COMBINED EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT PLANT SPACING

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CERTIFICATE

This is to certify that the thesis entitled ***"COMBINED EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT PLANT SPACING"*** *submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.) IN AGRONOMY****, embodies the result of a piece of bonafide research work carried out by* ***SAFAYET HOSEN****, Registration No.* ***18-09118*** *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.

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COMBINED EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT PLANT SPACING

ABSTRACT

The experiment was conducted at the Agronomy research farm of Sher-e-Bangla Agricultural University, Dhaka during the period from mid-March to June, 2019 to study the effect of different combinations of organic and inorganic fertilizers with different plant on yield of mungbean (BARI mung 5) using split plot design with three replications by assigning spacing in the main plot and fertilizer in the sub plot. The experiment comprised of two factors; Factor A: 3 level of spacing; S_1- 20 cm × 10 cm, S_2- 30 cm × 10 cm (recommended) and S_3- 45 cm × 15 cm; Factor B: 6 level of fertilizers; F_0- No fertilizer (control), F_1- Recommended dose of NPK, F_2- 5 t ha^{-1} cowdung, F_3- 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4- 2.5 t ha^{-1} cowdung + Recommended dose of NPK and F_5- 2.5 t ha^{-1} cowdung + ½ Recommended dose of NPK. Plant Height, number of leaves plant^{-1}, number of branches plant^{-1}, dry matter plant^{-1}, pod length, number of pods branch^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight, seed yield, stover yield, biological yield, harvest index were compared for different treatments. Among the three spacing, S_2 produced maximum seed yield (1022.8 kg ha^{-1}) while the lowest in S_3 (834.4 kg ha^{-1}). Cowdung had a significant effect on the growth and yield attributes of mungbean. The highest number of pods plant^{-1} (24.44) was found from S_3F_4 and the lowest (17.11) from the S_1F_0. The highest number of seeds pod^{-1} (12.9) found from S_3F_4 and the lowest (9.67) from the S_1F_0. The highest 1000 seed weight (51.47 g) was recorded from S_3F_4 and the lowest (45.25 g) was observed from the S_2F_0. The maximum seed yield (1156.7 kg ha^{-1}) was obtained by applying cowdung @ 2.5 t ha^{-1} along with recommended dose of NPK while minimum (930.0 kg h^{-1}) was found applying cowdung @ 5 t ha^{-1}. From the 18 treatment combinations, S_2F_4 was showed excellent performance when considering stover yield, biological yield. Plant spacing of 30 cm × 10 cm along with 2.5 t ha^{-1} + recommended dose of NPK application can be more beneficial for the farmers to get maximum yield from the cultivation of BARI Mung-5.

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LIST OF ABBREVIATION

%	=	Percent
@	=	At the rate
°C	=	Degree Celsius
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cv.	=	Cultivar (s)
DAS	=	Days After Sowing
HI	=	Harvest Index
et al.	=	And Others
FAO	=	Food and Agriculture Organization
G	=	Gram
IRRI	=	International Rice Research Institute
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
N	=	Nitrogen
SAU	=	Sher-e-Bangla Agricultural University
t/ha	=	Ton per hectare
kg/ha	=	Kelogram per hectare
TSP	=	Triple Super Phosphate
ha^{-1}	=	Per hectare
NS	=	Nonsignificant
CV%	=	Percentage of coefficient of variance
NPK	=	Nitrogen, Phosphorus and Potassium

CHAPTER I
INTRODUCTION

Mungbean (*Vigna radiata*) having a place with family Fabaceae, is made out of in excess of 150 species starting chiefly from Africa and Asia where the Asian tropical areas have the best greatness of hereditary variety (USDA-ARS, 2012). It is a significant heartbeat yield of Bangladesh and positions the third in protein substance and fourth position thinking about both grounds and creation (MoA, 2014). It develops well everywhere on the nation aside from the locale of Rangamati. Mungbean is a modest wellspring of effectively absorbable dietary protein which supplements the staple rice in the nation. Its seed contains 24.7% protein, 0.6% fat, 0.9 fibers and 3.7% debris (Potter and Hotchkiss, 1997).

As indicated by FAO (2013) suggestion, a minimum intake of pulse by a human should be 80 g/day, whereas it is 47.92 g in Bangladesh (BBS, 2016). Mungbean assumes a significant role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage production of mungbean is gradually declining (BBS, 2019). Mungbean is cultivated with lowest tillage, local varieties with no or minimum fertilizers, pesticides and very early or very late sowing, no practicing of irrigation and drainage facilities etc. with other different stress condition. All these factors are liable for low yield of mungbean which is incomparable with the yields of developed countries of the world (FAO, 1999). The low production of mungbean besides other factors may partially be due to lack of information regards to suitable production technology of this crop (Hussain *et al*., 2008).

In Bangladesh, total yield of pulses is only 0.65 million ton against 2.7 million tons requirement. This implies the lack is practically 80% of the complete prerequisite (Rahman and Ali, 2007). This is generally because of low yield (MoA, 2005). The explanations behind low yield are manifold: some are varietals and some are management. Because of the shortage of land, the scope of its extensive cultivation is very limited. Therefore, attempts must be made to enhance the yield per unit area by applying improved technology and management practices.

Agro-ecological condition of Bangladesh is favourable for growing mungbcan. The crop is sometimes cultivated throughout rabi season, however attributable to poor yield and marginal profit as compared to cereal crops, farmers like growing wheat to mungbean throughout rabi season. Besides, throughout the last decades, the discharge of high yielding cultivars of cereals have created it's cultivation less remunerative. Recently some photo-insensitive kharif cultivars are introduced that have already received attention to the farmers (Sarker *el at*., 1980). Throughout kharif season the crop fits well into the prevailing cropping system of the many areas of Bangladesh.

Crop residues and soil organic matter both could influence the diversity of soil microbial community and promote the crop growth and yield. Integrated use of nutrient may be one of the solutions to increase munghean yield as well as reducing cost of production and make the best use of locally available resources like animal dung, urine, crop residues etc. The use of organic matter as a low cost increase to the artificial fertilizers may help decreasing the cost of production. Integrated management of chemical fertilizers and organic wastes may be an important approach for sustainable production of crops. This may not only improve the efficiency of chemical fertilizers along with their minimal use in crop production besides increasing crop production and improving available major and minor nutrients (Rautaray *et al.*, 2003).

Management of soil organic matter has now become a major matter in dealing with the problems of soil fertility in Bangladesh. Depletion of soil fertility has arisen principally because of increasing cropping intensity. Increasing use of MVs, soil erosion, sandy soils, and higher decomposition of organic matter because of sub-tropical humid climate. Soil organic matter is a major factor in maintaining long-term soil productiveness since it is the reservoir of metabolic energy, which drives soil biological proccsscs involved in nutrient availability. A good quality soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% organic matter (BARC 2005). Organic matter substance of top soils particularly under high land and medium high land situations has declined over time. Organic matter is known as storehouse of plant nutrients and life force of a soil. Organic farming relies on large-scalc use of animal or farm yard manure (FYM), compost, crop residues, green manuring, vermicompost, bio-fertilizers and bio-pesticides. But it may not be possible to obtain desired production from sole use of organic fertilizers. Equilibrium use of fertilizer is important to obtain maximum seed yield.

Being leguminous in nature, mungbean needs little nitrogen but needs optimum doses of other major nutrients as recommended. Phosphorous (P) is a vital yield determining nutrient in legumes (Chaudhary *et al.,* 2008). It is a vital component of key molecules such as nucleic acids, phospholipids and ATP, and consequently, plants cannot grow without a dependable supply of this nutrient. P is also essential for the seed formation. It is known to encourage root growth and is associated with early maturity of crops. It not only improves the quality of fruits, forages, vegetables and seeds but also play role in disease resistance of plants. (Brady and Weil, 1999). Potassium (K) is the third macronutrient essential for plant growth, after nitrogen (N) and phosphorus (P). Unlike N and P; K is not an element of cell structure. Instead, it exists in mobile ionic form, and acts primarily as a catalyst (Wallingford, 1980). Potassium has a vital osmotic role in plants (Tisdale and Nelson, 1966) important function in arid environments for plants metabolism.

Seed yield is determined by genetic potential, planting density (Mansoor *et al*., 2010) and fertilizer executive (Hussain *et al*., 2014). High prospective yield of genotype is characterized by the large leaf area and high biomass addition (Mondal *et al*., 2011). However, plants require adequate space to grow in residents. In accordance with planting density, proper plant spacing management has an important key in maximizing yield (Ahamed *et al*., 2011) because it affects the degree of contest between individual plant to access potential capacity of land such as light, water and nutrient. Absorbed sunlight efficiency by crop needed to enough a leaf area to distributing equally, this aim done by changing row spacing and distributing plants over soil (Naseri *et al*., 2010). High planting density increases struggle among the plants and reduce occupation of plant to get light, water and nutrient. Individual plant at low population produce extra branch and pod, but number of pods per unit area become low so therefore reduced yield (Singh *et al*., 2003) as well as less efficient in land use (Sullivan, 2003).

In the increase of proper management practices for mungbean, population density plays an important key as it is one of the most important yield contributing characters. In lower plant population, individual plant performance is better than that of higher plant population but within acceptable limit higher plant population produces higher yield per hectare (Shukla and Dixit, 1996). Therefore, optimum plant population ensures normal plant growth due to efficient utilization of moisture, light, space and nutrients, thus increases the yield of crop.

In Bangladesh, few studies have been through on plant population and organic, inorganic fertilizer performance separately but no report has been found on the combined response of these factors on mungbean. Considering the above facts, the study has been undertaken to find out the influence of plant population, organic and inorganic fertilizer on growth and yield performance of mungbean cultivar.

Hence, the objectives of the study were:

i. To determine the interaction of different plant population on the growth and yield of mungbean.
ii. To find the effect of organic and inorganic fertilizers on mungbean yield.
iii. To find the best combination of organic and inorganic fertilizer with optimum spacing for better growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

The literature pertaining to influence of different organic manures, inorganic manures and plant population on growth and yield of mungbean are presented in this chapter. However, comparative information on effect of organic fertilizers on mungbean is not sufficient; analogies from other crops have also been included to highlight certain point of view.

2.1 Effect of inorganic fertilizer on crop attributes

2.1.1 Plant height

A study carried out by Achakzai *et al*. (2012) in the experimental field of Agricultural Research Institute (ARI), Quetta. The soil of the experimental area was basic in reaction, salt free, medium textured having low organic matter and total N contents. Four different varieties of mungbean *viz*., NM-92, NM-98, M-1 and NCM-209 grown in kharif season for two consecutive years *i.e*. 2007 and 2008 and six different levels of N fertilizer applied @ zero, 20, 40, 60, 80 and 100 kg ha^{-1}. Urea fertilizer was used as a source of N. The plot was arranged in a randomized complete block design (RCBD). Results showed that there was a significant diversity among different doses of N fertilizer to plant height. The plants of T_2 (20 + 50 + 30 kg NPK ha^{-1}) performed maximum height (36.81 cm) followed by T_3 (40 + 50 + 30 kg NPK ha^{-1}) (35.95 cm) and T_5 (80 + 50 + 30 kg NPK ha^{-1}) (34.82 cm) on the other hand, the short structure plant (29.64 cm) was obtained in plots receiving no fertilizer.

A field experiment carried by Oad and Buriro (2005) to work out the impact of various NPK level (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the expansion and yield of mungbean cv. AEM 96 in Tandojam, Pakistan. The various NPK level significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.25 cm.

2.1.2 Number of leaves plant^{-1}

Mondal *et al.* (2014) conducted a field experiments with mungbean (*Vigna radiata* L.) in the Crop Research and Seed Multiplication Farm, Burdwan University, West Bengal, India and found that leaf area per plant of mungbean was significantly improved by the split application of nitrogen fertilizer at 21 DAS.

Achakzai *et al*. (2012) reported that the maximum number of leaves plant^{-1} (5.71) recorded in treatment T_1 (No fertilizer), while the minimum (4.86) noted for T_4 (60 + 50 + 30 kg NPK ha^{-1}) dose of fertilizer.

A field experiment conducted by Sultana *et al.* (2009) to estimate the effect of nitrogen and weed managements on mungbean (*Vigna radiata*). They reported that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative period showed significantly higher leaves plant^{-1}.

Malik *et al.* (2003) conducted an experiment to find out the effect of varying level of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. They found that leaves plant^{-1} was significantly affected by varying level of nitrogen.

2.1.3 Dry matter weight plant^{-1}

Sultana *et al.* (2009) reported that the application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher dry matter production of mungbean.

A field experiment conducted by Asaduzzaman *et al*. (2008) were reported that, treatment 30 kg N ha^{-1} as basal + one irrigation at flower initiation stage (T_5) was significantly higher than other treatments in these accumulations. The highest above ground dry matter (23.36 g) was found at harvest (85 DAS). Significantly the minimum accumulation (15.63 g) was observed in control treatment (no fertilizer and no irrigation).

2.1.4 Number of branches plant^{-1}

Four different cultivars of mungbean viz., NM-92, NM-98, M-1, and NCM-209 grown in kharif season for two successive years i.e., 2007 and 2008. Six different levels of N fertilizer applied @ zero, 20, 40, 60, 80 and 100 kg ha^{-1}. Urea fertilizer used as a source of N. The plot was arranged in a randomized complete block design (RCBD). Results regarding number of branches plant^{-1} exhibited that there was a significant difference among various treatments of N fertilizer when compared it with their control treatment (T_1). The plants of T6 (100 + 50 + 30 kg NPK ha^{-1}) produced the maximum number of branches $plant^{-1}$ (3.83), while minimum (3.17) recorded for T_1 (No fertilizer) (Achakzai *et al*., 2012).

Sultana *et al.* (2009) reported that the application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly more number of branches (1.67) $plant^{-1}$.

Malik *et al.* (2003) conducted a study to find out the effect of varying level of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. They stated that the number of branches $plant^{-1}$ was found to be significantly higher by 25 kg N ha^{-1}.

2.1.5 Number of pods $plant^{-1}$

A study conducted by Hossen *et al*. (2015) at the research field of the Horticulture Research Center at Labukhali, Patuakhali during the time from January to March, 2014 to observe the most proper BARI mungbean variety and optimum rates of N concerning higher seed yield under the regional situation of Patuakhali (AEZ–13). Two BARI mungbean varieties namely BARI Mung–5 (V_1) and BARI Mung–6 (V_2) and five levels of N fertilizer including control *viz.* 0 kg N ha^{-1} (N_0), 30 kg N ha^{-1} (N_{30}), 45 kg N ha^{-1} (N_{45}), 60 kg N ha^{-1} (N_{60}), and 75 kg N ha^{-1} (N_{75}) were used for the study as level factor A and B, respectively. They reported that, the highest number of pods $plant^{-1}$ (10.45) was obtained in 45 kg N ha^{-1} followed by 30 kg N ha^{-1} (9.50 cm). Alternatively, the control treatment (without N) produced the minimum number of pods $plant^{-1}$ (7.55).

Asaduzzaman *et al*. (2008) carried out an experiment at the field of the Department of Agronomy, Sher-e-Bangla Agricultural University; Dhaka, Bangladesh to estimate the effect of nitrogen and irrigation managements on dry matter increase and yield of mungbean (*Vigna radiata* L.) cv. BARI mung-5 during the time from March to May, 2006. They found that, 30 kg N ha^{-1} as basal + one irrigation at flower initiation stage (T_5) gave significantly maximum number of pods per plant (43.30) while control treatment (no fertilizer and irrigation) gave the minimum pods $plant^{-1}$ (12.41).

Nigamananda and Elamathi (2007) conducted a field experiment to estimate the result of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of green gram cv. K-851. The recommended rate of N: P: K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments were as included: 1/2 basal N + foliar N as urea at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea; and 1/2 basal N + 1/2 foliar spraying as urea + 40 ppm NAA. 2% foliar spray of urea and NAA, applied at 35 DAS, resulted in the maximum values for number of pods plant^{-1} (38.3).

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at 0, 25 and 60 kg N ha^{-1}) and 0, 25, 50 and 60 kg P ha^{-1}) and reported that the number of pods plant^{-1} was amplified with the increasing rates of N up to 40 kg ha^{-1} followed by a reduce with further increase in N.

2.1.6 Number of seeds pod^{-1}

An experiment carried out by Hossen *et al*. (2015) to find out the most suitable BARI mungbean variety and optimum rates of N concerning higher seed yield under the regional condition of Patuakhali (AEZ–13). They reported that, among the nitrogen doses, nitrogen at the rate of 45 kg ha$^{–1}$ formed significantly the more seeds pod$^{–1}$ (9.70) followed by 30 kg N ha$^{–1}$ (9.30) whereas the minimum number of seeds pod$^{–1}$ (8.70) was taken from the control or without nitrogen.

Nigamananda and Elamathi (2007) carried out an experiment to estimate the effect of N application time as basal urea spray and use of plant growth regulator (NAA at 40 ppm) on the yield and yield components of green gram cv. K-851. The recommended rate of N: P: K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments were as included: 1/2 basal N + foliar N as urea at 25 or 35 days after sowing (DAS); 1/2 basal N + 1/4 at 25 DAS + 1/4 at 35 DAS as urea; and 1/2 basal N + 1/2 foliar spraying as urea + 40 ppm NAA. 2 % foliar spray of urea and NAA, applied at 35 DAS, resulted in the maximum seeds pod^{-1} (7.67).

Malik *et al*. (2003) investigated the effect of varying level of nitrogen (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 during 2001. It was observed that the number of seeds pod^{-1} was significantly affected by varying level of nitrogen and phosphorous.

2.1.7 Length of pod

Hossen *et al*. (2015) reported that the length of pod was increased significantly because of increasing dose of nitrogen up to 45 kg N ha$^{–1}$ and thereafter it decreased. The longest pod of mungbean (7.93 cm) was found in 45 kg N ha^{-1} followed by both 30 and 60 kg N ha$^{–1}$ (7.56 and 7.53 cm, respectively) where both doses were statistically identical in respect of pod length. On the other hand, the shortest pod (6.54 cm) was observed from the control (0 kg N ha^{-1}).

2.1.8 Weight of 1000 seeds

A pot experiment conducted by Razzaque *et al.* (2015) at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during kharif- II season (August to November) of 2010 to observed the nitrogen acquisition and yield of mungbean genotypes affected by different levels of nitrogen fertilizer in low fertile soil. Ten mungbean genotypes viz. IPSA-12, GK-27, IPSA-3, IPSA-5, ACC12890053, GK-63, ACC12890055, BARI Mung-6, BUmug- 4 and Binamoog- 5 and six nitrogen fertilizer levels viz. 0, 20, 40, 60, 80 and 100 kg N ha^{-1} were included as experimental treatments. Results indicated that, thousand seeds weight was not significantly affected by N fertilizer application.

Mahboob and Asghar (2002) studied the effect of seed inoculum at different nitrogen level on the yield and yield components of mungbean at the agronomic research station, Farooqabad in Pakistan during the year of 2000 and 2001. They revealed that with the application of NPK at the rate of 50-50-50 kg ha^{-1} significantly affected the 1000 seeds weight.

According to Hossen *et al*. (2015), application of N fertilizer at the rate of 45 kg $ha^{–1}$, the highest weight of 100–seed (4.52 g) was obtained by 30 kg N $ha^{–1}$ (4.35 g), while it was lowest (3.74 g) in control treatment (no nitrogen).

2.1.9 Seed yield

Haque *et al.* (2001) conducted a field experiment to study the effect of continued fertilizer, organic manure and mungbean residues on soil properties and yield of crops. The seed yield of mungbean increased significantly with increasing fertilizers over control. For mungbean (Binamoog-2) the maximum seed yield of 1.06 t ha^{-1} was obtained with inoculums + P10 K12 S4 kg ha^{-1} along with residual effect of fertilizer.

An experiment conducted by Hossen *et al*. (2015) at the research field of the Horticulture Research Center at Labukhali, Patuakhali to observe the most suitable BARI mungbean variety and optimum rates of N concerning higher seed yield under the local condition of Patuakhali (AEZ–13). They reported that, the higher weight of seeds $plant^{-1}$ (5.73 kg) was obtained from 45 kg N $ha^{–1}$ followed by 30 kg N $ha^{–1}$ (4.49 g) whereas it was lowest (1.78 g) in control or without N. Among the various doses of nitrogen, the seed production had higher (1.85 t ha^{-1}) in 45 kg N ha^{-1} followed by 30 kg N ha^{-1} (1.55 t ha^{-1}) and the minimum seed yield (0.99 t ha^{-1}) was obtained from the control treatment (no nitrogen).

According to Asaduzzaman *et al*. (2008), significantly maximum seed yield per plant (5.538 g) was produced in the treatment (30 kg N ha^{-1} as basal + one irrigation at flower initiation stage) and followed by T_3 (5.11 g) and also produced significantly maximum seed yield per hectare (1.65 t). The minimum yield per plant and per hectare was recorded from control and that was 3.64 g and 1.09 ton, respectively.

An experiment conducted by Sharma and Sharma (2006) for two years at the Indian Agricultural Research Institute, New Delhi on a sandy clay loam soil showed that the application of NP improved the total seed production of a rice-wheat-mungbean cropping system by 0.5-0.6 t ha^{-1}, NK by 0.3-0.5 t ha^{-1} and NPK by 0.8-0.9 t ha^{-1} compared to N alone, indicating that the balanced use of primary nutrients was more advantageous than their imbalanced application.

A field experiment was conducted to determine the effect of different NPK level (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 in Tandojam, Pakistan. The different NPK level significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording the highest seed yield of 1205.2 kg ha^{-1} (Oad and Buriro, 2005)

A study carried out by Kamal *et al.* (2001) at the BARI farm during the rainy season for 2000-2001 to find out the effect of various level of fertilizer and weeding of mungbean. Higher seed yield (1430 kg ha^{-1}) was recorded when fertilized @ 20-60-30 NPK kg ha^{-1} with two hand weeding at 20 and 30 DAE were used. This was followed by that obtained (1368 kg ha^{-1}) by using inoculum + 60-30 PK kg ha^{-1} with two hands weeding at 20 and 30 DAE. This result showed that application of fertilizer @ 20-60-30 kg ha^{-1} combine with two hands weeding at 20 and 30 DAE was economical for yield as well as quality seed production of mungbean.

2.2 Effect of organic fertilizer on crop attributes

Abraham and Lal (2003) carried out a field experiments from to investigate the effects of NPK fertilizer, organic manures (farm compost + vermicompost and farm compost + poultry manure) and biofertilizers on the productivity of black gram-wheat greengram cropping system. Pod counts for black gram and green gram and seed yield for wheat were highest with farm compost + poultry manure, but the maximum seed yield was recorded with farm compost + vermicompost inblack seed in the first year. The treatment biofertilizers + cow's urine recorded higher values of pod count in the first year and weight and seed yield in the second year in green gram.

Aktar *et al.* (2019) stated that plant height amplified progressively because of application of cowdung and poultry manure with inorganic fertilizers.

Bansal and Kapoor (1999) reported that mungbean (*Vigna radiata*) gave highest yield when cattle waste used. Maximum dry matter production occurred when cattle manure and rice straw inoculated with earthworms.

Kumar *et al.* (2003) revealed that FYM (farmyard manure) at 5 t/ha. vermieompost at 2.5 and 5 t/ha and 4 levels of fertilizers (control, no chemical fertilizer: 75% recommended dose of fertilizer. RDF; 100% RDF. N:P at 20:40 kg/ha; and 125% RDF) on the performance of munghean cv. Asha. Rhizobiu,n sp. inoculation significantly increased the seed yield. Increasing RDF levels up to 100% also increased seed yield. Vermieompost at 5 t/ha produced 16.5 and 9.5% higher seed yield compared to FYM at 5 t/ha and vermieompost at 2.5 t/ha, respectively. 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 ± vennicompost (both rates).

Mohammed *et al.* (2016) mentioned that significant variation in the number of pods per plant of lentil was observed due to different cowdung level. The highest number of pods plant^{-1} (55.9) produced in the treatment of inorganic fertilizer +1.5 t ha^{-1} cowdung.

Nandini Devi *et al.* (2013) noticed that the seed index of soybean was highest (12.86 g) with the integrated application of 75% RDF coupled with vermicompost at a rate of 1 t ha^{-1}. The above yield attributes was improved because of an adequate supply of nitrogen, phosphorus, potassium and sulphur to the crop at the early stages as well as steady supply of nutrient at later stages for application of manure.

An experiment carried out to study the effect of *Rhizobium* inoculation and various N sources on the growth and yield of cowpea cv. V-240. Vermicompost treated and *Rhizobium*-inoculated cowpea gave the highest plant height and dry matter plant^{-1} at 15, 30.45 and 60 days after sowing and at harvest. The highest number of nodules plant^{-1}, dry weight of nodules and number of pod plant^{-1} at harvest was obtained with *Rhizobium* inoculation and all N sources (Yadav and Malik 2005).

Khalilzadeh *et al.* (2012) directed a field experiment to investigate the effect of foliar spraying of Bio-organic fertilizers and urea on root and vegetative growth of mungbean (Vigna radiata L.) in a green-house condition. The experiment was conducted with four replications in Randomized Complete Design with ten treatments (Urea, Nitroxin, Amino acid, Green hum, Biocrop L-45, Nutriman N24 and Mas Raiz, cattle manure, water and control). Results showed that all traits were significantly affected by treatments apart from the number of second roots. Foliar application of urea and organic manure substantially improved the plant height, leaf area, shoot and root dry weights, root length, and number of roots. Similarly shoot and leave number and nodules root were also enhanced by the foliar spraying of Green hum and Amino acid, respectively. Whereas the lowest nodules root was observed in plants treated by nutriman N24 and urea. This improved growth of mainly because of nutrient availability in bio-organic fertilizer and uptake by plants.

2.3 Combined effect of organic and inorganic fertilizers

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 (*Vigna radiata*). 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, 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}), seeds yield (Kg ha^{-1}), harvest index (%) and seed protein contents (%) indicating primacy of integration of the two sources in having improved mungbean productivity.

While the effects of organic and inorganic fertilizers on mungbean (*Vigna radiata*) yield under arid climate were studied by Abbas *et al.* (2011), it was revealed that different combinations of organic and inorganic fertilizers significantly affected the pod number plant^{-1}, seed number pod^{-1} and seed yield. Maximum seed yield was obtained from the application of DAP at 124 Kg along with 10 tons ha^{-1} of poultry litter during both years, while application of DAP at 62 Kg and 10 tons of FYM ha^{-1} ranked second for seed yield.

Reddy and Reddy (1998) was conducted an experiment and completed that plant height at harvest, days to initial flowering, number of branches plant^{-1}, number of pods per plant, number of seeds pod^{-1} and yield were highest with 10 t ha^{-1} cowdung + 100% recommended NPK.

A field experiment conducted by Rupa *et al.* (2014) at Sher-e-Bangla Agricultural University farm during the time from February to April 2012 to study the effect of organic and inorganic fertilizers on growth and yield of mungbean (BARI Mung-5). Maximum numbers of pods/plant (25.6), seeds/pod (12.1), seeds/plant (312.6), seed yield/plant (14.6 g), 1000-seed weight (35.6 g), seed yield (1127.5 kg/ha), N content in seeds (3.39%), P content in seeds (0.35%) and K content in seeds (2.25%) was found from T_8 treatment whereas lowest was found from

Saleem *et al.* (2010) carried out an experiment of bio-economic effectiveness of maize-legumes based intercropping systems under different fertility treatments and its effects on subsequent wheat crop were evaluated at National Agriculture Research Center (NARC) Islamabad Pakistan. Higher CGR, NAR values were recorded of maize with half PM + half PK + inoculation. Wheat seed yield enhanced by 12 % and 11 % sown after mashbean and mungbean treated with PK (80:60 kg ha^{-1}) + Rhizobium inoculation correspondingly. In similar fashion, wheat seed yield enlarged by 20 % after 15 t ha^{-1} poultry manure and 15 % wheat seed yield was improved with poultry manure @ 7.5 t ha^{-1} + PK (40:30 kg ha^{-1}) + inoculation. In maize higher crop growth rate (CGR) and net assimilation rate (NAR) were registered in poultry manure plots 7.5 t ha^{-1} + PK (40:30 kg ha^{-1}) + inoculation treatment. Same variables increased the pH, NPK and organic matter in soil. Maize + mungbean with NPK (120:80:60 kg ha^{-1}) gave the maximum net benefit of Rs. 68720.75 ha^{-1} without wheat in succession and Rs. 96543.95 ha^{-1} with wheat in succession, respectively. According to partial financial statement analysis highest net benefit of Rs.148069.92 ha^{-1} was accrued in maize + mungbean – wheat sequence with half poultry manure + half PK + inoculation.

Rajkhowa *et al*. (2002) mentioned that the application of 100 per cent 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 pod^{-1} (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) carried out a field experiment to find out the effect of organic manures and inorganic fertilizers on growth and yield of mungbean (*Vigna radiata*). 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 seed 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}. Both varieties were equal in seed yield. Numbers of pods, number of seeds pod^{-1}, and 1000 seed weight were also almost higher in inorganic fertilizer treatment. The economic analysis revealed maximum net benefit from the treatment, where poultry manure was applied.

A pot experiment conducted by Shen *et al.* (2001) 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 CaCO3 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 CaCO3. Pig manure or wheat straw was more effective in ameliorating Al toxicity than was CaCO3. 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.

A study carried out by Ahmad *et al.* (2014) to optimizing the 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 tons ha^{-1}, T_2 include NPK at120-80-60 at kg ha^{-1}, T_3 using poultry manure at 20 tons ha^{-1}, T_4 included compost (Press mud) at 12.5 tons 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.

Saleem *et al.* (2011) conducted an experiment to evaluate the crop productivity of maize-legume intercropping system for yield and yield attributes under different fertility treatments at National Agriculture Research Center (NARC), Islamabad, Pakistan. According to results of the study it was revealed that half poultry manure +

half PK+ inoculation gave maximum maize seed yield of 4830.95 kg ha^{-1} and biological yield of 15330.29 kg ha^{-1} respectively, while cropping systems did not have an effect on seed and biological yields of maize to the significant extent. On the basis of agronomic as well as economic performance of maize + mungbean intercropping, it was well evident that combined use of organic, biofertilizers and chemical fertilizers was proved to be more dynamic and remunerative and can be recommended for maize growers to make higher income.

A field experiment carried out by Mollah *et al*. (2011) reported that in mungbean cultivation, the maximum seed yield (1384 kg/ha) was also recorded from NPKS for high yield goal with residual cowdung treatment. The results of NPKS application for high yield goal with residual cowdung had a positive effect on seed yield of mungbean. So, considering crop competence, and soil fertility, integrated plant nutrient management for high yield goal with 5 t/ha cowdung could be recommended for the Potato-Mungbean-T. *Aman* rice cropping pattern at Joypurhat.

2.4 Effects of plant density on growth and yield of mungbean

2.4.1 Effect on plant height

According to Rana *et al*. (2011), plant height did not differ significantly due to plant population up to 50 DAS but differed significantly thereafter and tallest plants at all the sampling dates were found in the 30 plants m^{-2}.

Mansoor *et al*. (2010) carried out an experiment with row spacings and seed rates and noticed that plant height were significantly affected by various seed rates and the tallest plants were observed in 20 cm row spacing and 40 kg ha^{-1} while the smallest plants in the treatment with 40 cm row spacing and 20 kg ha^{-1}.

Thakuria and Saharia (1990) stated that plant height increased with increasing number of plant population up to 330,000 plants ha^{-1} and further increased plant population will decreased plant height in mungbean.

2.4.2 Number of leaves plant^{-1}

An experiment conducted Taufiq and Kristiono (2016) at Muneng Experiment Farm in Probolinggo from March to May, 2013. Two factors consisted of five mung-bean genotypes (MMC679-2C-GT-2, MMC647d-GT-2, MMC554d-GT-2, MMC601f-GT-1 and Vima-1) and three levels of planting density (200,000, 333,333 and 500,000 plants ha^{-1}) were evaluated at two soil fertility managements (with and without fertilization).

The treatments were arranged in split plot design and replicated three times. The results of the research revealed that, maximum number of leaves plant^{-1} (10.00) was recorded from 200,000 plant ha^{-1} whereas the minimum (6.00) number of leaves plant^{-1} was recorded from 500,000 plant ha^{-1}.

2.4.3 Number of branches plant^{-1}

A field trial carried out by Rasul *et al.* (2012) to found the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mungbean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacing (S_1-30 cm, S_2- 60 cm and S_3- 90 cm) respectively. The results exposed that, the inter-row spacing of 30 cm affected the plant to produce more number of branches (6.24) and was statistically at par with that of inter-row spacing of 45 cm which produced 6.20 numbers of branches. The lowest number of branches per plant (5.93) was produced at inter-row spacing of 60 cm.

An experiment conducted by Kabir and Sarkar (2008) to study the effect of variety and planting density on the yield of mungbean in *Kharif* season (February to June). They were observed that, the highest number of branches plant^{-1} (2.33) was observed at 30 cm × 10 cm spacing and the lowest number of branches plant^{-1} (1.57) was observed at plant spacing 20 cm × 20 cm.

2.4.4 Dry matter weight plant^{-1}

Rao *et al.* (2015) investigated the extent and physiological bases of yield variation due to row spacing and plant density configuration in the mungbean (*Vigna radiata*) variety "Crystal" grown in different subtropical environments. They concluded that, the narrow row spacing resulted in 22% higher shoot dry matter compared to the wide rows.

An experiment conducted by Kebede *et al.* (2015) in 2012 main cropping season at Haramaya and Hirna research fields, eastern Ethiopia, to find out the effect of plant spacing and weeding frequency on weeds, yield components and yield of common bean. The experiment comprised 18 treatment combinations with three inter- and intra-row plant spacing, respectively, (30 cm × 10 cm, 30 cm × 15 cm, 40 cm × 10 cm) and six weeding frequencies (one weeding by hand hoeing two weeks after crop emergence, one weeding by hand-hoeing three weeks after crop emergence, one weeding by hand-hoeing four weeks after crop emergence, two weeding by hand hoeing two and five weeks after crop emergence, weed-free check, weedy check). It was observed that, plant spacing had no significant influence on above ground dry weight.

2.4.5 Number of pods plant^{-1}

Zaher *et al.* (2014) directed an experiment with four row spacing (S_1 = 15 cm, S_2 = 20 cm, S_3 = 25 cm and S_4 = 30 cm) and four weeding treatments (W_0 = No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 days after sowing (DAS) and W_3 = Weeding at 15, 30 and 45 days after sowing (DAS) were used and results showed that the highest number of pods plant^{-1} (43.29) was gained by 30 cm row spacing with three times of weeding.

From an experiment carried out by Mansoor *et al*. (2010) and revealed that number of pod clusters plant^{-1} were significantly affected by various seed rates.

2.4.6 Pod length

Zaher *et al.* (2014) conducted an experiment with four row spacing (S_1 = 15 cm, S_2 = 20 cm, S_3 = 25 cm and S_4 = 30 cm) and four weeding treatments (W_0 = No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 days after sowing (DAS) and W_3 = Weeding at 15, 30 and 45 days after sowing (DAS) were used and observed the highest pod length (6.69 cm) from 30 cm row spacing with three times of weeding.

According to Mansoor *et al*. (2010), pod length was significantly affected by various seed rates and the pods with maximum length were recorded in plots having 20 cm row spacing and 20 kg ha^{-1}.

Singh *et al.* (2003) conducted an experiment to investigate the effect of three seed rates (15, 20 and 25 kg ha^{-1}) on mungbean and reported that seed rate had no significant influenced on pod length. Similar result was found by Chowdhury (1999) in mungbean who stated that seed rate had no influenced on pod length because of seed size is mainly controlled by gene not by environment.

2.4.7 Number of seeds pod^{-1}

Zaher *et al.* (2014) conducted an experiment with four row spacing (S_1 = 15 cm, S_2 = 20 cm, S_3 = 25 cm and S_4 = 30 cm) and four weeding treatments (W_0 = No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 days after sowing (DAS) and W_3 = Weeding at 15, 30 and 45 days after sowing (DAS) were used and found the highest number of seeds pod^{-1} (9.43) was recorded by 30 cm row spacing with three times of weeding.

According to Chowdhury (1999), the number of seeds pod^{-1} decreased with increasing plant density in mungbean. The better number of seeds pod^{-1} was observed with lower seed rates of 20 kg ha^{-1} over 25 and 30 kg ha^{-1}.

2.4.8 Weight of 1000 seeds

Kabir *et al*. (2016) carried out a field experiment to find out the effect of plant growth regulator (NAA) and row spacing on growth and yield of mungbean. The results indicated that, the maximum 1000 seeds weight (44.26 g) was obtained from the 30 cm × 10 cm spacing (P_2) treatment whereas, the minimum 1000 seeds weight (37.72 g) was observed from the 20 cm × 10 cm spacing (P1) treatment, which was statistically similar in the 40 cm × 10 cm spacing i.e., P_3 treatment (40.00 g).

A field trial conducted by Rasul *et al.* (2012) to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mungbean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacing (S_1-30 cm, S_2- 60 cm and S_3- 90 cm) respectively. The results revealed that, among the inter-row spacing treatments, the maximum 1000-seed weight (49.30 g) was obtained at 60 cm inter-row spacing while the minimum one (46.31 g) was recorded from 30 cm inter-row spacing.

An experiment carried out by Kabir and Sarkar (2008) to study the effect of variety and planting density on the yield of mungbean in *Kharif*-I season (February to June) of 2003. They were observed that, the highest 1000-seed weight (32.06 g) was observed at 40 cm × 30 cm spacing followed in order by 30 cm × 10 cm (31.93 g) and the lowest one (31.38 g) was from plant spacing 20 cm × 20 cm

2.4.9 Seed yield

Zaher *et al.* (2014) conducted an experiment with four row spacing (S_1 = 15 cm, S_2 = 20 cm, S_3 = 25 cm and S_4 = 30 cm) and four weeding treatments (W_0 = No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 days after sowing (DAS) and W_3 = Weeding at 15, 30 and 45 days after sowing (DAS) were used. Results revealed that the highest seed yield (1591 kg ha^{-1}) and biological yield (3964 kg ha^{-1}) were gained by 30 cm row spacing with three times of weeding.

Kabir and Sarkar (2008) carried out an experiment to study the effect of variety and planting density on the yield of mungbean in *Kharif*-I season. The experiment comprised five varieties viz. BARIMung-2, BARIMung-3, BARIMung-4, BARIMung-5 and BINAMung-2 and three spacing of planting viz. 30 cm × 10 cm, 20 cm × 20 cm and 40 cm × 30 cm. Plant spacing of 30 cm × 10 cm produced the highest seed yield of mungbean while 40 cm × 30 cm spacing produced the lowest seed yield.

According to Singh *et al.* (2003), plant density of mungbean may play an important role in interception of solar radiation, which might increase the yield. Many mungbean researchers mentioned that plant density had tremendous result on growth and yield of mungbean. They also reported that seed yield increased with increasing seed rate in mungbean.

2.4.10 Harvest index (%)

Zaher *et al.* (2014) directed a field experiment with four row spacing (S_1 = 15 cm, S_2 = 20 cm, S_3 = 25 cm and S_4 = 30 cm) and four weeding treatments (W_0 = No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 days after sowing (DAS) and W_3 = Weeding at 15, 30 and 45 days after sowing (DAS) were used. The highest harvest index (44.26%) was achieved by 25 cm row spacing with two times of weeding.

According to Mansoor *et al*. (2010), harvesting index % was significantly affected by various seed rates and maximum harvest index % was recorded in plots with 40 cm row spacing and 20 kg ha^{-1}.

Mondal (2007) mentioned that seed yield is positively correlated with harvest index in mungbean in a population pressure study (250,000, 333,333, 400,000 or 500,000 plants ha^{-1}).

Harvest index is a measure of the efficiency of conversion of photosynthate into economic yield of a crop plant. Increased harvest index results in increased crop yield, probably because of improved partitioning of dry matter to reproductive parts (Gautom and Sharma, 1987).

CHAPTER 3

MATERIALS AND METHODS

Details of different materials used and methodologies followed in the experiment are presented in this chapter.

3.1 Experimental site

The experiment was conducted at the Agronomy Field at Sher-e-Bangla Agricultural University, Dhaka during the period from March to June, 2019 on "Combined effect of organic and inorganic fertilizers on growth and yield of mungbean under different plant spacing". Field view of the experimental field is shown in Appendix I.

3.2 Soil

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 are presented in Appendix III.

3.3 Climate

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.

3.4 Experimental details

3.4.1 Planting materials

The variety of mungbean used for the study conducted was BARI mung-5. The seeds of this variety were collected from the Pulses Research Station of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The important characteristic of this variety is mentioned below:

3.4.1.1 BARI mung-5 (Taiwani)

The variety was released by Bangladesh Agricultural Research Institute (BARI) in 1997. Average plant height is 40-45 cm. Leaves, pods and seeds are comparatively large. Leaves and seeds are darker green. Average weight of thousand seeds is 40-42 g. The variety is resistant to Cercospora leaf spot and yellow mosaic virus. Maximum seed yieldis 1.2-1.5 t ha^{-1}. Seeds contain 20-22 % protein and 49.46% carbohydrate.

3.4.2 Experimental treatments

Two factors were included in the experimcnt namely, Spacing and Fertilizer. The treatments were designated as follows:

Factor-A: Spacing-3

S_1 = 20 cm × 10 cm

S_2 = 30 cm × 10 cm (Recommended)

S_3 = 45 cm × 15 cm

Factor-B: Fertilizer combination-6

F_0 = Control

F_1 = Recommended dose of NPK

F_2 = 5 t ha^{-1} cowdung

F_3 = 5 t ha^{-1} cowdung + Recommended dose of NPK

F_4 = 2.5 t ha^{-1} cowdung + Recommended dose of NPK

F_5 = 2.5 t ha^{-1} cowdung + ½ Recommended dose of NPK

There were in total 18 (3×6) treatment combinations such as S_1F_0, S_1F_1, S_1F_2, S_1F_3, S_1F_4, S_1F_5, S_2F_0, S_2F_1, S_2F_2, S_2F_3, S_2F_4, S_2F_5, S_3F_0, S_3F_1, S_3F_2, S_3F_3, S_3F_4, S_3F_5

3.5 Experimental design and layout

The experiment was laid out in split-plot design having three replications. Spacing level placed in the main plot whereas fertilizer in the sub plots. There were 18 treatment combinations and 54 unit plots. The unit plot size was 3 m^2 (2 × 1.5 m^2). The main plot and sub-plot plots were separated by 1.0 m and 0.50 m spacing, respectively. Experimental design and layout is shown in Appendix II.

3.6 Procedure of the experiment

3.6.1 Land preparation

The experimental land was opened with a power tiller on 12 March, 2019. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 18 March, 2019 and was ready for sowing seeds.

3.6.2 Fertilizer application

The recommanded chemical fertilizers were applied as 40, 80, 30 kg ha^{-1} of Urea, TSP, MoP. All the fertilizers and cowdung were to as per treatment by broadcasting and were mixed with soil thoroughly at the time of final land preparation after making plot.

3.6.3 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.6.3.1 Thinning

After emergence of the seedlings the thinning was done where necessary on 30 March, 2019 (10 DAS) to maintain the recommended plant population $plot^{-1}$ which was specified in the experiment.

3.6.3.2 Weeding

The experimental plots were weeded two times. First weeding was done at the time of thinning (10 DAS) and second weeding on 27 DAS.

3.6.3.3 Irrigation and drainage

Irrigation water was added thrice to each plot, first irrigation was done as pre-sowing and other two were given at 15 DAS and 30 DAS, respectively.

3.6.3.4 Plant protection measures

Pest did not infest the mungbean crop at the early stage. The insecticide Sumithion 57 EC was sprayed @ 0.02% at the period of pod formation to control pod borer. No disease was observed in the experimental field.

3.7 Determination of maturity

At the time when 80% of the pods turned brown colour, the crop was assessed to attain maturity.

3.8 Harvesting and sampling

The crops were harvested at a time due to synchronous maturity of pods. At first 70% of early matured pods were harvested by hand picking at 58 days after sowing. Finally 4 days after first harvesting all plants were harvested plot-wise by uprooting and were bundled separately, tagged and brought to the threshing floor of the SAU farm. All of the harvested pods were kept separately in properly tagged gunny bags. Ten plants were randomly selected prior to maturity from each plot for data recording.

3.9 Threshing

The crop bundles were sundried for two days by placing them on threshing floor. Seed were separated from the plants by beating the bundles with bamboo sticks.

3.10 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to about 14% level. The dried seeds and straw were cleaned and weighed.

3.11 Data recorded on growth and yield parameters

3.11.1 Plant height (cm)

The plant height was measured from base of the plant to the tip of the main shoot for five randomly tagged plants with the help of scale at 15, 30, 45 DAS and harvest. The average of five plants was computed and expressed as the plant height in centimeters.

3.11.2 Number of leaves per plant

The numbers of green trifoliate leaves present on each plant were counted manually from the five tagged plants at 15, 30, 45 DAS and harvest. The mean number of leaves per plant was calculated and expressed in number per plant.

3.11.3 Number of branches per plant

The total number of branches originating from the main stem was counted at 30, 45 DAS and harvest from five earlier tagged plants. Average was worked out and expressed as number of branches per plant.

3.11.4 Number of pods per plant

The total number of pods from five randomly selected plants was counted manually from each treatment. Average was worked out and recorded as number of pods per plant.

3.11.5 Weight of oven dried per plant(g)

Five plants were collected and dried in the electric oven maintaining a temperature of $85^0 \pm 5^0$ C for 24 hours and dry weight was recorded with an electric balance at 15, 30, 45 DAS and harvest from three plants.

3.11.6 Number of seeds pod^{-1}and seed yield plant^{-1}(g)

Five pods were selected at random from the total number of pods harvested from tagged five plants. The seeds from each pod were separated, counted and average was worked out and expressed as number of seeds pod^{-1}.The yield of seeds from five randomly selected plants were counted from each treatment. Average was calculated and recorded as seed yield plant^{-1}(g).

3.11.7 Weight of thousand seed (g)

One hundred seeds were counted from the seed sample of each plot randomly 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.

3.11.8 Seed yield (kg ha^{-1})

The seed yield obtained from the net plot area 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 per plant was recorded in gram. The seed yield per hectare was computed and expressed in kg per hectare.

3.11.9 Straw yield (t ha^{-1})

After pod separation the plants were sundried for several days to a constant weight. Then the straw yield expressed in ton per hectare.

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

Biological yield was calculated using the following formula:

Biological yield = Seed yield + straw yield

3.11.11 Harvest index (%)

Harvest index was calculated with the following formula:

$$\text{Harvest Index} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.12 Statistical analysis

Data recorded for different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done following computer package MSTAT-C programme. Mean differences among the treatments were tested with Least Significant Differences (LSD) at 5% level.

CHAPTER IV

RESULTS AND DISCUSSION

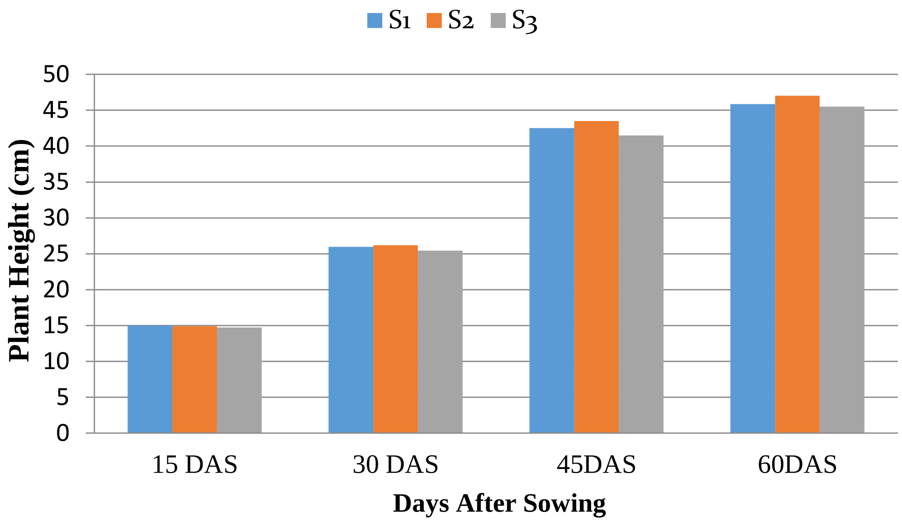
The data on different growth, yield contributing characters and yield were recorded to find out the suitable spacing and nutrient management on Mungbean. The results have been presented and discussed and possible explanations have been given under the following headings:

4.1. Growth parameters

4.1.1. Plant height

4.1.1.1 Effect of different spacing

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. From this experiment, result revealed that there was significant effect of spacing on plant height (Fig, 1 and Appendix IV). Highest plant height (14.99 cm was observed from the treatment of S_1 at 15 DAS which was statistically similar (14.91 cm) with S_2 treatment at 15 DAS. At 30, 45 and 60 DAS maximum plant height (26.18, 43.50 and 47.01 cm) was observed from S_2 treatment which was statistically similar (25.95 and 42.5 cm) with S_1 treatment at 30 and 45 DAS. Whereas lowest plant height (14.75, 25.45, 41.5 and 45.51 cm) was observed from the treatment of S_3 which was statistically similar (45.51) with S_3 treatment at 60 DAS. Plant height might be varied in different crops due to plant spacing; similar findings were also reported by Mansoor *et al*. (2010) in mungbean.

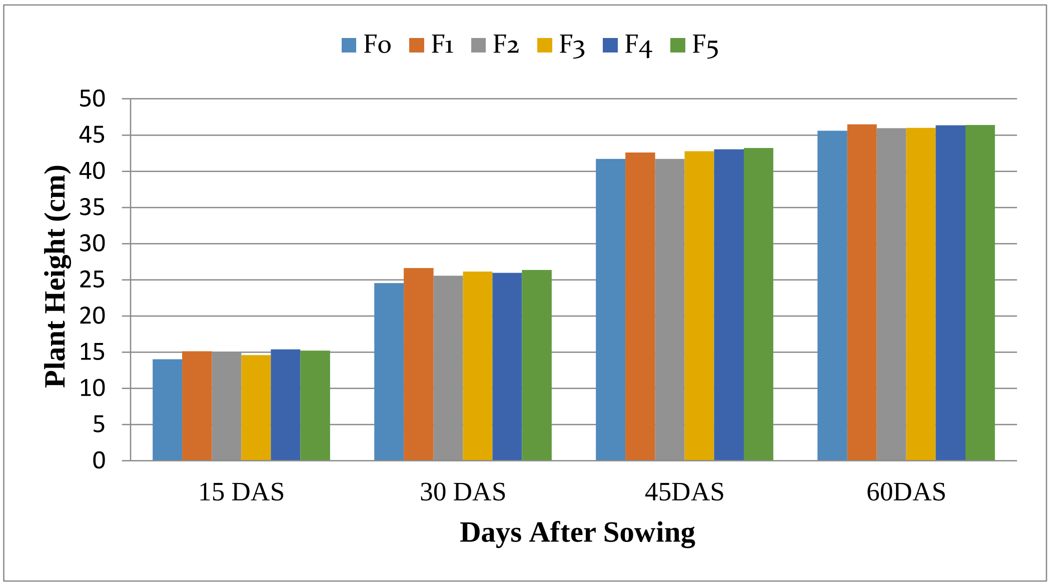


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 1. Effect of spacing on plant height of mungbean at different days after sowing [LSD $_{(0.05)}$ 0.17, 0.53, 1.03 and 0.45 at 15, 30, 45 and 60 DAS]

4.1.1.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant variation on plant height at different days after sowing (Fig, 2 and Appendix IV). Result revealed that highest plant height (15.40 cm at 15 DAS) was observed from the treatment of F_4 which was statistically similar (15.211 cm) with the treatment of F_5. At 30 DAS F_1 treatment showed highest plant height (26.622 cm) followed by F_5 (26.35 cm) and F_3 (26.15 cm) treatments which was also expressed statically similar result. At 45 DAS F_3 treatment showed highest plant height (42.77 cm) followed by F_5 (43.19 cm) and F_3 (42.77 cm) and F_1 (42.77 cm) treatments which was also expressed statically similar result. At 60 DAS, F_1 treatment showed highest plant height (46.48cm) followed by F_5 (46.40) and F_4 (46.36cm) expressed statically similar result. Whereas Lowest plant height (14.01, 24.52, 41.70 and 45.61 cm at 15, 30 45 and 60 DAS respectively) was observed from the treatment of F_0 which was statistically similar with F_2 (25.56 cm and 45.94 cm) treatment at 45 DAS and 60 DAS; and similar with F_3 (45.98 cm) treatment at 60 DAS. Similar findings were found by many scientists while experimenting with various crops. Combination of organic and inorganic fertilizers was create better by Channaveerswami (2005) in groundnut and Rajkhowa *et al*. (2002) in green gram than only inorganic fertilizers.



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 2. Effect of combination of organic and inorganic fertilizers on plant height of mungbean [LSD $_{(0.05)}$ = 0.21, 0.64, 0.96 and 0.47 at 15, 30, 45 and 60 DAS]

4.1.1.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and combination of organic and inorganic fertilizers showed significant variation on plant height at different days after sowing (Table 1). Result exhibit that highest plant height (15.73 cm) at 15 DAS was observed from the treatment combination of S_1F_5.Statically similar result (15.67, 15.6 and 15.37 cm) also exhibited at 15 DAS from the treatment combination of S_3F_1 followed by S_1F_4 and S_3F_4 treatment combination. At 30 DAS highest plant height (27.8cm) was observed from the treatment combination of S_2F_1 which was statically similar with (27.35 and 26.76cm) from S_1F_5 and S_3F_1 treatment combination. At 45 DAS 60 DAS highest plant height (45.07 and 48.15cm) was observed from the treatment combination of S_2F_5 which was statically similar with (44.21, 43.55 and 43.45 cm) from $S_2F_{4,}$ $S_2F_{3,}$ and S_1F_4 treatment combination at 45 DAS; with (47.51 and 47.51 cm) from S_2F_2 and S_2F_4 treatment combination at 60 DAS. Whereas the lowest plant height (13.2 and 23.86 cm) at 15 and 30 DAS were observed from the treatment combination of $S_3F_{0.}$ Statistically similar result (23.99 and 23.86 cm) with S_3F_2 and S_1F_0 treatment combination were observed at 30 DAS. At 45 and 60 DAS lowest plant height (40.37 and 44.53cm) were observed from the treatment combination of $S_3F_{2.}$ which was statistically similar with (40.91, 41.47, 41.48, 41.74, 41.75, 41.81 and 42.06 cm with S_1F_0, S_3F_4, S_3F_5, S_1F_2, S_3F_1, S_3F_3 and S_2F_0 treatment combination; at 60DAS statistically similar result (45.13, 45.19, 45.23 and 45.34 cm) also found with the treatment combination of S_1F_0, S_3F_4, S_3F_5 and S_2F_0.

Table 1. Interaction effect of spacing and combination of organic and inorganic fertilizers on plant height of mungbean at different days after sowing

Treatment Combinations	Plant Height (cm)			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
S_1F_0	14.03i	24.59fg	40.91ef	45.13gh
S_1F_1	14.57gh	25.31d-f	42.95b-d	45.97d-f
S_1F_2	15.35b-d	26.05c-e	41.74c-f	45.79d-g
S_1F_3	14.7gh	26.29b-d	42.95b-d	46.07de
S_1F_4	15.6a-c	26.14c-e	43.45a-c	46.39cd
S_1F_5	15.73a	27.35ab	43.01b-d	45.84d-g
S_2F_0	14.8fg	25.13ef	42.06c-f	45.34e-h
S_2F_1	15.1d-f	27.8a	43.11b-d	47.09bc
S_2F_2	14.7gh	26.63bc	43.01b-d	47.51ab
S_2F_3	14.43h	25.98c-e	43.55a-c	46.49cd
S_2F_4	15.23c-e	25.89c-e	44.21ab	47.51ab
S_2F_5	15.17de	25.65c-f	45.07a	48.15a
S_3F_0	13.2j	23.86g	42.13c-e	46.35cd
S_3F_1	15.67ab	26.76a-c	41.75c-f	46.39cd
S_3F_2	14.93e-g	23.99g	40.37f	44.53h
S_3F_3	14.6gh	26.17c-e	41.81c-f	45.39e-g
S_3F_4	15.37a-d	25.89c-e	41.47d-f	45.19f-h
S_3F_5	14.73f-h	26.05c-e	41.48d-f	45.23e-h
$LSD_{(0.05)}$	0.36	1.11	1.67	0.82
CV (%)	1.46	2.58	2.35	1.06

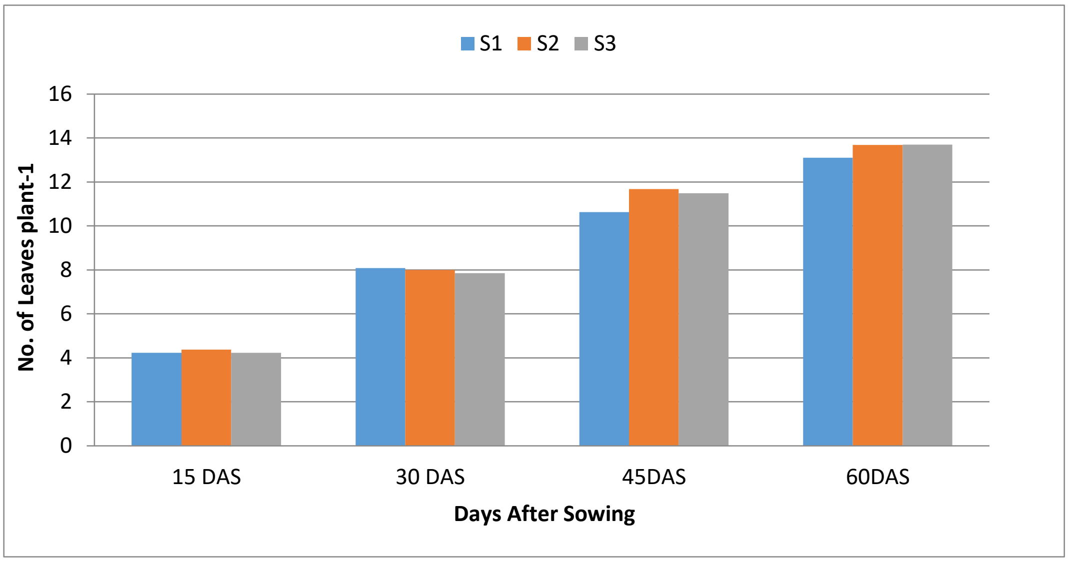
Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

4.1.2. Number of leaves plant^{-1}

4.1.2.1 Effect of different spacing

Different plant spacing showed significant effect on number of leaves plant^{-1}(Fig, 3 and Appendix V). From the experiment result exhibited that the maximum number of leaves plant^{-1} (4.38) was observed from the S_2 treatment at 15 DAS. At 30 DAS maximum number of leaves plant^{-1}(8.09) was observed from the S_1 treatment. At 45 DAS and 60 DAS maximum number of leaves plant^{-1} (11.68 and 13.70) was observed from the S_2

treatment which was statistically similar (11.49 and 13.68) with S_3 treatment at 45 DAS and 60 DAS. Whereas minimum number of leaves plant^{-1} (4.22) at 15 DAS was observed from the S_1 treatment with was statistically similar (4.22) with S_3 treatment. At 30 DAS minimum number of leaves plant^{-1}(7.84) was observed from the S_3 treatment and at 45 DAS and 60 DAS minimum number of leaves plant^{-1} (10.62 and 13.09) was observed from the S_1 treatment. This result was coincided with the result of Rasul *et al.* (2012). The inter-row spacing also affected the leaves of mungbean which might be because of variable availability of light, nutrients, etc. in case of varying spacing. These results were in agreement with those of Khan (2000).

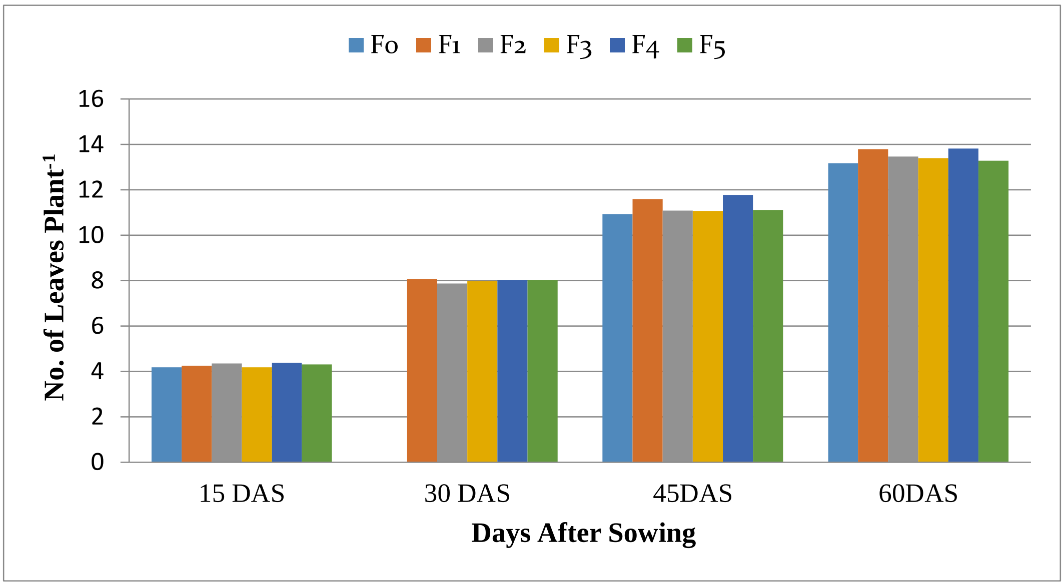


Note: S_1: 20 cm × 10 cm, S_2: 30 cm× 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 3. Effect of spacing on number of leaves plant^{-1} of mungbean at different days after sowing [LSD $_{(0.05)}$ = 0.05, 0.07, 0.20 and 0.29 at 15, 30, 45 and 60 DAS]

4.1.2.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on number of leaves plant^{-1} (Fig, 4 and Appendix V). From the experiment result exhibited that the maximum number of leaves plant^{-1}(4.38) was observed from the F_4 treatment at 15 DAS which was statistically similar (4.36) with F_2 treatment. At 30 DAS maximum number of leaves plant^{-1}(8.07) was observed from the F_1 treatment which was statistically similar (8.02 and 8.02) with F_4 and F_5 treatment. At 45 DAS maximum number of leaves plant^{-1}(11.79) was observed from the F_4 treatment which was statistically similar (11.60) with F_1 treatment and finally at 60 DAS maximum number of leaves plant^{-1}(13.82) was observed from the F_4 treatment which was statistically similar(13.79) F_1 treatment. Whereas minimum number of leaves plant^{-1} (4.18) at 15 DAS was observed with F_0 treatment which was statistically similar with (4.18) F_3 treatment. At 30 DAS minimum number of leaves plant^{-1} (7.87) was observed from F_2 which was statistically similar with (7.91) F_0 treatment. At 45 DAS and 60 DAS minimum number of leaves plant^{-1} (10.93 and 13.18) was observed from F_0 which was statistically similar with (11.09 and 11.11) F_2 and F_5 treatment at 45 DAS and with (13.29 and 13.18) from F_5 and F_3 treatment. The present results uphold with the findings of Mondal *et al.* (2014) where they concluded that leaf area per plant of mungbean was significantly increased by the split application of different doses of inorganic fertilizer.



Note: F_0 = Control, F_1 = Recommended NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended NPK

Figure 4. Effect of combination of organic and inorganic fertilizers on number of leaves plant^{-1} of mungbean [LSD $_{(0.05)}$ = 0.05, 0.08, 0.19 and 0.24 at 15, 30, 45 and 60 DAS]

4.1.2.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and combination of organic and inorganic fertilizers showed significant variation on number of leaves plant^{-1} at different days after sowing (Table 2). From the data result showed that maximum number of leaves plant^{-1} (4.67) was observed from the treatment combination of S_2F_5 at 15 DAS. At 30 DAS maximum number of leaves plant^{-1} (8.47) was observed from the treatment combination of S_1F_4. At 45 DAS and 60 DAS maximum number of leaves plant^{-1}(12.40 and 14.40) was observed from the treatment combination of S_3F_1 which was statistically similar with (12.27, 12.13, 12.07 and 12.07) from S_2F_0, S_2F_4, S_2F_2 and S_3F_4 at 45 DAS and with (14.33, 14.27 and 14.07) from S_2F_2, S_3F_4 and S_2F_0 treatment combination. Whereas minimum number of leaves plant^{-1} (4.07) was observed from the treatment combination of S_3F_5 at 15 DAS which was statistically similar(4.13, 4.13, 4.13, 4.13 and 4.13) with S_3F_3, S_3F_1, S_3F_0, S_1F_3 and S_1F_1 treatment combination. At 30DAS minimum number of leaves plant^{-1} (7.53) S_3F_2 treatment combination which was statistically similar (7.53 and 7.60) with S_2F_4 and S_3F_0 treatment combination. At 45 DAS and 60 DAS minimum number of leaves plant^{-1} (9.67 and 12.4) from S_1F_0 treatment combination which was statistically similar (12.8 and 12.8) with S_2F_5 and S_1F_2 treatment combination at 60 DAS.

Table 2. Interaction effect of spacing and combination of organic and inorganic fertilizers on number of leaves plnat^{-1} of mungbean at different days after sowing

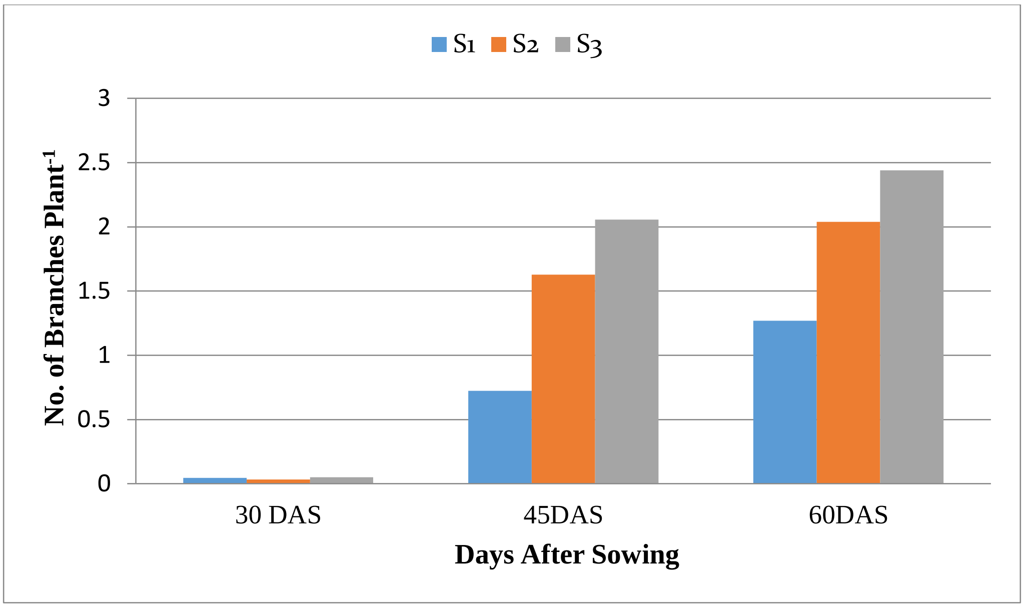
Treatment Combinations	Number of leaves			
	15 DAS	30 DAS	45DAS	60DAS
S_1F_0	4.2de	8cd	9.67h	12.4i
S_1F_1	4.13ef	8cd	10.93ef	13.3e-g
S_1F_2	4.2de	8.13bc	10.2g	12.8hi
S_1F_3	4.13ef	7.93de	11.13c-e	13.2f-h
S_1F_4	4.47b	8.47a	11.13c-e	13.67c-e
S_1F_5	4.2de	8cd	10.67f	13.2fh
S_2F_0	4.2de	8.13bc	12.27a	14.07a-c
S_2F_1	4.47b	8.13bc	11.47c	13.67c-f
S_2F_2	4.33c	7.93de	12.07ab	14.33ab
S_2F_3	4.27cd	8.2b	11.33c-d	13.67c-f
S_2F_4	4.33c	7.53f	12.13ab	13.53d-g
S_2F_5	4.67a	8.07bd	10.8ef	12.8hi
S_3F_0	4.13ef	7.6f	10.87ef	13.07gh
S_3F_1	4.13ef	8.07bd	12.4a	14.4a
S_3F_2	4.53b	7.53f	11d-f	13.27e-h
S_3F_3	4.13ef	7.8e	10.73f	13.33e-g
S_3F_4	4.33c	8.07bd	12.07ab	14.27ab
S_3F_5	4.07	8cd	11.87b	13.87b-d
$LSD_{(0.05)}$	0.09	0.15	0.34	0.42
CV (%)	1.23	1.11	1.79	1.85

Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

4.1.3 Number of branches plant^{-1}

4.1.3.1 Effect of different spacing

Different plant spacing showed significant effect on number of branches plant^{-1} (Fig, 5 and Appendix VII). From the experiment result exhibited that the maximum number of branches plant^{-1} (0.05, 2.06 and 2.44 at 30 DAS, 45 DAS and 60 DAS) was observed from S_3 treatment. Whereas minimum number of branches plant^{-1} (0.03) was observed from S_2 treatment at 30 DAS. At 45 DAS and 60 DAS minimum number of branches plant^{-1} (0.73 and 1.27) was observed from S_2 treatment. Spacing increases the number of branches per plant; it was also reported by Taufiq and Kristiono (2016), Rasul *et al.* (2012).

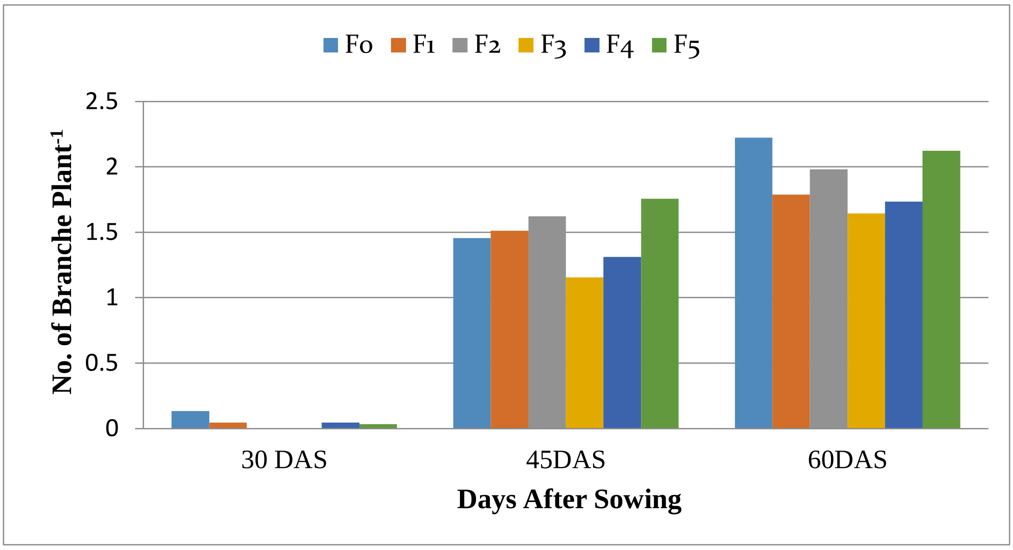


Note: S_1: 20 cm × 10 cm, S_2: 30 cm× 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 5. Effect of spacing on number of branches plant^{-1} of mungbean at different days after sowing [LSD $_{(0.05)}$ = 0.0003, 0.07 and 0.09 at 30, 45 and 60 DAS]

4.1.3.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on number of branches plant^{-1} (Fig, 6 and Appendix VII).From the experiment result exhibited that the maximum number of branches plant^{-1} (0.13) at 30 DAS was observed from F_0 treatment. At 45 DAS maximum number of branches plant^{-1} (1.76) F_5 treatment and at 60 DAS maximum number of branches plant^{-1} (2.22) F_0 treatment. Whereas minimum number of branches plant^{-1} (0.00 and 0.00) at 30 DAS were observed from F_2 treatment followed by F_3 treatment and at 45 and 60 DAS minimum number of branches plant^{-1} (1.16 and 1.64) was observed from F_3 treatment. The result obtained from the present study was similar with the findings of Achakzai *et al*. (2012) and Malik *et al.* (2003).



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 6. Effect of combination of organic and inorganic fertilizer on number of branches plant^{-1} of mungbean at different days after sowing [LSD $_{(0.05)}$ = 0.0003, 0.08 and 0.08 at 30, 45 and 60 DAS]

4.1.3.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction of spacing and combination of organic and inorganic fertilizer showed significant variation on number of branches plant^{-1} at different days after sowing (Table 3). From the data result showed that maximum number of branches plant^{-1} (0.20) was observed from the treatment combination of S_1F_0 at 30 DAS. At 45 DAS maximum number of branches plant^{-1} (2.27) was observed from the treatment combination of S_3F_0 which was statistically similar (2.20 and 2.20) with S_3F_1 and S_3F_5 treatment combination. And at 60 DAS maximum number of branches plant^{-1} (2.70) was observed from the treatment combination of S_3F_5 which was statistically similar (2.60) was observed from the treatment combination of S_3F_4. Whereas minimum number of branches plant^{-1} (0.00) was observed from the treatment combination S_3F_3 which was statistically similar with S_3F_2, S_3F_1, S_2F_5, 2_3F_3, S_2F_2, S_1F_5, S_1F_5, S_1F_4, S_1F_3 and S_1F_2 treatment combination at 30 DAS; with (0.33 and 0.87) at 45 and 60 DAS was observed from the treatment combination of S_1F_1 which was statistically similar with S_1F_4 followed by S_1F_3 at 60DAS.

Table 3. Interaction effect of spacing and combination of organic and inorganic fertilizers on number of branches plnat^{-1} of mungbean at different days after sowing

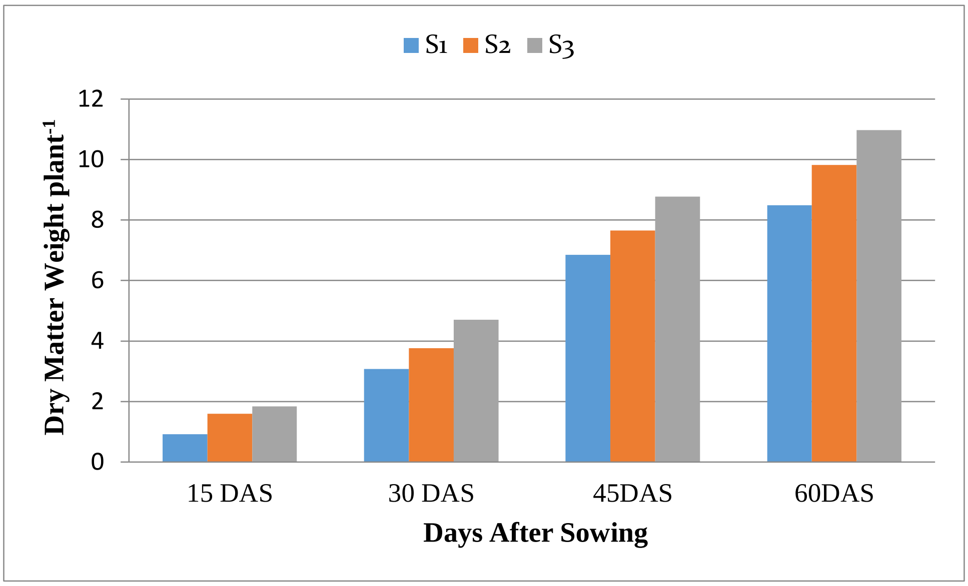
Treatment Combinations	Number of ranch/Plant		
	30 DAS	45 DAS	60 DAS
S_1F_0	0.2a	0.47i	1.67hi
S_1F_1	0.07d	0.33j	0.87k
S_1F_2	0e	1.33fg	1.75hi
S_1F_3	0e	0.53i	1k
S_1F_4	0e	0.6i	1k
S_1F_5	0e	1.07h	1.33j
S_2F_0	0.07d	1.63d	2.47b-d
S_2F_1	0.07d	2c	2.1e
S_2F_2	0e	1.47ef	1.8gh
S_2F_3	0e	1.4efg	1.93fg
S_2F_4	0.07d	1.27g	1.6i
S_2F_5	0e	2c	2.33d
S_3F_0	0.13b	2.27a	2.53bc
S_3F_1	0e	2.2ab	2.4cd
S_3F_2	0e	2.07bc	2.4cd
S_3F_3	0e	1.53de	2ef
S_3F_4	0.07d	2.07bc	2.6ab
S_3F_5	0.1c	2.2ab	2.7a
$LSD_{(0.05)}$	.0005558	0.14	0.14
CV (%)	7.83	5.56	4.44

Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

4.1.4 Dry matter weight plant^{-1} (g)

4.1.4.1 Effect of different spacing

Different plant spacing showed significant effect on dry matter weight plant^{-1} (g) (Fig, 7 and Appendix VI). From the experiment result exhibited that the maximum dry matter weight plant^{-1} (1.84, 4.70, 8.78 and 10.97 g at 15 DAS, 30 DAS, 45 DAS and 60 DAS) was observed from the S_3 treatment. Whereas minimum dry matter weight plant^{-1} (0.92, 3.08, 6.85 and 8.49 g at 15 DAS, 30 DAS, 45 DAS and 60 DAS) was observed from the S_1 treatment. Due to minor number of plants per unit area in lower population levels, there was less intra plant competition for nutrient, moisture, light and other resources, so they got chance to grow strongly and accumulate more dry matter. This was in conformity with Rana *et al*. (2011); Kabir and Sarkar (2008).

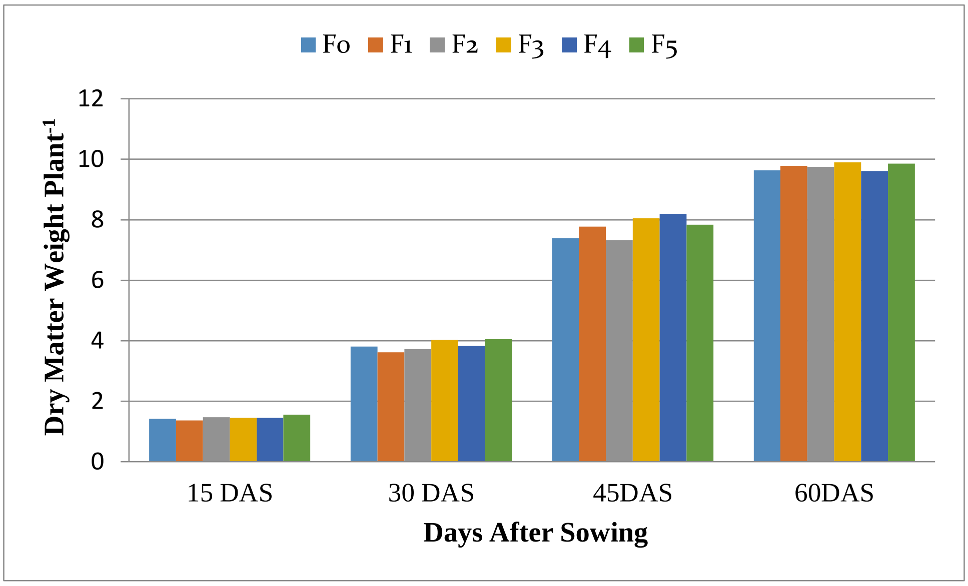


Note: S_1: 20 cm × 10 cm, S_2: 35 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 7. Effect of spacing on dry matter weight plant^{-1} of mungbean at different days after sowing [LSD $_{(0.05)}$ = 0.05, 0.13, 0.27 and 0.19 at 15, 30, 45 and 60 DAS]

4.1.4.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on dry matter weight plant^{-1} (g) (Fig, 8 and Appendix VI). From the experiment result exhibited that the maximum dry matter weight plant^{-1} (1.55 and 4.06 g at 15 DAS and 30 DAS) was observed from the F_5 treatment which was statistically similar (4.03 g) with F_3 treatment at 30 DAS. At 45 DAS maximum dry matter weight plant^{-1} (8.19 g) was observed from the F_4 treatment which was statistically similar (8.04 g) F_3 treatment. And at 60 DAS maximum dry matter weight plant^{-1} (9.89 g) was observed from the F_3 treatment which was statistically similar (9.86 and 9.78 g) with F_5 and F_1 treatment. Whereas minimum dry matter weight plant^{-1} (1.37 and 3.62) was observed from the F_1 treatment at 15 DAS and 30 DAS. At 45 DAS minimum dry matter weight plant^{-1}(7.33 g) was observed from the F_2 treatment which was statistically similar (7.39) with F_0 treatment and at 60 DAS minimum dry matter weight plant^{-1}(9.62 g) was observed from the F_4 treatment which was statistically similar (9.64) with F_0 treatment followed by (9.76) with F_2 treatment. Different nutrients management increased Dry matter weight of plant. It was also reported by Sultana *et al.* (2009) and Asaduzzaman *et al.* (2008)



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 8. Effect of combination of organic and inorganic fertilizers on dry matter weight plant^{-1} of mungbean at different days after sowing [LSD $_{(0.05)}$ = 0.0003, 0.08 and 0.08 at 30, 45 and 60 DAS]

4.1.4.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction of spacing and combination of organic and inorganic fertilizers showed significant variation on dry matter weight plant^{-1} at different days after sowing (Table 4). From the experiment result showed that the maximum dry matter weight plant^{-1} (2.06 g) was observed from the treatment combination of S_3F_3 which was statistically similar (2.02 g) with S_3F_5 treatment combination at 15 DAS. At 30 DAS, 45 DAS and 60 DAS the maximum dry matter weight plant^{-1} (5.12, 10.67 and 12.70 g) was observed from the treatment combination of S_3F_4 which was statistically similar (5.09 g) with S_3F_5 treatment combination at 30 DAS. Whereas minimum dry matter weight plant^{-1} (0.81 g) was observed from the treatment combination of S_1F_2 which was statistically similar (0.83 g) with S_1F_3 treatment combination at 15 DAS. At 30 DAS minimum dry matter weight plant^{-1} (2.86 g) was observed from the treatment combination of S_1F_4 which was statistically similar (2.91 g and 2.9667 g) with S_1F_0 and S_1F_1 treatment combination. At 45 DAS and 60 DAS minimum dry matter weight plant^{-1} (5.82 and

7.38) was observed from the treatment combination of S_1F_0 which was statistically similar (6.22 and 7.61 g) with S_1F_1 and S_1F_4 treatment combination.

Table 4. Interaction effect of spacing and combination of organic and inorganic fertilizers on dry matter weight plnat^{-1} of mungbean at different days after sowing

Treatment Combinations	Dry matter weight/plant (gm)			
	15 DAS	**30 DAS**	**45DAS**	**60DAS**
S_1F_0	0.94h	2.91j	5.82k	7.38l
S_1F_1	0.9h	2.97ij	6.22jk	7.82k
S_1F_2	0.81i	3.13i	7.48gh	9.85f
S_1F_3	0.83i	3.48h	7.32gh	8.77ij
S_1F_4	0.91h	2.86j	6.5j	7.61kl
S_1F_5	1.15g	3.12i	7.75fg	9.49g
S_2F_0	1.69d	4.1de	8.35de	10.43e
S_2F_1	1.63de	3.66gh	7.43gh	9.83f
S_2F_2	1.69d	3.49h	7.37gh	10.38e
S_2F_3	1.47f	3.83fg	8.75cd	10.43e
S_2F_4	1.63de	3.52h	7.42gh	8.54j
S_2F_5	1.49f	3.96ef	6.63ij	9.29gh
S_3F_0	1.64de	4.42c	8ef	11.11c
S_3F_1	1.58e	4.24d	9.68b	11.69b
S_3F_2	1.92b	4.55c	7.13hi	9.04hi
S_3F_3	2.06a	4.79b	8.07ef	10.48e
S_3F_4	1.81c	5.12a	10.67a	12.7a
S_3F_5	2.02a	5.09a	9.12c	10.79d
$LSD_{(0.05)}$	0.06	0.17	0.48	0.24
CV (%)	2.67	2.71	3.69	1.47

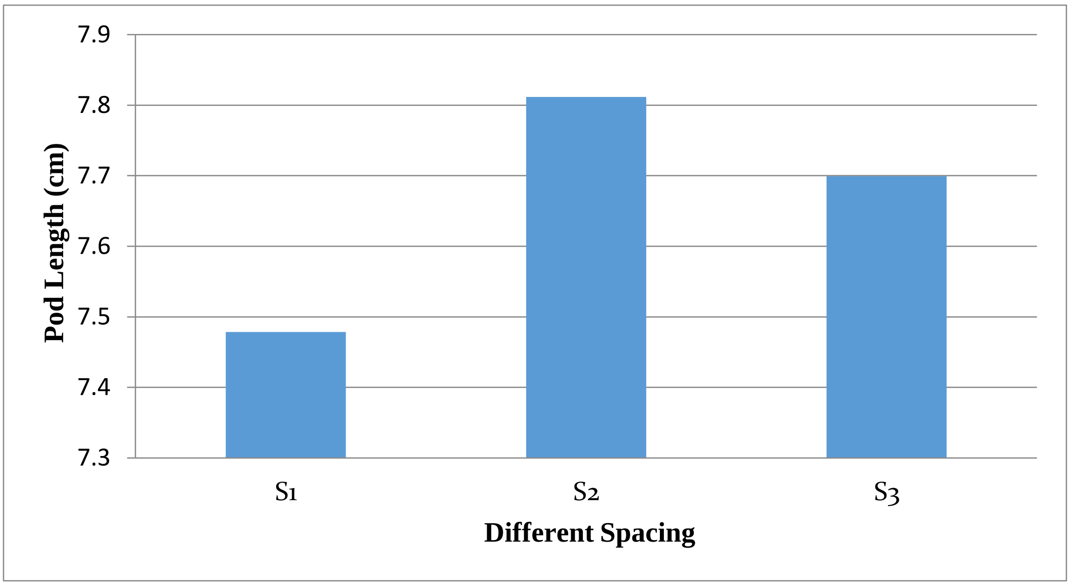
Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

4.2. Yield Contributing Parameters
4.2.1 Pod length (cm)

4.2.1.1 Effect of different spacing

Different plant spacing showed significant effect on pod length (cm) (Fig, 9 and Appendix VIII). The experimental result exhibited that the maximum pod length (7.81 cm) was observed from S_2 treatment which was statistically similar (7.7 cm) with S_3 treatment. Whereas minimum pod length (7.48 cm) was observed from S_1 treatment.

The low planting density per unit area *i e*. higher plant spacing helps the plant to uptake extra nutrient and water. They also get more sunlight which was helpful for photosynthesis, consequently more dry matter partitioning to the reproductive unit of plant (pod), thus amplified the pod length compared to the densely populated plot. The present finding consisted with the findings of Agasimani *et al*. (1984).

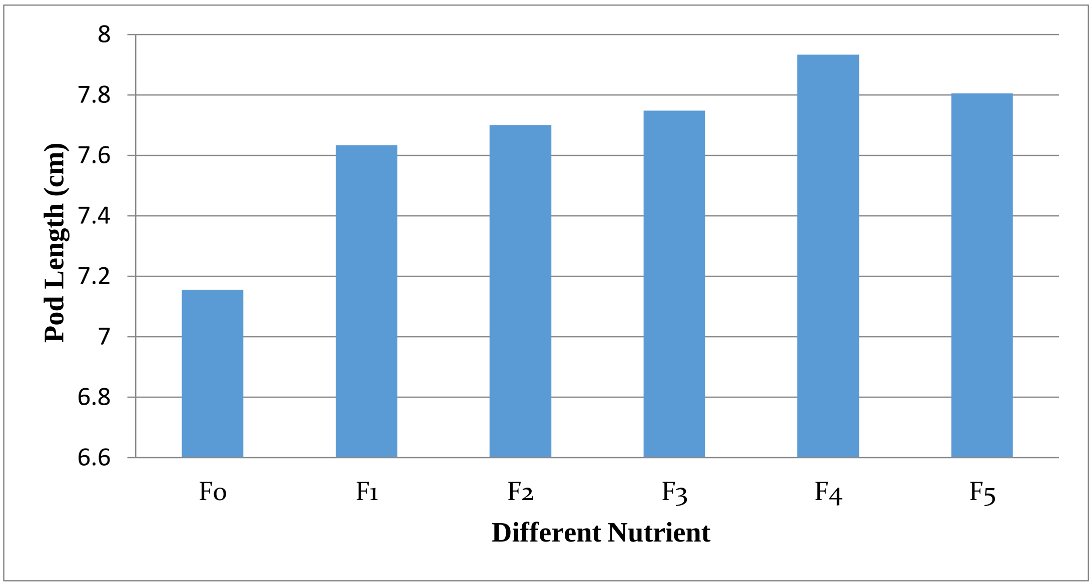


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 9. Effect of spacing on pod length of mungbean [LSD $_{(0.05)}$ =0.24]

4.2.1.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on pod length (cm) (Fig, 10 and Appendix VIII). The experimental result exhibited that the maximum pod length (7.93 cm) was observed from F_4 treatment, which was statistically similar to F_5 (7.81 cm) and F_3 (7.75 cm) treatment whereas minimum pod length (7.16 cm) was observed from F_0 treatment. Nitrogen might increase the branch number plant^{-1} of mungbean as a result the pod length increased and it was in full agreement with Hossen *et al*. (2015).



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 10. Effect of combination of organic and inorganic fertilizers on pod length of mungbean [LSD $_{(0.05)}$ = 0.2314]

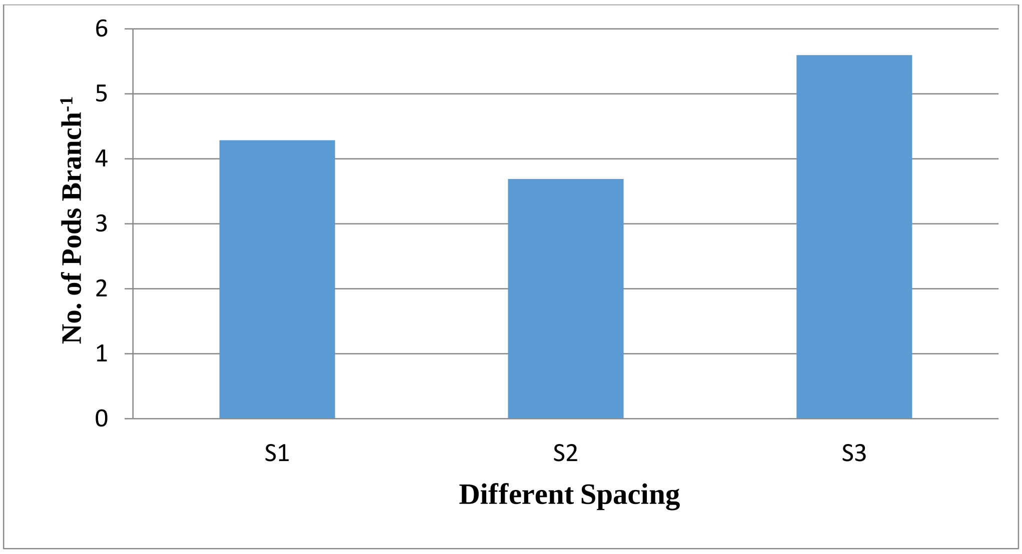
4.2.1.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and combination of organic and inorganic fertilizers showed significant variation on pod length. From the experimental results showed that the maximum pod length (8.06 cm) was observed from S_3F_4 treatment combination which was statistically similar to S_2F_4, S_2F_5, S_2F_3, S_3F_2,. S_3F_3, S_3F_5, S_1F_5, S_2F_1 S_2F_2 and S_1F_4 treatment combination. Whereas minimum pod length (6.78 cm) was observed from S_1F_0 treatment combination which was statistically similar (7.1cm) S_3F_0 treatment combination.

4.2.2 Number of pods branch^{-1}

4.2.2.1 Effect of different spacing

Different plant spacing showed significant effect on pods branch plant^{-1} (Fig, 11 and Appendix VIII). From the experiment result exhibited that the maximum pods branch plant^{-1} (5.6) was observed from S_3 treatment. Whereas minimum pods branch plant^{-1} (3.69) was observed from S_2 treatment. Number of pods per branch might be varied due to plant spacing. Hossen *et al*. (2015) found significant variation on number of pods per branch among mungbean plant.

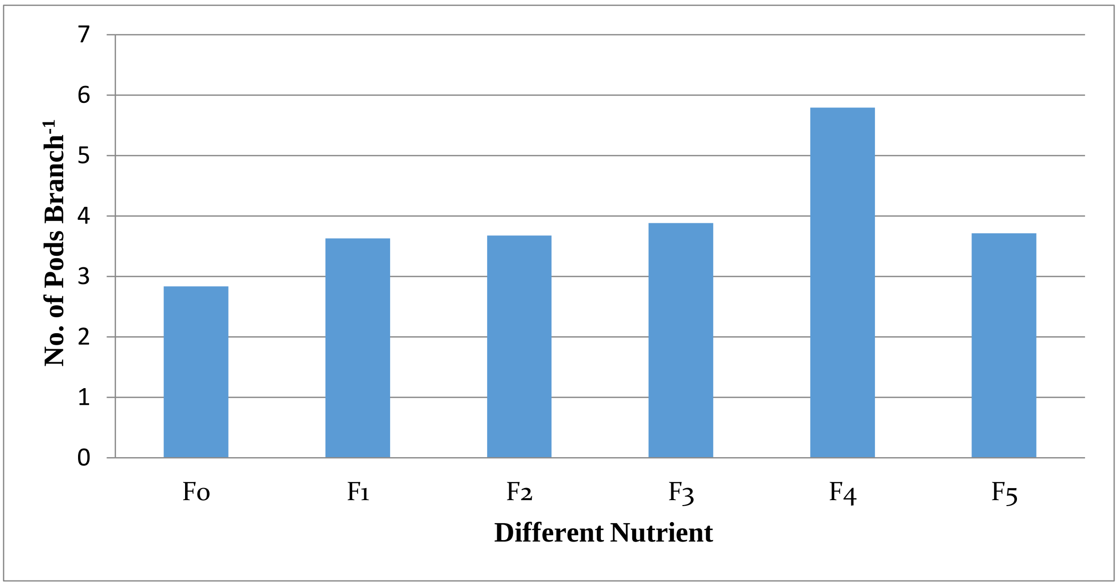


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 11. Effect of spacing on number of pods branch^{-1} of mungbean [LSD $_{(0.05)}$ = 0.13]

4.2.2.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on pods branch plant^{-1} (Fig, 12 and Appendix VIII). The experimental result exhibited that the maximum pods branch^{-1} (6.13) was observed from F_4 treatment whereas minimum (3.17) was observed from F_0. The results showed that application of organic manure along with chemical fertilizers resulted in clearly higher uptake of nutrients. Aslam *et al.* (2010) found that combined application of FYM, poultry manure and chemical fertilizer recorded higher number of pods branch^{-1} that indicating primacy of integration of the two sources in having improved mungbean productivity.



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 12. Effect of different combination of organic and inorganic fertilizer on number of pods branch^{-1} of mungbean [LSD $_{(0.05)}$ = 0.12]

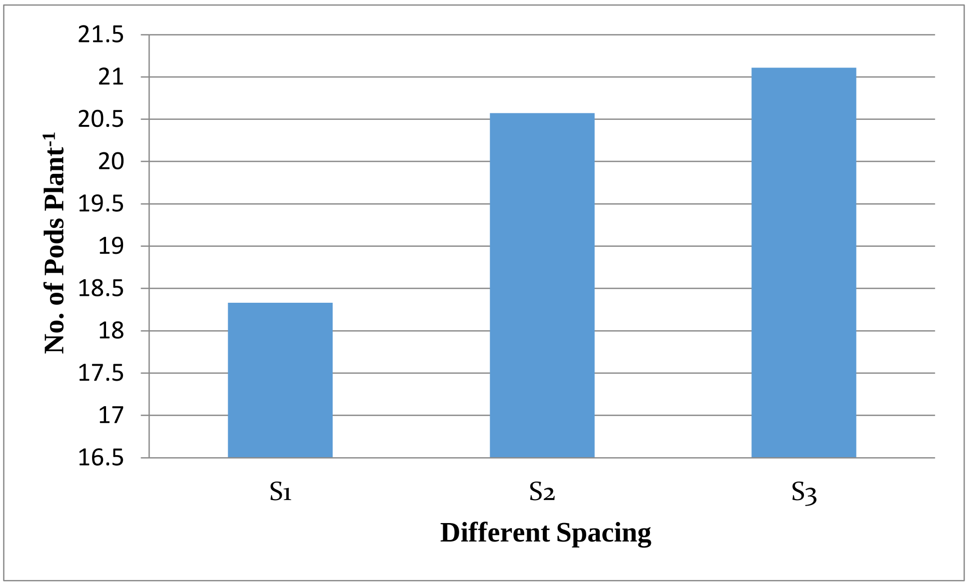
4.2.2.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and combination of organic and inorganic fertilizers showed significant variation on pods branch^{-1}. The experiment result showed that the maximum pods branch plant^{-1} (7.17) was observed from S_3F_4 treatment combination, Whereas minimum pods branch plant^{-1} (2.46) was observed from S_2F_0 treatment combination which was statistically similar (2.50, 2.5 and 2.64) with S_2F_0, S_1F_0 and S_2F_5 treatment combination, respectively.

4.2.3 Number of pods plant^{-1}

4.2.3.1 Effect of different spacing

Different plant spacing showed significant effect on number of pods plant^{-1} (Fig, 13 and Appendix VIII). The experimental result exhibited that the maximum number of pods plant^{-1} (21.11) was observed from S_3 treatment, which was statistically similar to (20.57) S_2 treatment. Whereas minimum number of pods plant^{-1} (18.33) was observed from S_1 treatment. Hossen *et al*. (2015) also found similar result, which supported the present finding.

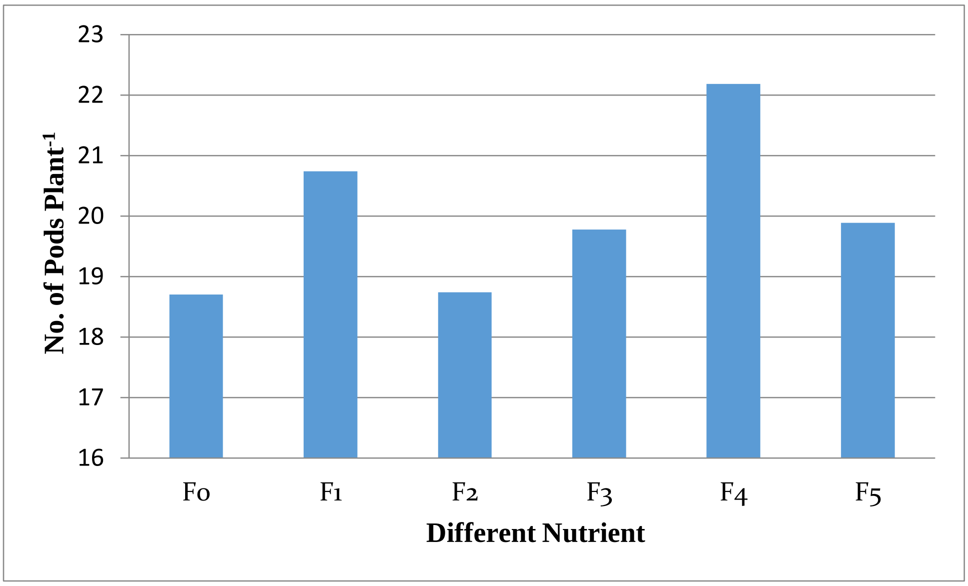


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 13. Effect of spacing on number of pods plant^{-1} of mungbean [LSD $_{(0.05)}$ =0.69]

4.2.3.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizer had significant effect on number of pods plant^{-1} (Fig, 14 and Appendix VIII). The experimental result exhibited that the maximum number of pods plant^{-1} (22.18) was observed from F_4 treatment whereas minimum number of pods plant^{-1} (18.7) was observed from F_0 treatment, which was statistically similar (18.74) to F_2 treatment. Hossen *et al*. (2015), Asaduzzaman *et al*. (2008) and Srinivas *et al.* (2002) found similar result, which supported the present study.



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 14. Effect of different combination of organic and inorganic fertilizer on number of pods plant^{-1}of mungbean [LSD $_{(0.05)}$ =0.6418]

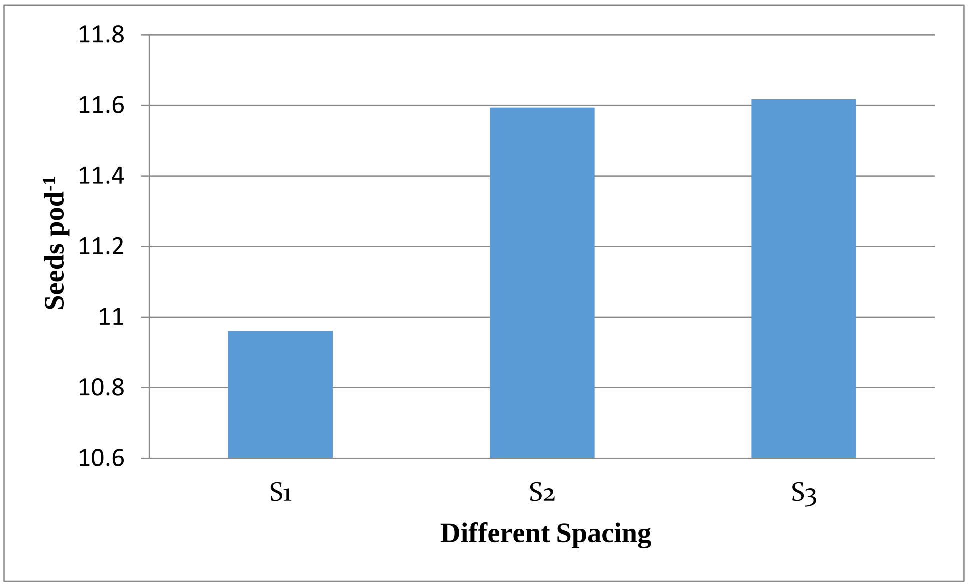
4.2.3.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and combination of organic and inorganic fertilizer showed significant variation on pods branch plant^{-1}. The experimental result showed that the maximum number of pods plant^{-1} (24.44) was observed from S_3F_4 treatment combination. While minimum number of pods plant^{-1} (17.11) was observed from S_1F_0 treatment combination which was statistically similar (17.55) with S_3F_2 treatment combination.

4.2.4 Number of seeds pod^{-1}

4.2.4.1 Effect of different spacing

Different plant spacing showed significant effect on seeds pod^{-1} (Fig, 15 and Appendix VIII). The experimental result exhibited that the maximum seeds pod^{-1} (11.62) was observed from S_3 treatment, which was statistically similar (11.59) to S_2 treatment. Whereas minimum seeds pod^{-1} (10.96) was observed from S_1 treatment. This result was not similar to the findings of Foysalkabir *et al.* (2016) and Rasul *et al.* (2012) who found that planting density significantly influenced the seeds pod^{-1}. They also found that lower planting density gave the higher number of seeds pod^{-1}.

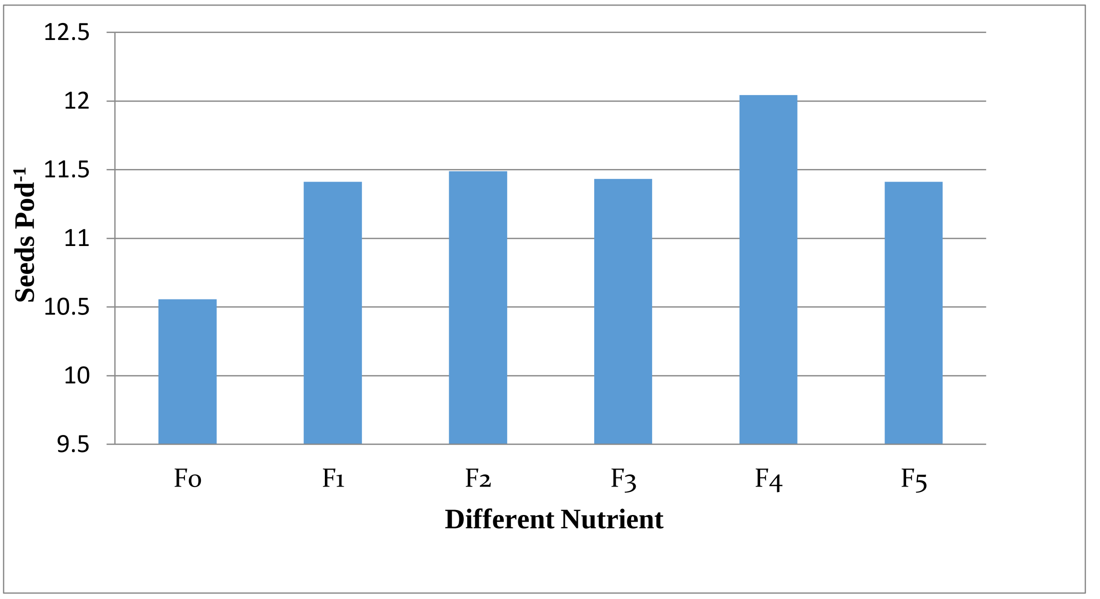


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 15. Effect of different spacing on number of seed pod-1 of mungbean [LSD $_{(0.05)}$ = 0.50]

4.2.4.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizer showed significant effect on seeds pod^{-1} (Fig, 16 and Appendix VIII). The experimental result exhibited that the maximum seeds pod^{-1} (12.04) was observed from F_4 treatment whereas minimum seeds pod^{-1} (10.56) was observed from F_0 treatment. Similar finding was observed by Nigamananda and Elamathi (2007)



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 16. Effect of combination of organic and inorganic fertilizers on seeds pod^{-1} of mungbean [LSD $_{(0.05)}$ = 0.48]

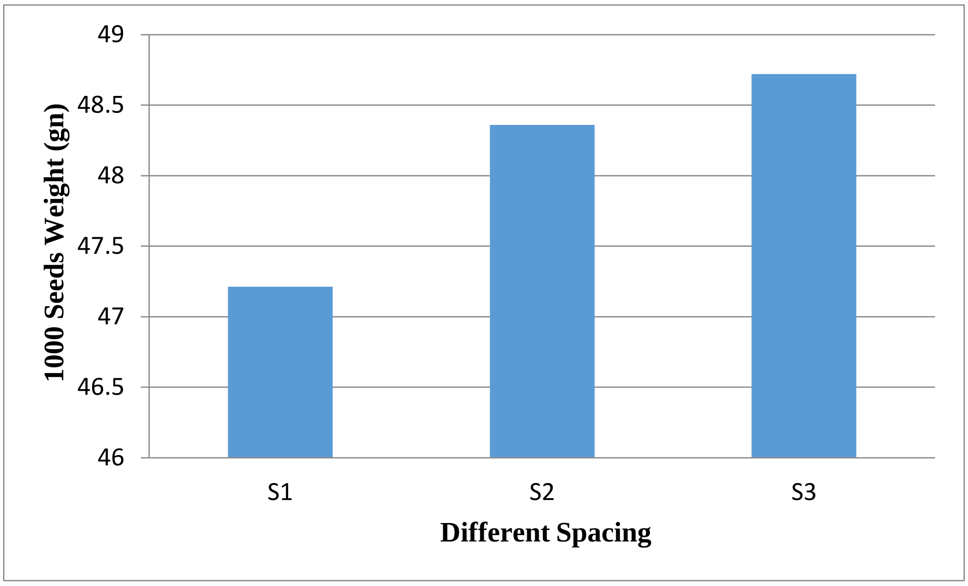
4.2.4.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and different combination of organic and inorganic fertilizers showed significant variation on seeds pod^{-1}. From the experiment result showed that the maximum seeds pod^{-1} (12.90) was observed from S_3F_4 treatment combination .Whereas minimum number of seeds pod^{-1} (9.67) was observed from S_1F_0 treatment combination.

4.2.5 1000 seeds weight (g)

4.2.5.1 Effect of different spacing

Different spacing showed significant effect on 1000 seeds weight of mungbean (Fig, 17 and Appendix VIII). The experimental result exhibited that the maximum 1000 seeds weight (48.72 g) was observed from S_3 treatment, which was statistically similar (48.36 g) to S_2 treatment. Whereas minimum thousand seeds weight (47.21 g) was observed from S_1 treatment. Varietal effect might be occurred due to genetic make-up on mungbean. Similar result also found by Rasul *et al.* (2012) where wider row spacing help to get highest 1000 seeds weight of mungbean. Plant spacing significantly affected the seed yield of legumes (Porwal *et al*., 1991).

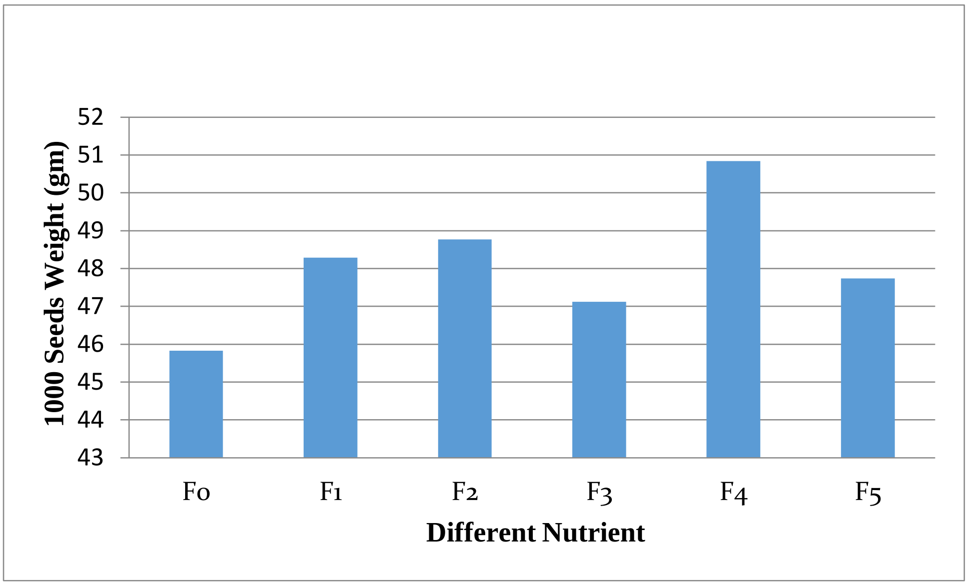


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 17. Effect of different spacing on thousand seeds weight of mungbean [LSD $_{(0.05)}$ =1.23]

4.2.5.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on thousand seed weight (Fig, 18 and Appendix VIII). From the experiment result exhibited that the maximum 1000 seeds weight (50.84 g) was observed from F_4 treatment. Whereas minimum thousand seeds weight (45.83) was observed from F_0 treatment. Same result was agreed with those obtained by Razzaque *et al.* (2015) and Hossen *et al*. (2015)



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 18. Effect of combination of organic and inorganic fertilizers on 1000 seeds weight of mungbean [LSD $_{(0.05)}$ =1.19]

4.2.5.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Interaction effect of spacing and combination of organic and inorganic fertilizers showed significant variation on thousand seeds weight. The experimental result showed that the maximum thousand seed weight (51.47 g) was observed from S_3F_4 treatment combination, which was statistically similar (51.43, 49.61, 49.61, 49.52 and 49.33 g) to the treatment combination of S_2F_4, S_1F_4, S_3F_1, S_3F_2, S_3F_1 and S_2F_2 treatment combination Whereas minimum number of thousand seeds weight (45.247 g) was observed from S_2F_0 treatment combination, which was statistically similar (45.74, 45.83, 46.51, 47.14, 47.34 and 47.37 g) to S_1F_0, S_1F_3, S_3F_0, S_1F_1, S_3F_3 and S_1F_2 treatment combination.

Table 5. Interaction effect of spacing and combination of organic and inorganic fertilizers on yield contributing characters of mungbean

Treatment Combinations	Yield Contributes characters				
	Pod length	Number of pods/branch	Number of pods/plant	Seeds/Pod (number)	1000 seed weight
S_1F_0	6.78d	2.5j	17.11i	9.67d	45.74fg
S_1F_1	7.51bc	4.5f	18.33gh	11.5bc	47.14d-g
S_1F_2	7.52bc	2.92i	18.33gh	11c	47.37c-g
S_1F_3	7.6b	5.19de	18.33gh	11c	45.83fg
S_1F_4	7.68ab	5.26d	19.33efg	11.33bc	49.61ab
S_1F_5	7.78ab	5.33d	18.56fgh	11.27bc	47.59b-f
S_2F_0	7.59b	2.46j	18.78fg	11c	45.25g
S_2F_1	7.77ab	3.82g	21.44cd	11.6bc	48.19b-e
S_2F_2	7.74ab	3.3h	20.33de	11.8bc	49.33a-d
S_2F_3	7.86ab	3.95g	21.44cd	11.8bc	48.2b-e
S_2F_4	8.06a	5.96c	22.78b	11.9b	51.43a
S_2F_5	7.86ab	2.64ij	18.67fgh	11.47bc	47.76b-f
S_3F_0	7.1cd	4.55f	20.22e	11c	46.51e-g
S_3F_1	7.62b	5.29d	22.44bc	11.13bc	49.52a-c
S_3F_2	7.84ab	5.09de	17.55hi	11.67bc	49.61ab
S_3F_3	7.79ab	6.51b	19.55ef	11.5bc	47.34d-g
S_3F_4	8.06a	7.17a	24.44a	12.9a	51.47a
S_3F_5	7.78ab	4.97e	22.44bc	11.5bc	47.88b-f
$LSD_{(0.05)}$	0.40	0.23	1.11	0.83	2.07
CV (%)	3.14	3.04	3.33	4.37	2.58

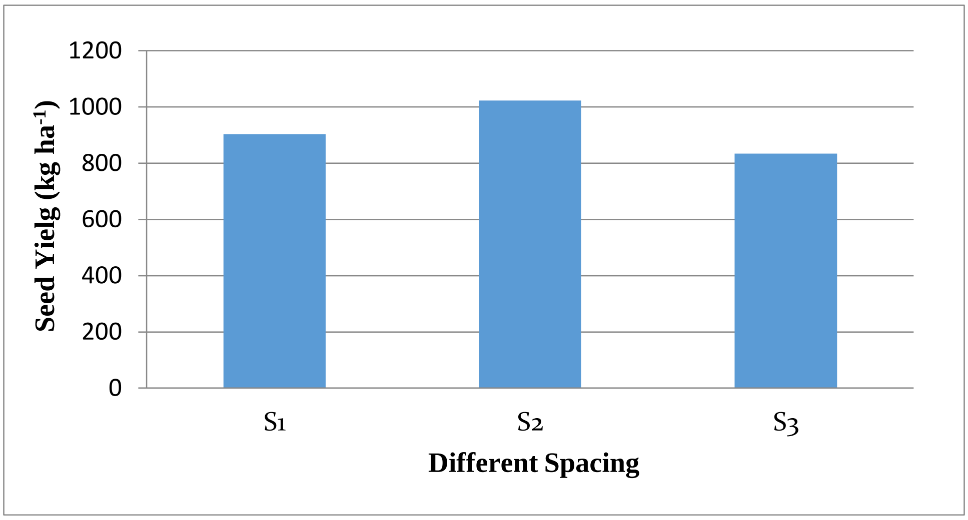
Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

4.3 Yield parameters

4.3.1 Seed Yield (kg ha^{-1})

4.3.1.1 Effect of different spacing

Seed yield of mungbean was significantly differed due to the application of different spacing (Fig, 19 and Appendix IX). The experimental result exhibited that the maximum seed yield (1022.8 kg ha^{-1}) was observed from S_2 treatment. Whereas minimum seed yields (834.4 kg ha^{-1}) was observed from S_3 treatment. In over occupied area plant produced low seed yield because there was huge intra plant competition between them for moisture, sunlight and soil nutrients. This result was also coincide with Rasul *et al.*, (2012); Ali *et al*. (2010); Panwar and Sirohi (1987) and Agarico (1985), who reported that, crop sown at inter-row spacing of 30 cm gave maximum seed yield while lowest seed yield was obtained at inter-row spacing of 60 cm.

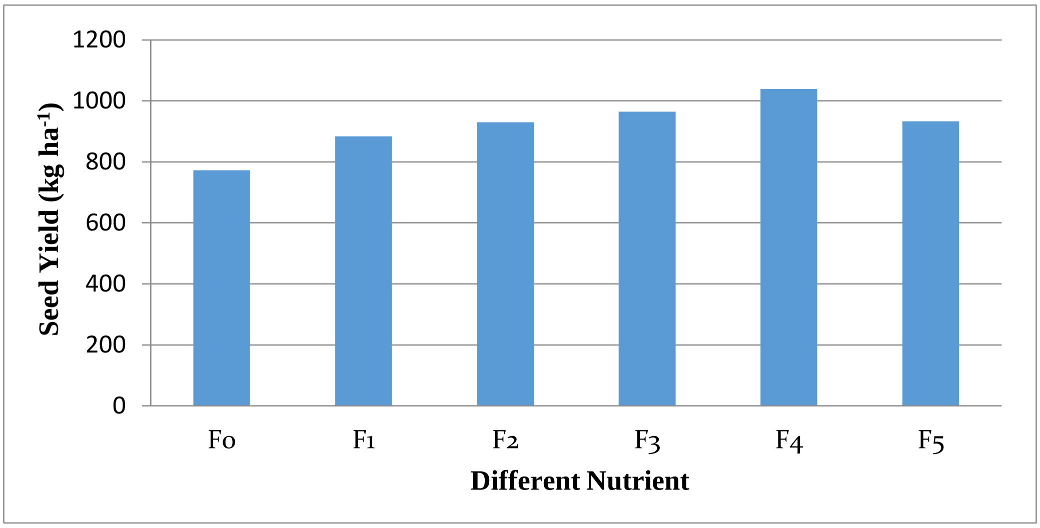


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3 : 45 cm × 15 cm

Figure 19. Effect of different spacing on seed yield of mungbean [LSD $_{(0.05)}$ = 29.59]

4.3.1.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on seed yield (kg ha^{-1}) of mungbean (Fig, 20 and Appendix IX). The experiment result exhibited that the maximum seed yield (1038.9 kg ha^{-1}) was observed from F_4 treatment. Whereas minimum seed yields (772.2 kg ha^{-1}) was observed from F_0 treatment. Consistent with its effect on pod number per plant, the effect was also significant on seed yield Haque *et al.* (2001), Asaduzzaman *et al*. (2008) and Kamal *et al.* (2001)



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 20. Effect of combination of organic and inorganic fertilizers on seed yield of mungbean [LSD $_{(0.05)}$ =27.699]

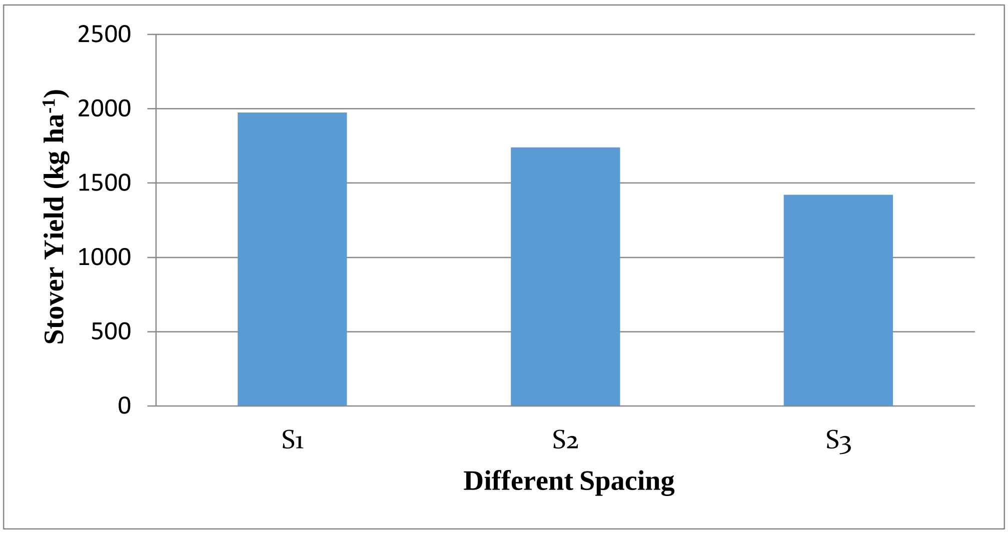
4.3.1.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Seed yield of mungbean was significantly differed due to the application of different spacing and nutrient management (Table 6). The result of the investigation revealed that the maximum seed yield (1156.7 kg ha^{-1}) was observed from S_2F_4 treatment combination whereas minimum seed yield (693.3 kg ha^{-1}) was observed from S_3F_0 treatment combination.

4.3.2 Stover Yield (kg ha^{-1})

4.3.2.1 Effect of different spacing

Stover yield of mungbean was significantly differed due to the application of different spacing. From the experiment result exhibited that the maximum stover yield (1974.2 kg ha^{-1}) was observed from S_1 treatment. Whereas minimum stover yields (1421.7 kg ha^{-1}) was observed from S_3 treatment. These results uphold with the findings of Foysalkabir *et al*. (2016) and Kabir and Sarkar (2008) where they concluded that stover yield differed significantly among the spacing.

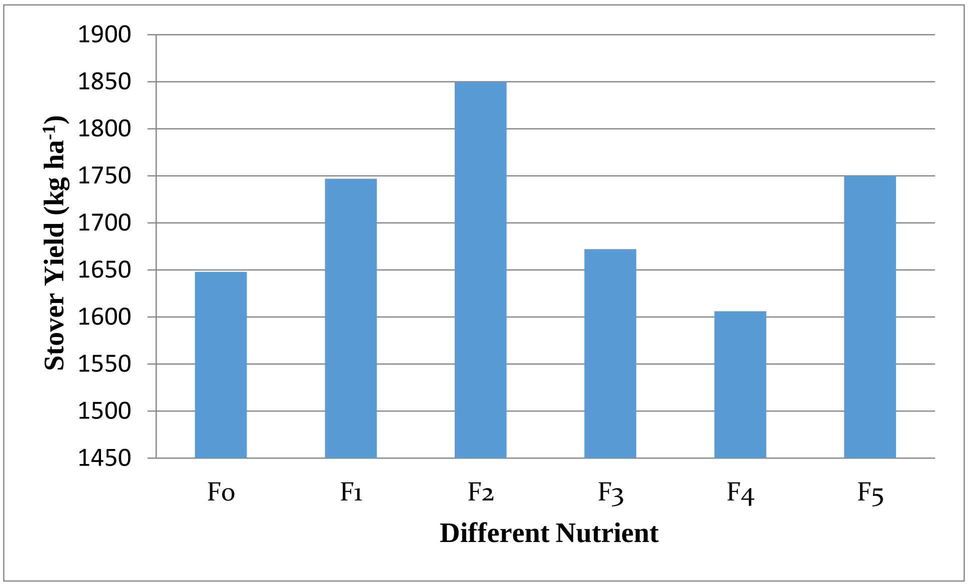


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 21. Effect of different spacing on stover yield of mungbean [LSD $_{(0.05)}$ = 53.43]

4.3.2.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on stover yield (kg ha^{-1}) of mungbean (Fig, 22 and Appendix IX). The experiment result exhibited that the maximum stover yield (1850 kg ha^{-1}) was observed from F_2 treatment. Whereas minimum stover yields (11606.3 kg ha-^{1}) was observed from F_4 treatment, which was statistically similar (1647.8) to F_0 treatment. Hossen *et al*. (2015) also found similar result which supported the present finding.



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 22. Effect of combination of organic and inorganic fertilizers on stover yield of mungbean [LSD $_{(0.05)}$ =50.74]

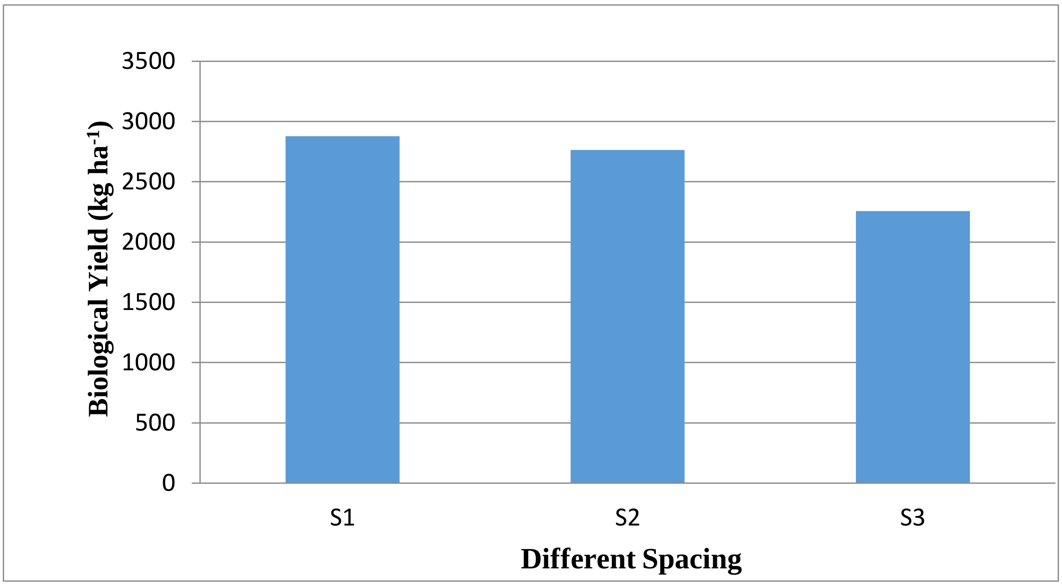
4.3.2.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Stover yield of mungbean was significantly differed due to the application of different spacing and combination of organic and inorganic fertilizers (Table 6). The result of the investigation revealed that the maximum stover yield (2180 kg ha^{-1}) was observed from S_1F_2 treatment combination whereas minimum stover yield (1258.7 kg ha^{-1}) was observed from S_3F_0 treatment combination which was statistically similar (1280 kg ha^{-1}) to S_3F_1 treatment combination .

4.3.3 Biological Yield (kg ha^{-1})

4.3.3.1 Effect of different spacing

Biological yield of mungbean was significantly differed due to the application of different spacing (Fig, 23 and Appendix IX). The experimental result exhibited that the maximum biological yield (2878.1 kg ha^{-1}) was observed from S_1 treatment. Whereas minimum biological yield (2256.2 kg ha^{-1}) was observed from S_3 treatment. The more biomass produced at low row spacing was because of more planting density contributing to the final biomass production. Same findings also found by Ghasempour and Ashori (2014) and Khan *et al.* (2001).

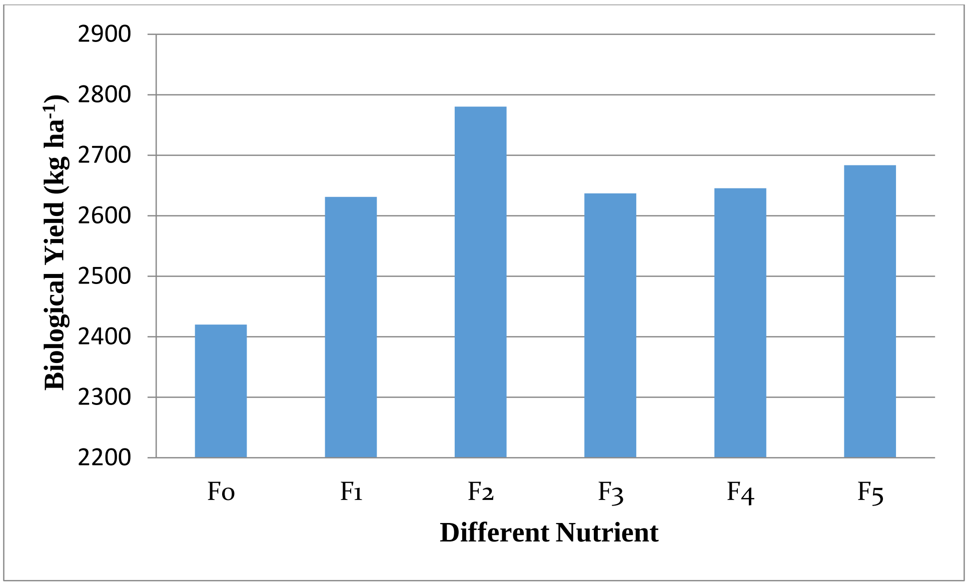


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 23: Effect of spacing on biological yield of mungbean [LSD $_{(0.05)}$ =140.53]

4.3.3.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on stover yield (kg ha^{-1}) of mungbean (Fig, 24 and Appendix IX). From the experiment result exhibited that the maximum biological yield (2780 kg ha^{-1}) was observed from F_2 treatment which was statistically similar (2683.2 kg ha^{-1}) with F_5 treatment. Whereas minimum biological yield (2420 kg ha^{-1}) was observed from F_0 treatment. The use of cowdung for increasing biological yield of legumes, inorganic fertilizers might be for the increasing of biological yield on mungbean. Same results were in agreement with findings of other researchers Mahboob and Asghar (2002)



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 24. Effect of combination of organic and inorganic fertilizers on biological yield of mungbean [LSD $_{(0.05)}$ =132.32]

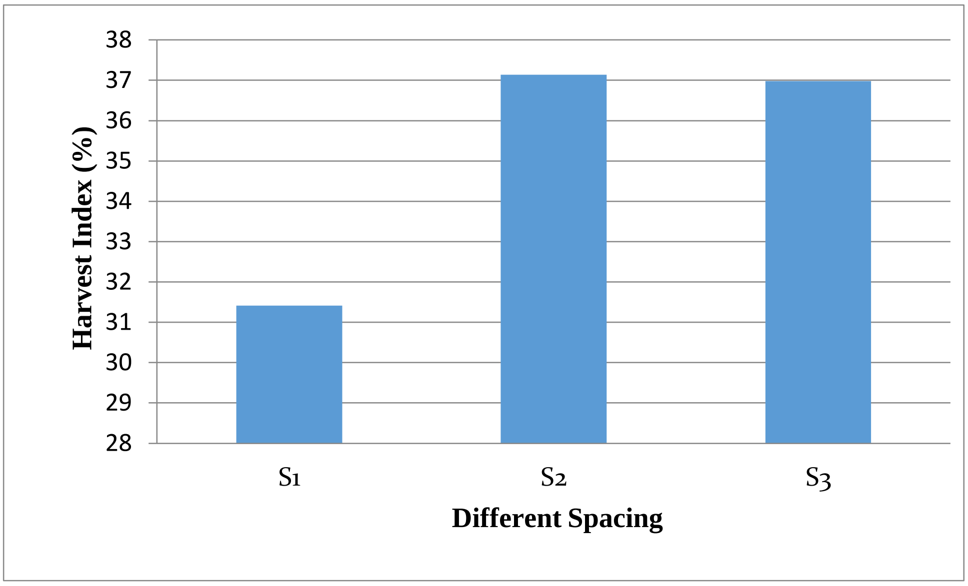
4.3.3.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Biological yield of mungbean was significantly differed due to the application of different spacing and nutrient management (Table 6). The result of the investigation revealed that the maximum biological yield (3076.7 kg ha^{-1}) was observed from S_1F_2 treatment combination which was statistically similar (3006.7, 2973.3, 2930, 2873.7 kg ha^{-1}) from S_2F_2, S_2F_1, S_1F_5 and S_1F_4 treatment combination whereas minimum biological yield (1952 kg ha^{-1}) was observed from S_3F_0 treatment combination, which was statistically similar (2083.3 kg ha^{-1}) to S_3F_1 treatment combination.

4.3.4 Harvest index (%)

4.3.4.1 Effect of different spacing

Harvest index (%) yield of mungbean was significantly differed due to the application of different spacing (Fig, 25 and Appendix IX). From the experiment result exhibited that the maximum harvest index (37.14%) was observed from S_2 treatment which was statistically similar (36.98%) with S_3 treatment. Whereas minimum harvest index (31.41%) was observed from S_3 treatment. This might be due to row spacing helped to get highest harvest index yield of mungbean as reported by Khan *et al.* (2001).

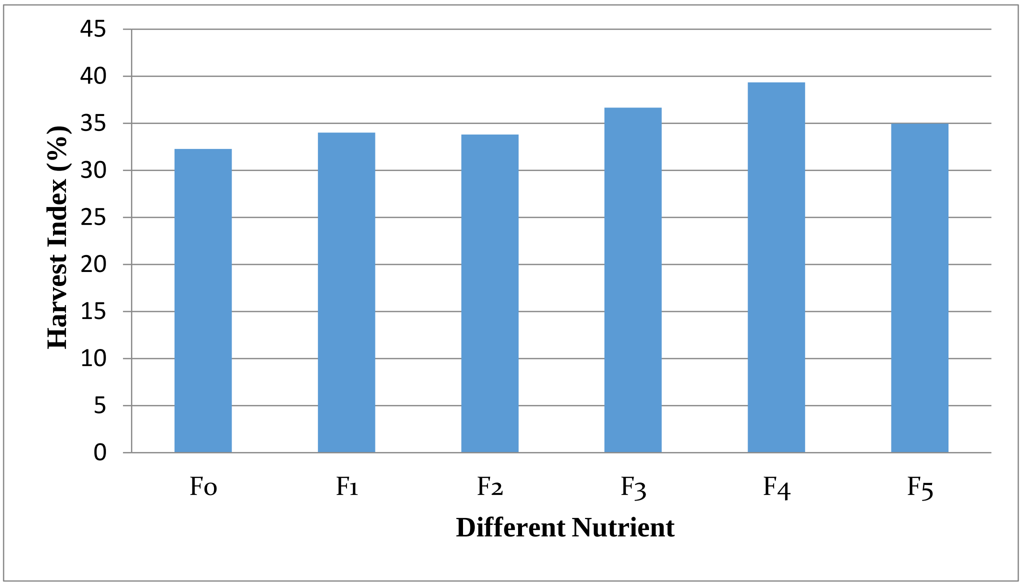


Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm

Figure 25: Effect of spacing on biological yield of mungbean [LSD $_{(0.05)}$ = 2.07]

4.3.4.2 Effect of combination of organic and inorganic fertilizers

Different combination of organic and inorganic fertilizers showed significant effect on harvest index of mungbean (Fig, 26 and Appendix IX). The experiment result exhibited that the maximum harvest index (39.35%) was observed from F_4 treatment. Whereas minimum harvest index (32.28%) was observed from F_0 treatment, which was statistically similar (33.81 and 34.02%) to F_2 and F_1 treatment. The result obtained from the present study was similar to the findings of Rasul *et al.* (2012) and Foysalkabir *et al*. (2016).



Note: F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

Figure 26. Effect of combination of organic and inorganic fertilizers on harvest index (%) of mungbean [LSD $_{(0.05)}$ =1.93]

4.3.4.3 Interaction effect of spacing and combination of organic and inorganic fertilizers

Harvest index (%) of mungbean was significantly differed due to the application of different spacing and combination of organic and inorganic fertilizers (Table 6). The result of the investigation revealed that the maximum harvest index (44.71%) was observed from S_2F_4 treatment combination. While minimum harvest index (28.19%) was observed from S_1F_0 treatment combination followed by (29.14, 29.97 and 31.06 %) with S_1F_2, S_1F_1 and S_1F_5 treatment combination.

Table 6. Interaction effect of spacing and combination of organic and inorganic fertilizers on yield characters of mungbean

Treatment Combinations	Yield character			
	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
S_1F_0	770k	1961.3b	2731.3c-f	28.191h
S_1F_1	850h-j	1986.7b	2836.7b-e	29.97gh
S_1F_2	896.7f-h	2180a	3076.7a	29.14h
S_1F_3	950de	1870cd	2820b-f	33.69d-f
S_1F_4	1046.7bc	1827de	2873.7a-d	36.42b-e
S_1F_5	910e-g	2020b	2930a-c	31.06f-h
S_2F_0	853.3h-j	1723.3f	2576.7fg	33.12e-g
S_2F_1	996.7cd	1976.7b	2973.3a-c	33.52d-g
S_2F_2	1050b	1956.7bc	3006.7ab	34.92c-e
S_2F_3	1050b	1596.7g	2646.7d-g	39.67b
S_2F_4	1156.7a	1430.3i	2587e-g	44.71a
S_2F_5	1030bc	1763ef	2793b-f	36.88b-d
S_3F_0	693.3l	1258.7j	1952j	35.52c-e
S_3F_1	803.3jk	1280j	2083.3ij	38.56bc
S_3F_2	843.3ij	1413.3i	2256.7hi	37.37bc
S_3F_3	893.3f-h	1550gh	2443.3gh	36.56b-e
S_3F_4	913.3ef	1561.7g	2475gh	36.9b-d
S_3F_5	860g-i	1466.7hi	2326.7h	36.96b-d
$LSD_{(0.05)}$	47.98	87.89	229.18	3.34
CV (%)	3.13	3.08	5.22	5.69

Note: S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, F_0 = Control, F_1 = Recommended dose of NPK, F_2 = 5 t ha^{-1} cowdung, F3 = 5 t ha^{-1} cowdung + Recommended dose of NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended dose of NPK, F_5= 2.5 t ha^{-1} cowdung + 1/2 Recommended dose of NPK

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was carried out at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during March, 2019 to May, 2019 to investigate the effect of different spacing and nutrient management on the growth and yield of mugbean. The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors having split plot design. Factor A: 3 level of spacing; S_1: 20 cm × 10 cm, S_2: 30 cm × 10 cm (Recommended), S_3: 45 cm × 15 cm, and factor B: 6 level of fertilizer management; F_0 = Control, F_1 = Recommended NPK, F_2 = 5 t ha^{-1} cowdung, F_3 = 5 t ha^{-1} Cowdung + Recommended NPK, F_4= 2.5 t ha^{-1} cowdung + Recommended NPK, F_5 = 2.5 t ha^{-1} cowdung + 1/2 Recommended NPK. There were 18 treatment combinations. The total numbers of unit plots were 54. The size of unit plot was 3.00 m (2 m ×1.5 m). Data on different growth, yield contributing characters and yield were recorded to find out the suitable spacing and best nutrient management for the highest yield of mugbean.

Different growth yield and yield contributing parameters were significantly influenced by different spacing. Highest plant height (14.99 cm) was observed from the treatment of S_1 at 15 DAS, at 30, 45 and 60 DAS 26.18, 43.50 and 47.01 cm were observed from S_2 treatment, maximum number of leaves plant^{-1} (4.38) was observed from the S_2 treatment at 15 DAS, at 30 DAS (8.1) from the S_1 treatment, at 45 DAS and 60 DAS (11.68 and 13.7) from S_2 treatment, maximum number of branches plant^{-1} (0.05, 2.06 and 2.44 at 30 DAS, 45 DAS and 60 DAS) , dry matter weight plant^{-1} (1.84, 4.7, 8.78 and 10.97 g at 15 DAS, 30 DAS, 45 DAS and 60 DAS) were observed from S_3 treatment, maximum pod length plant^{-1} (7.81 cm) was observed from S_2, maximum pods branch plant^{-1} (4.45) was observed from S_1 treatment, maximum number of pods plant^{-1} (21.11), seeds pod^{-1} (11.62), thousand seeds weight (48.72) were observed from S_3 treatment, maximum seed yield (1022.8 kg ha^{-1}) was observed from S_2 treatment, maximum stover yield (1974.2 kg ha^{-1}) and biological yield (2878.1 kg ha^{-1}) were observed from S_1 treatment and finally maximum harvest index (37.14%) was observed from S_2 treatment whereas lowest plant height (14.75, 25.45, 41.5 and 45.51 cm at 15, 30, 45 and 60 DAS) was observed from the treatment of S_3, minimum number of leaves plant^{-1} (4.22) at 15 DAS was observed from the S_1 treatment, at 30 DAS (7.84) from the S_3 treatment, at 45 DAS and 60 DAS (10.62 and 13.09) were observed from the S_1 treatment, minimum number of branches plant^{-1} (0.03) was observed from S_2 treatment at 30 DAS at 45 DAS and 60 DAS (0.72 and 1.27) were observed from S_2 treatment, minimum dry matter weight plant^{-1}(0.92, 3.08, 6.85 and 8.49 g at 15 DAS, 30 DAS, 45 DAS and 60 DAS) was observed from the S_1 treatment, minimum pod length plant^{-1} ((7.48 cm) was observed from S_1 treatment, minimum pods branch plant^{-1} (3.63) was observed from S_3 treatment, minimum number of pods plant^{-1} (18.33), seeds pod^{-1} (10.96), thousand seed weight (47.21) were observed from S_1 treatment, minimum seed yield (834.4 kg ha^{-1}) was observed from S_3 treatment, minimum stover yield (1421.7 kg ha^{-1}), biological yield (2256.2 kg ha^{-1}) and harvest index (31.41 %) were observed from S_3 treatment.

Different growth yield and yield contributing parameters were significantly influenced by different nutrient management. From the result it can be showed that the highest plant height (15.40 cm at 15 DAS) was observed from the treatment of F_4 at 30 DAS F_1 (26.62 cm), at 45 DAS F_3 (42.77 cm), at 60 DAS F_1 (46.48cm) treatment showed the highest plant height, maximum number of leaves plant^{-1} (4.38) from the F_4 treatment at 15 DAS at 30 DAS (8.07) from the F_1 treatment, at 45 DAS (11.78) from the F_4 treatment, at 60 DAS maximum number of leaves plant^{-1}(13.82) was observed from the F_4 treatment, maximum number of branches plant^{-1} (0.13) at 30 DAS was observed from F_0 treatment. At 45 DAS (1.76) from F_5 treatment and at 60 DAS (2.22) from F_0 treatment, maximum dry matter weight plant^{-1} (1.55 and 4.06 g at 15 DAS and 30 DAS) was observed from the F_5 treatment, at 45 DAS (8.19 g) from the F_4 treatment and at 60 DAS maximum dry matter weight plant^{-1} (9.89 g) was observed from the F_3 treatment, maximum pod length plant^{-1} (7.93 cm), pods branch^{-1} (5.8), pods plant^{-1} (22.18), seeds pod^{-1} (12.04), thousand seed weight (50.84 g), seed yield (1038.9 kg ha^{-1}) were observed from F_4 treatment, maximum stover yield (1850 kg h^{-1}) and biological yield (2780 kg ha^{-1}) were observed from F_2 treatment and harvest index (39.35%) was observed from F_4 treatment whereas Lowest plant height (14.01, 24.53, 41.7 and 45.61 cm at 15 ,30, 45 and 60 DAS respectively) was observed from the treatment of $F_{0,}$ minimum number of leaves plant^{-1} (4.18) at 15 DAS was observed with F_0 treatment at 30 DAS (7.87) from $F_{2,}$ at 45 DAS and 60 DAS (10.93 and 13.18) were observed from F_0 treatment, minimum number of branches plant^{-1} (0.00 and 0.00) at 30 DAS were observed from F_2 and F_3 treatment, at 45 and 60 DAS (1.16 and 1.64) were observed from F_3 treatment, minimum dry matter weight plant^{-1} (1.37 and 3.62) was observed from the F_1 treatment at 15 DAS and 30 DAS, at 45 DAS (7.33 g) from the F_2 treatment and at 60 DAS (9.62 g) was observed from the F_4 treatment , minimum pod length plant^{-1} (7.16 cm), pods branch plant^{-1} (2.84), number of pods plant^{-1} (18.70), seeds pod^{-1} (10.56), thousand seed weight (45.83), seed yield (772.2 kg ha^{-1}), were observed from F_0 treatment, minimum stover yield (1606.3 kg ha^{-1}) was observed from F_4 treatment, minimum biological yield (2420 kg ha^{-1}) was observed from F_0 treatment and finally minimum harvest index (32.28%) was observed from F_0 treatment.

Different growth yield and yield contributing parameters were significantly influenced by the interaction of different spacing and nutrient management. From the experiment result exhibited that the highest plant height (15.73 cm) at 15 DAS was observed from the treatment combination of S_1F_5 at 30 DAS (27.8 cm) from S_2F_1, at 45 DAS and 60 DAS highest plant height (45.07 and 48.15 cm) from the treatment combination of S_2F_5, maximum number of leaves plant^{-1} (4.67) was observed from the treatment combination of S_2F_5 at 15 DAS, at 30 DAS (8.47) from of S_1F_4, at 45 DAS and 60 DAS (12.40 and 14.40) was observed from the treatment combination of S_3F_1, maximum number of branches plant^{-1} (0.20) was observed from the treatment combination of S_1F_0 at 30 DAS, at 45 DAS (2.27) from S_3F_0 and at 60 DAS (2.7) from the treatment combination of S_3F_5, maximum dry matter weight plant^{-1} (2.06 g) was observed from the treatment combination of S_3F_3 at 15 DAS at 30 DAS, 45 DAS and 60 DAS (5.12, 10.67 and 12.70 g) from the treatment combination of S_3F_4, maximum pod length plant^{-1} (8.06 cm), pods branch^{-1} (6.1667), pods plant^{-1} (24.44), seeds pod^{-1} (12.9) , thousand seed weight (51.47 g) were observed from S_3F_4 treatment combination, maximum seed yield (1156.7 kg ha^{-1}) was observed from S_2F_4, maximum stover yield (2180 kg ha^{-1}) and biological yield (3076.7 kg ha^{-1}) were observed from S_1F_2 and finally maximum harvest index (44.71%) was observed from S_2F_4 treatment combination. Whereas lowest plant height (13.2 and 23.86 cm) at 15 and 30 DAS were observed from the treatment combination of S_3F_0 at 45 and 60 DAS lowest plant height (40.37 and 44.53cm) were observed from the treatment combination of S_3F_2, minimum number of leaves plant^{-1} (4.07) was observed from the treatment combination of S_3F_5 at 15 DAS, at 30 DAS (7.53) from S_3F_2 treatment combination, at 45 DAS and 60 DAS (9.67 and 12.4) from S_1F_0 treatment combination, minimum number of branches plant^{-1} (00) was observed from the treatment combination S_3F_3 at 30 DAS; with (0.33 and 0.87) at 45 and 60 DAS from S_1F_1 the treatment combination, minimum dry matter weight plant^{-1} (0.81g) from the treatment combination of S_1F_2 at 15 DAS at 30 DAS (2.86 g) from S_1F_4 at 45 DAS and 60 DAS (5.82 and 7.38) was observed from the treatment combination of S_1F_0, minimum pod length plant^{-1} (6.78) was observed from S_1F_0 treatment combination, minimum pods branch (2.460) was observed from S_2F_0 treatment combination, minimum number of pods plant^{-1} (17.11), number of seeds pod^{-1} (9.67) were was observed from S_1F_0, minimum number of thousand seed weight plant^{-1} (45.25 g) was observed from S_2F_0 treatment combination, minimum seeds yield (693.3 kg ha^{-1}), stover yield (1258.7 kg ha^{-1}), biological yield (1952 kg ha^{-1}) were observed from S_3F_0 treatment combination and finally minimum harvest index (28.19%) was observed from S_1F_0 treatment combination.

The results in this present piece of work indicated that the plants performed better in respect of seeds yield in S_2F_4 treatment than the control treatment (S_1F_0). It can be therefore, concluded from the above investigation that the combined application of spacing 30 cm × 10 cm (S_2) along with 2.5 t ha^{-1} Cowdung + Recommended dose of NPK (F_4) was found to be most suitable combination treatment for the highest yield of mungbean in AEZ 28 soils of Bangladesh. Based on the results of this experiment, further studies in the following areas may be suggested:

1. Such kind of study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh to evaluate the regional adaptability.
2. Other management practices may be used to reveal better results of futher studies.
3. Other combinations of organic manures and chemicals fertilizer may be used for further study to specify the specific combinations that are cost effective and eco-friendly.

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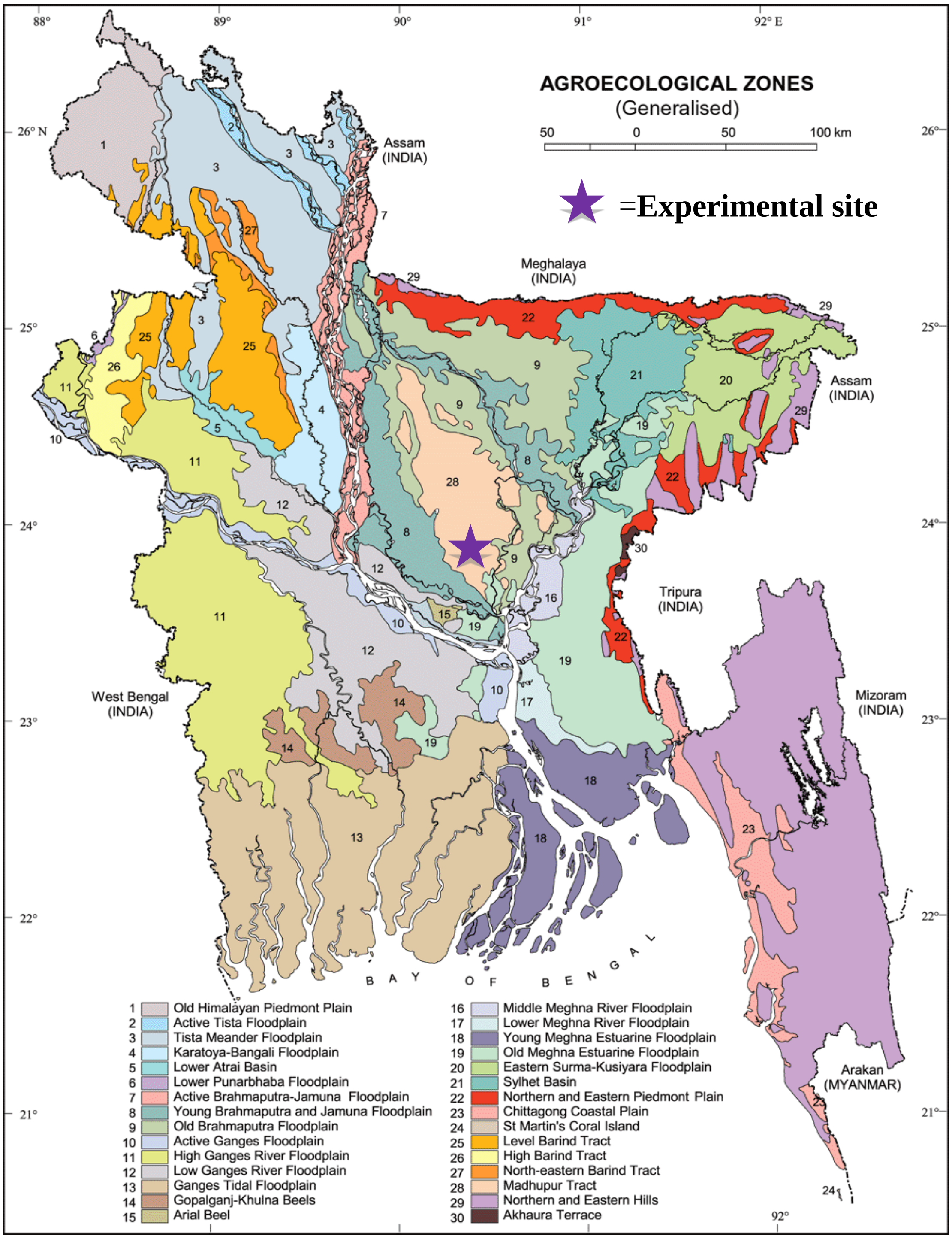
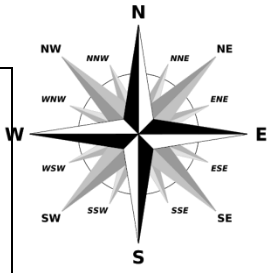
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II: Layout of experiment field.



2m

1m

R_1	R_2	R_3
S_1F_0	S_2F_0	S_3F_0
S_1F_1	S_2F_1	S_3F_1
S_1F_2	S_2F_2	S_3F_2
S_1F_3	S_2F_3	S_3F_3
S_1F_4	S_2F_4	S_3F_4
S_1F_5	S_2F_5	S_3F_5
S_2F_0	S_3F_0	S_2F_0
S_2F_1	S_3F_1	S_2F_1
S_2F_2	S_3F_2	S_2F_2
S_2F_3	S_3F_3	S_2F_3
S_2F_4	S_3F_4	S_2F_4
S_2F_5	S_3F_5	S_2F_5
S_3F_0	S_1F_0	S_2F_0
S_3F_1	S_1F_1	S_2F_1
S_3F_2	S_1F_2	S_2F_2
S_3F_3	S_1F_3	S_2F_3
S_3F_4	S_1F_4	S_2F_4
S_3F_5	S_1F_5	S_2F_5

F_0 = Control, F_1 = Recommended NPK, F_2 = 5 ton cowdung, F3 = 5 ton cowdung + Recommended NPK, F_4= 2.5 ton cowdung + Recommended NPK, F5= 2.5 ton cowdung + 1/2 Recommended NPK

Appendix III. Characteristics of soil of experimental field.

Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

A. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix IV. Analysis of variance of data on plant height (cm) of mungbean influenced by different combination of organic and inorganic fertilizers and their interaction at different days after sowing.

Mean square of plant height of mungbean at					
Source	Df	15DAS	30DAS	45DAS	60DAS
Replication (A)	2	0.07389	0.66667	0.5000	0.2450
Spacing (B)	2	0.28003*	2.48827*	17.9800*	11.0655*
Org & In-O Fertilizer (C)	5	2.32650*	5.00631*	3.8245*	1.0449*
B×C	10	0.75656*	2.34771*	1.6692*	1.9826*
Total	53				

*Significant at 5% level of probability

Appendix V. Analysis of variance of data on number of leaves plant^{-1} of mungbean influenced by different combination of organic and inorganic fertilizers and their interaction at different days after sowing.

Mean square of number of leaves plant^{-1} of mungbean at					
Source	Df	15DAS	30DAS	45DAS	60DAS
Replication (A)	2	0.00167	0.01167	0.02722	0.06222
Spacing (B)	2	0.14519*	0.27556*	5.70296*	2.12241*
Org & In-O Fertilizer (C)	5	0.06874*	0.05156*	1.04252*	0.62330*
B×C	10	0.07763*	0.20711*	1.23541*	0.85707*
Total	53				

*Significant at 5% level of probability

Appendix VI. Analysis of variance of data on dry matter weight plant^{-1} of mungbean influenced by different combination of organic and inorganic fertilizers and their interaction at different days after sowing.

Mean square of dry matter weight plant^{-1} of mungbean at					
Source	Df	15DAS	30DAS	45DAS	60DAS
Replication (A)	2	0.00249	0.0119	0.0746	0.0777
Spacing (B)	2	4.07991*	11.9265*	16.9143*	27.7889*
Org & In-O Fertilizer (C)	5	0.03385*	0.2642*	1.0798*	0.1127*
B×C	10	0.08*	0.23*	3.74*	4.71*
Total	53				

*Significant at 5% level of probability

Appendix VII. Analysis of variance of data on number of branches plant^{-1} of mungbean influenced by different combination of organic and inorganic fertilizers and their interaction at different days after sowing.

Mean square of number of branches plant^{-1} of mungbean at				
Source	Df	30 DAS	45 DAS	60 DAS
Replication (A)	2	0.00001	0.00744	0.00389
Spacing (B)	2	0.00130*	8.33495*	6.36540*
Org & In-O Fertilizer (C)	5	0.02152*	0.41525*	0.47511*
B×C	10	0.00619*	0.27304*	0.22144*
Total	53			

*Significant at 5% level of probability

Appendix VIII. Analysis of variance of the data on pod length (cm), number of pods/branch, number of pods/plant, seeds pod-1 (No.) and 1000-seed weight (g) of mungbean varieties as influenced by different combination of organic and inorganic fertilizers and their interaction at different days after sowing.

Mean square of yield contributing characters of mungbean						
Source	Df	**Pod Length**	**Number of pods/branch**	**Number of pods/plant**	**Seeds/pod**	**1000 seed weight**
Replication (A)	2	0.05	0.01	0.22	0.15	1.06
Spacing (B)	2	0.52*	3.79*	39.04*	2.49*	11.16*
Org & In-O Fertilizer (C)	5	0.65*	8.79*	15.57*	2.05*	25.58*
B×C	10	0.06*	2.52*	6.12*	0.49*	1.31*
Total	53					

*Significant at 5% level of probability

Appendix IX. Analysis of variance of the data on seed yield (kg/ha), stover yield (kg/ha), biological yield (kg/ha), and harvest index (%) of mungbean varieties as influenced by different combination of organic and inorganic fertilizers and their interaction at different days after sowing.

Mean square of yield characters of mungbean					
Source	Df	**Seed Yield (kg/ha)**	**Stover yield (kg/ha)**	**Biological yield (kg/ha)**	**Harvest index (%)**
Replication (A)	2	439	1667	10556	2
Spacing (B)	2	163280*	1384557*	1972685*	191.43*
Org & In-O Fertilizer (C)	5	71225*	69536*	125399*	56.14*
B×C	10	1464*	79920*	76138*	17.23*
Total	53				

*Significant at 5% level of probability