical time of weed competition is the range within which a crop must be weeded to save the crop from economic damages of weeds (Islam *et al*., 1989).

Management of mungbean insect pests also available which also need to be compared with other management tools.

Under the above circumstances, the present study was undertaken with the following objectives:

i. To compare the effect of different management practices for the growth and yield of mungbean.

ii. To find out the combination of management practices for achieving higher seed yield in mungbean.

CHAPTER II

REVIEW OF LITERATURE

2.1. Effect of sowing methods

Tickoo *et al*. (2006) carried out an experiment on mungbean using cultivars Pusa 105 and Pusa Vishal, which were sown in broadcast and furrow method with 36-46 and 58-46 kg NP ha^{-1} in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105 with furrow sowing. Row spacing at 22.5 cm resulted in higher grain yields in furrow sowing.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) and methods of sowing on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The methods of seed sowing significantly affected the crop parameters. The 10-30-30 kg of NPK ha^{-1} was the best treatment recording plant height of 56.25 cm, germination of 90.50%, satisfactory plant population of 162.00 m^{-2}, prolonged days taken to maturity of 55.50, long pods of 5.02 cm, seed weight per plant of 10.53 g, seed index of 3.52 g and the highest seed yield of 1205.2 kg ha^{-1} with line sowing than the broadcast.

Mahboob and Asghar (2002) studied the effect of seed sowing methods at different nitrogen levels on mungbean at the agronomic research station, Farooqabad in Pakistan. They revealed that various yield components like 1000-grain weight was affected significantly with 50-50-0 NPK kg ha^{-1} applied in line sowing. Again they revealed that seed sowing in line was more effective than the broadcasting and line sowing exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Thakur *et al*. (1996) conducted an experiment with green gram (*Vigna radiata*) grown in kharif [monsoon] 1995 at Akola, Maharashtra, which was given 0, 25, 50 or 75 kg P_2O_5 ha^{-1} as single superphosphate or diammonium phosphate in different methods of seed sowing. Seed and straw yields were not significantly affected by line sowing.

A field experiment was conducted by Patro and Sahoo (1994) during the winter season of 1991 at Berhampur, Orissa, with mungbean cv. Dhauli and PDM 54 applying 0, 15, 30, 45 or 60 kg P_2O_5 ha^{-1}. They observed that line sowing gave seed yields of 706, 974, 1049, 1234 and 1254 kg ha^{-1}, respectively with the treatments. There was significant difference between the yields of cultivars.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with 50 kg P ha^{-1} increased mungbean yield sowing in line. Results from the experiments of mungbean showed that the application of N with P and line sowing gave higher seed yield

2.2 Effect of irrigation

A field experiment was conducted by Patel *et al*. (2005) during the summer seasons of 2001, 2002 and 2003, in Sardarkrushinagar, Gujarat, India, to study the effects of irrigation scheduling (0.4, 0.6 and 0.8 IW:CPE ratios) and fertilizer doses (10 N kg + 20 kg P ha^{-1}, 20 kg N + 40 kg P ha^{-1}, and 30 kg N + 60 kg P ha^{-1}) on the yield of summer clusterbean. Irrigation at 0.8 and 0.6 IW:CPE ratio recorded almost similar seed yield (1238 and 1219 kg ha^{-1}, respectively), which was higher than that at 0.4 IW:CPE ratio. The highest straw yield (2848 kg ha^{-1}) was obtained when irrigation was applied at 0.8 IW:CPE ratio.

Biswas (2001) reported that irrigation frequency exerted a remarkable impact on yield of field bean. Application of 3 irrigations increased vegetable pod yield about 19% and 13% and seed yield about 53% and 30% over 1 and 2 irrigation respectively. He also reported that higher number of pods $plant^{-1}$, seeds pod^{-1} and pod length, with higher frequency of irrigation.

Rajput *et al*. (1995) conducted a field trial in rabi (winter) at Morena, Madhya Pradesh, the soil moisture depletion pattern was determined from gram (*Cicer* *arietinum*), peas, mustard (*Brassica juncea*), safflower and a fallow plot and reported that soil moisture influenced the germination of all the test crops.

Hutami and Achlan (1992) conducted an experiment with different water stress condition in mungbean field and reported that plant height of mungbean reduced significantly due to water stress condition but the application of irrigation ensure highest plant height compare to stress condition.

Swaraj *et al.* (1995) carried out a field experiment with applying water stress condition in mungbean and reported that with increasing severity and duration of water stress, the number of branches decreased. Murari and Pandey (1985) studied the influence of soil moisture levels on yield attributing characters of lentil and observed that irrigation increased number of branches. They also reported that straw yields were also increased significantly from non-irrigation to irrigation.

Islam *et al*. (1994) conducted an experiment on mungbean with different water stress condition in Japan and reported that plants produced lower leaf number under drought conditions. Arjunan *et al*. (1992) observed higher number of functional leaves in tolerant genotypes of groundnut under moisture deficit condition at harvest, which ensured plants a continued supply of photosynthesis to the sink until maturity. This means stress susceptible plants lost functioning of leaves that unable them to continue photo-assimilation and grain filling. In another experiment reduced leaf numbers were recorded for moisture stressed conditions in groundnut.

Hutami *et al.* (1991) have conducted an experiment on the water stress of mungbean. They observed that leaf area reduced in water stress conditions. Leaf growth is extremely sensitive to water stress condition and the reduction in leaf area due to moisture stress has been reported by many workers in many different crops. The total number of leaf of a plant may be changed due to either in leaf numbers or leaf sizes (Turk and Hall, 1980; Babu *et al.,* 1984; Pandey *et al.*, 1984, Patel *et al.,* 1983).

Hughes *et al.* (1981) observed a reduction of leaf area in response to water stress condition. Wien *et al.* (1979) reported substantially less number of leaves when field-grown cowpea was exposed to moderate drought stress. Reduced number of leaves could be due to the inhibition of initiation and differentiation of leaf primodia.

Decreased water application resulted in reduced total dry matter production and that resulted from declines in conservation of the intercepting radiation and thereby photo assimilation (Collinson *et al.,* 1996). Miah *et al.* (1996) suggested that in adequate soil moisture condition plant produced higher photosynthesis and dry matter in mungbean.

Islam *et al.* (1994) conducted an experiment on mungbean in Japan. Growth, canopy structure and seed yield of mungbean was evaluated under water stress conditions. Water logging, optimum moisture and drought conditions had constituted the treatments. The distribution patter of the dry matter was more or less similar in all the treatments. In an experiment with mungbean. They also observed that drought conditions reduced total dry matter of plants.

In dry soil condition lower shoot dry weight could result from the higher partitioning of dry matter to roots at the expense of shoots. The maximum reduction in yield due to moisture occurs during grain filling stage drastic yield reduction was also reported in mungbean due to water stress (Hamid *et al.*, 1990). The yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthetic rate and lower dry matter production.

Ludlow and Muchow (1990) argued that reduced shoot dry weight under moisture stress partitioned more biomass to roots at the expense of shoot growth. The results revealed that increase in moisture tension caused reduction in shoot weight.

In another experiment with cowpea Turk and Hall (1980) observed less shoot dry matter in increasing levels of drought stress, at all stages of growth. Wien *et al.*

(1979) reported slightly less shoot dry matter production with moderate drought stress cowpeas grown under field condition. EI-Nadi (1969) reported from his wheat experiment under water stress condition that the drier the soil, deeper the root development.

The effects of irrigation regimes (irrigation at 0.04 MPa at 15, 20 and 25 cm depth) and P rate on the yield and water use efficiency of French bean (*Phaseolus vulgaris* cv. Contender) were studied by Pal (2007) in Nadia, West Bengal, India, during the winter season from 2002-03 to 2004-05. Among the irrigation regimes, irrigation at 15-cm depth recorded the highest mean grain yield (1895 kg ha^{-1}). Irrigation at 25-cm depth resulted in the lowest level of water use (157.43 mm, on average) and greatest water use efficiency (11.39 kg ha^{-1} mm^{-1}).

Craufurd and Wheeler (1999) examined that total dry matter, seed yield and other physiological traits of cowpea at two locations in Nigeria. They obtained 50% reduction in seed yield under drought in both location, attended by the reduced radiation use efficiency and TDM. Sanaullah and Bano (1999) conducted an experiment and observed that drought stress significantly reduced the number of pods, seeds, and 1000-seed weight. Joseph *et al.* (1999) reported that water stress during pod filling stages significantly reduced pod initiation and pod growth rates and thereby reduced harvest Index (HI).

Collinson *et al.* (1996) observed that decreasing soil moisture levels resulted in a decline in total dry matter production and harvest index (HI). They also observed that a reduction in pod yield from 4.12 to 4.04 t ha^{-1} under stress condition. In a field experiment with lentil, Kumar *et al.* (1995) found that non-irrigated plot gave lower seed yield than in the irrigated ones.

Salam and Islam (1994) conducted a pot experiment in the glass house with some advanced mutant lentil lines (*Lens culinaris)* under different soil moisture regimes. Under stress they found that the mutant lines had greater filled pods, yield per plant and harvest indices (HI) than local cultivars. They also found that the mutant lines had higher biomass yield.

Islam *et al.* (1994) observed significantly higher seed yield of mungbean in optimum soil moisture condition followed by drought stress and water logging. Seed per plant and pod per plant contributed more to the seed yield per plant than the other yield contributing components. It was evident from this study that mungbean growth, canopy structure and seed yields were more susceptible to water logging than drought stress.

In a field experiment with mungbean, Hutami and Achlan (1992) observed that water stress condition significantly reduced number of pods per plant and number of seeds plant^{-1}. Decreased grain yield due to water stress was also reported in chickpea (Provakar and Suraf, 1991). Viera *et al.* (1991) reported a yield reeducation of 35 to 40% when drought stress was imposed during seed filling but found no effect on germination or vigour in soybean.

Erskine and Saena (1990) conducted an experiment and observed that moisture stress affected yield of lentil. They further noted that lentil production was limited by moisture stress. Singh and Saxena (1990) conducted an experiment and observed that moisture stress reduced yield of lentil. They also found that lentil production was limited by moisture stress.

Hamid *et al.* (1991) observed that, over watering and slight and severe water stress imposed at pre-flowering, flowering or pod development stages, reduced seed yield plant^{-1}, photosynthetic rate, water use efficiency and number of pods plant^{-1} in mungbean. Slight and severe water stress of pod development gave higher individual 1000-seed weight than unstressed control treatment (29.8, 28.5 and 24.1 g, respectively). Slight water stress at flowering gives the seed weight of 30.0 g compared with 25.06 g than the control. At pod development, control seed weight has been 24.4 g whereas neither water stress treatment has produced seeds.

Khade *et al.* (1990) found the highest number of pods (8.28) plant^{-1}, seeds (16.43) pod^{-1} and seed yield (1.03 t ha^{-1}) with 3 irrigations in *Vicia fcrbcr*.

Water stress affected canopy development (Kridemann, 1986) and overall growth process but there were varietal differences in stress tolerance. In an experiment with groundnut, exposed to field capacity, half field capacity and drought condition, Mehrotra *et al.* (1986) observed that the yield of mature pods, seeds per pod and 1000-seed weight were the least under drought conditions. Irrigation increased pigeon pea yield by 97% but drought during the reproductive phase was the major yield-limiting factor (ICRISAT, 1986).

Pandey *et al.* (1984) reported that mungbean was more susceptible to water deficits than many grain legumes. Hasan and Mahhady (1983) reported that interactions between soil salinity and available soil water induced significant effects on dry matter content, grain yield, grain number and 1000-grain weight of wheat. The stress conditions caused by high soil salinity and limited soil moisture progressively decreased the dry matter content of the wheat plant and triticale.

Turk *et al.* (1990) demonstrated the response of cowpea to different intensities of drought at different stages of growth and reported that yields were not reduced by drought imposed during the vegetative stage, while drought occurs during the flowering stage substantial yields reduction was obvious. Variation in yields resulted from variation in number of pods m^{-2} and small seed size.

2.3 Effects of fertilizers

Nigamananda and Elamathi (2007) carried out a study in Uttar Pradesh, India during 2005-06 to evaluate the effect of N application time as basal and as DAP (diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of green gram. The recommended rate of N: P: K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments included: 1/2 basal N + foliar N as urea or DAP at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea or DAP; and 1/2 basal N + 1/2 foliar spraying as urea or DAP + 40 ppm NAA. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS, resulted in the highest values for number of pods plant^{-1} (38.3), seeds/pod, flower number, fertility coefficient, grain yield (9.66 q ha^{-1}).

An experiment was conducted by Tickoo *et al.* (2006) with mungbean cultivars Pusa 105 and Pusa Vishal sown at 22.5 and 30 cm spacing and supplied with 36 - 46 and 58 - 46 kg NP ha^{-1} in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops than 30 cm.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The different NPK levels significantly influenced the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.25, germination of 90.50% seed weight per plant of 10.53 g and the highest seed yield of 1205.2 kg ha^{-1}.

Nadeem *et al.* (2004) studied the response of mungbean cv. NM-98 to seed inoculation and different levels of fertilizer (0-0, 15-30, 30-60 and 45-90 kg N-P_2O_5 ha^{-1}) under field conditions. Application of fertilizer significantly increased the growth of plant and yield. The maximum seed yield was obtained when 30 kg N ha^{-1} was applied along with 60 kg P_2O_5 ha^{-1}.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 in 2001. They observed that number of flowers per plant was found to be significantly higher by 25 kg N ha^{-1}. Number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}).

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg ha-1) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44. Plant growth and grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield.

Yakadri *et al.* (2002) studied the effect of nitrogen (40 and 60 kg ha^{-1}) on crop growth and yield of green gram (cv. ML-267). Application of nitrogen at 20 kg ha^{-1} resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

An investigation was conducted by Singh *et al.* (2002) to study the effect of N, P and K application on seed yield and nutrient uptake by blackgram at Central Agricultural University, Imphal, Manipur, India during 1998 and 1999. Treatments combinations of N (0 and 15 kg ha^{-1}), P (0, 30 and 60 kg ha^{-1}) and K (0 and 20 kg ha^{-1}) were tested. The highest yield was obtained from the application of 15:60:20 kg N : P_2O_5 : K_2O ha^{-1}. The total uptake of nutrients by blackgram was associated with higher biomass production.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on mungbean at the agronomic research station, Farooqabad in Pakistan. They reported that various yield components like 1000 grain weight were affected significantly with 50-50-0 kg ha^{-1} application of NPK.

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of nitrogen and phosphorus. Different rates of N (0, 25 and 60 kg ha^{-1}) and P (0, 25, 50 and 60 kg ha^{-1}) were tested. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N. They also observed that 1000-seed weight was increased with increasing rates of N up to 40 kg ha^{-1}.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers practices (no fertilizer) or using a combinations of fertilizer application (30 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 ton ha^{-1} with farmer's practices, while the highest yield was obtained by the fertilizer application (0.77 t ha^{-1}).

Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on summer mungbean. They reported that mungbean produced higher seed yield in with the application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Trivedi *et al*. (1997) carried a field experiment to study the effect of nitrogen, phosphorus and sulfur on yield and nutrient uptake of blackgram (*Vigna mungo*) at Gwalior, Madhya Pradesh during the 1990-91 kharif (monsoon) seasons. Application of 30 kg N, 60 kg P_2O_5 and 60 kg S ha^{-1} increased yield, net profit and nutrient uptake.

Trivedi (1996) conducted a field trial in the rainy seasons of 1990-91 at Gwalior, Madhya Pradesh, India with *P. mungo* (*Vigna mungo*) cv. Jawahar Urd-2 which was given 0-30 kg N, 0-60 kg P_2O_5 and 0 or 60 kg S ha^{-1}. Seed yield, net returns and N, P and S contents in seed increased with rate of N, P and S applications.

A field experiment was conducted by Satyanarayanamma *et al.* (1996) with five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two or three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Kaneria and Patel (1995) conducted a field experiment on a Vertisol in Gujarat, India with mungbean cv. K 581 using 0 or 20 kg N ha^{-1} levels. They found that application of 20 kg N ha^{-1} significantly increased the seed yield (1.14 t ha^{-1}) when compared with that of control (1.08 t ha^{-1}).

Bhalu *et al*. (1995) conducted a field experiment during the rainy season of 1990 at Junagadh, Gujarat with blackgram (*Vigna mungo*) and seed was inoculated with *Rhizobium* or not inoculated and given 10, 20 or 30 kg N and 20, 40 or 60 kg P_2O_5 ha^{-1}. Seed inoculation increased seed yield (471 vs. 434 kg ha^{-1}). Seed yield increased with up to 20 kg N (464 kg) and 40 kg P_2O_5 (475 kg). N and P uptakes and seed protein content increased with increasing N and P rates. Net return was the highest with seed inoculation.

Ali *et al*. (1995) carried out field trials at Mianchannu in 1992 and Layyah in 1993 on sandy loam soils low in organic matter, N and P and *V. mungo* was given no fertilizers or 50 kg N, 50 kg N + 50, 75, 100 or 125 kg P_2O_5 or 50 kg N + 125 kg P_2O_5 + 50 kg K_2O ha^{-1}. NPK gave the highest number of pods $plant^{-1}$ (23.03-23.75) and seed yield (1080-1082 kg ha^{-1}) but was not significantly better than 50 kg N + 75 kg P_2O_5, which gave the highest 1000-seed weight (49.30 and 42.75 g in the 2 trials, respectively). Straw yields did not differ significantly among the treatments.

Ardeshana *et al.* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen. They observed that seed yield increased with application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 ha^{-1}.

Singh *et al.* (1993) examined the effects of varying levels of N on mungbean cv. MH-85-61. They found that nitrogen application at the rate of 30 kg N resulted in the highest seed yield in mungbean.

Patel *et al.* (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilization under different levels of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P ha^{-1}, 20kg N + 40 kg P ha^{-1} and 0, 10, 20 or 30 kg S ha^{-1} as gypsum and found that plant growth with highest doses. Seed yield was 1.2 and 1.24 t ha^{-1} in 20 kg N + 40 kg P ha^{-1}.

Tank *et al*. (1992) found that mungbean fertilized with 20 kg N along with level of 40 kg P_2O_5 ha^{-1} increased seed yield significantly over the unfertilized control. They also reported that mungbean fertilized with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

Phimsirkul (1992) conducted a field trial on mungbean variety, U- Thong I grown in different soils under varying N levels. Results revealed that there was no effect of N fertilizer when mungbean was grown in Mab Bon soil. However, seed yield of mungbean was increased when the crop received N at 30 kg ha^{-1}.

Chowdhury and Rosario (1992) studied the effect of 0, 30, 60 or 90 kg N ha^{-1} levels on the rate of growth and yield performance of blackgram at los Banos, Philippines in 1988. They observed that N above the rate of 30 kg N ha^{-1} reduced the dry matter yield. Leelavathi *et al.* (1991) showed significant increase in seed yield of blackgram with 60 kg N ha^{-1}.

A field experiments was conducted by Sarkar and Banik (1991) to study the effect of N and P on yield of mungbean. Results showed that application of N along with P significantly increased the seed yield of mungbean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Bali *et al.* (1991) conducted a field trail on mungbean in kharif seasons on silty clay loam soil. They revealed that 1000 seed weight increased with 40 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with 50 kg P ha^{-1} increased mungbean yield. Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season of mungbean showed that the application of N with P and K at 40:20:25 kg ha^{-1} gave higher seed yield.

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen on the growth and yield performance of mungbean (*Vigna radiate* L. wilczek). He found that the plant height of mungbean cv. Mubarik was increased by nitrogen at 40 kg ha^{-1}.

Results of an experiment, conducted by Sardana and Verma (1987) in Delhi, India, revealed that application of nitrogen, phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of mungbean. They also stated that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increase in plant growth and seed yield of mungbean. They also stated that application of nitrogen, phosphorus and potassium fertilizers combinedly resulted in significant increases in 1000 seed weight.

Salimullah *et al.* (1987) reported that the yield contributing characters and yield was highest with the application of 50 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} in summer mungbean.

Patel and Parmer (1986) conducted an experiment on the response of green gram to varying levels of nitrogen and phosphorus. They observed that increasing N application to rainfed mungbean (cv. Gujrat-1) from 0 to 50 kg N ha^{-1} increased the number of pods per plant.

In trials, on clay soils during the summer season Patel *et al.* (1984) observed the effect of N levels (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. In that experiment, it was found that application of 30 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant. They observed that application of 40 kg P_2O_5 ha^{-1} along with 20 kg N ha^{-1} significantly increased the 1000-seed weight of mungbean.

Raju and Verma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusa Baishaki to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1}) in the presence and absence of seed inoculation with *Rhizobium.* They found that maximum dry matter weight per plant was obtained by the application of 60 kg N ha^{-1} along with inoculation with *Rhizobium.*

In an experiment, Yien *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods per plant. The rate of nitrogen and phosphorus was 50 kg and 75 kg ha^{-1}, respectively. Combined application of nitrogen and phosphorus significantly increased the dry weight of plants. Combination with 20 kg P ha^{-1} resulted in significant increase in the seed yield.

2.4 Effect of weeding

Kohli *et al*. (2006) carried out a field experiment in Hisar, Haryana, India, during the 2001 summer season to determine the effect of different weed management practices on the quality and economics of mungbean cv. K-851. The treatments comprised: 0.75 kg linuron ha^{-1}; 1.0 kg linuron ha^{-1}; 0.75 kg linuron ha^{-1} + hand weeding at 35 days after sowing (DAS); 1.0 kg pendimethalin ha^{-1}; 1.25 kg pendimethalin ha^{-1}; 1.0 kg pendimethalin ha^{-1} + hand weeding at 35 DAS; 200 g thiazopyr ha^{-1}; 240 g thiazopyr ha^{-1}; 200 g thiazopyr ha^{-1} + hand weeding at 35 DAS; 0.75 kg acetachlor ha^{-1}; 1.0 kg acetachlor ha^{-1}; 0.75 kg acetachlor ha^{-1} + hand weeding at 35 DAS; hand weeding at 20 and 30 DAS; weed free; weedy control. Data were recorded for grain yield, N uptake, P uptake, protein content, net return, profit over weedy control. Pendimethalin at 1.0 kg ha^{-1} + hand weeding at 35 DAS gave the highest grain yield (1.51 t ha^{-1}). Acetachlor at 0.75 kg ha^{-1} + hand weeding at 35 DAS gave the highest P uptake (11.3 kg ha^{-1}) while hand weeding at 20 and 30 DAS gave the highest protein content (22.5).

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of weeding (0, 1 and 2 weeding) on the yield and quality of blackgram. They observed that number of flowers plant^{-1} and pods plant^{-1} was found to be significantly higher by two times of weeding.

Two field experiments were conducted in Kalubia Governorate, Egypt, in 1999 and 2000 summer seasons by El-Metwally and Ahmed (2001) to investigate the effects on some weed control treatments, i.e. butralin (Amex-820) at 2.5 L feddan^{-1}, fluazifop-P-butyl [fluazifop-P] (Fusilade) at 2.0 L feddan^{-1}, bentazone (Basagran) at 0.75 L feddan^{-1}, butralin at 1.875 L feddan^{-1} + one hand hoeing (HH), fluazifop-P-butyl at 1.5 L feddan^{-1} + one HH, bentazone at 0.56 L feddan^{-1} + one HH, one HH, 2 HHs at 2 and 4 weeks after sowing, and unweeded control, on the growth, yield and yield components as well as chemical composition of mung bean cv. Kawmy-1. The common weeds in both growing seasons were *Amaranthus caudatus, Convolvulus arvensis, Xanthium spinosum, Cyperus rotundus* and *Cynodon dactylon.* All the weed control treatments decreased significantly fresh and dry weights of mungbean weeds compared to the unweeded treatment. The most effective treatments for weed control in mungbean were the 2 HHs, bentazone + one hand hoeing, bentazone and butralin + one HH. The 2 HHs treatments recorded the highest values of total carbohydrates and protein percentage, followed by the bentazone + one HH and butralin + one HH treatments. Application of bentazone + one HH and 2 HHs significantly increased the fresh and dry weights of plants and leaves, plant height, stem diameter, number of branches per plant, number of pods per plant, weight of pods per plant, number of seeds per pod, weight of 100-seed, biological yield per plant, seed yield per plant and feddan^{-1} compared with other treatments.

Weeds remain one of the most significant agronomic problems associated with organic arable crop production. It is recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms (Aebischer, 1997).

Ahmed *et al.* (1992) found that one hand weeding at 10 or 20 DAE produced higher yield than unweeded plots in mungbean during early kharif. They also observed highest grain yield of mungbean when weeded at 10 DAE.

The critical weed-free period represents the time interval between two separately measured components: the maximum weed-infested period or the length of time that weeds which have emerged with the crop can remain before they begin to interfere with crop growth; and the minimum weed free period or the length of time a crop must be free of weeds after planting in order to prevent yield loss (Weaver *et al.*, 1992).

Yield losses of about 79 - 89% due to weed infestation have been reported by Ahmed, 1991 from earlier experiment. Weeds can significantly reduce crop yield and quality in conventional and organic (Bulson, 1991) crops. Maximum seed yield was obtained when weeds were removed 20 days after sowing. In competition study, 20 % yield reduction in soybean occurred if weed control measure was not taken prior to 5weeks after emergence (Crook and Renner, 1990; Marwat and Nafziger, 1990).

The critical period of crop weed^{-1} competition was determined in mungbean (Kumar and Kairon, 1990; in cotton (Bryson, 1990); in wheat (Islam *et al.*, 1989) and in mustard (Dashora *et al.*, 1990).

Critical period of weed competition is the minimum weed free period essential during the life cycle of a crop to prevent yield loss. The critical period of weed control in interference study is the period up to which the weeds would be allowed without significant yield losses of crops (Bryson, 1990).

Islam *et al.*, (1989) stated that every crop has a stage during its life cycle when it is particularly sensitive to weed competition. Kumar and Kairon (1988) found that weed biomass increased and mungbean yield decreased with delay in weeding. However, delay in weeding did not affect the number of seeds pod^{-1}.

Higher yield of mungbean was observed in the early-weeded plots compared to late unweeded plots (Singh *et al.*, 1988). Pascua (1988) determined the critical period of weed control and competition on mungbean yield. The treatments that gave lower fresh weight of weed had higher number of seeds pod^{-1}. Higher percent yield reduction was recorded when the mungbean plants were exposed to longer weed competition. Maximum dry matter content was recorded under weed free condition followed by weed removal at 30 and 40 days after sowing (Kumar and Kairon, 1988).

Karim *et al*. (1986), found that critical period of weed competition was in between 20 and 30 days after sowing in jute. The critical period of crop and weed competition was determined in direct seeded Aus rice (Mamun *et al*., 1986) and also in transplanted Aus rice (Ahmed *et al*., 1986).

Sarker and Mondal (1985) observed that weeding at different dates after sowing affected some yield contributing characters and yield of mungbean. Grain yield was by 49 to 55% when weeds were not removed at all. Variable number of weeding in mungbean have been suggested viz., one weeding at 2 weeks after emergence, two weeding during early growth stage (Madrid and Vega, 1984), and three weeding during the first 3 weeks after sowing (Enyi, 1984) for optimum yield.

Removal of weeds at 10, 20 or 30 days after sowing produced higher yields of mungbean than weedy check (Yadav *et al*., 1983). The harmful effect of weed infestation did not begin just after emergence of seedling, rather the competition between the weeds and crop was found to be the most severe at a particular stage of crop growth which was known as critical period of crop-weed competition.

2.5 Effect of mulching

USDA-NRCS (2006) observed that crop residues are required to maintain sustainable production, a more viable option may be crops grown specifically as energy crops, including herbaceous energy crops like switch grass and short rotation woody crops like hybrid poplar. Being perennials, these crops require few field passes and little soil disturbance, resulting in low erosion rates.

Wilhelm *et al*. (2004) reported that the low-cost and abundance of harvesting crop residues make them competitive as gasoline additives. The eight leading U.S.

crops produce more than 500 million tons of residue each year. Corn, and to a lesser extent wheat, is receiving the most attention as a potential biomass feedstock. This is due to its concentrated production area and because it produces 1.7 times more residue (or stover) than other leading cereals, based on current production levels.

Mann *et al*. (2002) concluded that more information was needed on the long term effects of residue harvest, including its impact on: 1) water quality; 2) soil biota; 3) transformations of different forms of soil organic carbon (SOC); and 4) subsoil SOC dynamics.

Two field experiments were conducted by Phongpan and Mosier (2002) in a rice-fallow-rice cropping sequence during consecutive dry and wet seasons of 1997 on a clay soil to determine the fate and efficiency of broadcast urea in combination with three residue management practices (no residue, burned residue and untreated rice crop residue). During a 70 d follow period prior to flooding the soil for wet season rice, emissions of N_2O measured at weekly intervals from no residue, burned residue and residue treatments ranged from 25 to 128, 19 to 59 and 24 to 75 mg N m^{-2} ha^{-1}, respectively. Grain yield and N uptake were significantly increased by N application in the dry season but not significantly affected by residue treatments in either season.

Nelson (2002) also reasoned that subtracting the predicted amount of residue required to stay at or below T (calculated from the first set of analyses) from the amount of residue calculated from actual yield data would result in the amount of residue available for harvest. Some future hurdles to predict residue harvest potential from cropping systems include extending these results to all regions and soils, other crops, and extending the prediction to include more than just soil loss as a resource concern. To fully consider the soil quality impacts of residue removal, this method should also consider effects on soil organic matter, nutrients, biota, and future crop yield.

There is also sufficient quantity to support commercial scale production (DiPardo, 2000). However, removing crop residues for bio-energy use can have a negative effect on natural resource quality. Crop residues perform many positive functions for agricultural ecosystems including:

- Protecting soil from erosion, thereby maintaining water and air quality by reducing runoff and sediment (via reduced water-induced soil erosion) and air-borne particulates (through decreased wind erosion).
- Increasing or maintaining soil organic matter and nutrients, leading to improved soil and water quality
- Maintaining beneficial soil organisms and providing wildlife habitat; and
- Improving plant-available water and drought resistance, potentially increasing yields.

Gale and Cambardella (2000) reported that as a physical buffer, crop residues protect soil from the direct impacts of rain, wind and sunlight leading to improved soil structure, reduced soil temperature and evaporation, increased infiltration, and reduced runoff and erosion. While some studies suggest that plant roots contribute more carbon to soil than surface residues, crop residue contributes to soil organic matter and nutrient increases, water retention, and microbial and macroinvertebrate activity. These effects typically lead to improved plant growth and increased soil productivity and crop yield.

Glassner *et al*. (1999) reported that crop residues perform many positive functions for agricultural soils that reduce erosion and promote sustainable production. In many regions, cover crops are a viable alternative that offer soil protection and added organic matter. Green biomass, as with a cover crop, is considered to be 2.5 times more effective than crop residue in reducing wind erosion (in predictive models), especially if the residue is laying flat (McMaster and Wilhelm, 1997).

Paine *et al*. (1996) recommended growing these crops on marginal lands, such as highly erodible land, poorly drained soils or areas used for wastewater reclamation, which would avoid competition with food crops and increase the amount of arable land.

Karlen *et al*. (1994) found that 10 years of residue removal under no-till continuous corn in Wisconsin resulted in deleterious changes in many biological indicators of soil quality, including lower soil carbon, microbial activity, fungal biomass and earthworm populations compared with normal or double rates of residue return.

Lindstrom (1986) found increased runoff and soil loss with decreasing residue remaining on the soil surface under notill, with the study results suggesting a 30% removal rate would not significantly increase soil loss in the systems modeled. Reduction in these properties and populations suggests loss of soil function, particularly reduced nutrient cycling, physical stability, and biodiversity.

Other conservation practices such as contour cropping or conservation tillage must be used to compensate for the loss of erosion protection and soil organic

2.6 Effect of insecticides and fungicides

An experiment was conducted by Dubey (2007) in New Delhi, India to study the efficacy of *Trichoderma viride* (IARIP-2), *Pongamia glabra* [*P. pinnata*] cake and leaf extract and carboxin in different combinations and modes of application in field trials. The resulting yield of mungbean (*Vigna radiata*) was measured. Fifty-four combinations of different treatments were applied through soil, seed and foliar spray. Integration of soil application of P. glabra cake (200 kg ha^{-1}), seed treatment with *T. viride* (2.0 g kg^{-1} seed) +carboxin (1.0 g kg^{-1} seed)+*Rhizobium* sp. (25 g kg^{-1} seed) and foliar spray of *P. glabra* leaf extract (10%) suppressed disease severity significantly (92.7%). This treatment also increased seed germination (32.4%), improved plant vigour and enhanced production (49.2%). The same combination excluding carboxin was also effective and could be an option for organic production of mungbean. The integration of any two modes of applications of the treatments was superior to any single mode of application.

Field experiments were conducted by Ganapathy and Karuppiah (2004) during summer seasons in Tamil Nadu, India, to determine the efficacy of new insecticides against whitefly, mungbean yellow mosaic virus (MYMV) and urdbean leaf crinkle virus (ULCV) in mungbean cv. CO-4. The treatments comprised: seed treatment with 5 g imidacloprid kg^{-1} seed (T_1); seed treatment with 5 g thiamethoxam kg^{-1} seed (T_2); 0.25 ml imidacloprid $litre^{-1}$ at 15 days after sowing (DAS; T_3); 0.2 g thiamethoxam $litre^{-1}$ at 15 DAS (T_4); 0.1 g acetamiprid $litre^{-1}$ at 15 DAS (T_5); 0.25 ml fipronil $litre^{-1}$ at 15 DAS (T_6); 2.0 ml dimethoate $litre^{-1}$ at 15 DAS (T_7); 0.5 ml cypermethrin $litre^{-1}$ at 15 DAS (T_8); 1.0 ml neem oil $litre^{-1}$ 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^{-1}).

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

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

Management of insect pests of mungbean with insecticides using seed treatment and pre-sowing soil application followed by foliar application was studied by Ram and Singh (1999) at Pantnagar. Seed treatment with carbosulfan, monocrotophos, dimethoate, phosphamidon, methyl-o-demeton, methomyl and chlorpyriphos was evaluated for effect on germination and seedling vigour in the laboratory. Field efficacy of the effective doses of the above insecticides was evaluated, together with the pre-sowing soil application of phorate and carbofuran followed by foliar application of various insecticides at flowering against pests of mungbean. The insecticidal treatments significantly reduced the population of various insect pests in both seasons. Grain yield varied significantly from the lowest value of 214.2 and 353.3 kg ha^{-1} in untreated control to the highest value of 583.3 and 524.6 kg ha^{-1} 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^{-1} dosages, respectively, followed by sprays at flowering also gave higher grain yield than the untreated control.

The pod borer can also be controlled by Cymhush 10 EC @ 1.0 ml L^{-1} 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^{-1}) were evaluated by Dhiman *et al*. (1993) in a field experiment for the control of stemfly (*Ophiomyia phaseoli*) of mungbean. All of the tested granular insecticides were found to be more effective for controlling mungbean stemfly than the control condition.

The succession and abundance of insect pests on *Vigna radiata* and *V. mungo* were observed by Raj and Kalra (1995) in Hisar, India, during summer. These crops were attacked by 22 and 16 insect pest species, respectively, at different stages of growth. The most important insect pests were *Empoasca kerri*, *Ophiomyia phaseoli*, *Austroagallia* sp., *Bemisia tabaci* and *Nysius* sp. The peak populations of *E. kerri* (nymphs and adults), *O. phaseoli*, *Austroagallia* sp., *B. tabaci* and *Nysius* sp. (adults) was 6.40, 0.25, 10.82, 16.65 and 5.60 per plant, respectively on *V. radiata*, and 9.25, 0.75, 7.67, 19.25 and 4.05 insects per plant on *V. mungo*.

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

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

Different indices for developing an insecticide application schedule against *Euchrysopscnejus* were evaluated in mungbean and Fenitrothion @ 0.1% when egg number reached about 5.2 per meter was found as the best schedule for it (Rahman, 1989). In another trial was conducted by him 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.

Chemical control is one of the widely practiced methods of controlling insect pests. Modern insecticides are both effective and reliable and almost all the countries of the world are relying to them more and more for the solution of insect problem. But their excessive and indiscriminate use has resulted in the development of insecticide resistance against the pests and causing environmental pollution (Babu, 1988).

Rahman (1987) also reported that Fenitrothion or Sumithion 50 EC @ 2ml L^{-1} of water was recommended for the control of pod borer. Ahmad (1987) observed that pre sowing soil application of Carbofuran or Furadan 3G, Aldicarb 10 G or Phroate 10 G 1 kg a.i. ha^{-1} 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.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from September to December 2012 to study the effect of different management practices on the growth and yield of mungbean. The details of the materials and methods has been presented below under the following headings:

3.1 Experimental site

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

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 Deep Red Brown Terrace Soils.

3.3 Climate condition

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October.

3.4 Planting material

The variety BARI mung-5 was used as the test crops. The seeds were collected from the Pulse Research Centre of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. BARI mung-5 is the released varieties of mungbean, which was recommended by the national seed board. They grow both in *Kharif* and *Rabi* season. Life cycle of this variety ranges from 55-60 days. Maximum seed yield is 1.15-1.5 t ha^{-1}.

3.5 Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 04 and 10 September 2012, respectively. Experimental land was divided into 12 unit plots following the design of experiment where 12 treatments were randomly distributed to observe the effect of different management practices replicating three times.

3.6 Fertilizer application

Urea, Triple super phosphate (TSP) and Muriate of potash (MOP) were used as a source of nitrogen, phosphorous and potassium, respectively in the experimental plot. Urea, TSP and MOP were applied @ 45, 80 and 35 kg, respectively as recommended dose. All of the fertilizers were applied during final land preparation except urea and it was applied at 15 and 30 days after sowing (DAS).

3.7 Treatments of the experiment

The experiment consists of the following treatments:

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

3.8 Experimental design and layout

The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 21.9 m × 9.4 m was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment combinations were allotted randomly. There were 36 unit plots altogether in the experiment. The size of the each unit plot was 1.8 m × 1.2 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9 Sowing of seeds in the field

The seeds of mungbean were sown on 10 September, 2012. Before sowing, except in that no seed fungicide treatment seeds were treated with Bavistin to control the seed borne disease (but not with broadcast treatments). The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Row to row distance was 30 cm.

3.10 Intercultural operations

3.10.1 Thinning

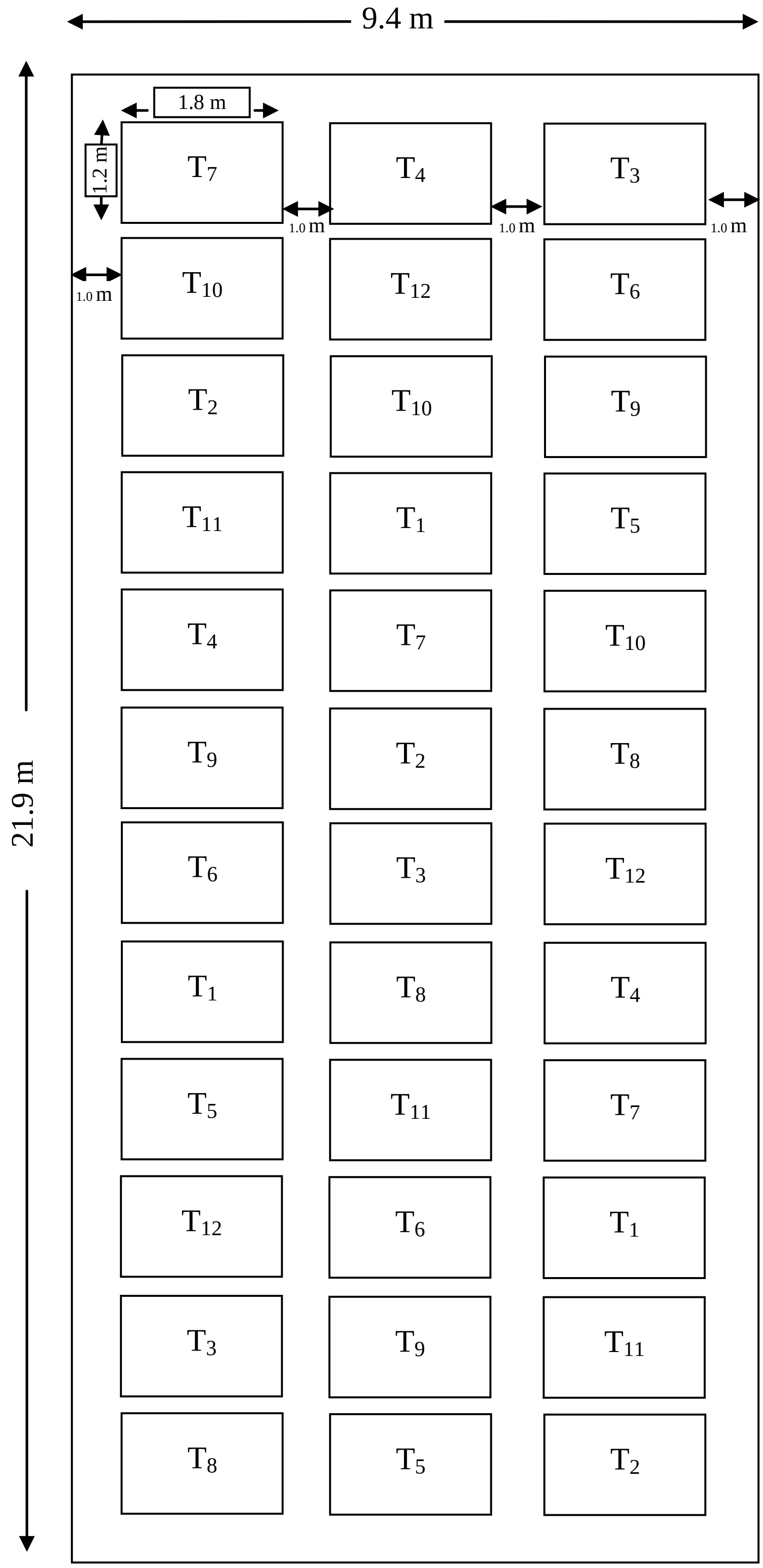
Seeds started germination of four Days after Sowing (DAS). Thinning was done two times; first at 8 DAS and second at 15 DAS to maintain optimum plant population in each plot. Thus plant was spaced at 30 cm × 10 cm.

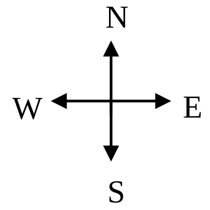
3.10.2 Irrigation and weeding

Irrigation was done as per requirements excepting those plots with no irrigation. The crop field was weeded as per treatment.

3.10.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1 litre/ha to control the insects as per treatment.





Plot size: 1.8 m × 1.2 m
Plot spacing: 0.50 m
Between block: 1.00 m

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

Figure 1. Layout of the experimental plot

3.11 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card for data recording. Plant height, number of leaves per plant, branches per plant were recorded from selected plants at an interval of 10 days started from 20 DAS and to harvest.

3.12 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color**.** The matured pods were collected by hand picking from a pre demarcated area of three linear meter at the center of each plot and converted to per hectare at 9% moisture.

3.13 Data collection

3.13.1 Crop Growth Characters

Plant height

The height of plant was recorded in centimeter (cm) at 20, 30, 40, 50 DAS (Days after sowing) and harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot that were tagged earlier. The height was measured from the ground level to the tip of the plant with the help of a meter scale.

Number of branches per plant

Total number of branches per plant was recorded at 20, 30, 40, 50 DAS (Days after sowing) and at harvest. Data were recorded by counting branches from each plant and as the average of 5 plants selected at random from the inner rows of each plot.

Number of leaves per plant

The number of branches per plant was recorded at 20, 30, 40, 50 DAS (Days after sowing) and at harvest. Data were recorded by counting branches from each plant and as the average of 5 plants selected at random from the inner rows of each plot.

Dry matter content per plant

Data from five sample plants from each plot were collected and gently washed with tap water, thereafter soaked with paper towel. Then fresh weight was taken immediately after soaking by paper towel. After taking fresh weight, the sample was oven dried at 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of plant was taken and expressed in gram. Dry matter content per plant was recorded at 20, 30, 40 and 50 DAS.

Estimated growth parameter

Using the data on total dry matter from each specific treatment, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) growth parameters were derived with following the below mentioned calculation (Hunt, 1978):

Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula:

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \ \text{g m}^{-2}\text{day}^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date (T_1)

W_2 = Total dry weight at current sampling date (T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Relative Growth Rate (RGR)

Relative growth rate was calculated using the following formula:

$$RGR = \frac{\text{Ln}W_2 - \text{Ln}W_1}{T_2 - T_1} \quad (\text{g g}^{-1}\text{day}^{-1})$$

Where,

W_1 = Total dry weight at previous sampling date (time T_1)

W_2 = Total dry weight at current sampling date (time T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Ln = Natural logarithm

3.13.2 Yield contributing characters and yield of mungbean

Days to 1st flowering

Days to 1st flowering were measured by counting the number of days required to start flower initiation in each plot.

Days to 80% pod maturity

Days to 80% pod maturity were measured by counting the number of days required to attain maturity of 80% pods. Maturity was measured on the basis of brown colour of leaves and stem and dark grey colour of pods.

Pods per plant

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as per plant basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

Seeds per pod

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

Pod length

Pod length was taken of randomly selected twenty pods and the mean length was expressed on per pod basis.

Weight of 1000-seed

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

Seed yield per hectare

The seeds collected from 2.16 (1.8 m × 1.2 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

Stover yield per hectare

The stover collected from 2.16 (1.8 m × 1.2 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.14 Statistical analysis

The data obtained for different parameters were statistically analyzed using MSTAT-C software to find out the significant difference among different treatments on yield and yield contributing characters of mungbean. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of different management practices on the growth and yield of mungbean. Data on different yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix I-VIII. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height varied significantly at 20, 30, 40 and 50 DAS and harvest for different management practices under the present study (Table 1). At 20, 30, 40, 50 DAS and harvest the tallest plant (14.72 cm, 38.31 cm, 44.60 cm, 56.70 cm and 59.30 cm, respectively) was recorded in T_1 (all management practices) which was statistically similar (13.76 cm, 36.60 cm, 42.59 cm, 53.79 cm and 58.08 cm, respectively) with T_{10} (all management but no mulching), whereas the shortest plant (8.19 cm, 22.03 cm, 28.23 cm, 43.03 cm and 47.20 cm, respectively) was observed in T_6 (all management but no weeding) which was statistically similar (8.27 cm, 22.98 cm, 30.85 cm, 44.09 cm and 50.08 cm) with T_4 (all management but no fertilizer) for same data recorded days. Plant height of any cultivar is mainly governed by different management practices especially fertilizer. It was found that all management practices was more effective for the vegetative growth of mungbean and that gave the tallest plant. This findings was supported by Dost *et al*. (2004), Bhattacharyya and Pal (2001), Shukla and Dixit (1996), Sattar and Ahmed (1995), Khurana and Poonam (1993) and Patel *et al.* (1984).

Table 1. Effect of different management practices on plant height of mungbean at different days

Treatment	Plant height (cm) at				
	20 DAS	30 DAS	40 DAS	50 DAS	Harvest
T_1	14.72 a	38.31 a	44.60 a	56.70 a	59.30 a
T_2	11.10 de	26.21 g	34.71 e	49.38 c-e	53.52 d-f
T_3	12.31 b-d	34.49 bc	40.07 bc	51.37 bc	51.42 fg
T_4	8.27 g	22.98 h	30.85 f	44.09 fg	50.08 g
T_5	11.67 cd	33.60 cd	39.27 bc	50.49 b-d	55.30 b-e
T_6	8.19 g	22.03 h	28.23 f	43.03 g	47.20 h
T_7	9.91 ef	29.88 ef	35.49 de	46.94 d-f	51.64 fg
T_8	11.28 c-e	33.06 cd	38.85 cd	49.83 c-e	54.85 c-e
T_9	9.31 fg	28.90 f	34.60 e	46.27 e-g	57.30 a-c
T_{10}	13.76 ab	36.60 ab	42.59 ab	53.79 ab	58.08 ab
T_{11}	12.82 bc	34.02 cd	40.12 bc	53.60 ab	56.41 a-d
T_{12}	11.01 de	31.52 de	37.46 c-e	49.61 c-e	52.98 e-g
SE	0.502	0.454	1.280	1.261	0.812
Level of significance	0.01	0.01	0.01	0.01	0.05
CV(%)	7.92	9.68	5.20	7.86	6.77

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

4.2 Number of branches per plant

Number of branches per plant varied significantly at 20, 30, 40 and 50 DAS and at harvest for different management practices under the present trial (Table 2). At 20, 30, 40, 50 DAS and at harvest the maximum number of branches per plant (1.80, 2.40, 3.20, 4.60 and 5.00, respectively) was recorded in T_1 which was followed (1.48, 2.30, 2.80, 3.60 and 4.80, respectively) by T_{10}, whereas the minimum number of branches per plant (0.60, 0.80, 0.84, 2.20 and 3.20, respectively) was observed in T_6 which was statistically similar (0.68, 1.40, 1.80, 2.40 and 3.26) with T_4 treatment.

4.3 Number of leaves per plant

Number of leaves per plant varied significantly at 20, 30, 40 and 50 DAS and at harvest for different management practices under the present trial (Table 3). At 20, 30, 40, 50 DAS and harvest the maximum number of leaves per plant (8.00, 12.90, 17.93, 21.90 and 27.03, respectively) was recorded in T_1 which was statistically similar (8.00, 12.07, 17.03, 21.23 and 26.27, respectively) with T_{10}, whereas the minimum number of leaves per plant (5.87, 8.97, 11.57, 14.93, 17.60, respectively) was observed in T_6 which was statistically similar (6.40, 9.33, 11.73, 14.43 and 17.83, respectively) with T_4 at 20, 30, 40 and 50 DAS and harvest, respectively. This findings was supported by Nigamananda and Elamathi (2007), Malik *et al*. (2003), Dost *et al*. (2004), Nadeem *et al.* (2004) and Rajender *et al*. (2003).

4.4 Dry matter content per plant

Dry matter content per plant of mungbean varied significantly at 20, 30, 40 and 50 DAS for different management practices under the present trial (Table 4). At 20, 30, 40 and 50 DAS, the highest dry matter content per plant (8.95 g, 11.08 g, 15.39 g and 17.50 g, respectively) was recorded in T_1 which was statistically similar (8.89 g, 10.91 g, 14.40 g, 16.79 g, respectively) with T_{10}, whereas the lowest dry matter content per plant (6.23 g, 8.01 g, 10.41 g and 12.70 g, respectively) was observed in T_6 which was statistically similar (6.98 g, 9.54 g, 12.23 g and 13.97 g, respectively) with T_4 at 20, 30, 40 and 50 DAS, respectively.

Table 2. Effect of different management practices on number of branches per plant of mungbean at different days

Treatment	Number of branches per plant at				
	20 DAS	30 DAS	40 DAS	50 DAS	Harvest
T_1	1.80 a	2.40 a	3.20 a	4.60 a	5.00 a
T_2	0.80 d-f	1.40 c	1.60 c	2.80 cd	4.46 ab
T_3	1.20 bc	1.60 bc	2.00 c	2.80 cd	4.40 a-c
T_4	0.68 ef	1.40 c	1.80 c	2.20 e	3.26 e
T_5	0.80 d-f	1.40 c	2.20 bc	2.40 de	3.60 de
T_6	0.60 f	0.80 d	0.84 d	3.00 c	3.20 e
T_7	1.00 c-e	1.40 c	2.20 bc	2.40 de	3.90 b-d
T_8	0.80 d-f	1.80 bc	2.00 c	3.00 c	4.60 ab
T_9	0.80 d-f	1.40 c	1.80 c	2.60 c-e	3.70 c-e
T_{10}	1.48 b	2.30 ab	2.80 ab	3.60 b	4.80 a
T_{11}	1.08 cd	1.40 c	2.00 c	3.00 c	4.40 a-c
T_{12}	1.20 bc	2.00 ab	2.80 ab	4.00 b	4.40 a-c
SE	0.314	0.453	0.610	0.496	0.635
Level of significance	0.01	0.05	0.05	0.01	0.05
CV(%)	14.28	10.01	12.84	7.81	12.05

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

Table 3. Effect of different management practices on number of leaves per plant of mungbean at different days

Treatment	Number of leaves per plant at				
	20 DAS	30 DAS	40 DAS	50 DAS	Harvest
T_1	8.00 a	12.90 a	17.93 a	21.90 a	27.03 a
T_2	6.93 c	10.70 bc	14.03 ef	16.50 f	19.23 de
T_3	6.77 cd	9.03 d	13.40 f	17.30 ef	21.43 c
T_4	6.40 d	9.33 d	11.73 g	14.43 g	17.83 e
T_5	7.60 b	10.93 b	14.93 c-e	19.67 cd	24.43 b
T_6	5.87 e	8.97 d	11.57 g	14.93 g	17.60 e
T_7	6.57 cd	9.77 cd	14.57 d-f	18.43 de	21.00 cd
T_8	7.87 ab	11.03 b	15.23 c-e	19.87 c	25.90 ab
T_9	6.63 cd	10.50 bc	15.43 cd	19.13 cd	22.13 c
T_{10}	8.00 a	12.07 a	17.03 ab	21.23 ab	26.27 ab
T_{11}	7.80 ab	12.00 a	15.93 bc	20.30 bc	25.87 ab
T_{12}	7.53 b	11.03 b	15.57 cd	19.40 cd	24.63 b
SE	0.139	0.321	1.005	1.132	1.081
Level of significance	0.05	0.01	0.01	0.01	0.05
CV(%)	12.80	5.09	4.81	8.06	5.39

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

Table 4. Effect of different management practices on dry matter content per plant of mungbean at different days

Treatment	Dry matter content per plant (g) at			
	20 DAS	30 DAS	40 DAS	50 DAS
T_1	8.95 a	11.08 a	15.39 a	17.50 a
T_2	7.34 b-d	9.94 a-c	12.30 c	14.92 bc
T_3	7.45 b-d	10.09 a-c	12.79 bc	15.41 bc
T_4	6.98 cd	9.54 bc	12.23 c	13.97 cd
T_5	7.73 a-c	10.37 a-c	12.65 bc	14.70 c
T_6	6.23 d	8.01 d	10.41 d	12.70 d
T_7	7.12 b-d	9.30 c	12.16 c	14.55 c
T_8	7.92 a-c	10.64 ab	13.00 bc	14.80 c
T_9	7.25 b-d	9.36 bc	12.12 c	14.67 c
T_{10}	8.89 a	10.91 a	14.40 ab	16.79 ab
T_{11}	7.53 b-d	9.53 bc	12.16 c	14.27 cd
T_{12}	8.39 ab	9.83 a-c	12.53 c	15.44 bc
SE	0.394	0.391	0.541	0.586
Level of significance	0.05	0.01	0.01	0.05
CV(%)	8.86	6.84	7.35	6.75

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

4.5 Crop growth rate

Crop growth rate (CGR) of mungbean showed non significant variation at 20-30 DAS, 30-40 DAS and 40-50 DAS for different management practices under the present trial (Table 5). At 20-30 DAS, the highest CGR (4.53 g $m^{-2}day^{-1}$) was recorded in T_8, while the lowest CGR (2.39 g $m^{-2}day^{-1}$) was found in T_{12}. At 30-40 DAS, the highest CGR (7.18 g $m^{-2}day^{-1}$) was recorded in T_1, whereas the lowest CGR (3.80 g $m^{-2}day^{-1}$) was found in T_5. At 40-50 DAS, the highest CGR (4.92 g $m^{-2}day^{-1}$) was recorded in T_2, whereas the lowest CGR (2.89 g $m^{-2}day^{-1}$) was found in T_4.

4.6 Relative growth rate

Relative growth rate (RGR) of mungbean showed non significant variation at 20-30 DAS, 30-40 DAS and 40-50 DAS for different management practices under the present trial (Table 6). At 20-30 DAS, the highest RGR (0.031 g g^{-1} day^{-1}) was recorded in T_4, while the lowest RGR (0.016 g g^{-1} day^{-1}) was found in T_{12}. At 30-40 DAS, the highest RGR (0.33 g g^{-1} day^{-1}) was recorded in T_1, whereas the lowest RGR (0.020 g g^{-1} day^{-1}) was found in T_5. At 40-50 DAS, the highest RGR (0.021 g g^{-1} day^{-1}) was recorded in T_2, whereas the lowest RGR (0.013 g g^{-1} day^{-1}) was found in T_4.

4.7 Days to 1st flowering

Days to 1st flowering of mungbean varied significantly due to different management practices under the present trial (Figure 2). The lowest days to 1st flowering (31.33) was recorded in T_1 which was statistically similar (31.67) with T_{10}, whereas the highest days to 1st flowering (41.33) was observed in T_6 which was followed (37.67 days) by T_4. This findings was supported by Nigamananda and Elamathi (2007) and Malik *et al*. (2003).

Table 5. Effect of different management practices on crop growth rate of mungbean at different days

Treatment	Crop Growth Rate (g $m^{-2} day^{-1}$) at		
	20 DAS-30 DAS	30 DAS-40 DAS	40 DAS-50 DAS
T_1	3.55	7.18	3.53
T_2	4.34	3.94	4.92
T_3	4.41	4.50	4.35
T_4	4.28	4.48	2.89
T_5	4.40	3.80	3.42
T_6	2.96	4.01	3.81
T_7	3.64	4.77	3.98
T_8	4.53	3.94	3.00
T_9	3.52	4.60	4.24
T_{10}	3.38	5.81	3.98
T_{11}	3.33	4.38	3.52
T_{12}	2.39	4.50	4.85
SE	0.635	0.726	0.982
Level of significance	NS	NS	NS
CV(%)	19.86	16.68	14.21

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

Table 6. Effect of different management practices on relative growth rate of mungbean at different days

Treatment	Relative growth rate (g g^{-1} day^{-1}) at		
	20 DAS-30 DAS	30 DAS-40 DAS	40 DAS-50 DAS
T_1	0.021	0.033	0.013
T_2	0.030	0.021	0.021
T_3	0.030	0.024	0.019
T_4	0.031	0.025	0.013
T_5	0.029	0.020	0.014
T_6	0.025	0.026	0.020
T_7	0.027	0.027	0.018
T_8	0.029	0.019	0.012
T_9	0.026	0.026	0.019
T_{10}	0.021	0.028	0.015
T_{11}	0.023	0.024	0.016
T_{12}	0.016	0.024	0.019
SE	0.005	0.004	0.004
Level of significance	NS	NS	NS
CV(%)	10.44	15.60	44.83

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

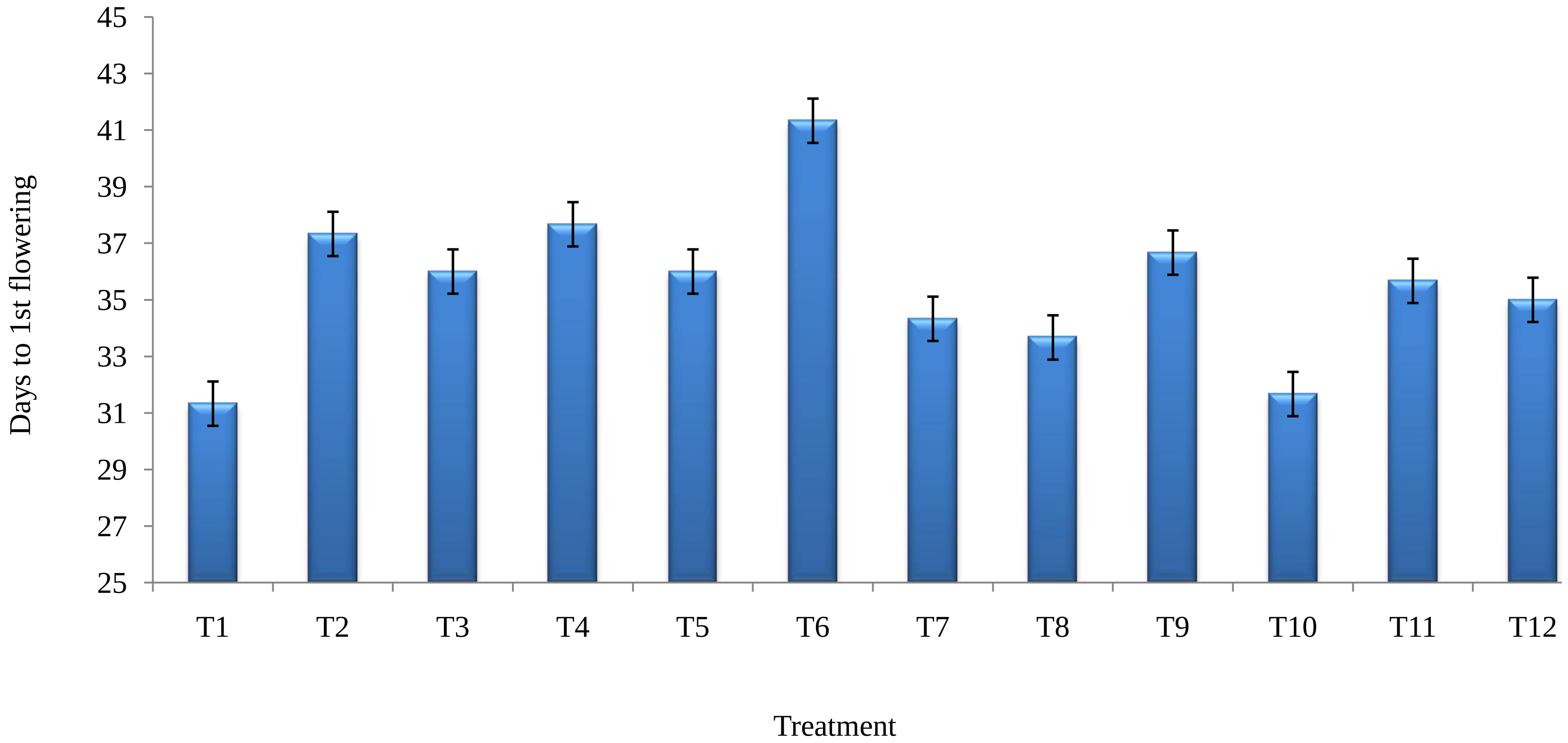


Figure 2. Effect of different management practices on days to 1st flowering of mungbean. The vertical bar denote SE value

4.8 Days to 80% pod maturity

Days to 80% pod maturity of mungbean varied significantly due to different management practices under the present trial (Table 7). The lowest days to 80% pod maturity (62.40) was recorded in T_1 which was statistically similar (63.40) with T_{10}, whereas the highest days to 80% pod maturity (71.00) was observed in T_6 which was similar (70.80 days) to T_4. Similar types of findings also reported by Sattar and Ahmed (1995), Salimullah *et al.* (1987).

4.9 Number of pods per plant

Number of pods per plant of mungbean varied significantly due to different management practices under the present trial (Table 7). The highest number of pods per plant (21.23) was recorded in T_1 which was statistically similar (20.74, 20.62 and 20.32) with T_{10}, T_3 and T_2, respectively, whereas the lowest number of pods per plant (13.14) was observed in T_6 followed (14.90 and 15.28) by T_4 and T_5, respectively. Data represents that all management practices was more effective for the vegetative growth of mungbean which leads for maximum reproductive growth and gave the maximum number of pods per plant. Similar types of finding also reported by Sattar and Ahmed (1995), Salimullah *et al.* (1987) and Patel *et al.* (1992) from their earlier study.

4.10 Number of seeds per pod

Number of seeds per pod of mungbean varied significantly due to different management practices under the present trial (Table 7). The highest number of seeds per pod (9.40) was recorded in T_1 which was statistically similar (9.13 and 8.90) with T_{10}, T_7 and T_8, respectively, whereas the lowest number of seeds per pod (5.73) was observed in T_6 which was similar (5.87) with T_4.

Table 7. Effect of different management practices on days to 80% pod maturity, number of pods per plant and number of seeds per pod of mungbean

Treatment	Days to 80% pod maturity	Number of pods per plant	Number of seeds per pod
T_1	62.40 d	21.23 a	9.40 a
T_2	69.20 a-c	20.32 a-c	7.60 c
T_3	69.20 a-c	20.62 ab	6.20 d
T_4	70.80 ab	14.90 f	5.87 d
T_5	66.60 a-d	15.28 f	6.53 d
T_6	71.00 a	13.14 g	5.73 d
T_7	65.60 cd	19.23 cd	8.90 ab
T_8	67.80 a-c	17.39 e	8.90 ab
T_9	68.00 a-c	18.50 de	6.47 d
T_{10}	63.40 d	20.74 ab	9.13 a
T_{11}	70.80 ab	18.68 d	7.93 bc
T_{12}	66.40 b-d	19.87 bc	6.17 d
SE	3.902	1.131	1.015
Level of significance	0.01	0.05	0.01
CV(%)	4.54	4.85	8.09

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

4.11 Pod length

Pod length of mungbean varied significantly due to different management practices under the present trial (Figure 3). The longest pod (9.74 cm) was recorded in T_1 which was statistically similar (9.68 cm) with T_{10}, whereas the shortest pod (5.79 cm) was observed in T_6 which was similar (6.34 cm) with T_4. This findings was supported by Dost *et al*. (2004), Bhattacharyya and Pal (2001), Shukla and Dixit (1996) and Khurana and Poonam (1993).

4.12 Weight of 1000-seed

Weight of 1000-seed of mungbean varied significantly due to different management practices under the present trial (Table 8). The highest weight of 1000-seed (38.34 g) was recorded in T_1, whereas the lowest weight (35.41 g) was observed in T_6. This findings was supported by the earlier findings of Dost *et al*. (2004) and Bhattacharyya and Pal (2001).

4.13 Seed yield per hectare

Seed yield per hectare of mungbean varied significantly due to different management practices under the present trial (Table 8). The highest seed yield (1.75 t ha^{-1}) was recorded in T_1 which was statistically similar (1.68 t ha^{-1}, 1.63 t ha^{-1}, 1.60 t ha^{-1} and 1.54 t ha^{-1}) with T_{10}, T_{11}, T_8, T_2 and T_5, whereas the lowest seed yield (1.11 t ha^{-1}) was observed in T_6 which was similar (1.12 t ha^{-1}, 1.14 t ha^{-1}, 1.20 t ha^{-1} and 1.23 t ha^{-1}) with T_4, T_9, T_{12} and T_3. Highest seed yield is the main objectives for using any type of management practices. Considering the vegetative growth of mungbean among the different combination all management practices was more effective for that this combination gave the maximum reproductive growth and well developed seed that leads to highest seed yield. This findings was supported by Dost *et al*. (2004), Bhattacharyya and Pal (2001), Shukla and Dixit (1996), Sattar and Ahmed (1995) and Khurana and Poonam (1993), Salimullah *et al.* (1987) and Patel *et al.* (1984).

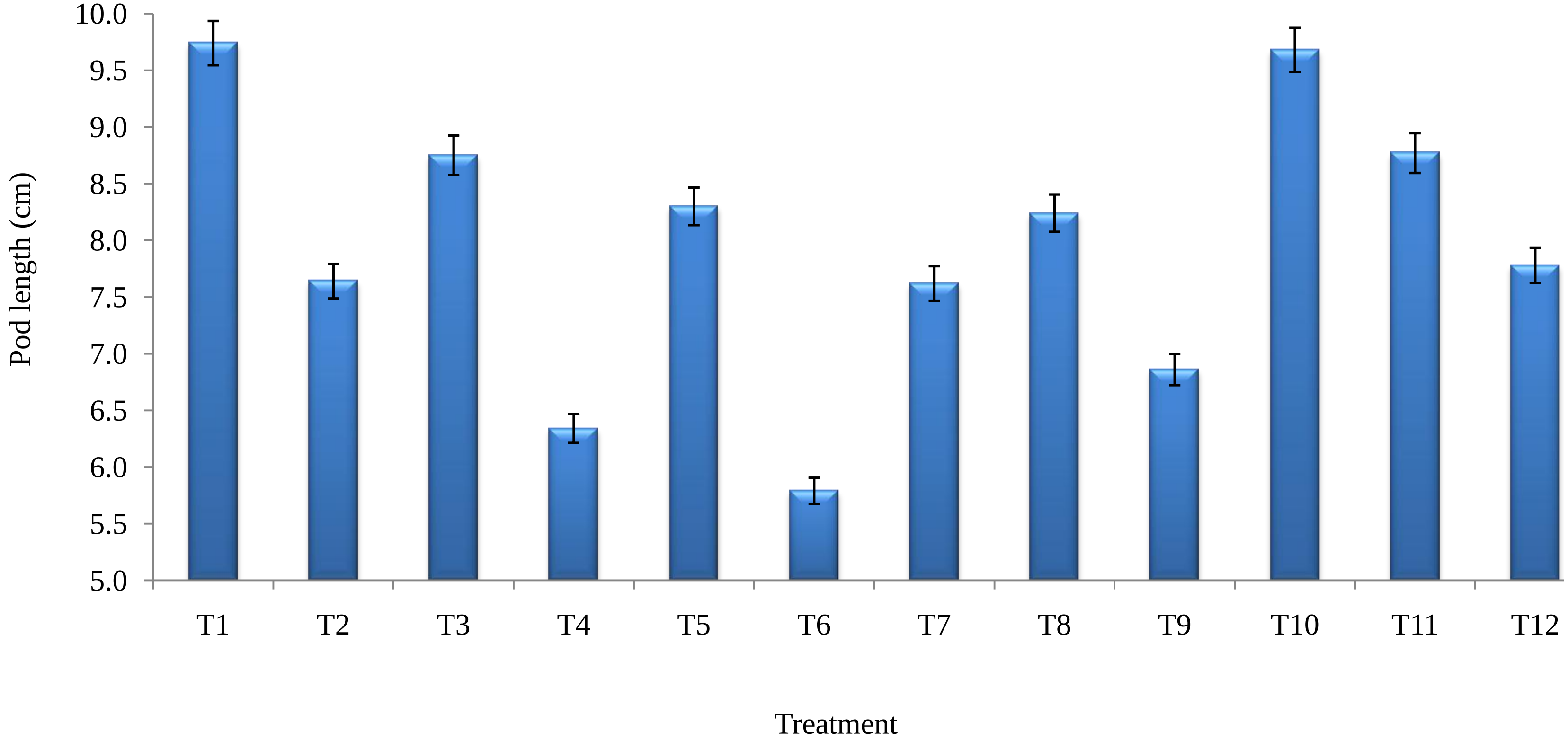


Figure 3. Effect of different management practices on pod length of mungbean. The vertical bar denote SE value

Table 8. Effect of different management practices on weight of 1000-seed, seed yield and stover yield of mungbean

Treatment	Weight of 1000-seed (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	38.34 a	1.75 a	3.37 a
T_2	36.09 bc	1.54 ab	2.96 bc
T_3	36.00 bc	1.23 c	2.86 bc
T_4	35.62 cd	1.12 c	2.40 d
T_5	36.78 bc	1.54 ab	2.75 c
T_6	35.41 d	1.11 c	2.36 d
T_7	35.82 cd	1.44 b	2.88 bc
T_8	37.48 ab	1.60 ab	2.77 c
T_9	35.70 cd	1.14 c	2.49 d
T_{10}	38.14 a	1.68 a	3.04 b
T_{11}	36.88 bc	1.63 ab	2.91 bc
T_{12}	37.57 ab	1.20 c	2.95 bc
SE	1.012	0.200	0.214
Level of significance	0.01	0.01	0.01
CV(%)	5.59	8.48	7.03

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

T_1: All management

T_2: All management but sowing in broadcast

T_3: All management but using 20% more seed rate

T_4: All management but no fertilizers

T_5: All management but no irrigation

T_6: All management but no weeding

T_7: All management but no thinning

T_8: All management but no fungicide

T_9: All management but no insecticide

T_{10}: All management but no mulching

T_{11}: All management but no seed treatment

T_{12}: All management but no pre-sowing irrigation

4.14 Stover yield per hectare

Stover yield per hectare of mungbean varied significantly due to different management practices under the present trial (Table 8). The highest stover yield (2.37 t ha^{-1}) was recorded in T_1 which was followed (2.04 t ha^{-1}) by T_{10}, whereas the lowest stover yield (1.36 t ha^{-1}) was observed in T_6 which was similar (1.12 t ha^{-1}, 1.14 t ha^{-1}, 1.20 t ha^{-1} and 1.23 t ha^{-1}) with T_4, T_9, T_{12} and T_3. This finding was supported by Nadeem *et al.* (2004), Rajender *et al*. (2003), Bhattacharyya and Pal (2001) and Khurana and Poonam (1993).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from September to December 2012 to study the effect of different management practices on the growth and yield of mungbean. The variety BARI mung-5 was used as the test crops. The experiment consists of the 12 treatments as- T_1: All management; T_2: All management but sowing in broadcast; T_3: All management but using 20% more seed rate; T_4: All management but no fertilizers; T_5: All management but no irrigation; T_6: All management but no weeding; T_7: All management but no thinning; T_8: All management but no fungicide; T_9: All management but no insecticide; T_{10}: All management but no mulching; T_{11}: All management but no seed treatment and T_{12}: All management but no pre-sowing irrigation. The single factor experiment was laid out in Randomized Complete Block Design with three replications.

At 20, 30, 40, 50 DAS and at harvest the longest plant (14.72 cm, 38.31 cm, 44.60 cm, 56.70 cm and 59.30 cm, respectively), maximum number of branches per plant (1.80, 2.40, 3.20, 4.60 and 5.00, respectively) and maximum number of leaves per plant (8.00, 12.90, 17.93, 21.90 and 27.03, respectively) was recorded from T_1, whereas the shortest plant (8.19 cm, 22.03 cm, 28.23 cm, 43.03 cm and 47.20 cm, respectively), minimum number of branches per plant (0.60, 0.80, 0.84, 2.20 and 3.20, respectively) and minimum number of leaves per plant (5.87, 8.97, 11.57, 14.93, 17.60, respectively) was observed in T_6. At 20, 30, 40 and 50 DAS, the highest dry matter content per plant (8.95 g, 11.08 g, 15.39 g and 17.50 g, respectively) was recorded in T_1, whereas the lowest (6.23 g, 8.01 g, 10.41 g and 12.70 g, respectively) in T_6. At 20-30 DAS, the highest CGR (4.53 g $m^{-2}day^{-1}$) was recorded in T_8, while the lowest CGR (2.39 g $m^{-2}day^{-1}$) in T_{12}. At 30-40 DAS, the highest CGR (7.18 g $m^{-2}day^{-1}$) was recorded in T_1, whereas the lowest CGR

(3.80 g $m^{-2}day^{-1}$) in T_5. At 40-50 DAS, the highest CGR (4.92 g $m^{-2}day^{-1}$) was recorded in T_2, whereas the lowest CGR (2.89 g $m^{-2}day^{-1}$) in T_4. At 20-30 DAS, the highest RGR (0.031 g g^{-1} day^{-1}) was recorded in T_4, while the lowest RGR (0.016 g g^{-1} day^{-1}) in T_{12}. At 30-40 DAS, the highest RGR (0.33 g g^{-1} day^{-1}) was recorded in T_1, whereas the lowest RGR (0.020 g g^{-1} day^{-1}) in T_5. At 40-50 DAS, the highest RGR (0.021 g g^{-1} day^{-1}) was recorded in T_2, whereas the lowest RGR (0.013 g g^{-1} day^{-1}) in T_4.

The lowest days to 1st flowering (31.33), lowest days to 80% pod maturity (62.40), highest number of pods per plant (21.23), highest number of seeds per pod (9.40), longest pod (9.74 cm), highest weight of 1000-seed (38.34 g), highest seed yield (1.75 t ha^{-1}) and highest stover yield (2.37 t ha^{-1}) was recorded in T_1, whereas the highest days to 1st flowering 41.33), highest days to maturity (71.00), lowest number of pods per plant (13.14), lowest number of seeds per pods (5.73), shortest pod (5.79 cm), lowest weight of 1000-seed (35.41 g), lowest seed yield (1.11 t ha^{-1}) and lowest stover yield (1.36 t ha^{-1}) was found in T_6.

From the above findings it was revealed that all management practices was essential for the growth and yield of mungbean. And treatments T_1, T_2, T_5, T_8, T_{10} and T_{11} showed identical seed yield which was statistically higher than others. T_1 had all the management which incurs the highest cost. So, other treatments deserve to be adoptable compared to T_1. Again, the treatments T_2, T_5, T_8, T_{10} and T_{11} included broadcast, sowing, no irrigation, no fungicides, no insecticide and no seed treatment respectively and all are cost reducing treatments. However, rejection of these treatments depends on the status of seed quality and soil moisture and pest-incidence which were seemed to be favorable in this study.

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APPENDICES

Appendix I. Analysis of variance of the data on plant height of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		20 DAS	30 DAS	40 DAS	50 DAS	Harvest
Replication	2	1.153	0.153	2.203	0.817	5.374
Treatment	11	8.420**	9.412**	38.620**	41.888**	11.030*
Error	22	1.661	1.327	7.204	10.622	4.203

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

Appendix II. Analysis of variance of the data on number of branches per plant of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square				
		Number of branches per plant				
		20 DAS	30 DAS	40 DAS	50 DAS	Harvest
Replication	2	0.003	0.021	0.016	1.422	0.722
Treatment	11	0.823**	0.102*	0.788*	8.814**	5.572*
Error	22	0.010	0.055	0.154	1.403	1.656

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

Appendix III. Analysis of variance of the data on number of leaves per plant of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square				
		Number of leaves per plant				
		20 DAS	30 DAS	40 DAS	50 DAS	Harvest
Replication	2	0.005	0.035	0.058	0.478	0.130
Treatment	11	0.168*	0.997**	11.308**	3.534**	5.219*
Error	22	0.050	0.144	0.979	0.625	1.859

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

Appendix IV. Analysis of variance of the data on dry matter content of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square			
		Dry matter content in plant (g) at			
		20 DAS	30 DAS	40 DAS	50 DAS
Replication	2	0.390	0.524	0.556	0.956
Treatment	11	1.348*	2.421**	3.263**	3.055*
Error	22	0.466	0.459	0.877	1.029

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

Appendix V. Analysis of variance of the data on crop growth rate (CGR) of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Crop Growth Rate (CGR) at		
		20-30 DAS	30-40 DAS	40-50 DAS
Replication	2	0.620	0.436	2.680
Treatment	11	1.933	1.258	0.925
Error	22	1.208	1.580	2.895

Appendix VI. Analysis of variance of the data on relative growth rate (RGR) of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square		
		Relative Growth Rate (RGR) at		
		20-30 DAS	30-40 DAS	40-50 DAS
Replication	2	0.0001	0.0001	0.0001
Treatment	11	0.0001	0.0001	0.0001
Error	22	0.0001	0.0001	0.0001

Appendix VII. Analysis of variance of the data on yield contributing characters of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square			
		Days to 1st flowering	Days to 80% pod maturity	Number of pods per plant	Number of seeds/pod
Replication	2	0.857	2.167	2.779	3.624
Treatment	11	20.413**	19.095**	16.064*	9.50**
Error	22	2.883	6.141	7.928	1.714

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

Appendix VIII. Analysis of variance of the data on yield contributing characters and yield of mungbean as influenced by different management practices

Source of variation	Degrees of freedom	Mean square			
		Pod length (cm)	Weight of 1000-seed (g)	Seed yield (t/ha)	Stover yield (t/ha)
Replication	2	0.004	2.507	0.001	0.009
Treatment	11	0.647**	4.910*	0.198**	0.395**
Error	22	0.066	1.827	0.033	0.058

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