DEVELOPMENT OF FERTILIZER PACKAGE FOR MUNGBEAN
(*Vigna radiata* L.)

A Thesis

By

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MASTER OF SCIENCE
IN
AGRONOMY

DEPARTMENT OF AGRONOMY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJAPUR

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Submitted to the Department of Agronomy

Hajee Mohammad Danesh Science and Technology University, Dinajpur In partial fulfillment of the requirements for the degree of

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DEDICATED

TO MY

BELOVED PARENTS

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ABSTRACT

An experiment was conducted at the On Farm Research Division, BARI, Chelopara, Bogra during the period from March to May, 2017 to study 'Development of fertilizer package for Mungbean (*Vigna radiata* L.)' using Randomized Completely Block Design with three replications. In this experiment 8 treatments were applied. These treatments were-T_1= 100% NPK (21-20-29 NPK Kg/ha), T_2= T_1+25% N (26.25-20-29 NPK Kg/ha), T_3= T_1+25% NP (26.25-25-29 NPK Kg/ha), T_4= T_1+25% NK (26.25-20-36.25 NPK Kg/ha),T_5= T_1+25% PK (21-25-36.5 NPK Kg/ha), T_6=T_1+25% NPK (26.25-25-36.25 NPK Kg/ha), T_7=75% of T_1 (17.75-15-21.75NPK Kg/ha), T_8 = Control (Native fertility). Result showed that a significant variation was observed among the treatments in respect of the maximum parameters. Nitrogen, Phosphorus and Potassium showed significant effect on all yield contributing characters as well as the seed yield of mungbean. The highest seed yield (1.53 ton/ha) was recorded at the T_6 treatment that is T_1+ 25% NPK (26.25-25-36.25 NPK Kg/ha). Treatment T_6 offered the highest number of branches per plant, number of leaves per plant, number of pods per plant, pod length, 1000-seed weight, straw yield, and biological yield whereas the lowest value of the same parameters was found in T_8 (control) treatment. It was revealed that the treatment T_6 was better than that of all other treatments.

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LIST OF ABBREVIATIONS

%	=	Percent
@	=	At the rate
^{0}C	=	Degree Celsius
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
CGR	=	Crop Growth Rate
CM	=	Chicken Manure
cv.	=	Cultivar (s)
CV	=	Coefficient Of Variation
DAE	=	Department Of Agricultural Extension
DAP	=	Di- ammonium Phosphate
DAS	=	Days After Sowing
DMRT	=	Duncans Multiple Range Test
EM	=	Effective Microorganism
et al.	=	And Others
FYM	=	Farm Yard Manure
MoA	=	Ministry Of Agriculture
MLT	=	Multiplication Testing Site
NAR	=	Net Assimilation Rate
NARC	=	National Agriculture Research Centre
NWFP		North West Frontier Province
RCBD	=	Randomized Complete Block Design
ppm	=	Parts Per Million
t/ha	=	Ton Per Hectare
TK./ha	=	Taka per Hectare

CHAPTER 1

INTRODUCTION

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INTRODUCTION

Mungbean (*Vigna radiata* L.) is an ancient and well known legume crop in Asia, particularly in the Indian subcontinent. It is one of the important pulse crop of Bangladesh, as it is an excellent source of easily-digestible protein of low flatulence, which complements the staple rice diet in the country. It contains amino acid, lysine which is generally deficit in food grains (Elias *et al.*1986). It is produced for both human consumption and as fodder. Its seed contains 51% carbohydrate, 26% protein, 10% moisture, 4% mineral and 3% vitamin (Afzal *et al.* 2008). This legume is known to have high nutrient values with excellent source of vegetable protein (seeds and sprouts contain to 28% of proteins). Sprout is rich in vitamins, minerals and amino acids (especially lizin). Mungbean is considered as a substitute of animal protein and forms a balanced diet when used with cereals (Khan and Malik, 2001; Anjum *et al.* 2006; Mansoor, 2007).

Since it is a short duration legume (maturing in 55 to 70 days), it fits well into many cropping systems, including rice and sugarcane under both rainfed and irrigated conditions. It increases small farmer's income and improves soil conditions. Mungbean can be grown as manure, hay, cover crop and forage or intercropped in cereals, sugarcane, sunflower or jute. On an average in Bangladeshi diet only 8 to 10% of the protein intake originates from animal sources, the rest can be met from plant sources by increasing the consumption of pulses. It is grown three times in a year covering 35313 ha with an average yield of 0.70 t ha^{-1} (BBS,2013).

In Bangladesh, total production of pulses is only 0.65 million ton against 2.7 million tons requirement. This means the shortage is almost 80% of the total requirement (Rahman & Ali, 2007). This is mostly due to low yield (MoA, 2005). It holds the 3rd in protein content and 3rd in acreage and production and first in market price (BBS, 2008).The reasons for low yield are manifold: some are varietals and some are management. Due to the shortage of land, the scope of its extensive cultivation is very limited.

Average yield of mungbean in Bangladesh is very low, which is primarily due to substandard methods of cultivation, poor crop stand, imbalanced nutrition, poor plant protection measures and lack of high yielding varieties. Mungbean yield and quality can be improved by the balanced use of fertilizers. Soil and fertilizer management is very complex and dynamic in nature. We are increasingly forced to meet up growing food needs from increase in yield from existing or even shrinking land areas. In this process, we are moving away from the traditional and rather static "soil dependent" agriculture to dynamic "fertilizer dependent" agriculture (BARC,2005).

Among the various factors affecting the production of mungbean in our country, the main cause limiting the productivity is improper and non-judicious use of manures and fertilizers which affect the growth and development of the crops and leads to reduced yield.

In recent years, it has been realized that, judicious application of nutrients are essential for higher yield and better quality of mungbean. Mungbeans are more susceptible to nutrient deficiencies than most crop plants because of their shallow and branched root system; hence they require and often respond well to addition of fertilizers. Under suitable agro- climatic conditions, nutrient management is the main factor which influences the growth and yield of mungbean to great extent. In modern agriculture, fertilizers constitute the major portion of cost of production of mungbean. It is possible to produce higher yields of good quality seeds by judicious application of nutrients.

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

Although studies on the balanced fertilization to mungbean applying from inorganic combinations and its effect on yield is extensive throughout the world, reports on those aspects under Bangladesh conditions in most cases are inconclusive. The present study was therefore undertaken in order to determine the optimum doses of plant nutrients with a suitable combinations of inorganic fertilizer for higher yield of mungbean seeds.

Objectives-

1. To determine appropriate fertilizer doses for mungbean.
2. To increase the yield and economic return of mungbean through fertilizer management.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The growth and yield response of mungbean towards application of fertilizer. Following review of literature includes reports as studied by several investigators who were engaged in understanding the problems that may help in the explanation and interpretation of results of the present investigation. In this chapter, an attempt has been made to review the available information in home and abroad regarding the growth and yield response of mungbean towards application of fertilizer.

2.1 Effect of Chemical Fertilizers Combination

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

Mollah *et al.* (2011) was conducted a field experiment at the Multiplication Testing Site (MLT), Joypurhat Sadar upazila with Potato- Mugnbean –T. Aman rice cropping pattern during November/2007 to November/2008 to verify different nutrient management approaches and to determine the economic dose of fertilizer for the said cropping pattern. The treatments were, soil test based fertilizer dose for moderate yield goal, soil test based fertilizer dose for high yield goal, integrated plant nutrient management, farmers' practice, and control. Cowdung was applied at the first crop potato only in the cropping sequence. The varieties for potato, mungbean and T. Aman rice were Diamant, BARI Mung-6, and BR11, respectively. The results demonstrated that the tuber yield of potato, seed yield of mungbean, and grain yield of T. Aman rice were significantly influenced by the different treatments. In mungbean, the highest 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 productivity, economic return, 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 and similar soils of Level Barind Agro-ecological zone for sustainable higher yield.

Salahin *et al.* (2011) was conducted a field experiment for three consecutive years to observe the effect of tillage and integrated nutrient management on soil physical properties and yield under tomato-mungbean- T. Aman cropping pattern during 2007-08, 2008-09 and 2009-10 at BARI, Gazipur. There were nine treatment combinations comprising three tillage practices i.e. T_1: tillage up to 8 cm depth, T_2: tillage up to 12 cm depth and T_3: tillage up to 20 cm depth and three levels of fertilizers i.e. F_1: recommended dose of chemical fertilizers only, F_2: cowdung @ 5tha^{-1} + (Recommended dose of chemical fertilizers-nutrients from cow dung) and F_3: native fertility (no fertilizer used) were tested in a split-plot design with three replications. Soil bulk density, particle density, porosity and field capacity were not significantly affected by tillage and organic and inorganic fertilizers but soil moisture significantly influenced by both treatments. The crop yields were significantly influenced by different treatment combinations of organic and inorganic fertilization but not by tillage practices. The combined effect of tillage and organic and inorganic fertilizers was non-significant in all aspects Rupa *et al.* (2014) was conducted an experiment at Sher-e-Bangla Agricultural University farm during the period from February to April 2012 to study the effect of organic and inorganic fertilizers on growth and yield of mungbean (BARI Mung -5). The experiment was followed by Randomized Completely Block Design with three replications. During the experiment following treatments were incorporated T_0; Control, T_1; 10 tha^{-1}

Cowdung (Recommended dose), T_2; 10 tha^{-1} Cowdung + 25 % of recommended dose of inorganic fertilizer, T_3; 10 tha^{-1} Cowdung + 50 % of recommended dose of inorganic fertilizer, T_4; 10 tha^{-1} + 75% of recommended dose of inorganic fertilizer, T_5; 10 tha^{-1} Vermicompost (Recommended dose), T_6; 10 tha^{-1} Vermicompost + 25% of recommended dose of inorganic fertilizer, T_7; 10 tha^{-1} Vermicompost + 50 % of recommended dose of inorganic fertilizer, T_8; 10 tha^{-1} Vermicompost + 75 % of recommended dose of inorganic fertilizer, T_9; 100 % Inorganic fertilizer. 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 while lowest was found from T_0.

Khalilzadeh *et al.* (2012) was done the study to determine the effect of foliar spraying of Bio-organic fertilizers and urea on root and vegetative growth of mungbean (*Vigna radiata* L.) in a greenhouse 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 except 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 and shoot length, volume and number of roots. Similarly shoot and leave number and nodules root were also improved by the foliar spraying of Green hum and Amino acid, respectively. While the lowest nodules root was observed in plants treated by nutriman N24 and urea. This improved growth of mainly due to nutrient availability in bio-organic fertilizer and uptake by plants.

An experiment was carried out by Bhuiyan *et al.* (2011) at the Bangladesh Agricultural University (BAU) Farm, Mymensingh from rabi season of 1999 to kharif-II season of 2002 in the Old Brahmaputra Floodplain Soils (AEZ 9) of Bangladesh to investigate the effect of integrated use of organic and inorganic fertilizers on yield and nutrient uptake of T.Aus rice and mungbean in the Wheat-T. Aus/ Mungbean-T.Aman cropping pattern. The results showed that application of organic manure along with chemical fertilizers resulted in markedly higher uptake of nutrients. The application of NPKS (HYG) fertilizers remarkably increased the crop yield. The lowest grain yield and the lowest nutrient uptake were noted in control plots receiving no fertilizer or manure.

Phanphruek *et al.* (2006) was conducted a field experiment in Pak Chong soil series at Lop Buri field crops experiment station in 2004 to investigate the effect of chicken manure and nitrogen fertilizer in sweet corn-mungbean cropping system under no-tillage system. The experimental design was a split plot with 5 replications. Main plot consisted of 2 soil preparations: conventional tillage and no-tillage. Subplot were nitrogen fertilizer and chicken manure (CM) applied for sweet corn (1st crop) which were 3 rates of nitrogen: 0, 10, 20 kgN/rai and CM 500 kg/rai + 5 kgN/rai, CM 500 kg/rai + 10 kgN/rai and CM 1000 kg/rai+5 kgN/rai. Nitrogen 20 kgN/rai produce highest yield (1515 kg/rai) significantly difference from the plot applied with 10 kgN/rai and treatment CM 500 kg/rai+5kgN/rai. However no significantly difference in corn yield as the effect of treatment CM 500 kg/rai+10 kgN/rai, CM 1000 kg/rai + 5 kgN/rai and 20 kgN/rai were observed. For mungbean (2nd crop) the result showed that CM residual effect significantly increased growth and seed weight.

Saleem *et al.* (2010) conducted an experiment of bio-economic efficiency 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 grain yield improved by 12 % and 11 % sown after mashbean and mungbean treated with PK (80:60 kg ha^{-1}) + Rhizobium inoculation respectively. In similar fashion, wheat grain yield increased by 20 % after 15 t ha^{-1} poultry manure and 15 % wheat grain 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 highest 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 budget analysis highest net benefit of Rs.148069.92 ha^{-1} was accrued in maize + mungbean – wheat sequence with half poultry manure + half PK +inoculation.

Rahman *et al.* (2014). was conducted an experiment to investigate the effect of different nutrients application on common bean at experimental field, Department of Botany, Hazara University, Mansehra during 2012-13 in Randomized Complete Block Design with three replicates and four treatments i.e. control(H_2O sprayal one), poultry manure, DAP (Di-ammonium Phosphate) and foliar spray of (NPK 20:20:20). The results showed that foliar spray of NPK significantly increased number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1}, biomass and grain yield.

Malik *et al.* (2003) carried out a field experiment on mungbean (*Vigna radiata* L.) in Pakistan to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean (*Vigna radiata L.*) cv. NM-98. Although plant population was not affected significantly, various growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted in the maximum seed yield (1,113 kg ha^{-1}). Protein content (25.6%) was maximum in plots treated with 50 kg N + 75 kg P ha^{-1}, followed by 25.1% protein content in plots treated at 25 kg N + 75 kg P ha^{-1}. The highest net income (Rs. 21,375) was obtained by applying 25 kg N + 75 kg P ha^{-1}.

Srinivas and Shaik (2002) conducted field experiment during the kharif seasons to study the effects of N (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) along with seed inoculation with *Rhizobium* culture on the growth and yield components of greengram. Plant height generally increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} followed by decrease with further increase in N. Number of seeds pod^{-1}, 1000-seed weight, seed and haulm yields generally increased. Seed inoculation with *Rhizobium* resulted in higher values for the parameters measured relative to the control. The interaction effects between N and P were not significant for the number of pods $plant^{-1}$, pod length, seed and haulms yield.

Patel *et al*. (2003) conducted a field experiment in Gujrat, India during the summer seasons of 1995 to 1998 on sandy loam soils to determine the suitable sowing date, and nitrogen and phosphorus requirements of summer mungbean (cv. GM3). Treatments comprised: all the 27 combinations of three sowing dates: 15 February, 1 March and 15 March; three nitrogen rates: 10, 20 and 30 kg N ha^{-1}; and three phosphorus rates: 20, 40 and 60 P ha^{-1}. Results indicated that sowing mungbean on 1 March recorded significantly higher grain yields, 37 and 16% higher than those of early (15 February) or late-sown crops (15 March), respectively. Application of 10 kg N ha^{-1} recorded significantly higher grain yield over the control. Treatment with 40 kg P ha^{-1} produced 15 and 18% higher grain yields than treatments with 20 and 60 kg P ha^{-1}, respectively. The highest net return of Rs. 18,240 ha^{-1} was recorded from mungbean sown on 1 March and treated with 20 kg N ha^{-1} and 40 kg Pha^{-1}.

Sharma *et al*. (2001) carried out a field experiment on mungbean cv. Pusa Baisakhi which was fertilized with various levels of nitrogen (0, 10 and 20 kg N ha^{-1}) and phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) under mid-hill conditions in Himachal Pradesh, India during the kharif seasons of 1998 and 1999. The highest levels of N and P_2O_5 applications resulted in the average maximum test weight, biological and grain yields, harvest index and seed protein content.

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

Sangakhara (2003) carried out a field experiment in Sri Lanka in 1999 to determine the impact of effective microorganisms (EM) on N dynamics in a cereal (maize cv. Ruwan) - legume (mungbean) cropping system, using 15N labeled maize or mungbean residues. EM increased the 15N concentrations of maize at the V_8 growth stage indicating better use of applied nutrients from organic matter. The uptake of 15N was greater from mungbean residues rather than from maize. EM also increased biological N fixation. The synergistic effects of EM in organic systems were evident from this field study.

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

Hayat *et al.* (2004) conducted a field experiment during kharif 2000 in Rawalpindi, Pakistan to find out the effect of N and *Rhizobium* sp. inoculation on the yield, N uptake and economics of mungbean (cultivars NM 92 and NCM 209). The treatments were: control; 500 g *Rhizobium* inoculum, 30, 60 and 90 kg N ha^{-1} and inoculum combined with N at 30, 60 and 90 kg ha^{-1}. N content was higher in nodules of NM 92 than NCM 209. The highest N content in nodules (2.80%) was obtained with inoculation + 30 kg N ha^{-1}. NCM 209 had higher N shoot content (2.13%) than NM 92 (1.87%). The highest shoot N content was obtained with inoculation + 30 kg N ha^{-1}. The highest soil N content was obtained with inoculation + 90 kg N ha^{-1}. NCM 209 produced higher yield than NM 92. The maximum economic yield for NM 92 and NCM 209 (768and 910 kg ha^{-1}, respectively) was obtained with inoculation + 90 kg N ha^{-1}. The maximum biological yield (4,889 kg ha^{-1}) was obtained in NCM 209 with inoculation + 30 kg N ha-

^{1}. NCM 209 showed higher biological yield than NM 92. The highest harvest index of 18.45% was obtained with inoculation + 30 kg N ha^{-1}. The maximum net income (Rs. 18,329 and Rs. 13,003 ha^{-1}) in NCM 209 and NM 92 was obtained with inoculation alone and inoculation + 30 kg N ha^{-1}, respectively. The highest benefit: cost ratio was obtained in NCM 209 with the inoculation treatment alone. A field experiment was laid out by Oad and Buriro (2005) to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30- 40 and 10-40-40 kg ha^{-1}) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.3 cm, germination of 90.5%, satisfactory plant population of 162, prolonged days taken to maturity of 55.5, long pods of 5.02 cm, seed weight per plant of 10.5 g, seed index of 3.52 g and the highest seed yield of 1,205 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

Rana and Choudhary (2006) conducted a field experiment during 2000 and 2001 in New Delhi, India to evaluate the relative moisture utilization by maize grown as sole crop or in maize-mungbean intercropping system. Total grain production in terms of maize equivalent was higher in maize (75 cm) + two rows of mungbean. Total N uptake and water use efficiency were also high estinmaize(75cm)+two rows of mungbean. All parameters increased with increasing concentration of N up to 120 kg ha^{-1}.

Tickoo *et al.* (2006) carried out a field experiment in Delhi, India during the kharif season of 2000 with mungbean cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1}. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Differences in the values of the parameters examined. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops. Sultana *et al*. (2009) conducted a field experiment during the period from March 2007 to June 2007 at Sher-e-Bangla Agricultural University, Dhaka with nitrogen and weed management in mungbean where nitrogen (0, 20 kg ha^{-1} at vegetative, 20 kg N ha^{-1} at vegetative and flowering) and weeding (no weeding, one weeding at vegetative, two weeding at vegetative and flowering) was done. Result showed that application of 20 kg N ha basal showed significantly higher values of all growth parameters like number of leaflet (24.3 at 20DAS and 24.3 at 40 DAS), leaf area (23.3 cm^2 at 20 DAS and 102.2 cm^2 at 40 DAS), Leaf dry weight (0.30, 6.99 and 10.61 g at 10, 17 and 24 DAS, respectively) and shoot dry weight (2.76 and 4.69 g at 17 and 24 DAS, respectively). This treatment also produced significantly more number of branches (1.67), pods $plant^{-1}$ (17.8) and seed yield (1,982 kg ha^{-1}).

Yaqub *et al*. (2010) carried out pattern based experiment at Pakistan to evaluate the induction of short-duration (maturity period, 55-70 days) mungbean [*Vigna radiata* (L.) Wilczek] as a grain legume in the pre-rice niche of the rice-wheat annual double cropping system and found that induction of a short-duration grain legume in the rice-wheat system appears to be more attractive as it offers short-term additional benefits to farmers and is equally beneficial in sustaining the productivity of rice-wheat system over time. The mungbean crop (grown without mineral N fertilizer) produced 1,166 kg ha^{-1} of grain in addition to 4,461 kg ha^{-1} of the manure biomass (containing 52 kg N ha^{-1}) that was ploughed under before planting rice with urea-N applied in the range of 0-160 kg N ha^{-1}. Averaged across urea-N treatments, manuring significantly increased the number of tillers $plant^{-1}$ (11% increases), rice grain yield (6% increase), grain N content (4% increase) and grain N uptake (9% increase). Significant residual effects of manuring were observed on the subsequent wheat crop showing higher grain yield (21% increases), grain N uptake (29% increase) and straw yield (15% increase). The results suggested the feasibility of including mungbean in the pre-rice niche to improve the productivity of the annual rice- wheat double cropping system.

Kayani *et al*. (2010) conducted experiment to investigate the impact of legume on the oncoming wheat crop. Mungbean (NM92) was planted during Kharif 2007. The wheat variety Inqalab-91 was sown before and after the mungbean plantation during Rabi 2006- 07 and 2007-08. Twelve different treatments were applied having different doses of N and P but Farm Yard Manure (FYM) remained constant. Six parameters were selected to investigate the potential effects of the legume viz., soil physico-chemical properties, plant height, spike length, number of grains spike^{-1}, 1000-seed weight and yield plot^{-1}. The results showed significant increase in plant height, spike length, number of grains/spike, 1000-grains weight and yield/plot after cropping mungbean. The yield was obtained at an increase of 26.90% after mungbean application. Based on results, cereal legume crop rotation is highly recommended.

A field experiment was conducted by Mohammad *et al*. (2010) to study the effect of crop residues and tillage practices on BNF, WUE and yield of mungbean (*Vigna radiata* L.) Wilczek) under semi-arid rainfed conditions at the Livestock Research Station, Surezai, Peshawar in North West Frontier Province (NWFP) of Pakistan. The experiment comprised of two tillage i) conventional tillage (T_1) and ii) no-tillage (T_0) and two residues i) wheat crop residues retained (+) and ii) wheat crop residues removed (-) treatments.BasaldosesofN@20:P@60kgha^{-1} was applied to mungbean at sowing time in the form of urea and single super phosphate respectively. Labeled urea having 5% N-15 atom excess was applied @ 20 kg N ha^{-1} as aqueous solution in micro plots (1m^2) in each treatment plot to assess BNF by mungbean. Similarly, maize and sorghum were grown as reference crops and were fertilized with N-15 labeled urea as aqueous solution having

1% N-15 atom excess @ 90 kg N ha^{-1}. The results obtained showed that mungbean yield (grain/straw) and WUE were improved in no-tillage treatment as compared to tillage treatment. Maximum mungbean grain yield (1224 kg ha^{-1}) and WUE (6.61 kg ha^{-1} mm^{-1}) were obtained in no-tillage (+ residues) treatment. The N concentration in mungbean straw and grain was not significantly influenced by tillage or crop residue treatments. The amount of fertilizer-N taken up by straw and grain of mungbean was higher under no- tillage with residues-retained treatment but the differences were not significant. The major proportion of N (60.03 to 76.51%) was derived by mungbean crop from atmospheric N_2 fixation, the remaining (19.6 to 35.91%) was taken up from the soil and a small proportion (3.89 to 5.89%) was derived from the applied fertilizer in different treatments. The maximum amount of N fixed by mungbean (82.59 kg ha^{-1}) was derived in no-tillage with wheat residue-retained treatment. By using sorghum as reference crop, the biological nitrogen fixed by mungbean ranged from 37.00 to 82.59 kg ha^{-1} whereas with maize as a reference crop, it ranged from 34.74 to 70.78 kg ha^{-1} under different treatments. In comparison, non-fixing (reference) crops of sorghum and maize derived upto 16.6 and 15.5% of their nitrogen from the labeled fertilizer, respectively. These results suggested that crop productivity, BNF and WUE in the rainfed environment can be improved with minimum tillage and crop residues retention.

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

2.2 Effect of Nitrogen Application

Achakzai *et al.* (2012) conducted a study was to evaluate the growth response of mungbean cultivars subjected to different rate of applied N fertilizer. The different N fertilizers exerted significant on plant height of Mungbean. The plants of T_2 (20 kg ha^{-1} N) gained maximum height (36.81 cm), whereas the short stature plants (29.64 cm) obtained in plots either receiving no fertilizer.

Asaduzzaman (2008) found that plant height of mungbean was significantly increased by the application of nitrogen fertilizer at 30 kg ha^{-1}.

A field experiment was conducted by Raman and Venkataramana (2006) in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram (*Vigna radiata*). There were 10 foliar spray treatments, consisting of water spray, 2% diammonium phosphate at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA. Crop nutrient uptake, yield and its attributes (pods plant^{-1} and seeds pod^{-1}) of greengram were augmented significantly due to foliar nutrition. The foliar application of 2% diammonium phosphate + NAA + Penshibao was significantly superior to other treatments in increasing the values of yield attributes.

Oad and Buriro (2005) conducted a field experiment 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 cv. AEM 96 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 plant height of 56.25 cm.

In a pot experiment at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Masud (2003) observed the highest plant height with the application of 30 kg N ha^{-1}.

Nursu"aidah *et al.* (2014) conducted an experiment on growth and photosynthetic responses of longbean (*Vigna unguiculata*) and mungbean (*Vigna radiata*) response to fertilization and they found that mungbean grown without fertilizer produced the highest number of pods per plant .

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher pods per plant.

A study was conducted by Nigamananda and Elamathi (2007) in Uttar Pradesh, India to evaluate 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 greengram 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 highest values for number of pods per plant (38.3).

Kulsum (2003) reported that different level of nitrogen showed significantly increased pods per plant of blackgram up to N 60 kg ha^{-1}.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al*. (2002) in Hisar, Haryana, India during the summer and reported that the number of pods per plant increased with increasing N rates.

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 observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N.

A study was conducted by Nigamananda and Elamathi (2007) in Uttar Pradesh, India to evaluate 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 greengram 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 highest seeds per pod (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 found that number seeds per pod was significantly affected by varying level of nitrogen and phosphorous.

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 observed 1000-seed weight increased with increasing rates of N up to 40 kg ha^{-1}.

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 durin the year of 2000 and 2001. They revealed that with the application of NPK at the rate of 50-50-0 kg ha^{-1} significantly affected the 1000 grains weight.

Azadi *et al.* (2013) conducted an experiment on the effect of different nitrogen level on seed yield and morphological characteristic of mungbean in the climate condition of Khorramabad and they found that the highest seed yield and pod length was obtained at 150 kg ha^{-1} urea.

Akbar *et al.* (2013) conducted an experiment on the interactive effect of cobaltand nitrogen on growth, nodulation, yield and protein content of field grown pea and observed that the highest seed yield in the treatment the 60 kg N ha^{-1} and 10 g Co ha^{-1}.

Sadeghipour *et al.* (2010) conducted an experiment on the production of mungbean (*Vigna radiata* L.) by nitrogen and phosphorus fertilizer application and they found that the maximum seed yield was obtained when 90 kg N ha^{-1} and 120 kg P_2O_5 ha^{-1} was applied.

Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher seed yield ha^{-1} (1982.05 kg).

Asaduzzaman*et al.* (2008) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, and Dhaka to evaluate the response of mungbean (*Vigna radiata* L.) to nitrogen and irrigation management. They found that 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage (35 DAS) gave significantly maximum seed yield per plant(5.53 g).

A study was conducted by Nigamananda and Elamathi (2007) in Uttar Pradesh, India to evaluate 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 greengram 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 highest grain yield (9.66 q ha^{-1}).

Tickoo *et al*. (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher grain yield (1.63 t ha^{-1}) compared to cv. Pusa 105.

A field experiment was conducted by Raman and Venkataramana (2006) in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram (*V. radiata*). There were 10 foliar spray treatments, consisting of water spray, 2% diammonium phosphate at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA. Crop nutrient uptake, yield and its attributes (number of pods per plant and number of seeds per pod) of green gram augmented significantly due to foliar nutrition. The foliar application of urea + NAA + Penshibao was significantly superior to other treatments in increasing the values of yield.

The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment.

A field study 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 increased the total grain 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.

Oad and Buriro (2005) conducted a field experiment 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}.

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

Malik *et al.* (2003) conducted an experiment to determine 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 observed that a fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted with maximum seed yield (1112.96 kgha^{-1}).

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20,

40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mungbean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al*. (2002) in Hisar, Haryana, India during the summer and reported that grain yield increased with increasing rates of up to 40 kg N ha^{-1} only.

Mahboob and Asghar (2002) studied the effect of seed inoculum at different nitrogen level on mungbean at the agronomic research station, Farooqabad in Pakistan. They revealed that seed inoculum + 50-50-0 NPK kg ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Kamal *et al.* (2001) conducted an experiment at the BARI farm during rainy season for 2000-2001 to determine the effect of various level of fertilizer and weeding of mungbean.

Superior seed yield (1430 kg ha^{-1}) was found 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 hand weeding at 20 and 30 DAE. This result showed that application of fertilizer @ 20-60-30 kg ha^{-1} combine with two hand weeding at 20 and 30 DAE was economical for yield as well as quality seed production of mungbean.

2.3 Influence of Phosphorus on Growth and yield of Mungbean

Malik *et al.* (2003) carried out a field experiment on mungbean (*Vigna radiata* L.) in Pakistan to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean (*Vigna radiata*) cv. NM-98. Although plant population was not affected significantly, various growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted in the maximum seed yield (1,113 kg ha^{-1}). Protein content (25.6%) was maximum in plots treated with 50 kg N + 75 kg P ha^{-1}, followed by 25.1% protein content in plots treated at 25 kg N + 75 kg P ha^{-1}. The highest net income (Rs. 21,375) was obtained by applying 25 kg N + 75 kg P ha^{-1}.

Srinivas and Shaik (2002) conducted field experiment during the kharif seasons to study the effects of N (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) along with seed inoculation with *Rhizobium* culture on the growth and yield components of greengram. Plant height generally increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} followed by decrease with further increase in N. Number of seeds pod^{-1}, 1000-seed weight, seed and haulm yields generally increased. Seed inoculation with *Rhizobium* resulted in higher values for the parameters measured relative to the control. The interaction effects between N and P were not significant for the number of pods $plant^{-1}$, pod length, seed and haulm yield.

Patel *et al*. (2003) conducted a field experiment in Gujrat, India during the summer seasons of 1995 to 1998 on sandy loam soils to determine the suitable sowing date, and nitrogen and phosphorus requirements of summer mungbean (cv. GM3). Treatments comprised: all the 27 combinations of three sowing dates: 15 February, 1 March and 15 March; three nitrogen rates: 10, 20 and 30 kg N ha^{-1}; and three phosphorus rates: 20, 40 and 60 P ha^{-1}. Results indicated that sowing mungbean on 1 March recorded significantly higher grain yields, 37 and 16% higher than those of early (15 February) or late-sown crops (15 March), respectively. Application of 10 kg N ha^{-1} recorded significantly higher grain yield over the control. Treatment with 40 kg P ha^{-1} produced 15 and 18% higher grain yields than treatments with 20 and 60 kg P ha^{-1}, respectively. The highest net return of Rs. 18,240 ha^{-1} was recorded from mungbean sown on 1 March and treated with 20 kg N ha^{-1} and 40 kg Pha^{-1}.

Sharma *et al*. (2001) carried out a field experiment on mungbean cv. Pusa Baisakhi which was fertilized with various levels of nitrogen (0, 10 and 20 kg N ha^{-1}) and phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) under mid-hill conditions in Himachal Pradesh, India during the kharif seasons of 1998 and 1999. The highest levels of N and P_2O_5 applications resulted in the average maximum test weight, biological and grain yields, harvest index and seed protein content.

Tickoo *et al.* (2006) carried out a field experiment in Delhi, India during the kharif season of 2000 with mungbean cultivars Pusa 105 and Pusa Vishal which were sown at

22.5 and

30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1}. Cultivar Pusa Vishal

recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Differences in the values of the parameters examined. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops.

2.3. Influence of Potassium on Growth and Yield of Mungbean

Ashraf *et al.* (2003) conducted a field experiment at Faisalabad in Pakistan to observe the effects of seed inoculation of a bio -fertilizer and NPK application on the performance mungbean cv. NM-98. The treatments consisted of the seed inoculation of *Rhizobium phaseoli* singly or in 12 combination with 20:50:0, 40:50:0 or 50:50:50 NPK kg ha^{-1} (urea), P (single super phosphate) and K (potassium sulphate) were applied during sowing. The tallest plants (69.9 cm) were obtained with seed inoculation + 50:50:0 kg NPK ha^{-1}. Seed inoculation + 50:50:0 or 50:50:50 kg ha^{-1} resulted in the highest number of pods plant^{-1} (29.0, 56.0, 63.9 and 32.6, respectively) and seed yield (1,053, 1,066, 1,075 and 1,072 kg ha^{-1}). Harvest index was the highest with seed inoculation in combination with NPK and 40:50:0 (25.23), 50:50:0 (24.70) or 50:50:50 (27.5). Seed inoculation along with NPK at 30:50:0 kg ha^{-1} was optimum for the production of high seed yield by mungbean cv. NM-98.

Panda *et al.* (2003) conducted field experiments in West Bengal, India to evaluate the effects of NK application on the productivity of yambean (*Pachyrhizus erosus*)-pigeonpea (*Cajanus cajan*) intercropping system and its residual effect on the succeeding mungbean (*Vigna radiata*). Marketable tuber yield of yambean increased linearly with increasing NK levels, with the highest being recorded with NK at 80 kg ha^{-1} applied in 2 splits (22.9 t ha^{-1}) closely followed by 100 kg NK ha^{-1} applied in 2 splits (22.4 t ha^{-1}). For pigeonpea, the maximum grain (14.38 q 13 ha^{-1}), stick (8.08 q ha^{-1}) and bhusa yield (9.96 q ha^{-1}) were recorded with 80 kg NK ha^{-1} applied in 2 splits. The highest level of NK (100 kg ha^{-1}) applied in 3 splits to yambean-pigeonpea intercropping system registered the maximum grain yield of the succeeding mungbean (9.43 q ha^{-1}), which was 33% higher than the untreated control.

A field experiment was laid out by Oad and Buriro (2005) to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.3 cm, germination of 90.5%, satisfactory plant population of 162, prolonged days taken to maturity of 55.5, long pods of 5.02 cm, seed weight per plant of 10.5 g, seed index of 3.52g and the highest seed yield of 1,205 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

Field studies was carried by out by Sangakkara *et al*. (2011) for testing the impact of fertilizer K on root development, seed yields, harvest indices, and N-use efficiencies of maize and mungbean, two popular smallholder crops over major and minor seasons. Application of 120 18 kg K ha^{-1} optimized all parameters of maize in the major wet season, whereas the requirement was 80 kg K ha^{-1} in the minor season. Optimal growth yields and N-use efficiencies of mungbean was with 80 kg K ha^{-1} in both seasons. Information regarding rates of fertilizer K that optimized N use and yield of maize and mungbean during each of the two tropical monsoonal seasons of South Asia is presented.

2.5 Influence of Sulphur on Growth and Yield of Mungbean

A field experiment was conducted by Sipai et al. (2016) for four consecutive years at

Centers of Excellence for Research on Organic Farming S. D. Agricultural University, Bhachau, Kutch, to study the effect of P, S and *Rhizobium* on yield, yield attributes and nodulation of Mungbean. The experiment consisting of three levels of phosphorus, three levels of sulphur (0, 20, 40 kg ha^{-1}) and two levels of *Rhizobium*, total 18 treatment combinations with three replications were comprised in factorial randomized block design. Application of 40 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} along with Rhizobium inoculation significantly increased the yields, yield attributes and nodulation of Mungbean as compared to control, but it remained at par with 20 kg P_2O_5 ha^{-1} and 20 kg

S ha^{-1}.Mazed *et al.* (2015) carried out a field experiment at the experimental farm of Sher-

e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh to study the growth and yield of Mungbean as influenced by potassium (K) and sulphur (S). Four levels of K and three levels of S (0, 3 and 6 5 kg ha^{-1}) were used in the study. The results revealed that grain and stover yield of mungbean increased with increasing levels of S.

The maximum significant grain and stover yield were obtained with the treatment combinations K_2S_2 (25 kg K ha^{-1} + 6 kg S ha^{-1}) and the same treatments combinations gave the highest plant height, number of branch $plant^{-1}$,yield attributes like number of pods per plant , number of seeds per pod , weight of 1000 seed. Ram & Katiyar (2013) carried out a field experiment was conducted under Instructional Farm of N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), to evaluate the influence of sulphur and zinc on mungbean for two consecutive summer seasons. The experiment was conducted with four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) and four levels of zinc (0, 5, 7.5 and 10 kg Zn ha^{-1}). The results revealed that application of 40 kg S ha^{-1} and 10 kg Zn ha^{-1} significantly increased the plant height, number of branches per plant, number of nodules per plant , number of pods per plant , number of seeds per pod , seed yield, protein content (%) and test weight was non-significant. The control (0 kg S × 0 kg Zn ha^{1}) had the poorest performance in respect of yield and protein content of mungbean seed. The increasing dose of zinc increased the seed yield with increasing dose of sulphur up to 40 kg S ha^{-1}. The highest seed yield (13.69 and 14.40 q ha^{-1}) was observed in combination with 40 kg S ha^{-1} and 10 kg Zn ha^{-1} which was significantly superior over rest of the combinations except 60 kg S ha^{-1} and 10 kg Zn ha^{-1}. The minimum seed yield (9.56 and 10.06 q ha^{-1}) was achieved with treatment having 20 kg S ha^{-1} and 5 kg Zn ha^{-1} and least was in control. A field experiment was conducted by Tripathi et al. (2012) to find out the effect of rhizobial strains and sulphur (S) levels (15, 30 and 45 kg ha^{-1}) on mungbean cultivars (SML-668, Pusa Vishal, and HUM-1). Application of 45 kg S ha^{-1} recorded higher plant height, primary branches, green tri-foliates, leaf area index, dry matter accumulation, nodule numbers and nodule dry weight, increased days to maturity, number of pod and higher grain and straw yield as compared to 6 cultivars Pusa Vishal and SML-668, and S application at 15 and 30 kg ha^{-1}, respectively. Nodule number was highest in HUM-1 × MO 5 and application of 45 kg S ha^{-1} in Pusa Vishal and HUM-1. A study was conducted by Dey and Basu (2009) in West Bengal, India to determine the effects of potassium and sulphur fertilizer on the growth, nodulation, yield and quality of green gram cv. B-1. Treatments comprised: 0, 20 and 40 kg K ha^{-1}, and 0, 20 and 40 kg S ha^{-1}. Growth characters such as plant height and dry matter accumulation in aerial plant parts were highest at 20, 40 and 65 days after sowing upon treatment with 40 kg K ha^{-1} along with 40 kg S ha^{-1}. The number of nodules and dry weight of nodules increased with increasing rates of sulphur and potassium. Yield components (i.e. number of pods plant, number of seeds per pod and 1000-seed weight) increased with increasing rates of sulphur and potassium. The increment in yield components further contributed to increased seed yield. Protein content also increased with increasing rates of sulphur and potassium. Yadav (2007) conducted an experiment to find out the effects of phosphorus and sulphur (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield of green gram cv. RMG-62 in a field experiment conducted in Rajasthan, India during the Kharif seasons. Plant height, number of branches per plant, number of pods per plant, number of seeds per pod, seed yield, stover yield and biological yield increased with increasing rates of phosphorus and sulphur up to 40 kg ha^{-1} and decreased thereafter. Srinivasarao *et al.* (2004) conducted an experiment with available sulphur (S) extracted in five extract ants, crop response to S application and use efficient use of S by mungbean and urdbean on different soil types of pulse growing regions of India. Among extract ants tested, 1 N NH_4OAc extracted higher S followed by Morgan's reagent, 0.001 NHCl, 0.15% CaCl2, and 1% NaCl. Response of

urdbean was in higher magnitude as compared to mungbean to 20 mg S kg^{-1}. In both the crops, larger response was obtained in Inceptisols followed by Vertisols 7 and lower response was found in Alfisols. Larger utilization of native soil S in case of Alfisols by both the crops resulted in lower levels of response to added fertilizer S. Owing to high degree of correlation with plant response, 0.15% Ca Cl_2 and Morgan's reagent can be used as soil test methods for assessing the available S supply and predicting the crop response to applied S on these soils. A trial was conducted by Siag and Yadav (2003) during Kharif seasons under irrigated conditions to study the response of mungbean cv. MUM 2 to sulphur(appliedasgypsum) with different application methods in sandy loam soil of

Rajasthan, India. Treatments comprised: two sulphur rates (20 and 40 kg ha^{-1}) and three application methods as basal, side dressing at 25 days after sowing (DAS) and half as basal + half as side dressing at 25 DAS, along with a control (no sulphur). The number of pods $plant^{-1}$ increased with increasing sulphur rates. Basal dose of 40 kg S ha^{-1} recorded the highest number of pods per plant (34.2). Plant heights, number of seeds per pod and 1000-seed weight were not influenced by different treatments in any year. Seed yield obtained at basal dose of 20 kg S ha^{-1} (973 kg ha^{-1}) was 42.9% higher than that of the control treatment (681 kg ha^{-1}). Seed yield was highest with a basal dose of 40 kg S ha^{-1} (1095 kg ha^{-1}), but did not differ significantly from 20 kg S ha^{-1}. A side dressing of 20 kg S ha^{-1} at 25 DAS did not increase grain yield over the control. Nita et al. (2002) conducted an experiment to find out the effects of K and S at 0, 20 and 40 kg ha^{-1},applied singly or in combination, on the growth and productive attributes of mungbean as well as on the fertility of the soil were determined in a field experiment conducted in West Bengal, India duringthesummerof1998-99 .Leaf area index, seed yield, protein yield, harvest index and net production value increased with increasing rates of K and S. Similarly, the status of N and P in soil decreased with increasing rates of K and S. The effects of phosphorus (30, 60 and 90 kg ha^{-1}), sulphur (0, 10, 20 and 30 kg ha^{-1}) and Rhizobium inoculation on the protein and S-containing amino acids of green gram (*V. radiata*) were determined in a field experiment conducted by Shahi *et al.*(2002)in Allahabad, Uttar Pradesh, India.

Application of P and S, and inoculation with Rhizobium enhanced the protein content in the grains of green gram, with 60 kg P ha^{-1} and 30 kg S ha^{-1} resulting in the highest increase in the protein content. Rhizobium inoculation also significantly increased the protein content in the grains of the crop. The S-containing amino acids were highest at 30 kg S ha^{-1}. The methionine, cystine and cysteine content of the grains were highest with the application of 30 kg S ha^{-1}, which was similar with the application of 20 kg S ha^{-1} . Pandey and Singh (2001) conducted an experiment with P_2O_5 the rate of 0, 25 or 50 kg ha^{-1} and S at 0, 20 and 40 kg ha^{-1} were applied as basal in Pura, Jammu and Kashmir, India. Mungbean responded significantly to the addition of P_2O_5 and S. The highest seed grain and stover yields were obtained at 50 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1}. The protein and sulphur-containing amino acid contents of the grains linearly increased with increasing rates of phosphorus and sulphur. The highest protein and sulphur-containing amino acid contents were observed at 50 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} and the lowest contents were observed in the control, during both the years.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter consists of the materials used and methodology followed in the experiment including a brief description of the experimental site, experimental design, soil, climate, land preparation, fertilizer application, planting materials, transplanting, intercultural operation, irrigation and drainage, data collection, data recording and their analysis. The details of investigation for achieving stated objectives are described below.

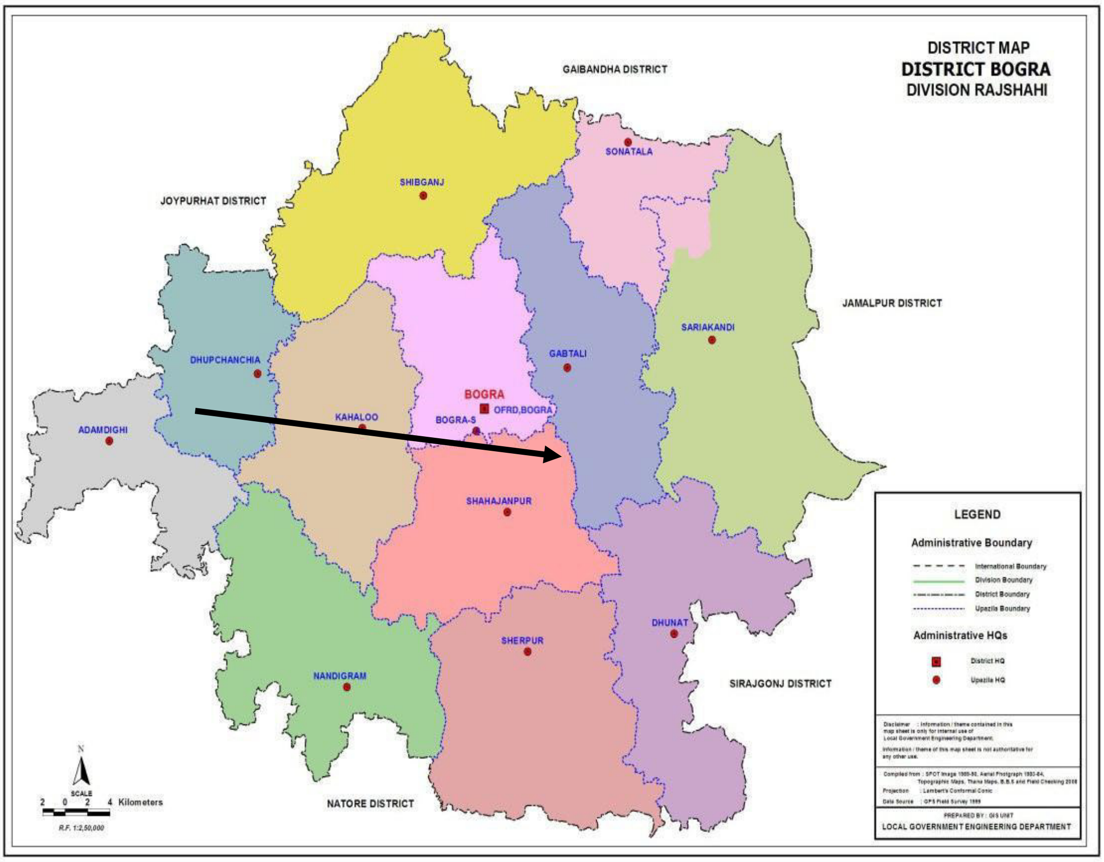

Figure 3.1: Location of the experimental site under On Farm Research Division, BARI, Chelopara, Bogra

3.1. Site Description

The experiment was conducted at the On Farm Research Division, BARI, Chelopara, Bogra during the period from March to May 2017. The experimental site was located at 24^{o} 51’03’’ N’ 89^{o} 22’15’’ E and 26 m above the sea level.

3.2. Agro-ecological Region

The experimental site belongs to the agro-ecological zone of “Karatoya Bangali Flood Plain”, AEZ-4. This was a region of complex relief and soils developed over the Madhupur clay, where floodplain sediments buried the dissected edges of the Karatoya Bangali Flood Plain, AEZ-4 leaving small hillocks of red soils as islands surrounded by flood plain.

3.3. Climate and Weather

The geographical location of the experimental site was under the sub-tropical climate characterized by three distinct seasons. The monsoon or rainy season extending from May to October, which is associated with high temperature, high humidity and heavy rainfall; the winter or dry season from November to 15 February, which is associated with moderately low temperature and the pre monsoon period or hot season from March to April, which is associated with some rainfall and occasional gusty winds. Information regarding monthly average maximum and minimum temperature, total rainfall and average relative humidity and sunshine during the period of study of the experimental site was collected from Bangladesh Meteorological Department, Agargaon, Dhaka and is presented in Appendix I. The experimental area possesses sub-tropical climate. The weather date including temperature, rainfall and relative humidity the period of experimentation recorded from On Farm Research Division, BARI, Chelopara, Bogra.

3.4. Soil

The soil on which the experiment was conducted is Karatoya Bangali Flood Plain, AEZ-4, a typical rice growing soil. Top soil was silty clay in texture, red brown terrace soil type, olive–gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The land was well drained with good irrigation facilities. The experimental site was a medium high land. The experimental site was above flood level and sufficient sunshine was available during the experimental period.

3.5. Planting Material

BARI Mung-6 was used as planting material in this study. This variety is suitable for summer season. Bangladesh Agricultural Research Institute released BARI mung-6 in 2003. Plant height of this variety ranges from 40 to 45 cm and seeds are deep green in color. One thousand seed weight is about 51-52 g. The variety requires 55 to 60 days to mature, and average yield is 1,500 kg ha^{-1}. It is also resistant to *Cercospora* leaf spot and tolerant to yellow mosaic virus (BARI, 2009).

3.6. Treatments under investigation

Treatments are-

T_1 = 100% NPK (21-20-29 NPK Kg/ha)

T_2 = T_1+25% N (26.25-20-29 NPK Kg/ha)

T_3 = T_1+25% NP (26.25-25-29 NPK Kg/ha)

T_4 = T_1+25% NK (26.25-20-36.25 NPK Kg/ha)

T_5 = T_1+25% PK (21-25-36.5 NPK Kg/ha)

T_6 = T_1+25% NPK (26.25-25-36.25 NPK Kg/ha)

T_7 = 75% of T_1 (17.75-15-21.75 NPK Kg/ha)

T_8 = Control

3.7. Experimental Design

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments. The experimental field was divided into 3 blocks. Each bock was again divided into 8 plots. The total numbers of unit plots of the experiment were 24 (8 × 3). The size of the unit plot was 4 m × 4 m (16 m^2). There were 0.50 m wide and 10 cm deep drains between blocks. Each treatment was again separated by drainage channel of 0.4m width and 10 cm depth.

3.8. Growing of Crops

3.8.1. Land Preparation

The land was irrigated before ploughing. After having field capacity, land was allowed to attain at too condition. On March to May, 2017, the first ploughing was done and final land ploughing was done on 4 March, 2017. According to experimental layout the experimental field was divided and arranged. On 4 March, 2017, the basal fertilizer doses were applied.

3.8.2. Fertilizer Application

Urea, triple super phosphate (TSP) and murate of potash (MoP) were used as sources of nitrogen, phosphorus and potash. All the fertilizers were applied as a basal dose before final land preparation.

3.8.3. Seed Sowing

Mungbean was sown on 15 March 2017. Healthy seeds of mungbean @ 35 kg ha^{-1} were sown by hand as uniformly as possible in furrows. Seeds were sown in the afternoon and immediately covered with soil to avoid sunlight. Line to line distance was 30 cm and plant to plant distance was maintained 15 cm.

3.9. Intercultural Operations

3.9.1. Weeding and Thinning

Weeding was done as per requirement. Thinning were done to maintain 15 cm plant to plant distance. The first thinning was done at 8 DAS and second one was done at 15 DAS.

3.9.2. Irrigation and Drainage

Two irrigations were applied, first one at 10 DAS and second at 30 DAS. After rainfall excess water was drained out to maintain proper soil moisture.

3.9.3. Insect Control

At the 50% pod formation stage, Malathion 57EC was sprayed @ 1.5 t ha^{-1} to control pod borer.

3.10. General Observation

The crops were monitored frequently to note any change in characters of plant. The crops looked good since the primary stage and maintained a satisfactory growth till harvest.

3.11. Determination of Maturity

At the time when 80% of the pods turned blakish in colour, the crops were assessed to attain maturity.

3.12. Harvesting and Sampling

The crops were harvested from central 1.0 m^2 area of each plot for biological yield data on different dates as they attained maturity. Five randomly selected plants from each plot were marked for recording data on plant height, leaves number, inflorescence number, flower and pod dropping. Pods were collected thrice throughout the growing period.

3.13. Threshing

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

3.14. Drying, Cleaning and Weighing

The collected seeds were dried in the sun for 1-3 days to reduce the moisture to about nearly 12% level. The dried seeds and straw were cleaned and weight of seeds per plot was corded.

3.15. Recording of Data

3.15.1. Plant Height

The height of plant was recorded in centimeter (cm) at harvest. Data were recorded from 5 plants selected at random from the outer side rows (started after 2 rows from outside) of each plot. The height of the plant was determined by measuring the distance from the soil surface to the tip of the top leaf.

3.15.2. Number of branches per plant

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

3.15.3. Number of leaves per plant

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

3.15.4. Number of flowers per plant

The total number of flower's per plant was counted manually at flowering stage from five tagged plants. The mean number of flowers per plant was calculated and expressed in number per plant.

3.15.5. Root length (cm)

The root length of five seedlings from the seed to the tip of the root was recorded in centimeter.

3.15.6. Shoot length (cm)

The length of five seedlings from the seed to the tip of the leaf blade was recorded in centimeter.

3.15.7. Pod dry weight (g)

The sun-dried pods of each plot were kept in an oven at 65^0 c for 72 hours. Drying was continued till the material become dry to ensure a constant weight then the average dry weight was calculated in grams.

3.15.8. Root dry weight (g)

The weight of five seedling roots was recorded and expressed in gram (gm) after oven drying at 70 degree centigrade for 72 h in an electric oven (Model-E28# 03-54639,Binder,Germany) and weight were recorded with an electrical balance 9Model-AND EK-3000).

3.15.9. Stem dry weight (g)

Fresh stems from five sample plants of each plot were kept in an oven at 65^0 C for 72 hours. Drying was continued till the material become dry to ensure a constant weight then the average dry weight was calculated in grams.

3.15.10. Leaf dry weight (g)

Fresh leaves weight of five sample plants from each plot were kept. After air drying, the samples keeping in envelopes were placed in an oven at 65^0 C for 72 hours till the materials were dried to ensure a constant weight. Then their mean dry weight was calculated in grams.

3.15.11. Number of pods per plant

Number of pods per plant was counted manually at harvest and number of pods per plant was calculated by dividing the value with the number of plants in each plot.

3.15.12. Pod length (cm)

Length of pod was measured in centimeter from 5 pods of plants and then the average seed number was calculated.

3.15.13. Number of seeds per pod

The number of seeds per pod was recorded. In that case every pod from each plot was taken and means were calculated.

3.15.14. 1000-seed weight (g)

Thousand cleaned sun dried seeds were counted from the seed stock obtained from each treatment combination and weighted by using an electrical balance and expressed in gram.

3.15.15. Seed yield (ton ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1}and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

3.15.16. Straw yield (ton ha^{-1})

After separation of seeds from plant and harvested crop was sun dried and the weight was recorded and then converted into ton ha^{-1}.

3.15.17. Biological yield (ton ha^{-1})

The summation of seed yield and above ground straw yield was the biological yield. Biological yield = Seed yield + Straw yield.

3.15.18. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula. Harvest index (HI %) = Seed yield/Biological yield× 100

3.15.19. Grossreturn

Gross return is the monetary value of total product and by-product. Per hectare gross returns from mungbean production was calculated by multiplying the total amount of production by their respective market prices.

3.15.20. Cost of treatment

The cost of mungbean production included the cost item like human labour and cultivation costs, material cost (including cost of seeds, fertilizers, manures etc), land use cost and interest on operating capital.

3.15.21. Gross margin

Gross margin is the reduction of gross return to cost of treatment.

3.16. Statistical analysis

The collected data on different growth and yield parameters and nutrient contents of mungbean were statistically analyzed. The means for all treatments were calculated and the analyses of variances for all the characters were performed by 'F' variance test using MSTAT-C computer package program. The significance of difference between pair of means was performed by the Dancan's Multiple Range Test (DMRT) (Russel, 1986).

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

This chapter contains the presentation and discussion of the results obtained from the present study. Results have been presented, discussed and possible interpretations were made through tables and graphs. The results obtained from this experiment have been presented under separate headings and sub-headings as follows:

4.1.1. Plant height

The data on plant height (cm) of mungbean at harvesting stage as influenced by different treatments are presented in Table 1. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest the highest plant height was obtained in T_6 treatment (50.70 cm) which was statistically similar with all other treatments except control treatment (36.70 cm). It seems from the results that chemical fertilizers significantly influenced among the treatment. Ram & Katiyar (2013) carried out a field experiment was conducted under Instructional Farm of N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) to evaluate the influence of sulphur and zinc on mungbean for two consecutive summer seasons. The experiment was conducted with four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) and four levels of zinc (0, 5, 7.5 and 10 kg Zn ha^{-1}). The results revealed that application of 40 kg S ha^{-1} and 10 kg Zn ha^{-1} significantly increased the plant height, number of branches per plant, number of nodules per plant, number of pods per plant, number of seeds per pod, seed yield, protein content (%) and test weight was non-significant.

4.1.2. Number of branches per plant

Number of branches per plant of mungbean at harvesting stage as influenced by different treatments are presented in Table 1. It was found that at harvest the highest number of branches per plant was obtained from T_6 treatment (8.33) which was statistically similar with all other treatments except T_7 (6.60) and T_8 treatment (3.80). Mazed *et al.* (2015) carried out a field experiment at the experimental farm of Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh to study the growth and yield of Mungbean as influenced by potassium (K) and sulphur (S). Four levels of K and three levels of S (0, 3 and 6 5 kg ha^{-1}) were used in the study. The results revealed that the treatments combinations gave the highest number of branches per plant among the treatments over control.

4.1.3. Number of leaves per plant

Number of leaves per plant of mungbean at harvesting stage as influenced by chemical fertilizers are presented in Table 1. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest the highest number of leaves was obtained from T_6 treatment (30.467) which was statistically similar with T_1(28.53) treatment and the lowest in T_8 treatment (21.00) that is control. Results showed that the combination of chemical fertilizers significantly increased the number of leaves per plant.

4.1.4. Number of flowers per plant

The data on number of flowers per plant of mungbean at harvesting stage as influenced by doses of fertilizers are presented in Table 1. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest the highest number of flowers was obtained from T_1 treatment (24.73) which was statistically similar

With T_6 (24.06) and T_2 (23.27). The lowest number of flowers was obtained from T_8 treatment (14.66). Results showed that the combination of chemical fertilizers significantly increased the number of flowers plant^{-1}.

Table 4.1. Morphological characteristics under different fertilizer package of mungbean

Treatment	Plant height(cm)	No. of branches per plant	No. of leaves per plant	No of flowers per plant
T_1	49.93a	7.667ab	28.533ab	24.733a
T_2	50.6a	7.400ab	26.333bc	23.267ab
T_3	46.23a	7.000ab	25.000c	21.333c
T_4	48.63a	7.067ab	25.333c	23.000b
T_5	49.50a	6.867ab	24.733c	19.600d
T_6	50.70a	8.333a	30.467a	24.067ab
T_7	49.23a	6.600b	24.067c	19.467d
T_8	36.70b	3.800c	21.000d	14.667c
CV (%)	5.96	11.22	5.88	6.24
Level of Significance	*	**	**	**

** Indicates 1% level of significance

* Indicates 5 % level of significance

ns = non significance

4.1.5. Root Length (cm)

The data on root length of mungbean at harvesting stage as influenced by different treatments are presented in Table 2. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest the highest root length was obtained from T_6 treatment (16.93 cm) that is T_1+ 25% NPK fertilizer. It was statistically similar with T_2 (15.47 cm) and T_7 (15.07cm) and different with all other treatments. The lowest root length was obtained from T_8 treatment (13.53 cm). Results showed that the combination of chemical fertilizers significantly increased the root length. Khalilzadeh *et al.* (2012) carried out a study to determine the effect of foliar spraying of Bio-organic fertilizers and urea on root and vegetative growth of mungbean (*Vigna radiata* L.) in a greenhouse 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 except 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 and shoot length and volume and number of roots.

4.1.6. Shoot Length (cm)

Shoot length of mungbean at harvesting stage as influenced by different doses of fertilizers are presented in Table 2. It was found that at harvest the highest shoot length was obtained from T_6 treatment (42.46 cm) which was statistically similar with T_1 treatment (41.73 cm) and differed from other treatments. The lowest shoot length was obtained from T_8 treatment (34.00 cm) that is control. Results showed that the combination of chemical fertilizers significantly increased the shoot length. Khalilzadeh *et al.* (2012) were done the study to determine the effect of foliar spraying of Bio-organic fertilizers and urea on root and vegetative growth of mungbean (*Vigna radiata* L.) in a greenhouse 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 except 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 and shoot length, volume and number of roots. Similarly shoot and leave number and nodules root were also improved by the foliar spraying of Green hum and Amino acid, respectively. While the lowest nodules root was observed in plants treated by nutriman N24 and urea. This improved growth of mainly due to nutrient availability in bio-organic fertilizer and uptake by plants.

4.1.7. Pod Dry Weight (g)

Pod dry weight of mungbean at harvesting stage as influenced by different treatments are presented in Table 2. The average values of the treatments involving (T_1- T_8) were observed; it was found that at harvest the highest pod dry weight was obtained from T_6 treatment (75.0g). It was significantly different with all other treatments. The lowest pod dry weight was obtained from T_8 treatment (57.66g). Results showed that the combination of chemical fertilizers significantly increased the pod dry weight.

4.1.8. Root Dry Weight (g)

Root dry weight of mungbean at harvesting stage as influenced by different doses of fertilizers are presented in Table 2. The average values of the treatments involving (T_1- T_8) were observed; it was found that at harvest the highest root dry weight was obtained from T_1 treatment (10.00g) which was statistically similar with all other treatments except T_3 and control treatment. The lowest root dry weight was obtained from T_8 treatment (4.33g) that is control. Results showed that the combination of chemical fertilizers significantly increased the root dry weight. Khalilzadeh *et al.* (2012) was done the study to determine the effect of foliar spraying of Bio-organic fertilizers and urea on root and vegetative growth of mungbean (*Vigna radiata* L.) in a greenhouse 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 except 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 and shoot length, volume and number of roots. Similarly shoot and leave number and nodules root were also improved by the foliar spraying of Green hum and Amino acid, respectively.

4.1.9. Stem Dry Weight (g)

Stem dry weight of mungbean at harvesting stage as influenced by different treatments are presented in Table 2. It was found that at harvest the highest stem dry weight was obtained from T_6 treatment (55.66g). It was similar with T_2 (53.00g) and T_7 (52.33g) treatment and the lowest in T_8 treatment (31.00g). Results showed that the combination of chemical fertilizers significantly increased the stem dry weight. Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher stem dry weight (4.69g).

4.1.10. Leaf Dry Weight (g)

Leaf dry weight of mungbean at harvesting stage as influenced by different treatments are presented in Table 2. It was found that at harvest the highest leaf dry weight was obtained from T_6 treatment (52.00g) which was statistically different with all other treatments. The lowest leaf dry weight was obtained from T_8 treatment (35.66 g). Results showed that the combination of chemical fertilizers significantly increased the leaf dry weight. Sultana *et al.* (2009) conducted an experiment at the experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and weed managements on mungbean (*Vigna radiata* L.). They found that application of 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} with one weeding at vegetative stage showed significantly higher leaf dry weight (0.30, 6.99 and10.61g).

Table 4.2. Growth characteristics under different fertilizer package of mungbean

Treatment	Root length (cm)	Shoot length (cm)	Pod dry weight (g)	Leaf dry weight(g))	Root dry weight(g)	Shoot dry weight(g)
T_1	14.267 b	41.733 ab	70.333 b	46.667bc	10.000 a	49.000 b
T_2	15.467 ab	39.867 bc	69.333 b	48.333 b	7.667 ab	53.000 a
T_3	13.800 b	37.800 c	64.667 c	44.333 c	7.333 a	47.000 bc
T_4	14.200 b	38.333 c	68.667 b	41.000 d	7.667 ab	40.333 b
T_5	14.200 b	39.333 bc	68.333 b	48.667 b	8.000 ab	44.667 c
T_6	16.933 a	42.467 a	75.000 a	52.000 a	9.667 ab	55.667 a
T_7	15.067 ab	39.000 c	64.333 c	46.667 bc	8.667 ab	52.333 a
T_8	13.533 b	34.000 d	57.667 d	35.667 e	4.333 c	31.000 c
CV(%)	9.51	5.53	4.20	4.14	16.34	4.95
Level of Significance	ns	**	**	**	**	**

**Indicates 1% level of significance

* Indicates 5 % level of significance

ns = non significant

4.1.11. Number of pods per plant

Number of pods per plant of mungbean at harvesting stage as influenced by different treatments are presented in Table 3. The highest number of pods per plant was obtained from T_6 treatment (20.77) which was followed by all other treatments except control treatment (12.03). Number of pods plant $^{-1}$ increased with increasing N rates. 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 observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N.

4.1.12. Pod Length (cm)

Pod length of mungbean at harvesting stage are presented in Table 3. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest the highest pod length was obtained from T_6 treatment (9.07 cm) which was statistically similar with all other treatments except control (4.24 cm). Azadi *et al.* (2013) conducted an experiment on the effect of different nitrogen level on seed yield and morphological characteristic of mungbean in the climate condition of Khorramabad and they found that the highest seed yield and pod length was obtained at 150 kg ha^{-1} urea.

4.1.13. Number of seeds per pod

Number of seeds per pod of mungbean at harvesting stage as influenced by different treatments are presented in Table 3. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest number of seeds per pod did not differ significantly. But numerical number of seeds per pod was highest in T_2 treatment (11.53) and lowest in T_8 treatment (10.87). Mazed *et al.* (2015) carried out a field experiment at the experimental farm of Sher-e-Bangla Agricultural University, Sher- e-Bangla Nagar, Dhaka-1207, Bangladesh to study the growth and yield of Mungbean as influenced by potassium (K) and sulphur (S).Four levels of K and three levels of S (0, 3 and 6 5 kg ha^{-1}) were used in the study. The results revealed that seed and stover yield of mungbean increased with increasing levels of S. The maximum significant seed and stover yield were obtained with the treatment combinations K_2S_2 (25 kg K ha^{-1} + 6 kg S ha^{-1}) and the same treatments combinations gave the highest plant height, number of branch per plant, yield attributes like number of pods $plant^{-1}$, number of seeds per pod, weight of 1000 seed.

4.1.14. 1000-seed weight(g)

1000-seed weight of mungbean at harvesting stage as influenced by different treatments are presented in Table 3. The highest 1000-seed weight was obtained from T_6 treatment (51.90 g). It was statistically similar with all other treatments except control treatment (44.63 g). Results showed that the combination of chemical fertilizers significantly increased the 1000-seed weight. 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 observed 1000-seed weight increased with increasing rates of N up to 40 kg ha^{-1}. Mahboob and Asghar (2002) studied the effect of seed inoculums 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 50-50-0 kg ha^{-1} significantly affected the 1000-seed weight.

4.1.15. Seed Yield(t/ha)

Seed yield of mungbean at harvesting stage as influenced by different treatments are presented in Figure 3. The highest seed yield was obtained from T_6 treatments (1.53 t/ha).

It was statistically similar with all other treatments except T_7 (1.04 t/ha) and T_8 (1.04 t/ha). Results showed that the combination of chemical fertilizers significantly increased the seed yield. Mollah *et al*. (2011) was conducted a field experiment at the Multiplication Testing Site (MLT), Joypurhat Sadar upazila with Potato- Mugnbean –T. Aman rice cropping pattern during November/2007 to November/2008 to verify different nutrient management approaches and to determine the economic dose of fertilizer for the said cropping pattern. The treatments were, soil test based fertilizer dose for moderate yield goal, soil test based fertilizer dose for high yield goal, integrated plant nutrient management, farmers' practice, and control. Cowdung was applied at the first crop potato only in the cropping sequence. The varieties for potato, mungbean and T. Aman rice were Diamant, BARI Mung-6, and BR11, respectively. The results demonstrated that the tuber yield of potato, seed yield of mungbean, and grain yield of T. Aman rice were significantly influenced by the different treatments. In mungbean, the highest seed yield (1384 kg/ha) was also recorded from NPKS for high yield goal with residual cowdung treatment. Sharma *et al*. (2001) carried out a field experiment on mungbean cv. Pusa Baisakhi which was fertilized with various levels of nitrogen (0,10 and 20 kg N ha^{-1}) and phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) under mid-hill conditions in Himachal Pradesh, India during the kharif seasons of 1998 and 1999.

The highest levels of N and P_2O_5 applications resulted in the average maximum test weight, biological and seed yields.

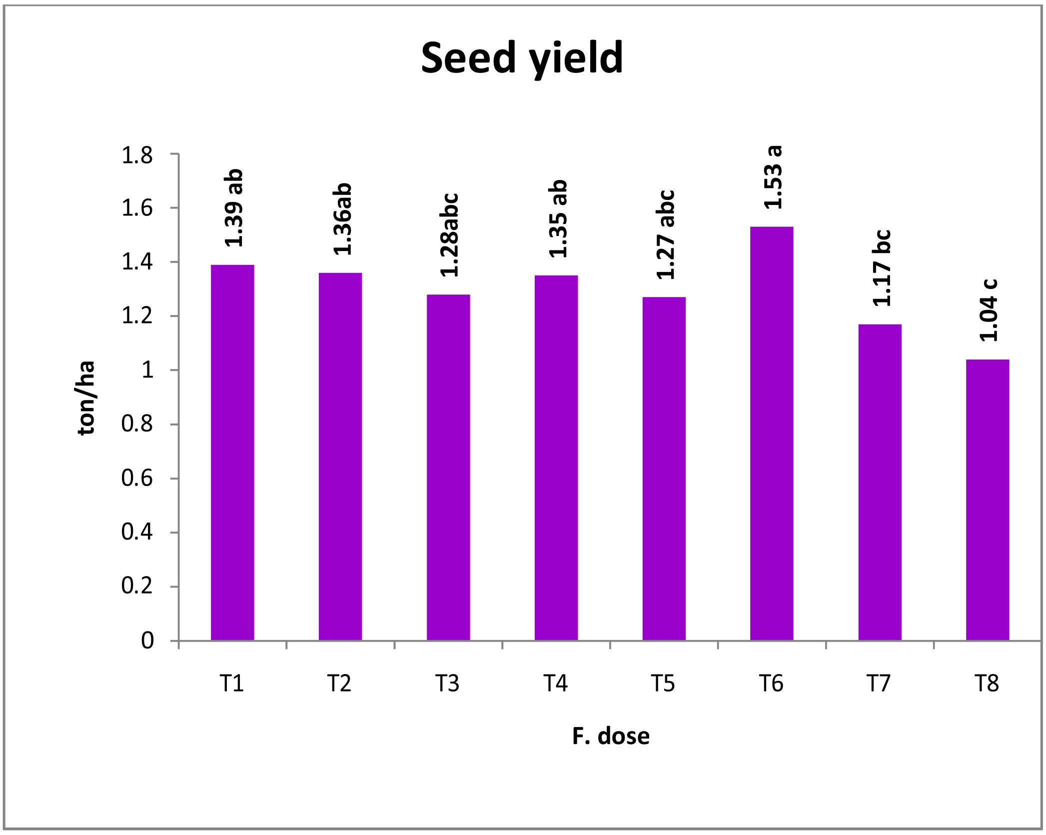

Figure 4.1. Effect of fertilizer package on seed yield of mungbean.

4.1.16. Straw Yield (t/ha)

Straw yield of mungbean at harvesting stage as influenced by different fertilizers are presented in Figure 3. The average values of the treatments involving (T_1- T_8) were observed; it was found that at harvest the highest straw yield was obtained from T_6 treatment (5.08 t/ha) which was statistically similar with all other treatment except control treatment (2.31 t/ha). The lowest straw yield was obtained from T_8 treatment (2.31 t/ha). Results showed that the combination of chemical fertilizers significantly increased the straw yield. Pandey and Singh (2001) conducted an experiment with P_2O_5 the rate of 0,25 or 50 kg ha^{-1} and S at 0, 20 and 40 kg ha^{-1} were applied as basal in Pura, Jammu and Kashmir, India. Mungbean responded significantly to the addition of P_2O_5 and S. The highest seed yield and straw yields were obtained at 50 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1}.

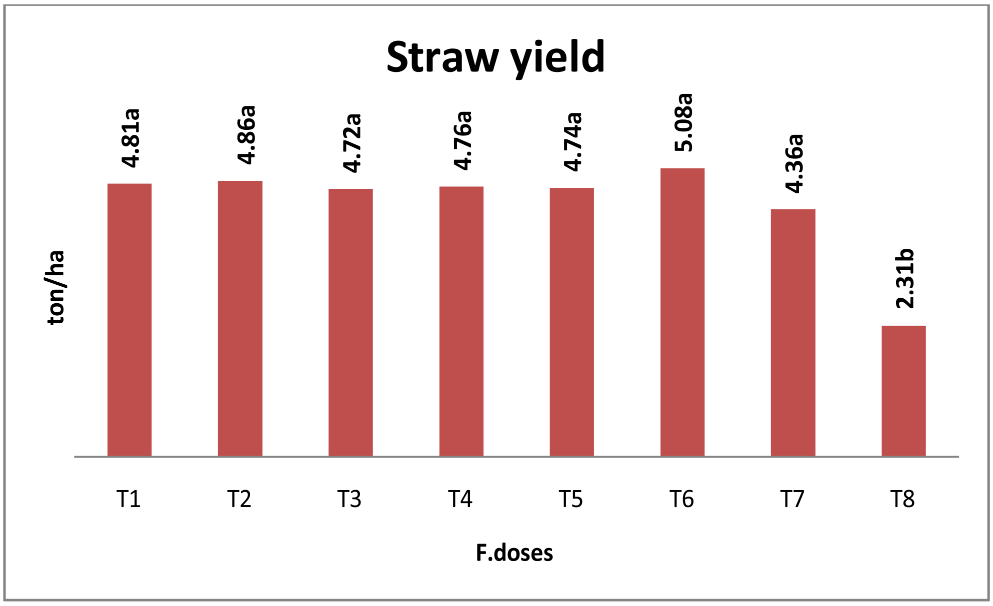

Figure 4.2. Effect of fertilizer package on straw yield of mungbean

4.1.17. Biological Yield (t/ha)

Biological yield of mungbean at harvesting stage as influenced by chemical fertilizers are presented in Figure 3. The average values of the treatments involving (T_1- T_8) were observed; it was found that at harvest the highest biological yield was obtained from T_6 treatment (6.61 t/ha) which was statistically similar with all other treatment except control (3.350 t/ha). Results showed that the combination of chemical fertilizers significantly increased the biological yield. Tickoo *et al.* (2006) carried out a field experiment in Delhi, India during the kharif season of 2000 with mungbean cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1}. Cultivar Pusa Vishal recorded higher biological and seed yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Sharma *et al.* (2001) carried out a field experiment on mungbean cv. Pusa Baisakhi which was fertilized with various levels of nitrogen (0, 10 and 20 kg N ha^{-1}) and phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) under mid-hill conditions in Himachal Pradesh, India during the kharif seasons of 1998 and 1999. The highest levels of N and P_2O_5 applications resulted in the maximum test weight, biological and seed yields.

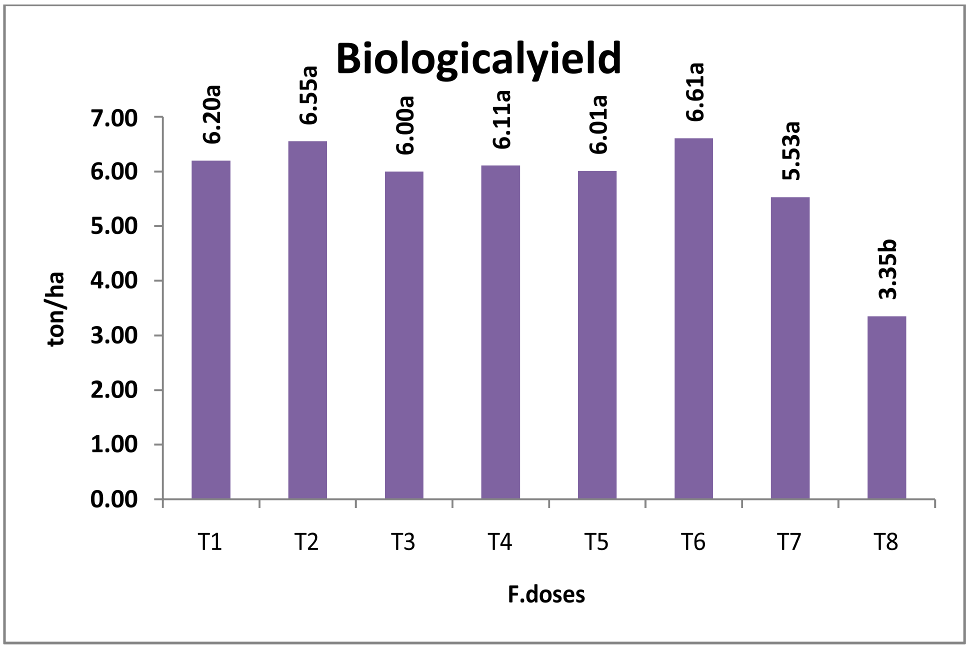

Figure 4.3. Effect of fertilizer package on biological yield of mungbean

4.1.18. Harvest Index (%)

Harvest index of mungbean at harvesting stage as influenced by different fertilizers are presented in Table 3. The average values of the treatments involving (T_1-T_8) were observed; it was found that at harvest the highest harvest index was obtained from T_8 treatment (31.05 %). It was statistically different with all other treatment. The lowest harvest index was obtained from T_5 treatment (21.14%) which was similar with other treatments except T_8. Results showed that the combination of chemical fertilizers significantly increased the harvest index. Sharma *et al.* (2001) carried out a field experiment on mungbean cv. Pusa Baisakhi which was fertilized with various levels of nitrogen (0, 10 and 20 kg N ha^{-1}) and phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) under mid-hill conditions in Himachal Pradesh, India during the kharif seasons of 1998 and 1999. The highest levels of N and P_2O_5 applications resulted in, biological yield and harvest index. Ashraf *et al*. (2003) conducted a field experiment at Faisalabad in Pakistan to observe the effects of seed inoculation of a bio -fertilizer and NPK application on the performance mungbean cv. NM-98. The treatments consisted of the seed inoculation of *Rhizobium phaseoli* singly or in combination with 20:50:0, 40:50:0 or 50:50:50 NPK kg ha^{-1} (urea), P (single super phosphate) and K (potassium sulphate) were applied during sowing. Harvest index was the highest with seed inoculation in combination with NPK and 40:50:0 (25.23), 50:50:0 (24.70) or 50:50:50(27.5).

Table 4.3. Yield and yield contributing characters of Mungbean under different fertilizer package at OFRD, Bogra during 2016-2017

Treatment	No. of pods per plant	Pod length (cm)	No. of seeds per pod	1000 seed weight(g)	Harvest index (%)
T_1	19.83a	9.060 a	11.13a	50.80a	23.420b
T_2	19.57a	8.973 a	11.53a	49.93ab	21.870b
T_3	18.87a	8.673 a	11.37a	50.43a	21.340b
T_4	18.90a	8.867 a	10.83a	49.90ab	22.090b
T_5	18.30a	8.633 a	10.87a	50.83a	21.140b
T_6	20.77a	9.073 a	11.27a	51.90a	23.150b
T_7	18.63a	8.213 a	11.07a	47.53ab	21.160b
T_8	12.03b	4.240 b	10.87a	44.63b	31.050a
CV(%)	10.57	10.73	5.55	5.91	5.74
Level of Significance	**	**	*	*	**

**Indicates 1% level of significance

* Indicates 5% level of significance

ns = non significance

4.1.19. Cost of Production (Tk/ha)

Cost of production of mungbean at harvesting stage as influenced by different fertilizers are presented in Figure 4. It was found that the highest cost of production was obtained from T_6 treatment (35262 Tk/ha). The lowest cost of production was obtained from T_8 treatment (30254 Tk/ha). Results showed that the combination of chemical fertilizers significantly increased the cost of treatment.

4.1.20. Gross return (Tk/ha)

Gross return of mungbean at harvesting stage as influenced by different fertilizers are presented in Figure 4. It was found that at harvest the highest gross return was obtained from T_6 treatment (122400 Tk/ha).The lowest gross return was obtained from T_8 treatment (83200 Tk/ha). Results showed that the combination of chemical fertilizers significantly increased the gross return. Patel *et al.* (2003) conducted a field experiment in Gujrat, India during the summer seasons of 1995 to 1998 on sandy loam soils to determine the suitable sowing date, and nitrogen and phosphorus requirements of summer mungbean (cv. GM3). Treatments comprised: all the 27 combinations of three sowing dates: 15 February, 1 March and 15 March; three nitrogen rates: 10, 20 and 30 kg N ha^{-1}; and three phosphorus rates: 20, 40 and 60 P ha^{-1}. The highest gross return of Rs. 18,240 ha^{-1} was recorded from mungbean sown on 1 March and treated with 20 kg N ha^{-1} and 40 kg P ha^{-1}.

4.1.21. Gross margin (Tk/ha)

Gross margin of mungbean at harvesting stage as influenced by different doses fertilizers are presented in Figure 4. The highest gross margin was obtained from T_6treatment (87138 Tk/ha). The lowest gross margin was obtained from T_8 treatment (52946 Tk/ha).

Results showed that the combination of chemical fertilizers significantly increased the gross margin.

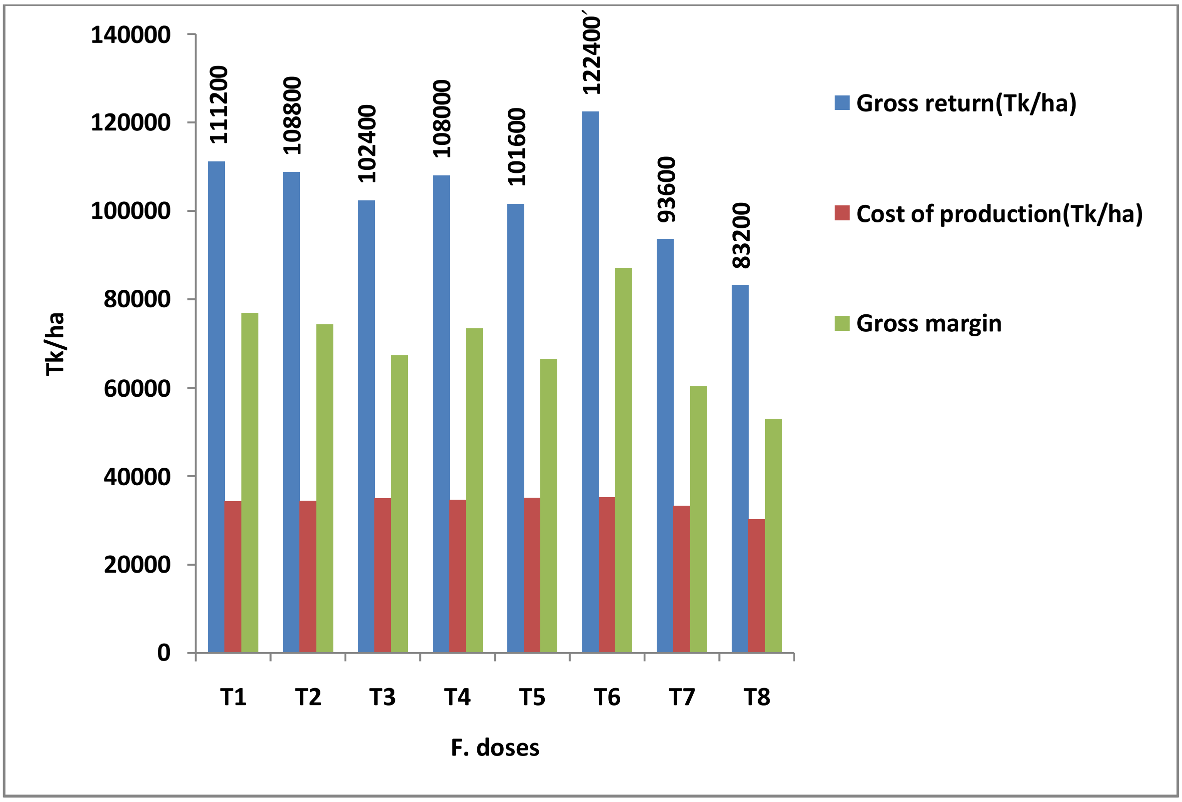

Figure 4.4. Effect of fertilizer package on gross return and gross margin of mungbean

CHAPTER 5

SUMMARY AND CONCLUSION

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Mungbean (*Vigna radiata* L.) is an ancient and well known legume crop in Bangladesh; It is one of the important pulse crop. It is an excellent source of easily-digestible protein of low flatulence, which complements the staple rice diet in the country. Production of mungbean by the influence of different doses of chemical fertilizers. The tallest plant height was observed in T_6 treatment (50.70cm) which was statistically similar with all other treatments except control treatment (36.70cm) and the lowest plant height was obtained from T_8 treatment (36.70cm). It seems from the results that chemical fertilizers significantly influenced among the treatment. The highest number of branches per plant was found from T_6 treatment (8.33) which was statistically similar with all other treatments except T_7 (6.60) and T_8 treatment (3.80). Similarly, the highest number of leaves per plant was obtained from T_6 treatment (30.46). It was followed by T_1 (28.53) treatment and the lowest number of leaves per plant was obtained from T_8 treatment (21.00).

The highest number of flowers per plant was found in T_1 treatment (24.73) which was statistically similar with T_6 (24.06) and T_2 (23.27). The lowest number of flowers per plant was obtained from control T_8 treatment (14.67). Results showed that the combination of chemical fertilizers significantly increased the number of flowers per plant. The highest root length was in T_6 treatment (16.93cm). It was statistically similar with T_2 (15.47 cm) and T_7 (15.07cm) and different with all other treatments. The lowest root length was found in control ($T_{8,}$ 13.53cm) treatment. The highest shoot length was obtained from T_6 treatment (42.467cm) which was statistically similar with T_1 treatment (41.73cm) and significantly different with all other treatments. The lowest shoot length was obtained from T_8 treatment (34.00cm). The highest pod dry weight was obtained from T_6 treatment (75.0g). It was significantly different with all other treatments. The lowest pod dry weight was obtained from T_8 treatment (57.67g). The highest root dry weight was obtained from T_1 treatment (10.00g) which was statistically similar with all other treatments except control treatment. The lowest root dry weight was obtained from T_8 treatment (4.33g).The highest stem dry weight was obtained from T_6 treatment (55.67g). It was similar with T_2 (53.00g) and T_7 (52.33g) treatment. The lowest stem dry weight was obtained from T_8 treatment (31.00g).The highest leaf dry weight was obtained from T_6 treatment (52.00 g) which was statistically different with all other treatments. The lowest leaf dry weight was obtained from T_8 treatment (35.667g).

The highest number of pods plant^{-1} was obtained from T_6 treatment (20.77) which was followed by all other treatments except control treatment. The lowest number of pods per plant was obtained from T_8 treatment (12.03). The highest pod length was found from T_6 treatment (9.07cm) which was statistically similar with all other treatments except control treatment (4.24cm).It was found that at harvest number of seeds per pod did not differ significantly. But numerical number of seeds per pod was highest in T_2 treatment (11.53) and lowest in T_8 treatment (10.87). The maximum 1000-seed weight was observe from T_6 treatment (51.90g). It was statistically similar with all other treatments except control treatment and the lowest 1000-seed weight was found in T_8 treatment (44.63g).The highest seed yield was obtained from T_6 treatment (1.53 t/ha). It was statistically similar with all other treatment except T_7 (1.04 t/ha) and T_8 (1.04 t/ha).The lowest seed yield was obtained from T_8 treatment (1.04 t/ha).

Results showed that the combination of chemical fertilizers significantly increased the seed yield. The highest straw yield was also observed from T_6 treatment (5.08 t/ha) which was statistically similar with all other treatments except control and the lowest straw yield was obtained from T_8 treatment (2.31 t/ha). Results showed that the combination of chemical fertilizers significantly increased the straw yield. From the economic point of view, the highest gross margin was also obtained from T_6 treatment (87138 Tk/ha) and the lowest was found in T_8 treatment (52946 Tk/ha).

From the above result, it was revealed that the treatment T_6 is economically and biologically better than that of all other treatments. Therefore, the fertilizer package of 26.25-25.00-36.25 kg $ha^{-1}$of NPK for BARRI mung-6 is suitable for Bogra region.

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APPENDIX

Appendix Meteorological Information

Appendix 1. Weekly average maximum and minimum temperature, average relative humidity and total rainfall during the period from July/16- March/17

Month	Temperature		Average relative (%)	Total rainfall (mm)
	Maximum	Minimum		
July/16				
1st	35.0	27.2	94	2.00
2nd	33.5	27.6	92	0.72
3rd	31.5	27.4	93	0.81
4th	34.2	26.5	92	0.06
August/16				
1st	32.7	27.2	88	0.32
2nd	33.4	28.3	96	0.33
3rd	34.6	29.0	92	0.34
4th	31.8	26.6	96	0.47
September/16				
1st	33.0	27.1	92	0.118
2nd	32.6	26.3	95	0.23
3rd	33.4	25.9	95	2.79
4th	34.0	26.2	93	2.66
October/16				
1st	33.2	26.5	96	0.14
2nd	32.8	24.3	96	177.19
3rd	32.8	23.0	92	0.03
4th	34.4	23.2	94	0.24

November/16				
1st	29.8	19.5	90	0
2nd	31.5	19.0	85	0
3rd	30.2	17.0	79	0
4th	29.6	17.8	94	0
December/16				
1st	31.0	14.8	97	0
2nd	24.0	12.3	94	0
3rd	25.5	13.4	92	0
4th	27.31	15.65	94.8	0
January/17				
1st	25.5	11.4	97	0
2nd	23.5	08.0	75	0
3rd	27.3	11.5	92	0.9
4th	27.66	14.26	91.2	0
February/17				
1st	29.5	15.5	94	0
2nd	29.6	16.2	91	0
3rd	31.0	21.0	95	0
4th	29.2	16.51	86.85	0
March/17				
1st	31.6	15.4	94	0.3
2nd	28.7	14.2	88	0.2
3rd	27.6	16.0	95	0.4
4th	29.26	21.59	91.3	1.16

April/17				
1^{st}	30.5	23.0	89.42	0.0
2^{nd}	35.0	23.52	85.42	8.0
3^{rd}	30.94	22.0	90.0	32.34
4^{th}	31.78	23.51	90.33	0.47
May/17				
1^{st}	33.14	22.91	88.28	0.38
2^{nd}	32.24	24.94	96.57	0.14
3^{rd}	33.61	24.28	90.71	1.05
4^{th}	34.86	26.32	90.7	0.73

Source: Bangladesh Meteorological Department (Climate Division), Agargoan, Dhaka.