EFFECT OF MANURES AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF TWO SELECTED MUNGBEAN VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF MANURES AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF TWO SELECTED MUNGBEAN VARIETIES"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY**, embodies the result of a piece of *bona fide* research work carried out by, Registration No. **09-03684** 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 been duly acknowledged.

Dated:
Dhaka, Bangladesh

Professor Dr. Md. Shahidul Islam
Supervisor

Dedicated To

My Beloved Parents

&

Md. Shafiqul Islam Uncle

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ABSTRACT

The experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to June 2015 (kharif-I season) to find out the effect of different manures and inorganic fertilizers on growth and yield of two selected mungbean varieties. The experiment consisted of two factors: factor A: five levels of manures and inorganic fertilizers;[T_0 = Control (no fertilizer or manure) T_1 = Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2 = Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3 = Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4 = Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] and factor B: two mungbean varieties; (V_1 = BARI Mung 5 and V_2 = BARI Mung 6). The experiment was laid out in split plot design with three replications. In case of manures and fertilizers, the maximum grain yield (1.53 t ha^{-1}) and maximum stover yield (1.88 t ha^{-1}) was recorded from T_4 treatment and minimum was from control treatment. In case of variety the maximum grain yield (1.58 t ha^{-1}) and minimum stover yield (1.45 t ha^{-1}) was obtained from V_2 (BARI Mung 6) variety on the other hand the minimum grain yield (1.29 t ha^{-1}) and maximum stover yield (1.91 t ha^{-1}) was obtained from V_1 (BARI Mung 5) variety. In case of combined effect the maximum grain yield (2.01 t ha^{-1}) and maximum stover yield (2.61t ha^{-1}) was recorded from T_4V_2 and minimum from T_0V_1. So, BARI Mung 6 performed the best result with the application of vermicompost @ 2.5 t ha^{-1} with recommended dose of fertilizer.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
SPD	Split Plot Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DMRT	Duncan`s Multiple Range Test
DAS	Days After Sowing
LSD	Least significance difference
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization

ABBREVIATIONS	ELABORATIONS
Fig	Figure
J.	Journal
PP.	Pages
g	Gram
ha^{-1}	Per hectare
t	Ton
%	Percentage
m^2	Square meter
kg	Kilogram
No.	Number
NOS	Number of species
^0C	Degree Celsius
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Sciences
HI	Harvest Index
Vol.	Volume

CHAPTER I

INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is an important short duration, drought tolerant pulse crop which also commonly known as “green gram”. Its seed contains 24.7% protein, 0.6% fat, 0.9% fiber and 3.7% ash (Potter and Hotchkiss, 1997) as well as sufficient quantity of calcium, phosphorus (P) and important vitamins. Due to its supply of cheaper protein source, it is designated as “poor man’s meat”. It has an edge over other pulses because of its high nutritive value, digestibility and non-flatulent behavior.

Bangladesh is an agro-based country where many crops are grown. Among them, pulses constitute the main sources of vegetable protein for people, especially the poor people of Bangladesh. In Bangladesh, the daily per capita consumption of pulses is only 13.29g, whereas World Health Organization has suggested 45g per capita per day for a balanced diet. Approximately, 1,08,000 tons of pulses are imported in Bangladesh each year. But to meet the suggested requirement of pulses of 45g per capita per day, the productions to be increased even more than three folds.

In Bangladesh, more than 75% of the total cropping area is occupied by rice where pulse crop covers only 2.8% of the total cropping area (BBS, 2005). Among the pulse crops the largest area is covered by lentil (40.17%) and mungbean is grown in only 6.34% area (BBS, 2005). The cultivation of mungbean in Bangladesh is tends to increase and it covers 54, 57, 68,74,75 and 81 thousand acres respectively in the 2008-09, 2009-10, 2010-11,2011-12,2012-13 and 2013-14 fiscal years (BBS, 2014). So mungbean can be a good solution for the increasing need of plant protein.

Average yield of mungbean in Bangladesh is very low, which is primarily due to substandard methods of cultivation, poor crop stand, imbalanced nutrition, poor plant protection measures and lack of high yielding varieties. The low yield of mungbean besides other factors may partially be due to lack of knowledge about nutrition and modern production technology (Hassan, 1997). Moreover, lack of attention on fertilizer use is also instrumental in lowering mungbean yields (Mansoor, 2007).

An improved variety is the first and foremost requirement for initiation and accelerated production program of any crop. Variety plays an important role in producing high yield of mungbean because different varieties responded differently for their genotypic characters. The possibilities of growing mungbean in summer are being experimented and some successes have already been made in Bangladesh. Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) developed 17 mungbean varieties with yield potentials in recent years. Very recently, with the introduction of some high yielding varieties like BARI Mung-6, BARI Mung-5 increasing attention is being paid to the cultivation of this crop in order to mitigate the alarmingly protein shortage in the diet of our people.

Mungbean is highly responsive to fertilizers and manures. It has a marked response to nitrogen (N), phosphorus (P) and potassium (K). These nutrients play a key role in plant physiological process. A balanced supply of essential nutrients is indispensable for optimum plant growth. Continuous use of large amount of N, P and K are expected to influence not only the availability of other nutrients to plants because of possible interaction between them but also the build up of some of the nutrients creating imbalances in soils and plants leading to decrease fertilizer use efficiency (Nayyar and Chhibbam,1992).

Cowdung is an age-old source of fertilizer. It provides all the necessary macronutrients and many micronutrients with increasing organic matter. Cowdung has relatively less N than some other manures, so it can be added directly to the soil without damaging plants. Fresh cowdung contains about the same ratio of N, P and K as a balanced commercial fertilizer but in much smaller quantities. One has to use 10 times as much as fresh manure commercial fertilizer to get the same amount of these macronutrients.

Poultry manure is an excellent source of organic fertilizer which is rich in micro and macronutrients. The recycling of poultry manure needs to be done in a manner that will not only improve soil physical, chemical and biological properties but also minimize environmental risks. Poultry farming is now getting popular in our country and its wastes are disposed here and there. So there is much scope to use poultry manure for crop cultivation. Poultry manure is a good source of organic matter and may play a vital role to improve soil fertility as well as supply micro and macronutrients for crop production. It has high content of N. Proper management of it may reduce the need for chemical fertilizer, allowing the small farmers to reduce cost of the production. Poultry manure improve nutrient status in soil and at the same time may reduce soil pollution ,which developed from the continuous use of chemical fertilizer.

Vermicompost is the product or process of composting using various worms, usually it is a heterogeneous mixture of decomposing vegetable or food waste, bedding materials etc. Vermicomposting is the processing of organic wastes with earthworms. During this process, elements like N, P, K, and Ca present in the waste are released and converted, through microbial activity, into forms more soluble and available to plants than those present in the original waste (Edwards and Burrows, 1988). Application of vermicompost might increase the availability of N, P and K to plant. This might also be due to improved nutritional environment in the rhizosphere as well as its utilization in the plant system leading to enhanced translocation to reproductive structures viz., pods, seeds and other plant parts. It was reported from an experiment that, showed the application of vermicompost had significant positive effects on growth performances and yield of plant as compare to control (Niranjan *et al.*, 2010).

Phosphorus plays a remarkable role in plant physiological processes. It is an essential constituent of majority of enzymes which are of great importance in the transformation of energy in carbohydrate metabolism in different types of plants and is closely related in cell division and seed development. Phosphorus is a key constituent of ATP and it plays a significant role in the energy transformation in plants and also in various physiological processes (Sivasankar *et al.,* 1982). It is also essential for energy storage and release in living cells. Phosphorus shortage restricted the plant growth and remains immature (Hossain, 1990). It influences nutrient uptake by promoting root growth and nodulation (Singh *et al*., 1999). Phosphorus enhances the uptake of N in the crop, which increases protein content of mungbean (Soni and Gupta, 1999).

Potassium, as a plant nutrient, is becoming increasingly important in Bangladesh and a good crop response to K is being reported from many parts of the country. Pulse crops showed yield benefits from K application. Improved K supply also enhances biological N fixation and protein content of pulse seed (Srinivasarao *et al*., 2003). The supply of P and K to leguminous crops is necessary especially at the flowering and pod setting stages (Zahran *et al.*, 1998). 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 (Tisdale *et al.*, 1990; Bukhsh *et al*., 2011).

Considering the above facts, the present investigation has been undertaken with the following objectives:

- To find out the optimum doses of manures and inorganic fertilizers for maximizing the growth and yield of two selected mungbean varieties and
- To study the combined effect of variety and manures and inorganic fertilizers on growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

Many research works on mungbean have been performed extensively in several countries especially in the South East Asian countries for its improvement of yield and quality. In Bangladesh, little attention has so far been given for the improvement of mungbean variety or its cultural management. Currently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started extensive research work on varietal development and improvement of this crop. Findings of various experiments related to the present study in home and abroad have been reviewed and discussed in this chapter.

2.1 Effect of variety of mungbean

Ali *et al*. (2005) carried out an experiment at BARI, Joydebpur, Gazipur to find out the response of inoculation with different plant genotypes of mungbean. Three varieties of mungbean viz. BARI mung-1, BARI mung-2, BARI mung-3 and Rhizobial inoculums (BARI Rvr 405) were used in this experiment. Irrespective of *Rhizobium* inoculum, BARI mung-1 gave the highest yield as well as dry matter production.

Solaiman *et al.* (2003) studied on the response of mungbean cultivars BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, BARI mung-6, BINA moog-2 and BU mung-1 to *Rhizobium sp.* strains TAL 169 and TAL 441. Irrespective of *Rhizobium* inoculam, they found significant difference in yield and yield contributing characters and dry matter production due to variety.

Bhuiyan *et al.* (2004) conducted a field experiment at Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, to study the response of inoculation with different plant genotypes. Four varieties of mungbean viz. BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, and Rhizobial inoculum (*Bradyrhizobium* strain RVr-441) were used in this experiment. They also found difference in performance due to variety.

Ali *et al*. (2004) conducted an experiment with mungbean varieties at BARI, Joydebpur, Gazipur. Each variety was tested with and without inoculation. Among three varieties, BARI mung-1 produced the highest yield (1.35t ha^{-1}).

2.2 Effect of manures and inorganic fertilizers

2.2.1 Effect of manures

A field experiment was conducted by Raundal and Sabale (2000) during 1997-98 in Maharashtra, in India showed that application of vermicompost to mungbean gave highest N content and protein in seed.

Karmegam and Daniel (2000) reported that application of vermicompost resulted in significant increase in growth and yield of cowpea.

A field trial was conducted by Reddy *et al.* (1998) during kharif season of 1997-98 showed that application of 60 kg P_2O_5 ha^{-1} through phospho-vermicompost significantly increased the growth, dry matter and yield of pea.

An experiment was carried out by Bhuiyan *et al.* (2004) at the Bangladesh Agricultural University (BAU) Farm, Mymensingh from *rabi* season of 1999 to *kharif-II* season of 2002 in the Old Brahmaputra Floodplain Soils (AEZ 9) of Bangladesh to investigate the effect of integrated use of manures and inorganic fertilizers on yield and nutrient uptake of T. Aus rice and mungbean in the Wheat-T. Aus/ Mungbean-T. Aman cropping pattern. The results showed that application of organic manure along with chemical fertilizers resulted in markedly higher uptake of nutrients. The application of NPKS (HYG) fertilizers remarkably increased the crop yield. The lowest seed yield and the lowest nutrient uptake were noted in control plots receiving no fertilizer or manure.

A field experiment was conducted by Shukla and Tyagi (2009) during 2004–07 in summer season to ascertain the effect of 2 organic inputs, viz enriched compost and vermicompost applied @ 2t ha^{-1}, on selected soil parameters for soil health, growth and nodulation of ‘Pusa Ratna’ mungbean [*V. radiata* (L.) Wilczek]. The beneficial effects were compared not only to soils but also the growth of the crop without organic inputs. Organic matters, like vermicompost and enriched compost enhanced soil physical properties and plant nutrients (N, P and K) at the time of crop establishment and early growth. Incorporation of vermicompost and enriched compost before sowing had a greater beneficial impact, especially on physical properties of soil. The added organic materials, like vermicompost and enriched compost increased germination growth of shoots, roots and enhanced nodulation, the slightly greater benefits were derived with vermicompost as compared to enriched compost. The selected microorganisms used were *Rhizobium*, a symbiotic N fixer and phosphate-solubilizing bacteria which helps in solubilization of fixed P.

A field experiment was conducted by Giraddi, (2001) and Giraddi *et al.*, (2006). They reported that, vermicomposting is a process of recycling of organic wastes in an environmentally safe method. Vermicompost is a mixture of worm casts, which is rich source of micro and macronutrients. The worm casts apart from increasing the density of microbes also provide the required nutrients to plants. It contains plant growth promoting substances such as NAA, cytokinins, gibberellins, etc. It also increases the efficacy of added fertilizers in the soil. On an average, vermicompost contains 0.80 to 1.10% N, 0.40 to 0.80% P_2O_5 and 0.80 to 0.98% K_2O while 10 to 52 ppm Cu, 186.60 ppm Zn and 930.00 ppm Fe.

A field experiment was conducted by Kumar *et al.* (2002) during 2001-02 on the sandy loam soil of Haryana, India to investigate the effect of *Rhizobium* sp. seed inoculation, FYM (farmyard manure) at 5 t ha^{-1}, vermicompost at 2.5 and 5 t ha^{-1}, and 4 levels of fertilizers (control, no chemical fertilizer; 75% recommended dose of fertilizer, RDF; 100% RDF. N:P at 20:40 kg ha^{-1}; and

125% RDF) on the performance of mungbean cv. Asha. *Rhizobium* sp. inoculation significantly increased the seed yield. Increasing RDF levels up to 100% also increased seed yield. Vermicompost at 5 t ha^{-1} produced 16.5 and 9.5% higher seed yield compared to FYM at 5 t ha^{-1} and vermicompost at 2.5 t ha^{-1}, respectively, in 2002. However, the organic amendment did not affect the seed pod^{-1} in 2001 and the 1000- seed weight in both years. The interaction of the different treatments was significant in 2002. Vermicompost application at both levels resulted in higher yield compared to FYM. Yield increased with increasing fertilizer rate up to 125% RDF, when applied with FYM, but yield was higher under the treatment 100% RDF + vermicompost (both rates).

Chinnamuthu and Venkatakrishnan (2001) reported that the application of vermicompost @ 2 t ha^{-1} recorded significantly higher plant height (147.80 cm) and 100 seed weight (4.14 g) compared to application of FYM @ 5 t ha^{-1} (140.80 cm and 4.06 g, respectively) to sunflower.

Govindan and Thirumurugan (2005) observed that the application of vermicompost (75%) had significantly recorded higher plant height (84.70 cm), leaf area index (3.40) over press mud (100% N) (78.20 cm and 2.70, respectively) in soybean.

Aruna and Narsa (1999) reported that the application of vermicompost @ 15 t ha^{-1} to soybean recorded significantly higher number of pods $plant^{-1}$(59.00), 100 seed weight (15.80 g), seed yield (1143 kg ha^{-1}), seed protein content (41.80 %) and seed oil content (24.30%) over the application of FYM @ 5 t ha^{-1} + 50 kg N ha^{-1} (29.70, 13.9 g, 782 kg ha^{-1}, 38.70% and 23.00%, respectively).

2.2.2 Effect of inorganic fertilizers on growth and yield of mungbean

2.2.2.1 Effect of nitrogen (N) on growth and yield of mungbean

Azadi *et al.* (2013) observed that different N levels influenced different growth and yield attributes of mungbean such as plant height, seed yield, stem diameter, number of node and 75 kg N ha^{-1} showed higher values than the other N doses (50, 100 and 150 kg N ha^{-1}).

Achakzai *et al.* (2012) found that different N levels influenced most of the growth attributes of the mungbean. Maximum days to flowering, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, plant height, number of branches $plant^{-1}$, leaf area, and seed yield recorded for plants subjected to highest dose of applied N fertilizer at 100 kg ha^{-1}.

Sultana *et al.* (2009) reported that application of 20 kg N ha^{-1} as basal dose and 20 kg N $ha^{-1}$with one weeding at vegetative stage showed significantly higher values of all growth parameters like leaf area, shoot dry weight, number of branches, pods $plant^{-1}$ and seed yield.

Sultana (2006) noticed that plant height of mungbean showed superiority at 30 kg N ha^{-1} followed by 40 kg N ha^{-1}. N fertilizer significantly influenced plant height at all growth stages of mungbean. At 20, 35, 50, 65 DAS and harvest the maximum heights were observed in the plants treated with 30 kg N ha^{-1}.

Ghosh (2004) used different levels of N and indicated that number of branches $plant^{-1}$ of mungbean was gradually increased with increasing N level at 25 kg N $ha^{-1.}$

Masud (2003) observed that highest plant height of mungbean with the application of 30 kg N ha^{-1} while Ghosh (2004) at 25 kg N ha^{-1}.

Rudreshappa and Halikatti (2002) explained the effect of N levels (0, 12.5 and 25 kg) on growth, yield and nutrient uptake of green gram in paddy fallows. Application of 12.5 kg N ha^{-1} was recorded to produce significantly higher seed yield. Further increase in N doses (25 kg ha $^{-1}$) did not significantly increase the yield.

Srinivas *et al.* (2002) examined the effects of N (0, 20, 40 and 60 Kg ha^{-1}) and P_20_5, 50 and 75 Kg ha^{-1}) along with seed inoculation with *Rhizobium* culture on the growth, yield and yield components of mungbean. They observed that number of pods $plant^{-1}$, pod length and seeds pod^{-1} were increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} and also observed that 1000 seed weight in greengram.

Tank *et al.* (1992) found that mungbean fertilized with 20 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} produced significantly higher number of pods $plant^{-1}$ over the unfertilized control.

Pathak *et al*. (2001) evaluated the effect of N levels (0, 10, 20 and 30 kg ha^{-1}) on growth and yield of mungbean under rainfed condition during the summer of 1999 and found that application of 20 kg N ha^{-1} yielded poorer than 30 kg N ha^{-1}. N nitrogen on mungbean cv. Mubarik. In both pot and field trials he showed 10 kg N ha^{-1} increased the number of pods $plant^{-1}$.

Mandal and Sikdar (1999) laid out a greenhouse pot experiment where mungbean (BARI Mung-5) grown on saline soil and given 0, 50 or 100 kg N ha^{-1} and 0, 75 or 150 kg P ha^{-1}. Growth and yield increased significantly with N application while P significantly increased the setting of pods and seeds. Root growth was significantly improved by both individual and combined application of these two fertilizers.

Mozumder (1998) studied the effect of five N levels (0, 20, 40, 60 and 80 kg N ha $^{-1}$) and two varieties of summer mungbean, BINA Mung-2 and Kanti, found that N exerted negative effect on the harvest index.

In an experiment with the foliar application of nutrients on the growth and yield of mungbean cv. Kowmy-1, Abd-El-Latif *et al.* (1998) revealed that application of urea increase the number of branches plant^{-1} on mungbean plant.

Provorov *et al*. (1998) observed the effect of seed inoculation of mungbean with strain CIAMI 901 of *Bradyrhizobium* and found that the seed yield was increased by 39.2% and 1000 seed weight 16%. These results were equivalent to applying 120 kg N ha^{-1}. Best results obtained with inoculations + 60 kg N ha^{-1}.

Satyanarayanamma *et al.* (1996) in a field experiment found that spraying of 2% urea at flowering and pod development stage produced the highest seed yield (1.59 t ha^{-1}) over the control.

Kaneria and Patel (1995) reported that the application of 10 kg N ha^{-1} to mungbean significantly increased seed yield attributes.

Quah and Jafar (1994) noted that plant height of mungbean was significantly increased by the application of N fertilizer with 50 kg ha^{-1} and also noted that 1000 seed weight of mungbean increased significantly by the application of N at 50 kg ha^{-1}.

Gopala *et al.* (1993) found that the response of mungbean cultivars (Pusa Baishakhi, LGG 407, LGG 410 and MS 267) to a uniform dose of 20 kg N ha^{-1} and found that plant height, net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR) were increased at 20 kg N ha^{-1}.

Tank *et al.* (1992) observed that mungbean fertilized with 40 kg N ha^{-1} produced the highest seed yield plant^{-1} while the lowest was observed in control treatment (0 kg N ha^{-1}).

Sarkar and Banik (1991) revealed that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in yield attributes. They found that the stover yield of mungbean increased significantly due to use of N up to 10 kg N

ha^{-1}. On an average, the stover yield increased by 24% due to the application 10 kg N ha^{-1} over no N. they also observed that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in number of pods $plant^{-1}$ over no N.

Agbenin *et al.* (1991) revealed that application of N significantly increased plant height, seed yield, dry weight, crop growth rate and nutrient uptake of mungbean over control.

Leelavathi *et al.* (1991) reported that different levels of N showed significant difference in seed yield of mungbean up to a certain level.

Samiullah *et al.* (1987) recorded that number of seeds pod^{-1} were the highest with 10 kg N + 75 kg P_2O_5 + 60 kg K_2O in summer mungbean.

Patel and Parmer (1986) observed that increasing N application to rainfed mungbean (*V. radiata* cv. Gujrat-1) from 0-45 kg ha^{-1} increase average seed yield from 0.83 to 0.94 t ha^{-1} and also increased protein content, plant height, number of branches $plant^{-1}$, pods $plant^{-1}$, seeds $plant^{-1}$ and 1000 seed weight.

Patel *et al.* (1993) studied that, in summer season on clayey soil application of 0, 10, 20 and 30 kg N ha^{-1} significantly increased the number of pods $plant^{-1}$.

2.2.2.2 Effect of phosphorus on growth and yield of mungbean

Malik *et al.* (2003) conducted a field experiment in Faisalabad, Pakistan in 2000 and 2001 to evaluate the interactive effects of irrigation and P on green gram *(V. radiata,* cv. NM-54). Five P doses (0, 20, 40, 60 and 80 kg *P* ha^{-1}) were arranged in a split plot design with four replications. Phosphorus application at 40 kg P_2O_5 ha^{-1} affected the crop positively, while below and above this rate resulted in no significant effects. Interactive effects of two irrigations and 40 kg P_2O_5 ha^{-1} were the most effective. The rest of the combinations remained statistically non-significant to each other. It may be concluded that greengram can be successfully grown with P at 40 kg P_2O_5 ha^{-1}.

Tickoo *et al.* (2006) carried out an experiment on mungbean and cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30.0 m spacing and was supplied with 36-46 and 58-46 kg of N and P ha^{-1} in a field experiment conducted in New Delhi. India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and seed yield (3.66 and 1.63 t ha^{-1}) respectively compared to cv. Pusa 105.Nitrogen and P rates had no significant effects on both the biological and seed yield of the crop. Row spacing at 22.5cm resulted in higher seed yields in both the cultivars.

A field experiment was conducted by Raman and Venkataramana (2006) during February to May 2002 in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram *(V. radiata).* There were 10 foliar spray treatments, consisting of water spray. 2% diammonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + Zn chelate, DAP + Penshibao + NAA, and DAP + NAA + Zn chelate. Crop nutrient uptake, yield and its attributes (number of pods/plant and number of seeds/pod) of greengram augmented significantly due to foliar nutrition. The foliar application of DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N, P and K uptakes, yield attributes and yield. The highest seed yield of 1529 kg ha^{-1} was recorded with this treatment.

A field experiment was conducted by Vikrant (2005) on a sandy loam soil in Hisar, Haryana India during kharif 2000-01 and 2001-02 to study the effects of P (0, 20, 40 and 60 kg $P_2O_5ha^{-1}$) applications to green gram cv. Asha. Application of 60 kg P, being at par with 40 kg P, was significantly superior to 0 and 20 kg ha^{-1} in respect of seed, stover and protein yields of green gram.

Manpreet *et al.* (2005) conducted a field experiment to assess the response of different mungbean genotypes in terms of nutrient uptake and quality to incremental levels of P application. Genotypes showed significant differences for straw and grain N content and grain P content while straw P content, N and P uptake differed non-significantly. Phosphorus application resulted in significant increase in N and P content and their uptake.

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 affected the crop parameters. The 10-30-30 kg NPK ha^{-1} the best treatment, recording plant height of 56.3. germination of 90.5%. satisfactory plant population of 162.0, prolonged days taken to maturity of 55.5. long pods of 5.02 corn, seed weight of 10.5 g, seed index of 3.5 g and the highest seed yield of 1205.2 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

A field experiment was conducted by Edwin *et al.* (2005) during 1995 and 1996 pre-kharif seasons in Imphal, Manipur, India to study the effect of sources viz. Single superphosphate (SSP), diammonium phosphate (DAP), mussoorie rock phosphate (MRP), phosphate solubilizing organism (PSO) and farmyard manure and levels of P (10, 15, 30 and 60 kg P_2O_5 ha^{-1}) on the growth and yield of greengram cv. AAU-34. The highest number of branches/plant(3.23) was obtained with 30 kg MRP + 30 kg SSP ha^{-1}. Single super phosphate at 60 kg ha^{-1} gave the highest number of clusters/plant(4.36). Pod length (7.34 cm), seeds/pod (10.5) 1000-seed weight (34.9 g) and seed yield (15.1 q ha^{-1}). Maximum plant height (31.2 cm), dry matter/plant (36.1 g) and number of pods/plant(l 7.4) was obtained with 60 kg DAP ha^{-1}.

Khan *et al.* (2004) conducted a study to determine the effect of different levels of P on the yield components of mungbean cv. NM-98 in D.I. Khan. Pakistan in 2000. Treatments comprised: 0, 20, 40, 60, 80, and 100 kg P ha^{-1}. The increase in P levels decreased the days to flowering and increased the branches/plant, number of pods/ plant, 1000-grain weight and grain yield. The highest yield of 1022 kg ha^{-1} was obtained at the phosphorus level of 100 kg ha^{-1} compared to a 774 kg ha^{-1} yield in the control. However, the most economical P level was 40 kg ha^{-1}, because it produced a grain yield statistically comparable to 100 kg P ha^{-1}.

A field experiment was conducted by Manpreet *et al.* (2004) in Ludhiana. Punjab. India during summer 2000 to investigate the response of mungbean genotypes (SML 1 34. SML 357 and SML 668) to P application (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) under irrigated conditions. Yield attributes such as number of branches/plant and pods/plant were significantly higher in SML 357 and SML 134. whereas pod length and 100-seed weight were higher in SML 668. which accounted for higher grain yield in this cultivar compared to SML 134 but was at par with SML 357. The straw yield showed the reverse trend with significantly higher value for SML 1 34, thus lowering the harvest index significantly compared to SML 668 and SML 357. Phosphorus application showed a non-significant effect on number of branches/plant, number of seeds/pod, pod length and 100-seed weight. However, the increase in P level showed significant increase in the number of pods $plant^{-1}$, which accounted for significantly higher grain and straw yields at higher levels (40 and 60 kg ha^{-1}) compared to lower levels (0 and 20 kg ha^{-1}). Harvest index remained unaffected with P application. The economic optimum P level for all the 3 summer mungbean genotypes was found to be 46.1 kg P_2O_5 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 yield and the maximum seed yield was obtained when 30 kg N ha^{-1} was applied along with 60 kg P_2O_5 ha^{-1}.

Asif *et al* (2003) conducted a field trial to find out the influence of P fertilizer on growth and yield of mungbean in India. They found that various levels of P significantly affected the number of leaves $plant^{-1}$, number of pods $plant^{-1}$, plant height, number of grain pod^{-1} and 1000 grain weight. Phosphorus level of 35 kg ha^{-1} produced the maximum grain yield.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of N (0, 25, and 50 kg ha^{-1}) and P (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/plant was found to be significantly higher by 25 kg N ha^{-1}. Number of seeds/pod was significantly affected by varying levels of N and P. Growth and yieldcomponents were significantly affected by varyinglevels of nitrogen andphosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1}resulted with maximum seed yield (1.1 t ha^{-1}).

Satish *et al.* (2003) conducted an experiment in Haryana, India in 1999 and 2000 to investigate the response of mungbean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels (0, 20, 40 and 60 kg P_2O_5 ha^{-1}). Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P ha^{-1}. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851. Phosphorus at 40 and 60 kg ha^{-1} increased the number of pods/plant grain yield and grains per pod over the control and P at 20 kg ha^{-1}. The number of branches plant^{-1} increased with increasing P rates.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different N 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 N kg ha^{-1}, P kg ha^{-1}, K kg ha^{-1} application. Again they revealed that seed inoculation with 50-50-0 kg N ha^{-1}, K kg ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of N and P. 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/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} along with increasing rates of P which was then followed by a decrease with further increase in N.

Yadav and Rathore (2002) carried out a field trial to find out the effect of P and iron fertilizer on yield, protein content and nutrient uptake in mungbean on loamy sandy soil in India. The results indicated that the seed and stover yield increased with the increasing P levels but significantly increased up to 60 kg $P_2O_5ha^{-1}$.

Umar *et al.* (2001) observed that plant height and numbers of branches $plant^{-1}$ were significantly increased by P application. Number of pods $plant^{-1}$, number of seeds per pod, 1000-seed weight and grain yields were also increased significantly by application of P along with N.

Teotia *et al.* (2001) conducted a greenhouse experiment to study the effect of P and S interaction on yield and nutrient composition of mungbean cv. *Pant Moong-2* and revealed that P and S applied individually or in combination increased the N and K content of the grain and straw and the yield of the plant.

Two field experiments were conducted in Kalubia Governorate. Egypt, in 1999 and 2000 summer seasons by Ahmed (2001) to investigate the effects of P levels (0, 15. 30 and 45 kg ha^{-1}) on the growth, yield and yield components as well as chemical composition of mungbean cv. Kawmy-1. Growth, yield and yield components of mungbean were markedly improved with the addition of 45 kg P ha^{-1}. Addition of 45 kg P ha^{-1} markedly increased total carbohydrates and protein percentages compared with other treatments. Application of 45 kg

P ha^{-1} markedly increased the number of pods $plant^{-1}$. Addition of 30 kg P ha^{-1} was the recommended treatments to obtain the best results for growth, yield and yield components as well as chemical composition of mungbean.

Prasad *et al.* (2000) conducted a pot experiment to study the effect of K on yield K-uptake by summer mungbean (cv. T-44) and showed that the grain yield increased K application but result was statistically non-significant. Increasing K levels significantly increased K uptake. Available K in soil after K harvest of crop increased with increasing levels of K.

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 t $ha^{-1}$with farmers practices, while the highest yield was obtained by the fertilizer application (0.77 t ha^{-1}).

Mastan *et al.* (1999) stated that the number of pods $plants^{-1}$ of summer mungbean cv. LOG 127 increased with increasing P rates.

Mitra *et al.* (1999) reported that mungbean grown in acid soils of Tripura, The maximum number of pods/plants were recorded with application of 50 kg P_2O_5 ha^{-1}.

Raundal *et al.* (1999) also reported that application of phosphorus 60 kg ha^{-1} to mungbean grown in Kharif season significantly increase the dry matter yield.

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 with the application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Singh and Ahlawat (1998) reported that application of P to mungbean cv. PS 16 increased the number of branches $plant^{-1}$ up to 12.9 kg ha^{-1} when grown in a sandy loam soil, low in organic carbon and N, and medium in P and K and with a pH of 7.8.

Ramamoorthy and Raj (1997) obtained 517 kg ha^{-1} seed yield of rainfed green gram without applied P and the highest (1044 kg) with 25 kg P_2O_5 ha^{-1}.

Sharma and Singh (1997) carried out a field experiment during 1989 and 1990 to study the effect of various levels of P (0, 25, 50 and 75 kg ha^{-1}) on the growth and yield of mungbean. Results of their study revealed that application of P at 30 kg ha^{-1} enhanced the plant height significantly.

Thakur *et al.* (1996) conducted an experiment with greengram *(Vigna radiata)* grown in kharif [monsoon] 1995 at Akola, Maharashtra, India which was given 0. 25. 50 or 75 kg P_2O_5 ha^{-1} as single superphosphate or diammonium phosphate. Seed and straw yields were not significantly affected by P source, and seed yield averaged 0.91, 1.00, 1.24 and 1.13 t ha^{-1}, respectively. Phosphorus uptake was also highest with 50.

Shukla and Dixit (1996) conducted a field trial to study the response of mungbean to different levels of P. They also reported that application of P up to 50 kg P_2O_5 ha^{-1} significantly increased the vigour of the plants resulted in more dry matter production.

Bayan and Saharia (1996) carried out an experiment to study the effect of P on mungbean during the kharif seasons of 1994-95 in Bishanath Chariali Assam, India. The results indicated that plant height was unaffected by P application.

Rajkhowa *et al.* (1992) reported that application of P at 0- 60 kg P_2O_5 ha^{-1} increased seed yield of mungbean. However, the increase was significant up to 20 kg P_2O_5 ha^{-1} application.

Satter and Ahmed (1992) reported that P application up to 60 kg P_2O_5 ha^{-1} on mungbean progressively and significantly increased nodulation, shoot length and weight, grain yield and total protein content.

Singh and Chaudhary (1992) conducted a field experiment with green gram and observed that P had beneficial effect on branches $plant^{-1}$, yield attributes and yield. Application of 30 kg P_2O_5 ha^{-1} recorded significantly higher values of these attributes than the control.

Sarkar and Banik (1991) conducted a field experiment and stated that increase in P_2O_5 up to 60 kg ha^{-1} progressively increased the number of nodules/plants of mungbean.

Solaiman *et al*, (1991) found that higher dose of P decrease the grain and other parameters. Phosphorus application at the rate of 60kg P_2O_5 ha^{-1} significantly increased nodule number, dry weight of plant tops and mungbean yield.

Patel and Patel (1991) observed that plant height of mungbean showed superiority at 60 kg P_2O_5 ha^{-1} followed by 40 kg P_2O_5 ha^{-1} application rate, growth on the soil which was sandy in texture, low in total N (0.04%), higher in available Phosphorus (77.33kg ha^{-1}) and rich in available K (388.15 kg ha^{-1}) with the pH 7.5. Thus plant height was found to be increased with increasing levels of phosphorus from 0 to 60 kg ha^{-1}.

Reddy *et al.* (1990) set up an experiment with three cultivars of mungbean in 1987, applying 0 or 50 kg P_2O_5 ha^{-1} as a basal dressing or 50 kg P_2O_5 ha^{-1} in two equal split dressing at the sowing and flowering stages. They found that application of P increased the dry matter accumulation in mungbean.

Thakuria and Saharia (1990) observed that P levels significantly influenced the grain yield of green gram. The highest plant height, pods $plant^{-1}$ and the grain yield were recorded with 20 kg P_2O_5 ha^{-1}, which was of equal value with 40 and 60 kg P_2O_5 ha^{-1}.

Kalita (1989) conducted an experiment with applying 30 kg P_2O_5 ha^{-1} to mungbean and observed that application of P increased the number of pods $plants^{-1}$. In another trial, Reddy *et al.* (1990) found similar result.

Arya and Kalra (1988) found that application of P had no effect on the growth of summer mung, while number of grains per pod, weight of 1000-seeds and grain yield were found to be increased with increasing level of P from zero to 50 kg P_2O_5 ha^{-1}. Phosphorus content was also found to be affected by application of P.

Ahmed *et al.* (1986) carried out an experiment with various levels of P on the growth and yield of mungbean. They noted that P application up to 60 kg ha^{-1} progressively and significantly enhanced the plant height. They also stated that P application significantly increased plant height, number of pods $plant^{-1}$, grain and straw yields and protein content of mungbean.

Samiullah *et al.* (1986) conducted a field experiment on summer mung to study the effect of four levels of P (0, 30, 45, 60 P_2O_5 ha^{-1}). They noted that 60 kg P_2O_5 ha^{-1} proved optimum for yield parameters such as length, 1000 seed weight, pod number, seed number and seed yield.

Patel *et al.* (1984) studied the effect of 0, 20, 40, 60 and 80 kg P_2O_5 ha^{-1} on growth and seed yield of summer mungbean. They said that 40 kg P_2O_5 ha^{-1} significantly increased the seed yield, number of pods $plant^{-1}$ and 1000-seed weight.

Rajput and Verma (1982) found the beneficial effect of P on grain yield, number of pods $plant^{-1}$ and seeds per pod of mungbean. The highest response was recorded with 50 kg P_2O_5 ha^{-1} in most of the characters.

Anwar *et al.* (1981) reported beneficial effect of P application on greengram in respect to number of pods $plant^{-1}$, number of seed $plant^{-1}$, weight of 1000 seeds at low doses of P but higher doses of P showed depressing effect. The maximum grain yield of 1446.6 kg ha^{-1} was recorded at 60 kg P_2O_5 ha^{-1} compared to only 886.6 kg ha^{-1} in control.

Sharma and Yadav (1976) conducted field experiment using 4 doses of P (0, 40, 80 and 120 kg P_2O_5 ha^{-1}).They reported that P application had a significant effect on grain yield of gram. They observed that yield increased up to a dose of 50 kg P_2O_5 ha^{-1}, but declined slightly when the doses were further increased. Straw yield was not significantly affected by P levels.

2.2.2.3 Effect of potassium on growth and yield of mungbean

Panda *et al.* (2003) conducted field experiments in West Bengal, India to evaluate the effects of N K application on the productivity of yambean (*Pachyrhizus erosus*)-pigeonpea (*Cajanus cajan*) intercropping system and its residual effect on the succeeding mungbean (*V. radiata*). Marketable tuber yield of yambean increased linearly with increasing NK levels, with the highest being recorded with NK at 80 kg ha^{-1} applied in 2 splits (22.9 t ha^{-1}) closely followed by 100 kg NK ha^{-1} applied in 2 splits (22.4 t ha^{-1}). For pigeonpea, the maximum grain (14.38 q ha^{-1}), stick (8.08 q ha^{-1}) and bhusa yield (9.96 q ha^{-1}) were recorded with 80 kg NK ha^{-1} applied in 2 splits. The highest level of NK (100 kg ha^{-1}) applied in 3 splits to yambean-pigeonpea intercropping system registered the maximum grain yield of the succeeding mungbean (9.43 q ha^{-1}), which was 33% higher than the untreated control.

Ashraf *et al*. (2003) conducted a field experiment at Faisalabad in Pakistan to observe the effects of seed inoculation of a biofertilizer and NPK application on the performance mungbean cv. NM-98. The treatments consisted of the seed inoculation of *Rhizobium phaseoli* singly or in combination with 20:50:0, 40:50:0 or 50:50:50 NPK kg ha^{-1} (urea), P (single super phosphate) and K (potassium sulphate) were applied during sowing. The tallest plants (69.9 cm) were obtained with seed inoculation + 50:50:0 kg NPK ha^{-1}. Seed inoculation + 50:50:0 or 50:50:50 kg ha^{-1} resulted in the highest number of pods $plant^{-1}$ (29.0, 56.0, 63.9 and 32.6, respectively) and seed yield (1,053, 1,066, 1,075 and 1,072 kg ha^{-1}). Harvest index was the highest with seed inoculation in combination with NPK and 40:50:0 (25.23), 50:50:0 (24.70) or 50:50:50 (27.5). Seed inoculation along with NPK at 30:50:0 kg ha^{-1} was optimum for the production of high seed yield by mungbean cv. NM-98.

Field studies was carried by out by Sangakkara *et al*. (2011) for testing the impact of fertilizer K on root development, seed yields, harvest indices, and N-use efficiencies of maize and mungbean, two popular smallholder crops over major and minor seasons. Application of 120 kg K ha^{-1} optimized all parameters of maize in the major wet season, whereas the requirement was 80 kg K ha^{-1} in the minor season. Optimal growth yields and N-use efficiencies of mungbean was with 80 kg K ha^{-1} in both seasons. Information regarding rates of fertilizer K that optimized N use and yield of maize and mungbean during each of the two tropical monsoonal seasons of South Asia is presented.

Potassium is one of the most required nutrients by all living organisms (Evans and Sorger, 1966). Potassium is absorbed as the K^+ cation in greater quantities than most other elements except N. While it is immobile in soils, K is very mobile once it has been taken up by the plant (Smith, 1996). The major role of K in plant growth and development is serving as an enzyme activator or cofactor for well over 60 enzymes (Blevins, 1985).

The role of K in photosynthesis is complex. The activation of enzymes by K and its involvement in adenosine triphosphate (ATP) production is important in regulating the rate of photosynthesis (Blevins, 1985; Troeh and Thompson., 1993). ATP, a high-energy molecule product from photosynthesis, is used as the energy source for many other chemical reactions in plant. When plants are K-deficient, the rate of photosynthesis and ATP production are reduced, and all of the processes dependent on ATP are slowed down. Conversely, plant respiration increases which also contributes to slower growth and development (Blevins, 1985; Troeh and Thompson., 1993).

In carbohydrate metabolism, K deficiency will result in the accumulation of reducing sugars (glucose and fructose) with decreases in complex carbohydrates, such as starch. The accumulation of reducing sugars is due to the decreased activity of particular K-activated enzymes, such as starch synthetase, that allow simple sugars to be converted into complex carbohydrates (Murata and Akazawa, 1969). Potassium is also important for all of the major steps involved in protein synthesis in plants (Blevins, 1985). These steps include transport of amino acids to the sites of protein production, enzyme activation, and neutralizing the charge of acidic amino acid residues to establish the proper hydration for optical conformation of enzymatically active forms of protein (Blevins, 1985).

Another major role of K is dealing with osmotic potential maintenance, water uptake, and stomatal aperture (Troeh and Thompson, 1993). As K moves into the guard cells around the stomata, water is also transferred into the cells, increasing turgor pressure and making cells swell. As a result, stomata become open and allow gases to move freely in and out. When water supply is short, K is pumped out of the guard cells causing the reverse action and the stomata are closed tightly to prevent loss of water. If K supply is inadequate, the stomata become slow to respond and closure is delayed. As a result, plants with an insufficient supply of K are much more susceptible to water stress (Armstrong, 1998; Arquero *et al.*, 2006).

Accumulation of K in plant roots produces a gradient of osmotic pressure that draws water into the roots. Therefore, plants deficient in K are less able to absorb water and are more subjected to stress when water is in short supply. High K helps increase crop tolerance to drought stress (Armstrong, 1998; Arquero *et al*., 2006; Martinez *et al*., 2003). More K permits the maintenance of turgor pressure as the plant's environment become drier. With sufficient K, plants can continue to photosynthesize, regulate water loss, and grow through dry periods.

Potassium is necessary for the uptake and translocation of various nutrients. Blevins *et al*. (1978) concluded that K has an important role as a counter ion for the uptake and translocation of nitrate ($NO3^-$) within the plant. On the other hand, enriched K soil may cause increased antagonism among nutrient cations competing for uptake and translocation. Classen and Wilcox (1974) found that increasing K levels decreased the Mg and Ca in the tissue of corn. Very high levels of K can result in Mg deficiency and eventually Ca deficiency (Jones *et al.*, 1991; Senclair, 1993). Potassium and P also interact. Hydroponically-grown wheat seedlings (*Triticum aestivum* L.) absorbed less K when the level of P in nutrient solution was increased (Reinbott and Blevins, 1991). However, P and K together have been found to have a synergistic effect on yield, generating an extra 15% positive yield interaction for soybeans and 50% for Coastal Bermuda-grass (Armstrong, 1998).

Potassium deficiency symptoms, such as thin cell walls, weakened stalks and stems, and accumulation of sugars and unused N in leaves, encourage disease infection (Tisdale *et al*, 1990; Armstrong, 1998). Each of these symptoms reduces plant resistance to infection by fungal, bacteria, and viral disease organisms.

In legume production, K is essential in every stage of growth. Potassium is needed to maintain favorable plant water status, regulate nutrient uptake, and encourage photosynthesis and plant growth (Reetz and Murrell, 1998). Nitrogen fixation by soybean and other legume plants relies on plant photosynthesis. Substantial amounts of photosynthate are required for N-fixing activity in mature nodules (Fujikake *et al.,* 2003). As K deficiency reduces the rate of photosynthesis, the photosynthate is limited and, thus, root nodule activities are suppressed. In addition, soybean grain yields are affected by K fertilization since a large proportion of K absorbed by the soybean plant is allocated into the seed.

2.3 Combined effect of manures and inorganic fertilizers

Effects of manures and inorganic fertilizers on mungbean (*V. radiata*. L.) yield under arid climate were studied by Abbas *et al.* (2011) at adaptive research farm Karor and at farmer's field during two kharif seasons of 2006 and 2007. In these experiments different combinations of manures and inorganic fertilizers were used for comparison. Experiments were laid in randomized complete block design with seven treatments. AZRI 2006, a promising variety of mung-bean (*V. radiate.* L.) for arid climate was used as a test variety. The results revealed that different combinations of manures and inorganic fertilizers significantly affected the pod number plant^{-1}, seed number pod^{-1} and grain yield. Maximum grain yield was obtained from the application of DAP at 124 kg along with 10 t ha^{-1} of poultry litter during both years, while application of DAP at 62 kg and 10 t of FYM ha^{-1} ranked second for grain yield.

Rajkhowa *et al*. (2002) reported that the application of 100% RDF along with vermicompost @ 2.5 t ha^{-1} recorded significantly higher plant height (52.7 cm), number of pods plant^{-1} (12.67), seeds per pod (12.00), 100 seed weight (4.6 g), seed yield (5.35 q ha^{-1}), seed yield (5.4 q ha^{-1}) and it was on par with the application of 75% or 50% RDF + vermicompost (2.5 t ha^{-1}) over control in mungbean.

Malligawad *et al*. (2000) in groundnut revealed that application of RDF (25:75:25 kg NPK kg ha^{-1}) + vermicompost @ 1 t ha^{-1} recorded significantly higher pod yield (3389 kg ha^{-1}) compared to FYM @ 4 t ha^{-1}+ 50% RDF (3232 kg ha^{-1}), RDF alone (3148 kg ha^{-1}) and no NPK application (2742 kg ha^{-1}).

Kale *et al*. (1994) observed that the application of vermicompost @ 5 t ha^{-1} + 50% RDF recorded significantly higher value of growth yield components and yield of sunflower compared to FYM @ 5 t ha^{-1} + RDF.

Channaveerswami (2005) reported that combined application of vermicompost @ 2.5 t ha^{-1} + RDF (25:50:50 kg NPK ha^{-1}) + copper ore tailing recorded higher plant height (43.94 cm), number of branches (6.92), and less number of days to 50% flowering (35.15), number of matured pods (17.06), pod yield (3337 kg ha^{-1}) and kernel yield (2362 kg ha^{-1}) 100 seed weight (35.26 g). This seed obtained with this treatment also recorded higher seed quality parameters like, germination (94.31%), seedling length (23.85cm), seedling dry weight (4.60 g), seedling vigour index (2249) and lower electrical conductivity (0.186 dSm^{-1}) in mungbean and groundnut.

Pawar *et al*. (1995) reported that the application of vermicompost @ 2.50 t ha^{-1} along with 100 % RDF recorded significantly higher seed yield (74.80 q ha^{-1}). However, *in situ* vermiculture and application of 50 % RDF recorded a yield equivalent to that with 100 % RDF. They further observed that the application of vermicompost @ 2.50 t ha^{-1}along with 50 % RDF recorded seed yield on par with 100 % RDF in maize.

Patil (1998) reported that in groundnut the maximum pod yield (30.04 q ha^{-1}) was recorded with the application of vermicompost @ 2.50 t ha^{-1}+ fly ash @ 30 t ha^{-1} + RDF. Whereas, the lowest pod yield (20.66 q ha^{-1}) was recorded with the application of RDF alone.

A field investigation was carried out by Aslam *et al.* (2010) in Pakistan to evaluate the effect of organic and inorganic sources of phosphorous on the growth and yield of mungbean (*V. radiata* L.). FYM, poultry manure and chemical fertilizer were accumulated at various concentrations to formulate different treatments. Analysis of data revealed significant differences with respect to plant height, number of plants m^{-2}, leaf area (cm^2), root length (cm), number of pod bearing branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, pod size (cm), number of seeds $plant^{-1}$, 1000 seed weight (g), biological yield (kg ha^{-1}), seed yield (kg ha^{-1}), harvest index (%) and grain protein contents (%) indicating primacy of integration of the two sources in having improved mungbean productivity.

Rajkhowa *et al*. (2002) reported that the application of 100 % RDF along with vermicompost @ 2.5 t ha^{-1} recorded significantly higher plant height (52.7 cm), number of pods $plant^{-1}$ (12.67), seeds per pod (12.00), 100 seed weight (4.6 g), seed yield (5.35 q ha^{-1}), seed yield (5.4 q ha^{-1}) and it was on par with the application of 75% or 50% RDF + vermicompost (2.5 t ha^{-1}) over control in mungbean.

Naeem *et al.* (2006) was carried a field experiment out to determine the effect of organic manures and inorganic fertilizers on growth and yield of mungbean (*V. radiata* L.). Experiment comprised of two varieties (NM-98 & M-1) and four fertility levels as NPK @ 25 - 50 -50 kg ha^{-1}, poultry manure @ 3.5 t ha^{-1}, FYM @ 5 t ha^{-1} and Bio-fertilizer @ 8 g kg^{-1} seed. NPK fertilizers and organic manures were applied at the time of seed bed preparation. Wheat grain yield was recorded highest (1104 kg ha^{-1}) with the application of the inorganic fertilizers (NPK @ 25-50-50 kg ha^{-1}). Among organic nutrient a source, poultry manure @ 3.5 t ha^{-1} was found the best followed by FYM @ 5 t ha^{-1}. Numbers of pods, number of seeds per pod, 1000 grain weight were also almost higher in inorganic fertilizer treatment. The economic analysis revealed maximum net benefit from the treatment, where poultry manure was applied.

Shen *et al.* (2001) was conducted a pot experiment to investigate the effects of organic materials on the alleviation of Al toxicity in acid red soil Crop production in red soil areas may be limited by Al toxicity. A possible alternative to ameliorate Al toxicity is the application of such organic manure as crop straw and animal manure. Ground wheat straw, pig manure or $CaCO_3$ were mixed with the soil and incubated, at 85% of water holding capacity and 25°C, for 8 weeks. Growth of mung bean seedling was improved substantially by the application of organic material or $CaCO_3$. Pig manure or wheat straw was more effective in ameliorating Al toxicity than was $CaCO_3$. Mung bean plants receiving pig manure or wheat straw contained relatively high concentrations of P, Ca and K in their leaves. It is suggested that the beneficial effect of organic manure on mung bean is likely due to decreasing concentrations of monomeric inorganic Al concentrations in soil solution and improvement of mineral nutrition.

Ahmad *et al.* (2014) was the study describes the optimizing organic and inorganic fertilizers recommendations for wheat-sorghum and wheat-mung bean crop rotations under rainfed conditions. Five different treatments including T_0 as Control, T_1 with farmyard manure (FYM) at 30 t ha^{-1}, T_2 include NPK at120-80-60 at kg ha^{-1}, T_3 using poultry manure at 20 t ha^{-1}, T_4 included compost (Press mud) at 12.5 t ha^{-1} and in T_5, Inoculation by Phosphorus mobilizing microorganisms at 2.5 packets ha^{-1} was used only for wheat while, sorghum and mungbean were planted on the residual nutrients. Net benefits for the poultry manure were highest mainly due to high wheat yield and marginal rate of return are also high. The results were also confirmed using residual analysis.

Crop productivity of maize-legume intercropping system for yield and yield attributes were evaluated by Saleem *et al.* (2011) under different fertility treatments at National Agriculture Research Center (NARC), Islamabad, Pakistan during 2007 and 2008 using complete randomized strip block design replicated thrice. Three cropping systems were kept in vertical blocks and five fertility treatments were placed in horizontal blocks. According to results of the study it was revealed that half poultry manure + half PK+ inoculation gave maximum maize grain yield of 4830.95 kg ha^{-1} and biological yield of 15330.29 kg ha^{-1} respectively, while cropping systems did not have an affect on grain and biological yields of maize to the significant extent. On the basis of agronomic as well as economic performance of maize + mashbean intercropping, it was well evident that combined use of organic, biofertilizers and chemical fertilizers was proved to be more productive and remunerative and can be recommended for maize growers to elevate income.

CHAPTER III

MATERIALS AND METHODS

Details of the experimental materials and methods followed in the study are presented in this chapter. The experiment was carried out during the period from March to June (kharif-I season) of 2015 for finding out the effect of different manures and inorganic fertilizers on growth and yield of two selected mungbean varieties.

3.1 Experimental site

The experiment was carried out at the Sher-e-Bangla Agricultural University (SAU) farm, Dhaka. The experimental site is situated at $23^{o}77'$ North Latitude and $90^{o}30'$ East Longitude. The elevation of the experimental site is 8.0 m above the sea level. The area belongs to the Agro-ecological Zone (no. 28): (Madhupur Tract). The geographical location of the experimental site has been shown on the MAP in Appendix I.

3.2 Climate of the experimental site

The climate of the experimental site is sub-tropical, wet and humid. Heavy rainfall occurs in the monsoon (mid-April to mid-August) and scanty during rest of the year. The climate data have been represented in Appendix II.

3.3 Soil type of the experimental site

The experiment was conducted on silty clay loam soil of the Order Inceptisols. The soil of SAU farm is high land having irrigation facilities. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix III.

3.4 Crop: Mungbean

BARI mung-5 (V_1) and BARI mung-6 (V_2) was used in the study. The salient characteristics of these varieties are presented below:

BARI mung-5

Bangladesh Agricultural Research Institue (BARI) released BARI mung-5 in 1997 as high yielding variety. Plant height of this variety ranges from 40 to 45 cm and seeds are deep green in colour and bigger in size. One thousand seed weight is about 40-42 g. The variety requires 60 to 65 days to mature, and average yield is 1,200-1,500 kg ha^{-1}. It is also resistant to *Cercospora* leaf spot and tolerant to yellow mosaic virus (BARI, 2009).

BARI mung-6

Bangladesh Agricultural Research Institue (BARI) released BARI mung-6 in 2003. Plant height of this variety ranges from 40 to 45 cm and seeds are deep green in colour. One thousand seed weight is about 51-52 g. The variety requires 55 to 58 days to mature, and average yield is 1,500 kg ha^{-1}. It is also resistant to *Cercospora* leaf spot and tolerant to yellow mosaic virus (BARI, 2009).

3.5 Treatments of the experiment

The experiment was consisted with two factors:

Factor A: Manures and inorganic fertilizers (5 levels)

T_0: Control (no fertilizer or manure)

T_1: Recommended dose of fertilizer

[45 kg urea ha^{-1}+ 100 kg TSP ha^{-1}+ 58 kg MoP ha^{-1}] (Afzal, *et al.*, 2008)

T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1})

T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1})

T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

The chemical composition of the organic manures used in the experiment has been shown in [Appendix IV (A)].

Factor B: Variety (2 levels)

$V_{1=}$ BARI mung-5

$V_{2=}$ BARI mung-6

3.6 Experimental design

The experiment was laid out in a split plot design with three replications. Each plot was measured 3 m x 2 m [Appendix IV (B)].

3.7 Land preparation

The experimental land was opened with a power tiller and subsequently ploughed twice followed by laddering. Weeds, stubbles and crop residues were removed. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in the [Appendix IV (B)].

3.8 Fertilizer application

manures (cowdung,poultry manure and vermicompost) were applied along with urea, TSP, MoP, gypsum, zinc sulphate and boric acid as per treatments during the final land preparation.

3.9 Sowing of mungbean seed

Mungbean was sown on 01 March, 2015. Healthy seeds of mungbean @ 35 kg ha^{-1} were sown by hand as uniformly as possible in furrows. Seeds were sown in the afternoon and immediately covered with soil to avoid sunlight. Line to line distance was maintained 30 cm.

3.10 Intercultural operation

Weeding was done at 12 and 35 days after sowing. Thinning was done on the same date of 1^{st} weeding to maintain optimum plant density. Plant to plant distance was maintained at 15 cm. A light irrigation was given after sowing for germination of seed. Pest did not infest the mungbean crop at the early stage. The insecticide Sumithion 57 EC was sprayed @ 0.02% at the time of pod formation to control pod borer. No disease was observed in the experimental field.

3.11 Harvesting and sampling

Mungbean pods were harvested thrice respectively at 55 DAS,60 DAS and 65 DAS from the plants of predemarked 1m^2 area for recording yield data.The seeds collected from all the pods were weighed and converted it into t ha$^{-1.}$

3.12 Threshing, drying, cleaning and weighing

The crop bundles were sun dried for two days on threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks. The collected seeds were dried in sun to lower the moisture content to 12% level. The dried and cleaned seed and stover were weighed plot-wise.

3.13 Data collection of growth and yield parameters

3.13.1 Plant height

The plant height was measured from base of the plant to the tip of the main shoot for ten randomly tagged plants with the help of scale at 15 DAS, 25 DAS, 35 DAS, 45 DAS and 55 DAS. The average of ten plants was computed and expressed as the plant height in centimeters.

3.13.2 Number of leaves plant^{-1}

The numbers of green trifoliate leaves present on each plant were counted manually from the ten tagged plants at 15 DAS, 25 DAS, 35 DAS, 45 DAS and 55 DAS. The mean number of leaves plant^{-1} was calculated and expressed in number plant^{-1}.

3.13.3 Number of branches plant^{-1}

The total number of branches originating from the main stem was counted at 15 DAS, 25 DAS, 35 DAS, 45 DAS and 55 DAS from ten earlier tagged plants. Average was worked out and expressed as number of branches plant^{-1}.

3.13.4 Dry weight of mungbean plant

Total dry matter weight of stem plant^{-1} was recorded at the time of 15, 25, 35, 45 and 55 DAS by uprooting three random plant samples and separating the stem carefully. The plant samples were oven dried at 72 °C temperature until a constant level from which the weight of total dry matter were recorded. Data were recorded as the average of 3 sample plants plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

$$\text{Dry matter content of plant (\%)} = \frac{\text{Weight of oven dried plant}}{\text{Fresh weight of plant}} \times 100$$

3.13.5 Number of pods plant^{-1}

The total number of pods from ten randomly selected plants was counted manually from each treatment. Average was worked out and recorded as number of pods plant^{-1}.

3.13.6 Pods length (cm)

Ten pods were selected at random from the total number of pods harvested from tagged ten plants. The length of each pod was measured and average was calculated out and expressed as number of seeds pod^{-1}.

3.13.7 Number of seeds pod^{-1}

Ten pods were selected at random from the total number of pods harvested from tagged ten plants. The seeds from each pod were separated, counted and average was worked out and expressed as number of seeds pod^{-1}.

3.13.8 1000-grain weight

One hundred seeds were counted from the seed sample of each plot separately and then their weight was recorded by the help of an electrical balance. These values were multiplied by ten to determine the weight of thousand seed.

3.13.9 Days to first emergence

Days to first emergence was considered when the plants within a plot were emerged from soil. The number of days to first emergence was recorded from the date of sowing.

3.13.10 Days to 80 % emergence

Days to 80% emergence was considered when 80% of the plants within a plot were emerged from soil. The number of days to 80% emergence was recorded from the date of sowing.

3.13.11 Days to 80 % flowering

Days to 50% flowering was considered when 50% of the plants within a plot were showed up with flowers. The number of days to 50% flowering was recorded from the date of sowing.

3.13.12 Days to 80 % pod maturity

Days to harvesting was considered when the 80% pod of the plants within a plot becomes blackish in color. The number of days to maturity was recorded from the date of sowing.

3.13.13 Stover yield (t ha^{-1})

The crop was harvested and threshed respective plots wise. Seeds and stover were separated, cleaned and dried in the sun. Then stover yield plot^{-1} was recorded at 12% moisture level. The yield plot^{-1} was converted to hectare basis.

3.13.14 Seed yield (t ha^{-1})

The seed yield obtained from the plot of each treatment was added with the yield obtained for ten tagged and harvested plants. The seeds were cleaned and dried in shade for five days. After size grading seed weight plant^{-1} was recorded in gram. The seed yield ha^{-1} was computed and expressed in kg ha^{-1}.

3.13.15 Biological yield (t ha^{-1})

Biological yield was calculated using the following formula:

Biological yield = Grain yield + Stover yield.

3.13.16 Harvest index (%)

Harvest index was calculated with the help of following formula and it was calculated on dry weight basis.

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield (Seed weight)}}{\text{Biological Yield (Total dry weight)}} \times 100$$

3.14 Statistical analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques to obtain the level of significance by using MSTAT-C computer package program (Freed,1986). The significant differences among the treatment means were compared by Least Significant Difference (LSD) test at 5% level of probability.

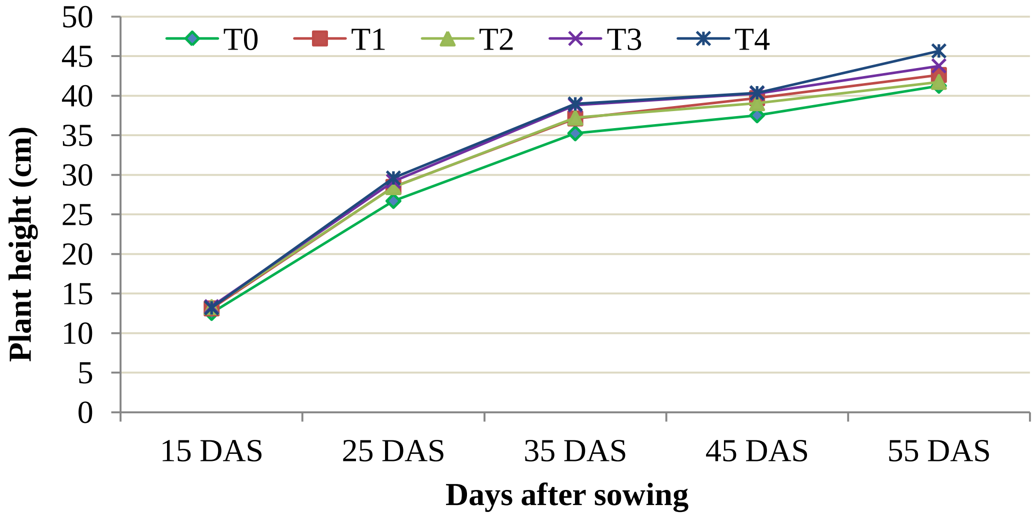
CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to find the growth and yield of two mungbean varieties influenced by different manures and inorganic fertilizers. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix V-XI. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following heading.

4.1 Plant height (cm)

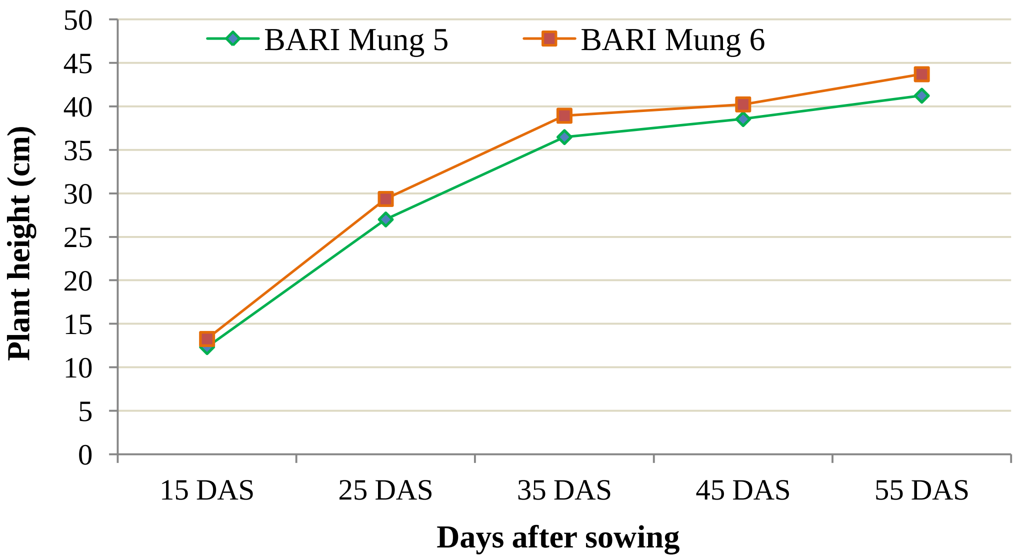
Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at 45 and 55 DAS on plant height except 15, 25 and 35 DAS (Appendix V). At 25, 35, 45 and 55 DAS, the tallest plant (29.61, 38.97, 40.38 and 45.67 cm respectively) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] and the shortest plant (26.70, 35.25, 37.53 and 41.26 cm respectively) was found from T_0 treatment (control) respectively (Figure 1).

Significant differences were observed due to the two different varieties of mungbean at 35, 45 and 55 DAS on plant height except 15 and 25 DAS (Appendix V). At 15, 25, 35, 45 and 55 DAS, the tallest plant (13.27, 29.37, 38.94, 40.24 and 43.71 cm respectively) was recorded from V_2 variety (BARI Mung 6) and the shortest plant (12.33, 27.01, 36.48, 38.55 and 41.24 cm respectively) was found from V_1 variety (BARI Mung 5) respectively (Figure 2).



T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Figure 1. Effect of manures and inorganic fertilizers on plant height of mungbean plant ($LSD_{0.05}$= 1.25, 2.72, 2.80, 2.51 and 3.85 at 15, 25, 35, 45 and 55 DAS, respectively)



V_1: BARI Mung 5, V_2: BARI Mung 6

Figure 2. Effect of variety on plant height of mungbean plant ($LSD_{0.05}$ = 0.79, 1.72, 1.77, 1.58 and 2.43 at 15, 25, 35, 45 and 55 DAS, respectively)

Significant differences were observed due to the interaction of the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at 25, 35, 45 and 55 DAS on plant height except 15 DAS (Appendix V). At 15, 25, 35, 45 and 55 DAS, the highest plant height (14.43, 30.85, 41.20, 42.88 and 46.05 cm respectively) was recorded from T_4V_2 treatment combination and the shortest plant (11.81, 24.73, 32.86, 36.20 and 39.01 cm respectively) was found from T_0V_1 treatment combination, respectively (Table 1).

Table 1. Combined effect of variety and manures and inorganic fertilizers on plant height of mungbean at different days after sowing (DAS)

Treatment	Plant height (cm)				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
T_0V_1	11.81c	24.73 b	32.86 d	36.20 b	39.01 d
T_1V_1	13.25 a-c	28.37 ab	38.43 a-c	38.53 ab	44.86 a-c
T_2V_1	13.61 ab	28.36 ab	38.06 bc	39.73 ab	41.30 a-d
T_3V_1	12.28 bc	28.32 ab	35.43 cd	37.13 b	39.56 cd
T_4V_1	13.717 ab	29.41 a	37.60 bc	41.16 a	41.49 a-d
T_0V_2	13.28 a-c	28.06 ab	37.63 bc	38.86 ab	43.53 a-d
T_1V_2	13.01 a-c	28.56 ab	35.83 cd	39.61 ab	40.59 bcd
T_2V_2	12.99 a-c	28.03 ab	38.70 a-c	39.86 ab	42.41 a-d
T_3V_2	12.67 a-c	28.06 ab	40.34 ab	41.01 a	46.00 ab
T_4V_2	14.43 a	30.85 a	41.20 a	42.88 a	46.05 a
LSD $_{(0.05)}$	**1.77**	**3.85**	**3.97**	**3.55**	**5.44**
CV %	**7.89**	**7.84**	**6.14**	**5.26**	**7.48**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

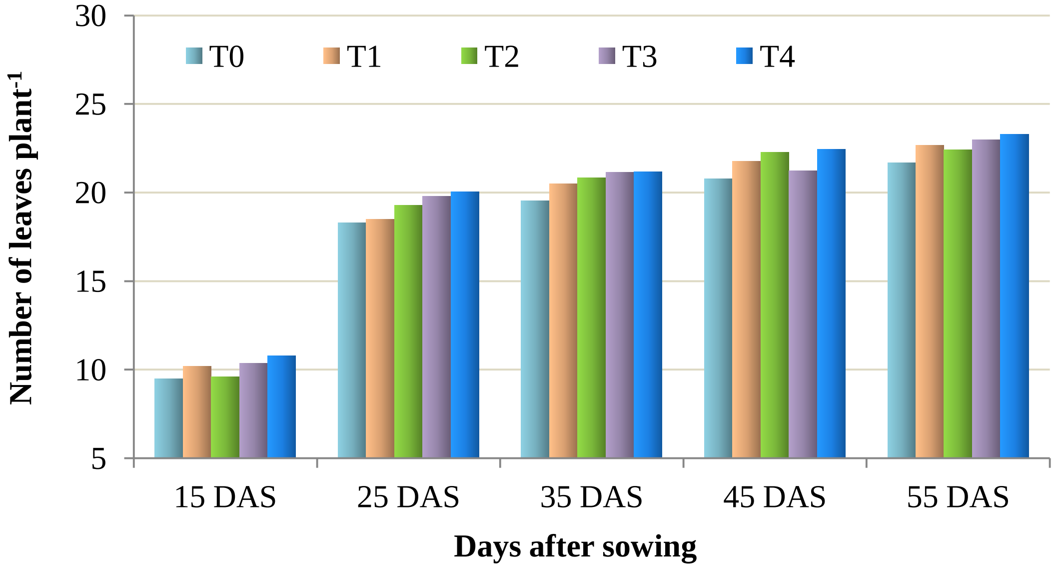
V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

It seems from the results that combination of vermicompost and inorganic fertilizers significantly increased the plant height. Actually organic fertilizers help to increase the organic matter content of soil, thus reducing the bulk density and decreasing compaction. Thus plants get a suitable growing environment which promotes better growth and development. Similar sort of findings were found by many scientists while experimenting with various crops. Combination of organic and inorganic fertilizers was found better by Channaveerswami (2005) in groundnut and Rajkhowa *et al*. (2002) in green gram than only inorganic fertilizers.

4.2 Number of leaves plant^{-1}

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at 25, 35, 45 and 55 DAS on number of leaves plant^{-1} except 15 DAS (Appendix VI). At 15, 25, 35, 45 and 55 DAS, the maximum number of leaves plant^{-1} (10.78, 20.05, 21.17, 22.45 and 23.30 respectively) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] and the minimum number of leaves plant^{-1} (9.48, 18.31, 19.53, 20.78 and 21.68 respectively) was found from T_0 treatment (control) respectively (Figure 3).

Significant differences were observed due to the different varieties of mungbean at 35, 45 and 55 DAS on number of leaves plant^{-1} except 15 and 25 DAS (Appendix VI). At 15, 25, 35, 45 and 55 DAS, the maximum number of leaves plant^{-1} (10.44, 19.86, 20.88, 21.85 and 22.84 respectively) was recorded from V_2 variety (BARI Mung 6) and the minimum number of leaves plant^{-1} (9.74, 18.91, 19.40, 20.56 and 21.78) was found from V_1 variety (BARI Mung 5) respectively (Figure 4).



T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Figure 3. Effect of manures and inorganic fertilizers on number of leaves plant of mungbean ($LSD_{0.05}$= 0.86, 0.89, 1.44, 1.51 and 1.22 at 15, 25, 35, 45 and 55 DAS, respectively)

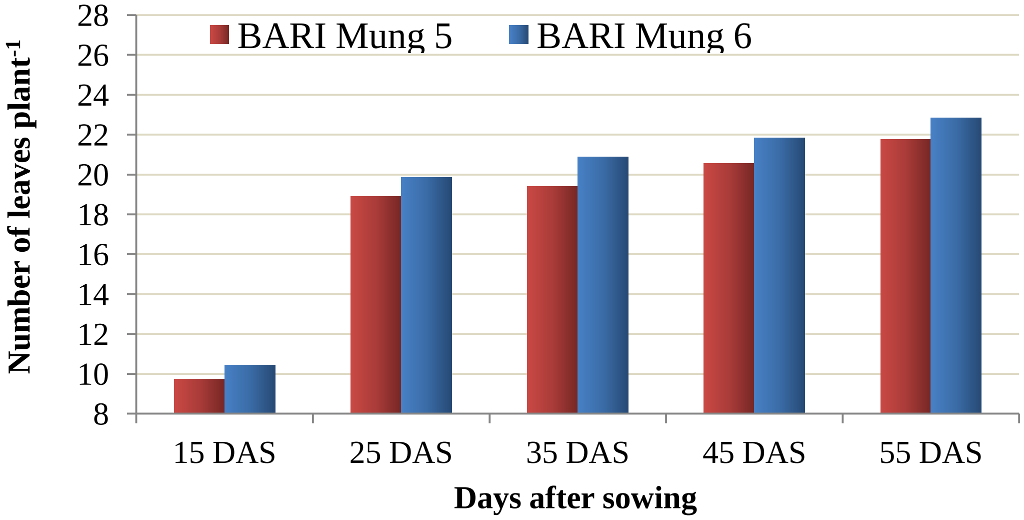


Figure 4. Effect of variety on number of leaves plant of mungbean ($LSD_{0.05}$= 0.54, 0.56, 0.91, 0.95 and 0.77 at 15, 25, 35, 45 and 55 DAS, respectively)

Table 2. Combined effect of variety and manures and inorganic fertilizers on number of leaves plant^{-1} of mungbean at different days after sowing (DAS)

Treatment	Number of leaves plant^{-1}				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
T_0V_1	8.56 b	17.40 d	18.83 b	20.10 c	21.01 d
T_1V_1	10.80 a	19.40 a-c	20.70 ab	22.43 ab	23.33 a-c
T_2V_1	9.60 ab	18.93 c	20.86 ab	21.50 a-c	22.66 a-d
T_3V_1	9.60 ab	19.01 c	20.53 ab	21.60 a-c	22.63 a-d
T_4V_1	10.13 a	19.83 a-c	21.06 a	22.20 a-c	24.30 a
T_0V_2	9.63 ab	19.23 bc	20.23 ab	20.26 c	22.36 b-d
T_1V_2	10.76 a	19.60 a-c	19.93 ab	21.13 bc	22.03 cd
T_2V_2	10.40 a	19.63 a-c	21.43 a	21.46 ac	21.68 cd
T_3V_2	10.60 a	20.60 a	21.80 a	23.08 ab	23.96 ab
T_4V_2	10.80 a	20.26 ab	21.01 a	23.30 a	24.16 a
LSD $_{(0.05)}$	**1.22**	**1.26**	**2.04**	**2.14**	**1.73**
CV %	**7.08**	**3.80**	**5.78**	**5.76**	**4.44**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at 25, 35, 45 and 55 DAS on number of leaves plant^{-1} except 15 DAS (Appendix VI). At 15, 25, 35, 45 and 55 DAS, the highest number of leaves plant^{-1} (10.80, 20.26, 21.01, 23.30 and 24.16) were recorded from T_4V_2 treatment combination and the lowest values (8.56, 17.40, 18.83, 20.10 and 21.01) were found from T_0V_1 treatment combination, respectively (Table 2).

The results showed that the combination of vermicompost and inorganic fertilizers significantly increased the number of leaves plant^{-1} than sole use of inorganic fertilizers. As organic fertilizers help to improve the soil condition and inorganic fertilizers assure quick availability of essential nutrients, the combination of two proved better than single use of the each. Patil (1998) found better growth by using combination of manures and inorganic fertilizers than only inorganic fertilizers in mungbean.

4.3 Number of branches plant^{-1}

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at 25, 35, 45 and 55 DAS on number of branches plant^{-1} (Appendix VII). At 25, 35, 45 and 55 DAS, the maximum number of branches plant^{-1} (1.51, 2.61, 4.34 and 7.08) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] and the minimum number of branches plant^{-1} (1.36, 1.99, 3.72 and 6.21) was found from T_0 treatment (control) respectively (Table 3). Singh *et al*. (1999) also found similar results with increasing rate of NPK and they noted that the number of branches plant^{-1} generally increased with the application of inorganic fertilizers.

Significant differences were observed due to the different two varieties of mungbean at 35, 45 and 55 DAS on number of branches plant^{-1} except 25 DAS (Appendix VII). At 25, 35, 45 and 55 DAS, the maximum number of branches plant^{-1} (1.48, 2.69, 4.42 and 6.90) was recorded from V_2 variety (BARI Mung 6) and the minimum number of branches plant^{-1} (1.47, 2.26, 4.02 and 6.47) was found from V_1 variety (BARI Mung 5) respectively (Table 4).

Table 3. Effect of manures and inorganic fertilizers on number of branches plant^{-1} of mungbean at different days after sowing (DAS)

Treatment	Number of branches plant^{-1}			
	25 DAS	**35 DAS**	**45 DAS**	**55 DAS**
T_0	1.36 b	1.99 b	3.72 b	6.21 b
T_1	1.51 a	2.58 a	4.31 a	6.79 a
T_2	1.51 a	2.82 a	4.55 a	7.03 a
T_3	1.51 a	2.87 a	4.60 a	6.82 a
T_4	1.51 a	2.61 a	4.34 a	7.08 a
LSD $_{(0.05)}$	**0.07**	**0.50**	**0.50**	**0.51**
CV %	**5.53**	**18.67**	**11.17**	**7.09**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Table 4. Effect of variety on number of branches plant^{-1} of mungbean at different days after sowing (DAS)

Treatment	Number of branches plant^{-1}			
	25 DAS	**35 DAS**	**45 DAS**	**55 DAS**
V_1	1.47	2.26 b	4.02 b	6.47 b
V_2	1.48	2.69 a	4.42 a	6.90 a
LSD $_{(0.05)}$	**-**	**0.32**	**0.32**	**0.31**
CV %	**3.70**	**16.27**	**9.70**	**6.16**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at 35, 45 and 55 DAS on number of branches plant^{-1} except 25 DAS (Appendix VII). At 25, 35, 45 and 55 DAS, the highest number of branches plant^{-1} (1.51, 3.71, 5.44 and 7.92) was recorded from T_4V_2 treatment combination and the lowest number of branches plant^{-1} (1.35, 2.03, 3.76 and 6.24) was found from T_0V_1 treatment combination,respectively (Table 5).

Table 5. Combined effect of variety and manures and inorganic fertilizers on number of branches plant^{-1} of mungbean at different days after sowing (DAS)

Treatment	**Number of branches plant^{-1}**			
	25 DAS	**35 DAS**	**45 DAS**	**55 DAS**
T_0V_1	1.35 b	2.03 cd	3.76 cd	6.24 cd
T_1V_1	1.51 a	2.52 bc	4.25 bc	6.73 bc
T_2V_1	1.51 a	2.44 c	4.17 c	6.65 c
T_3V_1	1.51 a	2.62 bc	4.35 bc	6.83 bc
T_4V_1	1.51 a	2.71 bc	4.44 bc	6.92 bc
T_0V_2	1.36 b	1.36 d	3.09 d	5.57 d
T_1V_2	1.51 a	2.64 bc	4.25 bc	6.85 bc
T_2V_2	1.51 a	3.21 ab	4.37 bc	7.42 ab
T_3V_2	1.51 a	2.52 bc	4.94 ab	6.73 bc
T_4V_2	1.51 a	3.71 a	5.44 a	7.92 a
LSD $_{(0.05)}$	**0.10**	**0.71**	**0.70**	**0.71**
CV %	**3.70**	**16.27**	**9.70**	**6.16**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Combination of vermicompost and inorganic fertilizers significantly increased the number of branches plant^{-1} than sole use of inorganic fertilizer. As organic fertilizers help to improve the soil condition and inorganic fertilizers assure quick availability of essential nutrients, the combination of two proved better than single use of the each. Channaveerswami (2005) reported that combined application of vermicompost @ 2.5 t ha^{-1} + RDF (25:50:50 kg NPK ha^{-1}) + copper ore tailing recorded higher number of branches (6.92) in mungbean.

4.4 Dry weight of mungbean (g $plant^{-1}$)

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at 15, 25, 35, 45 and 55 DAS on dry weight $plant^{-1}$ (Appendix VIII). At 15, 25, 35, 45 and 55 DAS, the maximum dry weight $plant^{-1}$ (0.71 g, 5.98 g, 16.49 g, 30.84 g and 36.49 g) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] and the minimum dry weight of plant (0.78 g, 6.05 g, 12.63 g, 19.33 and 25.01 g) was found in T_0 treatment (control) respectively (Table 6).

Table 6. Effect of manures and inorganic fertilizers on dry weight $plant^{-1}$ of mungbean at different days after sowing (DAS)

Treatment	**Plant dry weight (g)**				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
T_0	0.78 b	6.05 ab	12.63 c	19.33 c	25.01 c
T_1	0.71 b	5.98 b	15.38 ab	23.31 bc	29.76 bc
T_2	0.73 b	5.83 b	14.24 b	23.25 bc	28.37 bc
T_3	0.36 c	5.31 c	15.22 ab	26.99 ab	32.30 ab
T_4	1.25 a	6.53 a	16.49 a	30.84 a	36.49 a
LSD $_{(0.05)}$	**0.16**	**0.51**	**1.40**	**4.36**	**5.02**
CV %	**13.62**	**8.44**	**7.54**	**14.26**	**10.53**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Significant differences were observed due to the different two varieties of mungbean at 15, 25, 35, 45 and 55 DAS on dry weight of plant (Appendix VIII). At 15, 25, 35, 45 and 55 DAS, the maximum dry weight of plant (0.92, 6.15, 15.22, 25.38 and 30.17 g) was recorded from V_2 variety (BARI Mung 6) and the minimum dry weight of plant (0.61, 5.73, 14.27, 21.11 and 27.06 g) was found from V_1 variety (BARI Mung 5) respectively (Table 7).

Table 7: Effect of variety on plant dry weight of mungbean plant at different days after sowing (DAS)

Treatment	**Plant dry weight (g)**				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
V_1	0.61 b	5.73 b	14.27 a	21.11 b	27.06 b
V_2	0.92 a	6.15 a	15.22 a	25.38 a	30.71 a
LSD $_{(0.05)}$	**0.10**	**0.32**	**0.89**	**2.75**	**3.17**
CV %	**17.42**	**7.07**	**7.84**	**14.52**	**13.62**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at 15, 25, 35, 45 and 55 DAS on dry weight plant^{-1} (Appendix VIII). At 15, 25, 35, 45 and 55 DAS, the highest dry weight of plant (1.83 , 7.23 , 18.02 , 35.55 and 40.68 g) was recorded from T_4V_2 treatment combination and the lowest dry weight of plant (0.33 , 4.86 , 11.69 , 18.79 and 24.36 g) was found from T_0V_1 treatment combination respectively (Table 8).

Kale *et al*. (1994) observed that the application of vermicompost @ 5 t ha^{-1} + 50% RDF recorded significantly higher value of growth yield components and yield of mungbean and sunflower compared to FYM @ 5 t ha^{-1} + RDF.

Table 8. Combined effect of variety and organic and inorganic fertilizers on plant dry weight of mungbean plant at different days after sowing (DAS)

Treatment	Plant dry weight (g)				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
T_0V_1	0.33 g	4.86 f	11.69 f	18.79 f	24.36 d
T_1V_1	0.66 c-e	5.83 b-e	14.96 b-d	26.13 b-d	32.30 bc
T_2V_1	0.76 cd	6.46 bc	15.77 bc	26.44 bc	30.93 b-d
T_3V_1	0.46 e-g	5.61 de	14.24 c-e	25.01 b-e	30.40 b-d
T_4V_1	1.11 b	5.90 b-e	15.18 b-d	24.17 b-f	32.31 bc
T_0V_2	0.83 c	6.51 b	12.71 ef	22.44 c-f	25.65 cd
T_1V_2	0.60 d-f	6.06 b-d	15.26 b-d	28.98 b	27.21 b-d
T_2V_2	0.70 cd	5.21 ef	13.57 d-f	20.07 d-f	25.81 cd
T_3V_2	0.40 fg	5.76 c-e	16.53 ab	19.87 ef	34.21 ab
T_4V_2	1.83 a	7.23 a	18.02 a	35.55 a	40.68 a
LSD $_{(0.05)}$	**0.23**	**0.72**	**1.99**	**6.16**	**7.10**
CV %	**17.42**	**7.07**	**7.84**	**14.52**	**13.62**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

4.5 Number of pods plant^{-1}

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at harvesting stage on number of pods plant^{-}(Appendix IX). The maximum number of pods plant^{-1} (12.65) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] which is statistically identical to T_3 treatment and on the other hand the minimum number of pods plant^{-1} (9.83) was found from T_0 treatment which is statistically identical to T_1 and T_2 treatment (Table 9). Ashraf *et al.* (2003)

found that NPK 50:50:50 kg ha^{-1} resulted in the highest number of pods $plant^{-1}$. Aruna and Narsa Reddy (1999) reported that the application of vermicompost @ 15 t ha^{-1} to soybean recorded significantly higher number of pods $plant^{-1}$. Mastan *et al.* (1999), Kalita (1989) and Reddy *et al.* (1990) also found similar results.

Significant differences were observed due to the different two varieties of mungbean at harvesting stage on number of pods $plant^{-1}$ (Appendix IX). The maximum number of pods $plant^{-1}$ (11.80) was recorded from V_2 variety (BARI Mung 6) and on the other hand the minimum number of pods $plant^{-1}$ (10.41) was found from V_1 variety (Table 10).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at harvesting stage on number of pods $plant^{-1}$ (Appendix IX). The highest number of pods $plant^{-1}$ (12.78) was recorded from T_4V_2 treatment combination which is statistically identical to T_1V_1, T_2V_1, T_3V_1, and T_3V_2 and on the other hand the lowest number of pods $plant^{-1}$ (9.19) was found from T_0V_1 treatment combination (Table 11). Combination of vermicompost and inorganic fertilizers increased the number of pods $plant^{-1}$ than use of inorganic fertilizer alone. This may be because combination of manures and inorganic fertilizers improves soil physical properties, which provide health and favourable soil conditions to enhance nutrient use efficiency. Channaveerswami (2005) reported that combined application of vermicompost @ 2.5 t ha^{-1} + RDF (25:50:50 kg NPK ha^{-1}) + copper ore tailing recorded higher number of matured pods (17.06) in mungbean. Patil (1998) reported that in mungbean the maximum pod yield (30.04 q ha^{-1}) was recorded with the application of vermicompost @ 2.50 t ha^{-1} + fly ash @ 30 t ha^{-1} + RDF, whereas, the lowest pod yield (20.66 q ha^{-1}) was recorded with the application of RDF alone. Abbas *et al.* (2011) found that application of DAP at 124 kg along with 10 t ha^{-1} of poultry litter yielded maximum number of pods $plant^{-1}$.

4.6 Pod length (cm)

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at harvesting stage on pod length (Appendix IX). The highest pod length (9.36) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] which is statistically identical to T_2 and T_3 treatment and on the other hand the lowest pod length (8.08) was found from T_0 treatment which is statistically identical to T_1 treatment (Table 9).

There is no significant differences were observed due to the different two varieties of mungbean at harvesting stage on pod length (Appendix IX). The highest pod length (8.64 cm) was recorded from V_2 variety (BARI Mung 6) and on the other hand the lowest pod length (7.65 cm) was found from V_1 variety (Table 10).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at harvesting stage on pod length (Appendix IX). The highest pod length (9.50) was recorded from T_2V_2 treatment combination which is statistically similar to T_3V_1, T_4V_1, T_0V_2, T_3V_2 and T_4V_2 and on the other hand the lowest pod length (7.93) was found from T_0V_1 treatment combination which is statistically identical to T_1V_1 and T_2V_1 treatment combination (Table 11).

4.7 Number of seeds pod^{-1}

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at harvesting stage on number of seeds pod^{-1} (Appendix IX). The maximum number of seeds pod^{-1} (9.61) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t/ha)] which is statistically identical to T_1, T_2 and T_3 treatment and on the other hand the minimum number of seeds pod^{-1} (8.17) was found from T_0 treatment (Table 9).

There is no significant differences were observed due to the different two varieties of mungbean at harvesting stage on number of seeds pod^{-1} (Appendix IX). The maximum number of seeds pod^{-1} (9.18) was recorded from V_2 variety (BARI Mung 6) and on the other hand the minimum number of seeds pod^{-1} (8.16) was found from V_1 variety (Table 10).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at harvesting stage on number of seeds pod^{-1} (Appendix IX). The highest number of seeds pod^{-1} (10.23) was recorded from T_2V_2 treatment combination which is statistically identical to T_4V_2 treatment combination and on the other hand the lowest number of branches per pod (8.60) was found from T_0V_1 which is statistically identical to T_1V_2 treatment combination (Table 11). Combination of vermicompost and inorganic K fertilizers increased the number of seeds pod^{-1}. This may be because combination of manures and inorganic fertilizers improves soil physical properties, which provide health and favourable soil conditions to enhance nutrient use efficiency. Similar results were reported by Channaveerswami (2005) in mungbean and groundnut and Rajkhowa *et al.* (2002) in green gram and mungbean. Patil (1998) reported that in mungbean the maximum number of seeds pod^{-1} was recorded with the application of vermicompost @ 2.50 t ha^{-1} + fly ash @ 30 t ha^{-1} + RDF, whereas, the lowest number of seeds pod^{-1} was recorded with the application of RDF alone.

4.8 1000-grain weight

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at harvesting stage on 1000-grain weight (Appendix IX). The maximum 1000-grain weight (37.19 g) was recorded from T_4 treatment [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})]

which is statistically identical to T_2 and T_3 treatment and on the other hand the minimum 1000-grain weight (34.32 g) was found from T_0 treatment which is statistically identical to T_1 treatment (Table 9). Kumar *et al.* (2002) who found that seeds plant^{-1} was not influenced by organic amendment But Chinnamuthu and Venkatakrishnan (2001) reported that the application of vermicompost @ 2 t ha^{-1} recorded significantly higher 1000 seed weight (4.14 g) in mungbean.

Significant differences were observed due to the different two varieties of mungbean at harvesting stage on 1000-grain weight (Appendix IX). The maximum 1000-grain weight (36.30 g) was recorded from V_2 variety (BARI Mung 6) and on the other hand the minimum 1000-grain weight (35.07 g) was found from V_1 variety (BARI Mung 5) (Table 10).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean harvesting stage on 1000-grain weight (Appendix IX). The highest 1000-grain weight (38.55 g) was recorded from T_2V_2 treatment combination and on the other hand the minimum 1000-grain weight (35.08 g) was found from T_0V_1 which is statistically identical to T_1V_1, T_2V_1, T_0V_2, T_1V_2 and T_3V_2 treatment combination (Table 11). Similar results were reported by Channaveerswami (2005) in mungbean and Rajkhowa *et al*. (2002) in green gram. Patil (1998) reported that in groundnut and mungbean the maximum 1000-seed weight was recorded with the application of vermicompost @ 2.50 t ha^{-1} + fly ash @ 30 t ha^{-1} + RDF, whereas, the lowest 1000-seed weight was recorded with the application of RDF alone.

Table 9. Effect of manures and inorganic fertilizers on pods plant^{-1}, pod length, seeds pod^{-1} and 1000-grain weight of mungbean

Treatment	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed weight (g)
T_0	9.83 b	8.08 b	8.17 b	34.32 b
T_1	10.68 b	8.43 b	8.88 a	35.28 b
T_2	10.74 b	8.91 a	9.34 a	35.77 a
T_3	12.01 a	9.03 a	9.15 a	35.90 a
T_4	12.65 a	9.36 a	9.61 a	37.19 a
LSD $_{(0.05)}$	**1.74**	**0.79**	**0.94**	**1.84**
CV %	**13.05**	**9.47**	**10.12**	**15.71**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry panure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Table 10. Effect of variety on pods plant^{-1}, pod length, seeds pod^{-1} and 1000-grain weight of mungbean

Treatment	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed weight (g)
V_1	10.41 b	7.65 b	8.16 b	35.07 b
V_2	11.80 a	8.64 a	9.18 a	36.30 a
LSD $_{(0.05)}$	**1.10**	**0.50**	**0.59**	**1.16**
CV %	**12.39**	**7.54**	**8.45**	**16.58**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6

Table 11. Combined effect of variety and manures and inorganic fertilizers on pods plant^{-1}, pod length, seeds pod^{-1} and 1000-grain weight of mungbean

Treatment	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed weight (g)
T_0V_1	9.19 b	7.93 b	8.01 c	35.08 b
T_1V_1	11.66 a	7.96 b	9.15 a-c	35.76 b
T_2V_1	12.35 a	8.00 b	8.99 a-c	35.83 b
T_3V_1	12.34 a	8.93 ab	8.60 bc	36.50 ab
T_4V_1	12.31 a	8.81 ab	9.32 a-c	36.67 ab
T_0V_2	10.46 ab	8.73 ab	8.99 a-c	35.59 b
T_1V_2	11.33 ab	8.56 ab	8.61 bc	35.60 b
T_2V_2	11.05 ab	9.50 a	10.23 a	38.55 a
T_3V_2	12.53 a	9.03 ab	9.74 ab	35.31 b
T_4V_2	12.78 a	9.01 ab	10.08 a	36.96 ab
LSD $_{(0.05)}$	**2.46**	**1.11**	**1.32**	**2.61**
CV %	**12.39**	**7.54**	**8.45**	**16.58**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry anure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

4.9 Days to 1st emergence

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at initial stage on Days to 1st emergence (Appendix X). The maximum Days to 1st emergence (2.56 days) was recorded from T_0 (control) treatment which is statistically similar to T_1, T_2 and T_3 treatment and on the other hand the minimum Days to 1st emergence (1.90 days) was found from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment (Table 12).

Significant differences were observed due to the two varieties of mungbean at initial stage on Days to 1st emergence (Appendix X). The maximum Days to 1st emergence (2.32 days) was recorded from V_1 variety (BARI Mung 5) and on the other hand the minimum Days to 1st emergence (2.02 days) was found from V_2 variety (Table 13). Bhuiyan *et al.* (2004) reported the similar results. Ali *et al.* (2005) also reported the similar results.

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean initial stage on Days to 1st emergence (Appendix X). The highest Days to 1st emergence (2.90 days) was recorded from T_0V_1 treatment combination which is statistically identical to T_0V_2 and on the other hand the minimum Days to 1st emergence (1.80 days) was found from T_4V_2 treatment combination (Table 14).

4.10 Days to 80 % emergence

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at initial stage on Days to 80 % emergence (Appendix X). The maximum days to 80 % emergence (4.60 days) was recorded from T_0 (control) treatment and on the other hand the minimum days to 80 % emergence (3.33 days) was found from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment (Table 12).

Significant differences were observed due to the different two varieties of mungbean at initial stage on Days to 80 % emergence (Appendix X). The maximum Days to 80 % emergence (4.12 days) was recorded from V_1 variety (BARI Mung 5) and on the other hand the minimum Days to 80 % emergence (3.96 days) was found from V_2 variety (Table 13). Bhuiyan *et al.* (2004) reported the similar results. Ali *et al.* (2005) also reported the similar results.

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two varieties of mungbean initial stage on Days to 80 % emergence (Appendix X). The maximum Days to 80 % emergence (4.91 days) was recorded from T_0V_1 treatment combination and on the other hand the minimum Days to 80 % emergence (3.16 days) was found from T_4V_2 treatment combination (Table 14).

4.11 Days to 80 % flowering

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers on Days to 80 % flowering (Appendix X). The maximum Days to 80% flowering (34.10 days) was recorded from T_0 (control) treatment which is statistically identical to T_1 and T_2 treatment and on the other hand the minimum Days to 80% flowering (31.36 days) was found from T_4 treatment which is statistically identical to T_3 treatment (Table 12).

Significant differences were observed due to the different two varieties of mungbean on Days to 80 % flowering (Appendix X). The maximum Days to 80 % flowering (35.22 days) was recorded from V_1 variety (BARI Mung 5) and on the other hand the minimum Days to 80 % flowering (32.16 days) was found from V_2 variety (Table 13).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean on Days to 80 % flowering (Appendix X). The maximum Days to 80 % flowering (36.43 days) was recorded from T_0V_1 treatment combination and on the other hand the minimum Days to 80 % flowering (32.21 days) was found from T_4V_2 treatment combination which is statistically identical to T_4V_1 and T_2V_2 treatment combination (Table 14).

4.12 Days to 80 % pod maturity

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers at harvesting stage on Days to 80% pod maturity (Appendix X). The maximum days to 80% pod maturity (50.51 days) was recorded from T_0 (control) treatment which is statistically similar to T_1, T_2 and T_3 treatment and on the other hand the minimum days to 80 % pod maturity (47.45 days) was found from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment (Table 12).

Significant differences were observed due to the different two varieties of mungbean at harvesting stage on Days to 80 % pod maturity (Appendix X). The maximum Days to 80 % pod maturity (50.90 days) was recorded from V_1 variety (BARI Mung 5) and on the other hand the minimum Days to 80 % pod maturity (47.62 days) was found from V_2 variety (Table 13) Bhuiyan *et al.* (2004) reported the similar results. Ali *et al.* (2005) also reported the similar results. Solaiman *et al.* (2003) reported the similar results.

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean at harvesting stage on days to 80% pod maturity (Appendix X). The maximum days to 80 % pod maturity (54.47 days) was recorded from T_0V_1 treatment combination and on the other hand the minimum days to 80% pod maturity (46.56 days) was found from T_4V_2 treatment combination which is statistically identical to T_4V_1 treatment combination (Table 14).

Table 12. Effect of manures and inorganic fertilizers on days to 1st emergence, days to 80 % emergence, days to 80 % flowering and days to 80 % pod maturity of mungbean

Treatment	Days to 1st emergence	Days to 80 % emergence	Days to 80 % flowering	Days to 80 % pod maturity
T_0	2.56 a	4.60 a	34.10 a	50.51 a
T_1	2.46 a	4.30 b	33.86 a	49.25 ab
T_2	2.40 a	4.08 c	34.41 a	50.01 ab
T_3	2.30 a	4.12 c	31.41 b	49.08 ab
T_4	1.90 b	3.33 d	31.36 b	47.45 b
LSD $_{(0.05)}$	**0.35**	**0.16**	**2.54**	**2.91**
CV %	**11.53**	**2.34**	**4.85**	**3.07**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1}+ 100 kg TSP ha^{-1}+ 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Table 13. Effect of variety on days to 1st emergence, days to 80 % emergence, days to 80 % flowering and days to 80 % pod maturity of mungbean

Treatment	Days to 1st emergence	Days to 80 % emergence	Days to 80 % flowering	Days to 80 % pod maturity
V_1	2.32 a	4.12 a	35.22 a	50.90 a
V_2	2.02 b	3.96 b	32.16 b	47.62 b
LSD $_{(0.05)}$	**0.22**	**0.10**	**1.61**	**1.84**
CV %	**12.67**	**3.22**	**6.23**	**4.87**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6

Table 14. Combined effect of variety and manures and inorganic fertilizers on days to 1st emergence, days to 80 % emergence, days to 80 % flowering and days to 80 % pod maturity of mungbean

Treatment	Days to 1st emergence	Days to 80 % emergence	Days to 80 % flowering	Days to 80 % pod maturity
T_0V_1	2.90 a	4.91 a	36.43 a	54.47 a
T_1V_1	2.41 a-c	3.30 ef	33.03 a-d	51.47 ab
T_2V_1	2.21 cd	4.23 d	34.51 a-d	50.61 a-c
T_3V_1	2.23 b-d	4.40 cd	36.23 a-c	50.46 a-c
T_4V_1	2.01 cd	3.50 e	31.32 d	46.71 c
T_0V_2	2.80 a	4.51 bc	36.13 ab	49.43 bc
T_1V_2	2.73 ab	4.30 cd	32.41 cd	47.53 bc
T_2V_2	2.01 cd	4.66 b	32.23 d	47.40 bc
T_3V_2	2.21 cd	3.52 e	36.13 ab	48.03 bc
T_4V_2	1.80 d	3.16 f	32.21 d	46.56 c
LSD $_{(0.05)}$	**0.50**	**0.22**	**3.60**	**4.12**
CV %	**12.67**	**3.22**	**6.23**	**4.87**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP/ha), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1}).

4.13 Stover yield (t ha^{-1})

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers on Stover yield (AppendixXI). The maximum Stover yield (1.88 t) was recorded from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment which is statistically similar to T_3 treatment and on the other hand the minimum Stover yield (1.46 t) was found from T_0 (control) treatment (Table 15).

Significant differences were observed due to the different two varieties of mungbean after harvesting on Stover yield (Appendix XI). The maximum Stover yield (1.91 t) was recorded from V_1 variety (BARI Mung 5) and on the other hand the minimum Stover yield (1.45 t) was found from V_2 variety (Table 16).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean after harvesting on Stover yield (Appendix XI). The maximum Stover yield (2.61 t) was recorded from T_4V_2 treatment combination and on the other hand the minimum Stover yield (1.23 t) was found from T_0V_1 treatment combination which is statistically identical to T_0V_2 and T_1V_2 treatment combination (Table 17).

4.14 Seed yield (t ha^{-1})

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers on seed yield (Appendix XI). The maximum seed yield (1.53 t) was recorded from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment which is statistically similar to T_3 treatment and on the other hand the minimum seed yield (1.04 t) was found from T_0 (control) treatment (Table 15). Oad and Buriro (2005) found that 10-30-30 kg NPK ha^{-1} was the best treatment for seed yield of mungbean cv. AEM 96 in Tandojam, Pakistan during the spring season of 2004. Roy and Singh (2006) reported in malt barley that the application of vermicompost @10 t ha^{-1} recorded higher seed yield (44 q ha^{-1}). Aruna and Narsa (1999) reported that the application of vermicompost @ 15 t ha^{-1} to soybean recorded significantly seed yield (1143 kg ha^{-1}).

Significant differences were observed due to the different varieties of mungbean on seed yield (Appendix XI). The maximum seed yield (1.58 t) was recorded from V_2 variety (BARI Mung 6) and on the other hand the minimum seed yield (1.29 t) was found from V_1 (BARI Mung 5) variety (Table 16).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean on seed yield (Appendix XI). The maximum seed yield (2.01 t) was recorded from T_4V_2 treatment combination and on the other hand the minimum seed yield (1.05 t) was found from T_0V_1 treatment combination which is statistically identical to T_1V_1 and T_0V_2 treatment combination (Table 17).

It is revealed from the result that combination of vermicompost and inorganic potassium fertilizers increased the seed yield ha^{-1}. This may be because manures are known to contain plant nutrients, growth promoting substances and beneficial microflora which in combination with inorganic fertilizers provide favourable soil conditions to enhance nutrient use efficiency. Similar results were reported by Channaveerswami (2005) in mungbean and groundnut and Rajkhowa *et al*. (2002) in green gram. Patil (1998) reported that in groundnut and mungbean the maximum seed yield ha^{-1} was recorded with the application of vermicompost @ 2.50 t ha^{-1} + fly ash @ 30 t ha^{-1} + RDF,whereas, the lowest seed yield $ha^{-1}$was recorded with the application of RDF alone. Abbas *et al.* (2011) found that application of DAP at 124 kg along with 10 t ha^{-1} of poultry litter yielded maximum seed yield ha^{-1}. Rajkhowa *et al*. (2002) reported that the application of 100% RDF along with vermicompost @ 2.5 t ha^{-1} recorded significantly higher plant height (52.7 cm), number of pods $plant^{-1}$ (12.67), seeds per pod (12.00), 100 seed weight (4.6 g), seed yield (5.35 q ha^{-1}), seed yield (5.4 q ha^{-1}) and it was at par with the application of 75% or 50% RDF + vermicompost (2.5 t ha^{-1}) over control in mungbean.

Table 15. Effect of manures and inorganic fertilizers on yields and harvest index of mungbean

Treatment	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
T_0	1.46 c	1.04 c	2.50 c	41.60 d
T_1	1.60 b	1.27 b	2.87 b	44.25 b
T_2	1.65 b	1.30 b	2.95 b	44.06 b
T_3	1.87 a	1.46 a	3.33 a	43.84 c
T_4	1.88 a	1.53 a	3.41 a	44.86 a
LSD $_{(0.05)}$	**0.27**	**0.22**	**0.33**	**0.46**
CV %	**11.58**	**7.21**	**8.75**	**3.81**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1}+ 100 kg TSP ha^{-1}+ 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Table 16. Effect of variety on yields and harvest index of mungbean

Treatment	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})	Biological yield(t ha^{-1})	Harvest Index (%)
V_1	1.91 a	1.29 b	3.20 a	40.31 b
V_2	1.45 b	1.58 a	3.03 a	52.14 a
LSD $_{(0.05)}$	**0.16**	**0.14**	**0.21**	**3.37**
CV %	**12.75**	**12.79**	**8.46**	**4.04**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6

Table 17. Combined effect of variety and manures and inorganic fertilizers on yields and harvest index of mungbean

Treatment	Stover yield ($t\ ha^{-1}$)	Seed yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest Index (%)
T_0V_1	1.23 d	1.05 d	2.28 e	46.05 c-e
T_1V_1	1.78 bc	1.17 d	2.95 b	39.66 g
T_2V_1	1.77 bc	1.34 cd	3.11 cd	43.09 f
T_3V_1	1.49 cd	1.29 cd	2.78 de	46.41 c-e
T_4V_1	2.13 b	1.74 ab	3.87 b	44.96 d-f
T_0V_2	1.25 d	1.17 d	2.42 e	48.35 bc
T_1V_2	1.17 d	1.54 bc	2.71 de	56.83 a
T_2V_2	1.77 bc	1.61 bc	3.38 c	47.63 b-d
T_3V_2	1.61 c	1.65 bc	3.26 c	50.61 b
T_4V_2	2.61 a	2.01 a	4.62 a	43.51 ef
LSD $_{(0.05)}$	**0.41**	**0.31**	**0.47**	**3.22**
CV %	**12.75**	**12.79**	**8.46**	**4.04**

In a column, means with same letter (s) are not significantly different by LSD at 5% level of significance

V_1: BARI Mung 5, V_2: BARI Mung 6, T_0: Control (no fertilizer or manure), T_1: Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

4.15 Biological yield ($t\ ha^{-1}$)

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers after harvesting on biological yield (Appendix XI). The maximum biological yield (3.41 t) was recorded from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment which is statistically similar to T_3 treatment and on the other hand the minimum biological yield (2.50 t) was found from T_0 (control) treatment (Table 15).

Significant differences were observed due to the different varieties of mungbean after harvesting on biological yield (Appendix XI). The maximum biological yield (3.20 t) was recorded from V_1 variety (BARI Mung 5) and on the other hand the minimum biological yield (3.03 t) was found from V_2 (BARI Mung 6) variety (Table 16).

A significant difference was observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean after harvesting on biological yield (Appendix XI). The maximum biological yield (4.62 t) was recorded from T_4V_2 treatment combination and on the other hand the minimum biological yield (2.28 t) was found from T_0V_1 treatment combination which is statistically similar to T_0V_2 treatment combination (Table 17).

4.16 Harvest index (%)

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers on harvest index (Appendix XI). The maximum harvest index (44.86%) was recorded from T_4 [Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})] treatment and on the other hand the minimum harvest index (41.60%) was found from T_0 (control) treatment (Table 15).

Significant differences were observed due to the tested two varieties of mungbean on harvest index (Appendix XI). The maximum harvest index (52.14 %) was recorded from V_2 variety (BARI Mung 6) and on the other hand the minimum harvest index (40.31 %) was found from V_1 (BARI Mung 5) variety (Table 16).

Significant differences were observed due to the application of different levels of manures and inorganic fertilizers with two different varieties of mungbean on harvest index (Appendix XI). The maximum harvest index (56.83%) was recorded from T_1V_2 treatment combination and on the other hand the minimum harvest index (39.66 %) was found from T_1V_1 treatment combination (Table 17).

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted in the Agronomy Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from March to June 2015 (kharif-I season) to find out the effect of different of manures and inorganic fertilizers on growth and yield of two selected varieties of mungbean. The experiment consisted of two factors: Factor A: Two varieties of mungben; V_1 = BARI Mung 5 and V_2 = BARI Mung 6. Factor B: Five levels of manures and inorganic fertilizers; T_0 = Control (no fertilizer or manure) T_1 = Recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}), T_2 = Recommended dose of fertilizer + cowdung (3 t ha^{-1}), T_3 = Recommended dose of fertilizer + poultry manure (2 t ha^{-1}), T_4 = Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1}). There were 10 treatment combinations. The experiment was laid out in Split Plot Design (SPD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum level of manures and inorganic fertilizes on two different varieties of mungbean.

At 55 days after sowing the longest plant height (45.67 cm), maximum number of leaves plant^{-1} (23.30), maximum number of branches plant^{-1} (7.08), the maximum plant dry weight (36.49 g), maximum number of pod plant^{-1} (12.65), highest length of pod (9.36 cm), maximum number of seeds pod^{-1} (9.61), the maximum 1000- seed weight (37.19 g), minimum days to 1st emergence (1.90 days), minimum days to 80 % emergence (3.33 days), minimum days to 80 % flowering (31.36 days), minimum days to 80 % pod maturity (47.45 days), maximum stover yield (1.88 t ha^{-1}), maximum seed yield (1.53 t ha^{-1}), maximum biological yield (3.41 t ha^{-1}) and maximum harvest index (44.86 %) were recorded from the T_4 treatment that is Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1}). On the other hand, at 55 days after sowing, the shortest plant height (41.26 cm), minimum number of leaves plant^{-1} (21.68), minimum number of branches plant^{-1} (6.21), minimum plant dry weight (25.01 g), the minimum number of pod plant^{-1} (9.83), highest length of pod (8.08 cm), minimum number of seeds pod^{-1} (8.17), the minimum 1000- seed weight (34.32 g), maximum days to 1st emergence (2.46 days), maximum days to 80 % emergence (4.60 days), maximum days to 80% flowering (34.10 days), maximum days to 8 % pod maturity (50.51 days), minimum stover yield (1.46 t ha^{-1}), minimum seed yield (1.04 t ha^{-1}), minimum biological yield (2.50 t ha^{-1}) and minimum harvest index (41.60%) were recorded from the T_0 treatment that control treatment.

At 55 days after sowing the longest plant height (43.71 cm), maximum number of leaves plant^{-1} (22.84), maximum number of branches plant^{-1} (6.90), the maximum plant dry weight (30.71 g), maximum number of pod plant^{-1} (11.80), highest length of pod (8.64 cm), maximum number of seeds pod^{-1} (9.18), the maximum 1000- seed weight (36.30 g), minimum days to 1st emergence (2.02 days), minimum days to 80 % emergence (3.96 days), minimum days to 80 % flowering (32.16 days), minimum days to 80 % pod maturity (47.62 days), minimum stover yield (1.45 t ha^{-1}), maximum seed yield (1.58 t ha^{-1}), minimum biological yield (3.03 t ha^{-1}) and maximum harvest index (52.14 %) were recorded from the V_2 variety that is BARI Mungbean 6. On the other hand, at 55 days after sowing, the shortest plant height (41.24 cm), minimum number of leaves plant^{-1} (21.78), minimum number of branches plant^{-1} (6.47), minimum plant dry weight (27.06 g), the minimum number of pod plant^{-1} (10.41), highest length of pod (7.65 cm), minimum number of seeds pod^{-1} (8.16), the minimum 1000- seed weight (35.07 g), maximum days to 1st emergence (2.32 days), maximum days to 80 % emergence (4.12 days), maximum days to 80 % flowering (35.22 days), maximum days to 80 % pod maturity (50.90 days), maximum stover yield (1.91 t ha^{-1}), minimum seed yield (1.29 t ha^{-1}), maximum biological yield (3.20 t ha^{-1}) and minimum harvest index (40.31 %) were recorded from the V_1 variety that is BARI Mungbean 5.

At 55 days after sowing the longest plant height (46.05 cm), maximum number of leaves plant^{-1} (24.16), maximum number of branches plant^{-1} (7.92), the maximum plant dry weight (40.68 g), maximum number of pod plant^{-1} (12.78), minimum days to 1st emergence (1.80 days), minimum days to 80% emergence (3.16 days), minimum days to 80% flowering (32.21 days), minimum days to 80 % pod maturity (46.56 days), maximum stover yield (2.61 t ha^{-1}), maximum seed yield (2.01 t ha^{-1}), maximum biological yield (4.62 t ha^{-1}) and maximum harvest index (43.09 %) were recorded from the T_4V_2 treatment combination that is recommended dose of fertilizer + vermicompost (2.5 t ha^{-1}) with BARI Mungbean 6 and the highest length of pod (9.50 cm), maximum number of seeds pod^{-1} (10.23), the maximum 1000- seed weight (38.55 g) were recorded from the T_2V_2 treatment combination that is recommended dose of fertilizer + cowdung (3 t ha^{-1}) with BARI Mungbean 6. On the other hand, at 55 days after sowing the shortest plant height (39.01 cm), minimum number of leaves plant^{-1} (21.01), minimum number of branches plant^{-1} (6.24), minimum plant dry weight (24.36 g), the minimum number of pod plant^{-1} (9.19), highest length of pod (7.93 cm), minimum number of seeds pod^{-1} (8.60), the minimum 1000-seed weight (35.59 g), maximum days to 1st emergence (2.90 days), maximum days to 80% emergence (4.91 days), maximum days to 80 % flowering (36.43 days), maximum days to 80% pod maturity (54.47 days), minimum seed yield (1.05 t/ha), minimum biological yield (2.28 t ha^{-1}) and minimum harvest index (46.05 %) were recorded from the T_0V_1 treatment combination that is control treatment with BARI Mungbean 5 and minimum stover yield (1.17 t ha^{-1}) was recorded from T_1V_2 treatment combination that is recommended dose of fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1}+ 58 kg MoP ha^{-1}) with BARI Mungbean 6.

Based on the result of the present study it was found that BARI Mungbean 6 variety performed the highest yield (2.01 t ha^{-1}) with the application of recommended dose of inorganic fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}) and vermicompost at the rate of 2.5 t ha^{-1} for mungbean production in Kharif –I season.

The cumulative effect of inorganic fertilizer (45 kg urea ha^{-1} + 100 kg TSP ha^{-1} + 58 kg MoP ha^{-1}) and vermicompost at the rate of 2.5 t ha^{-1} performed the best result for BARI Mung 6 than BARI Mung 5. In this experiment only two varieties have selected. So, further experiment should be conducted with more varieties of mungbean and different levels of manures and inorganic fertilizers.

CHAPTER VI
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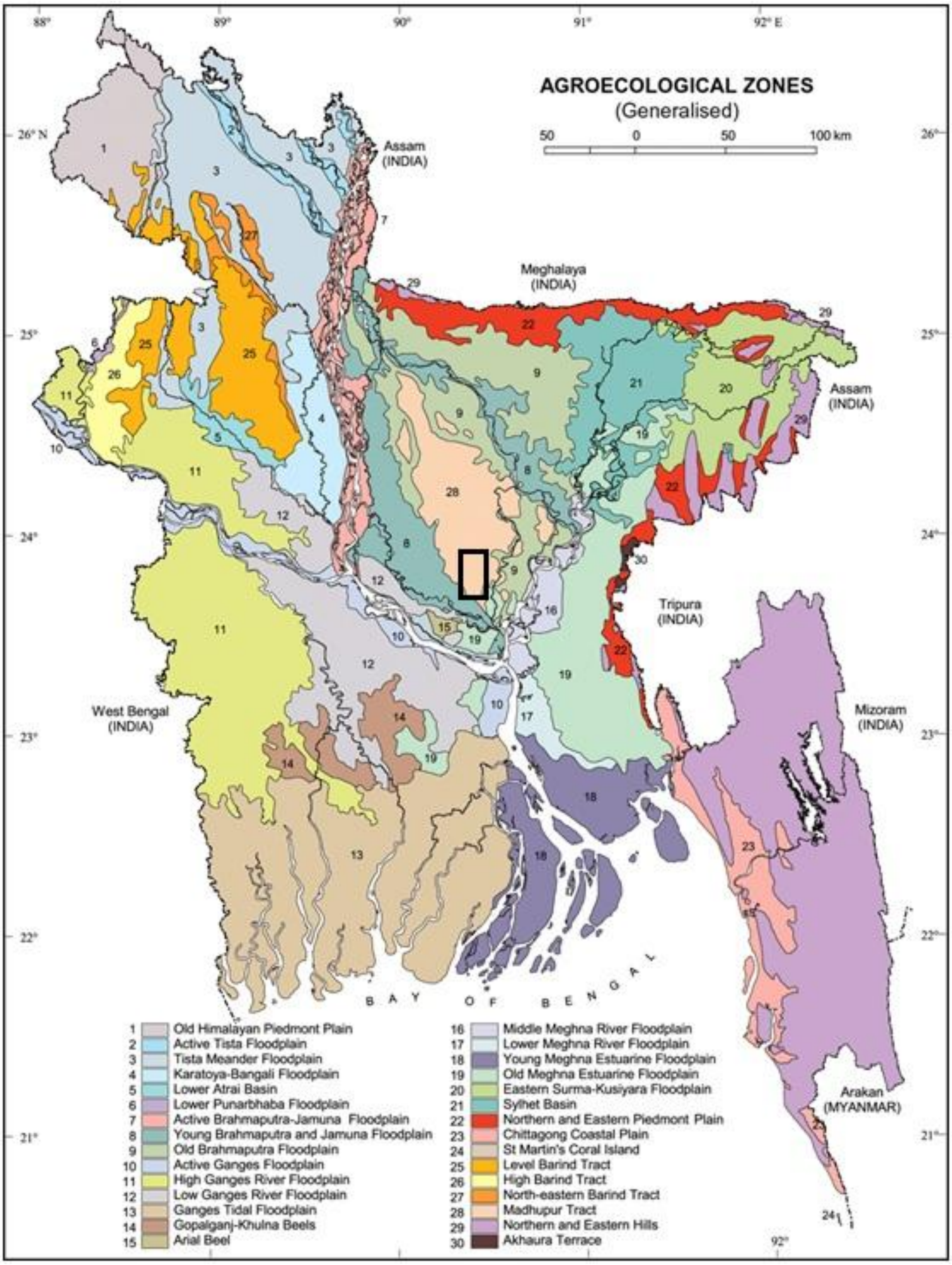
APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from February to July, 2015

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall
	Maximum	Minimum		
February ,15	28.10	12.70	79	32
March ,15	34.40	17.60	70	61
April , 15	37.30	21.40	66	137
May, 15	36.20	23.25	72	245
June, 15	36.42	25.50	81	315
July, 15	34.25	27.20	80	329

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix III. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	**Characteristics**
Location	Agronomy Research Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total N (%)	0.075
Available P (ppm)	12.78
Exchangeable K (%)	0.32
Available K (ppm)	43.29
Available S (ppm)	16.17

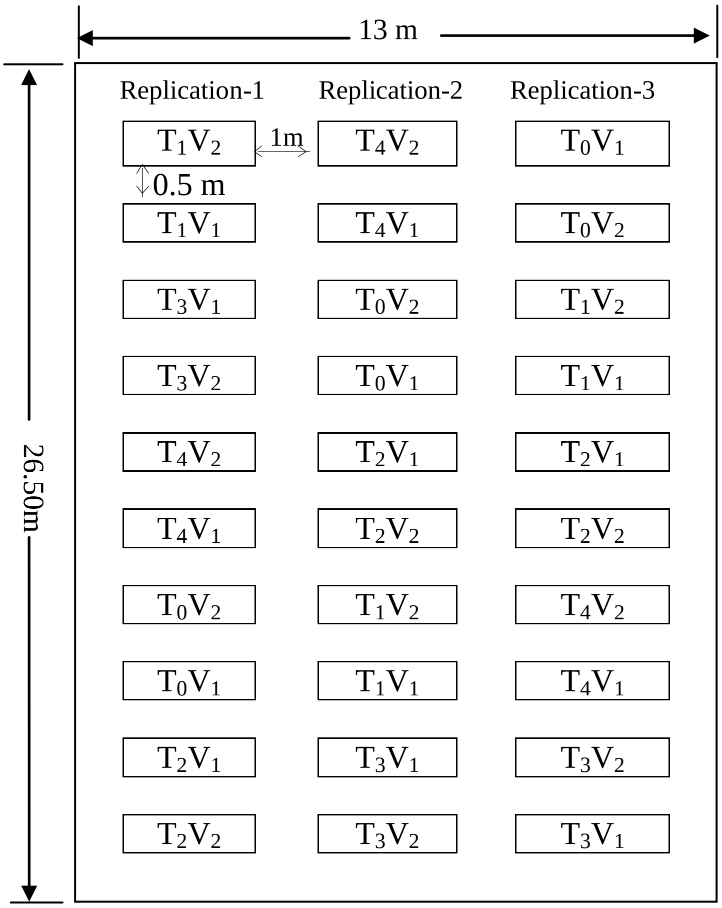
Source: Soil Resource Development Institute (SRDI)

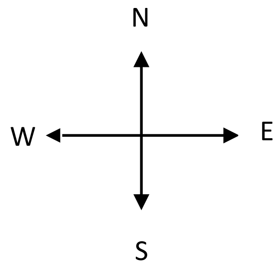
Appendix IV(A): Chemical compositions of the organic manures used for the experiment (Oven dry basis)

Organic fertilizer	N (%)	P (%)	K (%)
Cowdung	0.9	0.5	1.1
Poultry manure	1.3	0.5	1.3
Vermicompost	1.3	2.7	2.6

Source : SRDI

Appendix IV(B): Field layout of the experimental plot





Plot size: 3 m x 2 m
Spacing: 30 cm x 15 cm
Spacing between plots: 0.50 m
Spacing between replication: 1 m

Where,

Factor A: Manures and inorganic fertilizers (5 levels)

T_0: Control (no fertilizer or manure)

T_1: Recommended dose of fertilizer

(45 kg urea ha^{-1}+ 100 kg TSP ha^{-1}+ 58 kg MoP ha^{-1})

T_2: Recommended dose of fertilizer + cowdung (3 t ha^{-1})

T_3: Recommended dose of fertilizer + poultry manure (2 t ha^{-1})

T_4: Recommended dose of fertilizer + vermicompost (2.5 t ha^{-1})

Factor B: Variety (2 levels)

V_1 : BARI Mung 5

V_2 : BARI Mung 6

Appendix-V. Analysis of variance of data on plant height of mungbean

Source of variation	Degrees of freedom (df)	Mean square of plant height at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.046	5.133	30.089	4.7611	34.987
Factor A: Manures and inorganic fertilizer	4	0.640	8.634	14.474	8.201*	4.998*
Error	8	1.731	5.093	3.950	4.127	2.285
Factor B: Variety	1	0.904	14.200	45.436*	21.420*	45.855*
Interaction (A X B)	4	2.899	5.303*	19.832*	6.391*	27.389**
Error	10	1.067	5.054	5.363	4.286	10.085
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-VI. Analysis of variance of data on number of leaves of mungbean

Source of variation	Degrees of freedom (df)	Mean square of number of leaves at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.252	3.951	3.589	3.443	5.144
Factor A: Manures and inorganic fertilizer	4	1.742	2.668**	2.738*	2.965*	2.889*
Error	8	0.262	0.454	1.864	2.988	1.495
Factor B: Variety	1	3.675	6.816	1.728*	0.602*	0.024*
Interaction (A X B)	4	0.964*	0.785*	1.540*	4.609*	5.406**
Error	10	0.510	0.542	1.422	1.561	1.027
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-VII. Analysis of variance of data on number of branches of mungbean plant

Source of variation	Degrees of freedom (df)	Mean square of number of branches at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.00	0.006	0.052	0.052	0.052
Factor A: Manures and inorganic fertilizer	4	0.00	0.027**	0.735*	0.735*	0.735*
Error	8	1.975	0.0067	0.232	0.232	0.232
Factor B: Variety	1	0.00	0.001	0.374*	0.374*	0.374*
Interaction (A X B)	4	0.00	0.001	1.797**	1.797**	1.797**
Error	10	0.00	0.003	0.175	0.175	0.175
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-VIII. Analysis of variance of data on dry weight of mungbean plant

Source of variation	Degrees of freedom (df)	Mean square of dry weight of plant at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.147	0.065	1.633	1.704	0.566
Factor A: Manures and inorganic fertilizer	4	0.596**	1.148**	12.592**	113.685**	111.478**
Error	8	0.011	0.252	1.245	12.455	10.253
Factor B: Variety	1	0.736**	1.323*	5.427*	12.262*	3.195*
Interaction (A X B)	4	0.501**	1.623**	8.962**	53.003*	51.242*
Error	10	0.018	0.177	1.347	12.925	17.156
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-IX. Analysis of variance of data on pods plant^{-1}, pod length, seeds pod-1 and 1000- seed weight of mungbean

Source of variation	Degrees of freedom (df)	Mean square of			
		pod plant^{-1}	pod length	seeds pod^{-1}	1000-seed weight
Replication	2	2.337	0.645	0.448	1.408
Factor A: Manures and inorganic fertilizer	4	6.717*	0.538*	0.589*	2.183**
Error	8	2.294	0.671	0.863	2.079
Factor B: Variety	1	1.156*	0.001	0.003	0.406**
Interaction (A X B)	4	1.506*	1.344*	2.696*	4.857**
Error	10	2.068	0.426	0.601	2.315
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-X. Analysis of variance of data on days to 1st emergence, days to 80 % emergence, days to 80 % flowering and daysto 80 % pod maturity of mungbean

Source of variation	Degrees of freedom (df)	Mean square of			
		Days to 1st emergence	Days to 80 % emergence	Days to 80 % flowering	Days to 80 % pod maturity
Replication	2	0.208	0.085	11.781	5.075
Factor A: Manures and inorganic fertilizer	4	0.398*	1.353**	2.668*	8.175*
Error	8	0.072	0.009	2.671	2.195
Factor B: Variety	1	3.260*	0.176*	69.921*	80.360**
Interaction (A X B)	4	0.543**	1.198**	4.313*	14.599*
Error	10	0.087	0.017	4.416	5.772
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-XI. Analysis of variance of data on yields and harvest index of mungbean

Source of variation	Degrees of freedom (df)	Mean square of			
		Stover yield	Seed yield	Biological yield	Harvest Index (%)
Replication	2	0.086	0.064	0.033	6.712
Factor A: Manures and inorganic fertilizer	4	0.431**	0.033*	2.451**	15.815*
Error	8	0.038	0.0108	0.075	3.136
Factor B: Variety	1	1.492*	0.604*	0.161*	306.049**
Interaction (A X B)	4	0.514**	0.455**	0.421**	93.818**
Error	10	0.046	0.034	0.070	3.533

** : Significant at 1% level of probability;   * : Significant at 5% level of probability