IMPACT OF ADDED FOLIAR SPRAY OF UREA AND BORON ON GROWTH AND YIELD OF MUNGBEAN

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IMPACT OF ADDED FOLIAR SPRAY OF UREA AND BORON ON GROWTH AND YIELD OF MUNGBEAN

BY

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CERTIFICATE

This is to certify that the thesis entitled **"Impact of Added Foliar Spray of Urea And Boron on Growth And Yield of Mungbean"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of *bonafide* research work carried out by **MST. LATA PERVIN**, Registration No. **15-06967** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2016

Dhaka, Bangladesh

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Dedicated To

My Beloved Parents

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IMPACT OF ADDED FOLIAR SPRAY OF UREA AND BORON ON GROWTH AND YIELD OF MUNGBEAN

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ABSTRACT

The experiment was conducted at the Agronomy research field, Sher–e- Bangla Agricultural University, Dhaka, during the period from March 2016 to May 2016 to study the Impact of added foliar spray of urea and boron on growth and yield of mungbean varieties. The experiment consists of two varieties *viz*. V_1 = BARI Mung-5 and V_2 = BARI Mung-6 and eight levels of fertilizer management *viz*. T_1 = Recommended fertilizer (RF), T_2 = RF + Foliar spray (FS) of water at flower initiation (FI), T_3 = RF + Urea (2%) FS at FI, T_4 = RF + Boron (1%) FS at FI, T_5 = RF + Urea (2%) + Boron (1%) FS at FI, T_6 = Urea (2%) FS at FI, T_7 = Boron (1%) FS at FI and T_8 = Urea (2%) + Boron (1%) FS at FI. The experiment was laid out in Split Plot Design with three replications. In this experiment, both variety and combined foliar application of N and B had significant effect on most of the growth and yield contributing parameters irrespective of mungbean varieties. Results indicated that the variety, BARI Mung-6 gave the tallest plant (49.27 cm), highest leaves plant^{-1} (9.68), branches plant^{-1} (2.50), above ground dry matter content plant^{-1} (22.40 g), nodules plant^{-1} (64.50), pods plant^{-1} (21.08), pod length (8.68 cm), seeds pod^{-1} (10.04), 1000 seed weight (52.25 g), seed yield (810.58 kg ha^{-1}), stover yield (1273.35 kg ha^{-1}) and harvest index (38.34%). In case of fertilizer management, the tallest plant (58.42 cm), highest leaves plant^{-1} (11.20), branches plant^{-1} (4.35) and nodules plant^{-1} (87.33) were recorded from T_3 (RF + Urea 2% FS at FI) but the highest above ground dry matter content plant^{-1} (25.27 g), pods plant^{-1} (25.37), pod length (9.73 cm), seeds pod^{-1} (10.43), 1000 seed weight (55.67 g), seed yield (1121.00 kg ha^{-1}), stover yield (1467.00 kg ha^{-1}) and harvest index (43.31%) were recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI). Regarding combined effect, the tallest plant (59.97 cm), maximum leaves plant^{-1} (11.30), branches plant^{-1} (4.63) and nodules plant^{-1} (88.33) were recorded from the treatment combination of V_2T_3 but highest above ground dry matter content plant^{-1} (25.52 g), pods plant^{-1} (25.89), pod length (10.40 cm), seeds pod^{-1} (10.46), 1000 seed weight (56.67 g), seed yield (1159.00 kg ha^{-1}), stover yield (1472.00 kg ha^{-1}), biological yield (2631.00 kg ha^{-1}) and harvest index (44.05%) were recorded from the treatment combination of V_2T_5.So, BARI Mung-6 along with T_5 (RF + Urea 2% + Boron 1% FS at FI) is suggested for yield improvement in mungbean cultivation.

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Miligram
ml	=	MiliLitre
NaOH	=	Sodium hydroxide
No.	=	Number
^oC	=	Degree Celceous
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
µg	=	Microgram

CHAPTER I

INTRODUCTION

Pulses are the main source of plant protein for the people, particularly for the poor section of Bangladesh and it is called the poor men's meat as it is the cheapest source of protein. Mungbean (*Vigna radiata* L.) belongs to family Fabaceae, is an important pulse crop and ranks fourth position considering both acreage and production in Bangladesh (MoA, 2014). It is composed of more than 150 cultivated species and originated mainly from Africa and Asia and the Asian tropical regions have the greatest magnitude of genetic diversity of mungbean (USDA-ARS GRIN, 2012).

Mungbean contains 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg 100 grams of seed^{-1}, respectively (Frauque *et al.*, 2000). According to FAO (2013) recommendation, a minimum per capita intake of pulse should be 80 g day^{-1}, where as it is 7.92 g day^{-1} in Bangladesh (BBS, 2011). This is because of fact that national production of the pulses is not adequate to meet our national demand.

The total production of mungbean in Bangladesh in 2013-14 was 1.81 lac metric tons from the area of 1.73 lac hectares with an average yield 1.04 t ha^{-1} (MoA, 2014). Mungbean is one of the most important pulse crops in Bangladesh.Its edible seed is characterized by higher digestibility, flavour, high protein content and absence of any flatulence effects (Ahmad *et al.*, 2008).

It is cultivated with minimum tillage, use of local varieties with no or minimum fertilizers especially nitrogen, no pesticides or insecticides and very early or very late sowing, no practicing of irrigation and drainage facilities etc. All these factors are responsible for low yield of mungbean which is incomparable with the yields of developed countries of the World (FAO, 1999).

Variety plays an important role in producing high yield of mungbean because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. Worldwide, a total of 43,027 mungbean accessions are available at core collections or Gene Bank at different stations of the World. Up to date, over 110 mungbean cultivars have been released by AVRDC in South and Southeast Asia and around the world (Ali and Gupta, 2012). AVRDC has developed several mungbean with superior lines for production in the tropics and subtropics which are early and uniformly maturing (55-65 days), disease resistant, and high yielding. Research findings revealed that different variety produced different seed yield of mungbean (Tripathi *et al*., 2012; Islam *et al*., 2006). The yield of mungbean in Bangladesh has been increased obviously by using high yielding mungbean varieties and improvement of management practices.

Farmers of Bangladesh are very careless to use balance doses of fertilizer for cultivation of pulse crops due to their own judgement. As a result, their crops do not give expected yield. The imbalanced application of chemical fertilizers is also detrimental to the soil and environment.

Mungbean plays a significant role in sustaining crop productivity by adding nitrogen through *rhizobial* symbiosis and crop residues (Sharma and Behera, 2009). Nitrogen is most useful for pulse crops because it is the component of protein (BARC, 1997). Root nodule weight per plant was highest with 30 kg N ha^{-1}. Mungbean seed yield showed more responsive to foliar application of N (Ezzat *et al*., 2012). Foliar applied N to mungbean was found to increase seed yields (Abdo, 2001). The foliar application of nitrogen alone was more effective than NPK in producing higher number of seeds per pod (Hamayun *et al*., 2011). 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 in mungbean (Ezzat *et al*., 2012). Foliar feeding is often the most effective and economical way to improve plant nutrient deficiency (Pradeep and Elamathi, 2007). Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers during flowering becomes helpful in increasing the yield (Patel *et al.* 1984). On the other hand, excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder (Obreza and Vavrina, 1993).

Boron (B) ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc. It is an essential mineral element for all vascular plant like mungbean. It plays a vital role in the physiological processes of plants such as cell maturation, cell elongation and cell division, sugar transport, hormone development, carbohydrate, protein and nucleic acid metabolisms, cytokinins synthesis and phenol metabolisms (Lewis, 1980). Studies revealed that deficiency of boron cause prominent reduction of growth, nodulation, yield percentage, vigour and viability in legume and cereal crops (Ahmad *et al*., 2012). Boron supply increases the uptake and reutilization of N, P, K, Na, Ca and other (Yaseen *et al*., 2004). Mungbean yield was significantly increased due to the application of B (Quddus *et al*., 2011). Boron is a naturally occurring micronutrient in the soil along with other elements in the form of borates. It has principal role in plant cell wall and membrane constancy (Bassil *et al*., 2004). Application of boron has significant effect of yield of mungbean (Ashraf, 2009).

Boron is a trace element that can be applied in soil as well as foliar. In many times it is observed that foliar applied boron causes increased in yield more than soil applied boron because boron is required more at reproductive stage and foliar applied is instantly available for plant in compare to soil applied boron. Foliar applied boron increased the plant height, nodules plant^{-1}, dry weight plant^{-1} and pods plant^{-1}, 1000-seed weight, grain yield and haulm yield over the control (Dixit and Elamathi, 2007, Kaisher *et al*., 2010).

Under the above observations, the present study was undertaken to work out the growth and yield of mungbean varieties as affected by foliar application of urea and boron with the following objectives:

1. To compare the growth and yield of different mungbean varieties
2. To determine the management practices of fertilizer application in mungbean
3. To study the combined effect of variety and fertilizer management on growth and yield of mungbean

CHAPTER II

REVIEW OF LITERATURE

Mungbean is an important pulse crops in Bangladesh as well as many countries of the world. For that a very few studies related to yield and development of mung bean have been carried out in Bangladesh as well as many other countries of the world. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect of variety, nitrogen and boron on the yield of mungbean and other legumes.

2.1 Effect of variety

Ali *et al*. (2014) investigated the effect of sowing time on yield and yield components of different mungbean varieties, a field experiment was conducted during 2012 at agronomic research area, University of Agriculture, Faisalabad, Pakistan. Different sowing times (15^{th} June, 25th June, 5th July and 15th July) were assigned to main plots and varieties (NM-2011, NM-2006, AZRI-2006 and NM-98) were allocated to subplots. Different mungbean varieties also responded significantly towards yield and yield components and NM-2011 variety outperformed in terms of maximum seed yield (1282.87 kg ha^{-1}) than rest of varieties.

Parvez *et al*. (2013) conducted an experiment to study the performance of mungbean as affected by variety and level of phosphorus. The experiment comprised four varieties *viz*. BARI Mung-6, Binamoog-4, Binamoog-6 and Binamoog-8 and four levels of phosphorus viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1}, and laid out in a Randomized Complete Block Design with three replications. Results revealed that the longest plant, highest number of branches $plant^{-1}$, number of total pods $plant^{-1}$, seeds $plant^{-1}$ and seed weight $plant^{-1}$ were obtained from BARI Mung-6. Binamoog-6 produced the highest seed yield which was as good as Binamoog-8. The second highest and the lowest seed yield were recorded from Binamoog-4 and BARI Mung-6, respectively. The highest stover yield was obtained from Binamoog-8 followed by Binamoog-4. The lowest stover yield was recorded from BARI Mung-6.

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). Cultivar HUM-1 and application of 45 kg S ha^{-1} recorded higher plant height, primary branches, green trifoliates, 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 cultivars Pusa Vishal and SML-668. Nodule number was highest in HUM-1 × MO 5. Strain MO 5 showed maximum grain protein irrespective of cultivars and sulphur levels.

A field trial was conducted by Rasul *et al*. (2012) to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mungbean varieties V1, V2, V3 (NM-92, NM-98, and M-1) were grown at three inter-row spacings respectively. Highest seed yield was obtained for variety V2 at 30 cm spacing. Among varieties V2 exhibited the highest yield 727.02 kg ha^{-1}, while the lowest seed yield 484.79 kg ha^{-1} was obtained with V3.

Field studies were carried out by Kumar *et al*. (2009) in Haryana, India to determine the growth behaviour of mungbean genotypes sown on different dates under irrigated conditions. The treatments consisted of 2 genotypes (SML 668 and MH 318) and 6 sowing dates starting from 1 March to 19 April, at of 10-day intervals. Results showed that SML 668 had higher plant height than MH 318 and the less height of both the genotypes during summer was due to low average temperature during the initial growth stage. SML 668 accumulated more dry matter than MH 318. The contribution of leaves and stem was more in SML 668, whereas the contribution of pods towards total above ground biomass harvest was higher in MH 318.

Quaderi *et al*. (2006) conducted an experiment in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) on the growth, yield and yield contributing characters of two modern mungbean varieties viz. BARI Mung- 4 and BARI Mung- 5. The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with 3 replications. Among the mungbean varieties, BARI Mung -5 performed better than that of BARI Mung -4.

To study the nature of association between *Rhizobium phaseoli* and mungbean an experiment was conducted by Muhammad *et al*. (2006). Inocula of two *Rhizobium* strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains × mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM-209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to evaluate the effect of biofertilizer and plant growth regulators (GA3 and IAA) on growth of 3 cultivars of summer mungbean. Among the mungbean varieties, Binamoog-5 performed better than that of Binamoog -2 and Binamoog- 4.

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm 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 by Tickoo *et al*. (2006). Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105.

To evaluate the effects of crop densities (10, 13, 20 and 40 plants m-2) on yield and yield components of two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A), a field experiment was conducted by Aghaalikhani *et al*. (2006) at the Seed and Plant Improvement Institute of Karaj, Iran, in the summer of 1998. The results indicated that VC-1973A had the highest grain yield. This line was superior to the other cultivars due to its early and uniform seed maturity and easy mechanized harvest.

Rahman *et al*. (2005) carried out an experiment with mungbean in Jamalpur, Bangladesh, involving 2 planting methods, i.e. line sowing and broadcasting; 5 mungbean cultivars, namely Local, BARI Mung- 2, BARI Mung- 3, Binamoog- 2 and Binamoog -5. Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of Binamoog -2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

Studies were conducted by Bhati *et al*. (2005) to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean showed that K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher grain yield and 13.7% higher fodder yield than the local cultivar.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen and phosphorus on the productivity of mungbean. K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods plant^{-1}, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit:cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) under Kasetsart mungbean breeding project in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbean cultivars was also conducted in the farmer's field.

Two summer mungbean cultivars, i.e. Binamoog- 2 and Binamoog- 5, were grown during the kharif-1 season (February-May), in Mymensingh, Bangladesh, under no irrigation or with irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by Shamsuzzaman *et al*. (2004). Data were recorded for days to first flowering, days to first leaf senescence, days to pod maturity, flower + pod abscission, root, stem+leaf, pod husk and seed dry matter content, pods plant^{-1}, seeds pod^{-1}, 100-seed weight, seed yield, biological yield and harvest index. The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence, which were significantly delayed under different irrigated frequencies. Binamoog- 2 performed slightly better than Binamoog- 5 for most of the growth and yield parameters studied.

An experiment was conducted by Abid *et al*. (2004) in Peshawar, Pakistan to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-1. Data were recorded for days to emergence, emergence m-2, days to 50% flowering, days to physiological maturity, plant height at maturity and grain yield. Sowing on 15 April took more number of days to emergence but showed maximum plant height. The highest emergence m-2 and higher mean grain yield was recorded in NM-92 than M-1.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season in Uttaranchal, India, to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

To find out the effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mungbean cultivars were investigated by Hossain and Solaiman (2004). The mungbean cultivars were BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, Binamoog-2 and BU mung-1. Among the cultivars, BARI Mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg ha^{-1}. *Rhizobium* strain TAL169 did better than TAL441 in most of the studied parameters. It was concluded that BARI Mung- 4 in combination with TAL169 performed the best in terms of nodulation, plant growth, seed and stover yields, and seed protein content.

The performance of 20 mungbean cultivars were evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela. Data on plant height, clusters $plant^{-1}$, pods $plant^{-1}$, pod length, seeds pod^{-1}, grain yield by plant and yield ha^{-1} were recorded. Significant differences in the values of the parameters measured due to cultivar were recorded. The average yield was 1342.58 kg ha^{-1}. VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

Effect of sowing rates on the growth and yield of mungbean cultivars NM-92, NARC mung-1 and NM-98 was evaluated by Riaz *et al*. (2004) in Faisalabad, Pakistan. NM-98 produced the maximum pod number of 77.30, grain yield of

983.75 kg ha^{-1} and harvest index value of 24.91%. NM-92 also produced the highest seed protein content of 24.64%.

Brar *et al*. (2004) introduced SML 668 high yielding variety of summer mungbean selection from AVRDC line NM 94, is a cultivar recommended for general cultivation in irrigated areas of Punjab, India. This early maturing cultivar flowers in 34 days and matures in 60 days. It has an average plant height of 44.6 cm and bears an average of 16 pods plant^{-1} and 10.4 seeds pod^{-1}. Seeds are bold with 100-seed weight of 5.7 g and devoid of hard seeds. Protein content is 22.7% and water absorption capacity is high (91%).

Seed treatment with biofertilizers in controlling foot and root rot of mungbean cultivars Binamoog-3 and Binamoog-4 was investigated by Mohammad and Hossain (2003) under field conditions in Pakistan. Treatment of seeds of Binamoog-3 with biofertilizer showed a 5.67% increase in germination over the control, but in case of Binamoog-4 10.81% increase in germination over the control was achieved by treating seeds with biofertilizer. The biofertilizers caused 77.79% reduction of foot and root rot disease incidence over the control along with Binamoog-3 and 76.78% reduction of foot and rot disease in Binamoog-4. Seed treatment with biofertilizer also produced up to 20.83% higher seed yield in Binamoog-3 and 12.79% higher seed yield Binamoog-4 over the control.

2.2 Effect of nitrogen

Razzaque *et al*. (2015) conducted a pot experiment to find out the nitrogen acquisition and yield of mungbean genotypes affected by different levels of nitrogen fertilizer in low fertile soil. Ten mungbean genotypes viz. IPSA-12, GK-27, IPSA-3, IPSA-5, ACC12890053, GK-63, ACC12890055, BARI Mung-6, BUmug- 4 and Binamoog- 5 and six nitrogen fertilizer levels viz. 0, 20, 40, 60, 80 and 100 kg N ha^{-1} were included as experimental treatments. Results indicated that increasing applied nitrogenous fertilizer in low fertile soil increased nitrogen acquisition of mungbean which increased number of pods plant^{-1} and seeds pod^{-1} and finally increased yield of mungbean upto 60 kg N ha^{-1} irrespective of genotype and thereafter decreased. Genotype IPSA - 12 produced the highest seed yield (14.22 g plant^{-1}) at 60 kg N ha^{-1}. The lowest yield (7.33 g plant $^{-1}$) was recorded in ACC12890053 in control. From regression analysis, the optimum dose nitrogen for mungbean cultivation in the low fertile soil is 54 kg ha^{-1}.

Azadi *et al*. (2013) carried out an experiment to evaluate and determine the appropriate nitrogen fertilization the morphological characteristics and seed yield of mungbean three cultivars, In this study, different levels of nitrogen fertilizer (control, 50, 100, 150 kg/ha urea) as sub-plots and three mungbean cultivars (Partow, Gohar, locally) was considered as the main factor. The result of analysis variance on morphological characteristics on seed yield showed that between different cultivar in the eyes of first pod height and seed yield were significant at 5% level probability. In addition, between different amounts of nitrogen fertilizer for stem diameter and number of node and seed yield showed significantly different. Interaction between urea fertilizer and cultivars, number of nodes and seed yield were significant effect at 1% and 5% level probability. The highest seed yield of 8.9 grams per square meter and the number of sub-branches with (1.5) and the height of the first pod from ground level with (25.51 cm) and stem diameter (1.13 cm) and number of nodes (8.28 pcs) and pod length (7.5 cm) was obtained at 150 kg/ha urea. Between different amount of nitrogen fertilizer, 150 kg/ha urea, showed higher values than the other. In this experiment, 150 kg/ha nitrogen fertilizer with partow cultivar (V1) is the most appropriate treatment and suitable for this region.

Achakzai *et al*. (2012) conducted an experiment to evaluate the growth response of mungbean cultivars subjected to different levels of applied N fertilizer. Four different cultivars of mungbean viz., NM-92, NM-98, M-1, and NCM-209. Six different levels of N fertilizer applied @ zero, 20, 40, 60, 80 and 100 kg ha^{-1}. While, a constant dose of P_2O_5 and K_2O also applied to each N level (except control, zero). Urea fertilizer used as a source of N, while TSP and MOP as sources of P & K, respectively. Maximum days to flowering (48.25) and number of branches plant^{-1} (3.83) recorded for plants subjected to highest dose of applied N fertilizer viz., 100 kg ha^{-1}. Similar responses toward added N fertilizer also noted for various cultivars of mungbean. Maximum days to flowering (47.72) and number of leaves plant^{-1} (5.86) recorded for NCM-209. Whereas, the maximum plant height (38.52 cm) branches plant^{-1} (3.72) obtained for mungbean cultivar M-1. The correlation coefficient (r) studies exibited that plant height (0.593), plant^{-1} (r=0.325),branches plant^{-1} (r=0.187) and leaf area (r=0.342) significantly ($p<0.05$) and positively correlated with their grain yield (kg ha^{-1}). However, days to 50% flowering (r=-0.265) are also significantly but negatively associated with their grain yield (kg ha^{-1}). Thus based on correlation studies it could revealed that cultivars under cultivation displayed a wide range of variation for most of the mentioned growth traits and could be exploited in breeding programme to enrich the mungbean genetic treasure.

Tickoo *et al.* (2006) carried out an experiment on mungbean cultivars Pusa 105 and Pusa Vishal of which seeds 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 boilogical and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Difference 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.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1}was the best treatment, recording plant height of 56.25, germination of 90.50%, satisfactory plant population of 162.0 prolonged days taken to maturity of 55.50, long pods of

5.02 cm, seed weight per plant of 10.53 g, seed index of 3.52 g and the highest seed yield of 1205.20 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

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

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

Rajender *et al.* (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44 Grain yield increased with increasing N retes 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 of 1999-2000. The number of branches, pods per plant, seeds per pod, 1000-seed weight and straw yield increased with increasing N rates, whereas grain yield increased with increasing rates of up to 30 kg N ha^{-1} only.

Mahboob and Asghar (2002) studied effect of seed inoculation at different nitrogen levels on mungbean at the agronomic research station, Farooqabad in Pakistan. They revealed that various yield components like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1}. Again they revealed that seed inoculation + 50-50-0 NPK kg ha^{-1}exibited superior performance in respect of seed yield (955 kg ha^{-1}).

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 kg P ha^{-1} were tested. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1}followed by a decrease with further increase in N. They also observed that 1000-seed weight increased with increasing rates of N up to 40 kg ha^{-1}along with increasing rates of P.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers practices (no fertilizer) or using a combinations of fertilizer application (30 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 ton $ha^{-1}$with farmer's practices, while the highest yield was obtained by the fertilizer application (0.77 ton ha^{-1}).

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

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

2.3 Effect of foliar spray of nitrogen

Rao *et al.* (2016) a field experiment was carried out during Rabi season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, to find out effect of foliar nutrition on physiological and biochemical parameters of mungbean under irrigated conditions. Among foliar nutrients Urea @ 2% resulted higher yield and superior over other foliar sprays. Application of 2% urea resulted more plant height, leaf area, shoot dry weight and by increasing total chlorophyll content, photosynthetic rate and total protein content.

Mahajan *et al.* (2016) carried out a field experiments in sesame on deep black soil of Mamurabad farm, Oilseed Research Station, Jalgaon (Maharashtra) during 2009 and 2010 to find out suitable combination of soil and foliar application of urea and diammonium phosphate for seed yield maximization and remunerative treatments . They found that soil application of RDF + foliar spray of 2 percent urea twice at flowering and pod formation stages significantly increased the yield contributing characters *viz.*, number of pod plant $^{-1}$ and number of seeds pod^{-1}. These characters significantly contributed in producing higher seed and oil yields and also more remunerative over soil application of RDF alone.

Rahman *et al.* (2014) was carried out a trial and observed that foliar spray of N, P and K significantly increased pods/plant, seeds / pod, biomass and grain yield. It may be resulted that foliar spray of N, P and K is the suitable application for the maximum yield of mungbean.

Doss *et al.* (2013) Pot culture experiment was carried out to evaluate the effect of Diammonium phosphate (DAP), Potash (K), Nitrogen (N) and Naphthalene Acetic Acid (NAA) foliar spray treatment on the growth, yield and biochemical constituents of blackgram. The experiment was conducted at Agriculture Farm of St. Joseph‟s College, Trichy, Tamilnadu state during winter 2006 to 2007. Foliar spray treatment with the aqueous solution of nutrients (2% DAP, 1% K, 2% N and 200 ppm NAA, w/v) was done to the 22nd and 30th day old black gram seedlings and also observed that growth, yield and grain yield was significantly increased with foliar application of nutrients. Maximum grain yield was recorded when spread with 1% K + 200 ppm NAA concentration.

Juli *et al.* (2013) observed the effect of foliar application of urea at different stages on growth and yield of chickpea. The highest seed yield and yield contributing characters were recorded with double spray of 2 % urea at 50 % flowering and at 10 days after 50 % flowering. The results also showed double spray of 2 % urea through foliar application significantly increased the pod plant^{-1}, seed size, seeds pod^{-1} and 1000 seed weight.

Ezzat *et al*. (2012) found with an experiment that mungbean seed yield per hectare showed more response to foliar applied N than that with K. The best seed yield per hectare was reported from the combined effect of 76 Kg P_20_5 ha^{-1} and foliar spraying with N. Protein percentage in mungbean seeds was not affected by either soil or foliar applications and ranged between 20.6 to 22.9%. However, protein yield kg ha^{-1} significantly increased when the plants were fertilized with 76 Kg P_20_5 ha^{-1} and foliar sprayed with N.

Lateef *et al.* (2012) two sets of field experiments were conducted in two successive summer seasons to study the effect of soil and foliar fertilization of mungbean. The first set consider the effect of late foliar application of N or K under different levels of phosphatic fertilization on mungbean yield and chemical constituents.Kawmy-l was fertilized with 0,19,38,57 and 76 Kg P_20_5 ha^{-1} at sowing and foliar application of N as 1 % urea solution with K as potassium sulphate 36% K_20 solution; both N and K were applied at early pod formation stage. The second set of experiments objectives was to evaluate the effect of micronutrient application when combined with urea. From this experiment it could be resulted that mungbean productivity responds to combined soil application of P at 57 Kg P_20_5 ha^{-1} and late foliar applied N at early pod formation stage. Foliar spray of urea combined with Fe or Zn may increase seed yield and improve the quality of seeds.

Khalilzadeh *et al*. (2012) was carried out an experiment on growth characteristics of mungbean affected by foliar application of urea and bio-organic fertilizers. They found that foliar application of urea and organic manure substantially improved leaves plant^{-1} and improved number and dry weight of nodule.

Venkatesh and Basu (2011) observed that the effect of foliar application of urea on growth, yield and quality of chick pea. Seed yield and yield contributing characters were the highest recorded with 2 % foliar spray of urea at 75 DAS. Seed size, leaf and seed nitrogen content as well as protein content were also higher recorded in same treatment.

Mondal *et al.* (2010) concluded that seed protein content, leaf area, chlorophyll content, yield and yield attributes of greengram was increased by foliar application of 1.5 % urea at an interval of 4 days of vegetative growth stages at Mymensingh (Bangladesh).

Jeyakumar *et al.* (2008) found that foliar spray of 3 percent (%) urea at flowering and then increased significantly the number of pods plant^{-1}, 1000 grain weight and ultimately grain yield in blackgram.

A study was conducted by Nigamananda (2007) to evaluate the effect of N application time as basal and as DAP (Diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of mung bean cv, K-851. The recommended rate of N:P:K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments included: V basal N + foliar N as urea or DAP at 25 or 35 days after sowing (DAS); V basal N + V at 25 DAP + V at 35 DAS as urea or DAP; and V basal N + V foliar spraying as urea or DAP + 40 ppm NAA. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS, resulted in the highest values for number of pods/plant (38.3), seeds/pod, test weight flower number, fertility, fertility coefficient and grain yield (9.66 q ha^{-1}).

Sritharan *et al.* (2007) concluded that 2 percent (%) urea had the profound effect in improving the total chlorophyll content, soluble protein content and NRase activity. Foliar sprays of 2 percent urea showed the highest grain yield of 955.20 kg/ha. The yield may be enhancement due to the improved morphological, physiological, biochemical and yield parameters, viz., plant height, number of pods per plant, grain yield, harvest index, chlorophyll content, soluble protein content and nitrate reductase activity.

A field experiment was conducted by Raman and Venkataramana (2006) to investigate the effect of foliar nutrition on crop nutrient uptake and yield of mungbean. There were 10 foliar spray treatments, consisting of water spray, 2% diamonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N, P and K uptakes, yield attributes and yield. The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment.

Sritharan *et al.* (2005) observed that significant increase in the growth characters like plant height and leaf area due to foliar application of 2 % urea sprayed at three stages of crop growth like vegetative, flowering and pod filling stage for blackgram.

2.4 Effect of Boron

A study was conducted by Tahir *et al*. (2013) at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron on the genotype NIAB Mung-2006. The treatments were comprised of four sulphur levels i.e. 0, 12, 24 and 36 kg ha^{-1} and three boron levels i.e. 0, 4 and 8 kg ha^{-1}. Gypsum was used as sulphur source and boric acid for boron. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased plant height (58.30 cm), number of pods $plant^{-1}$ (21.33), 1000-seed weight (35 g), number of nodules $plant^{-1}$ (13.33), biological yield (7688 kg ha^{-1}) and seed yield (1200 kg ha^{-1}).

An experiment was carried out by Quddus *et al*. (2011) in Calcareous Low Ganges River Floodplain Soil (AEZ 12) at Pulses Research Sub-Station (PRSS), Madaripur during Kharif I to evaluate the effect of zinc (Zn) and boron (B) on the yield and yield contributing characters of mungbean and to find out the optimum dose of Zn and B for yield maximization. There were four levels of zinc (0, 0.75, 1.5, and 3.0 kg ha^{-1} and boron (0, 0.5, 1.0, and 2 kg ha^{-1}) along with a blanket dose of N20 P25 K35 S20 kg ha^{-1}. Results showed that the combination of Zn1.5B1.0 produced significantly higher yield (3058 kg ha^{-1}) and (2631 kg ha^{-1}). The lowest yield (2173 kg ha^{-1}) and (1573 kg ha^{-1}, were found in control (Zn0B0) combination.

Biswas *et al*. (2010) conducted a two-year field experiment during kharif season of 2005 and 2006 at the Pulses and Oilseeds Research Sub-station, Beldanga, Murshidabad, West Bengal, India to study the effect of molybdenum spray and seed inoculation on nodulation, growth and seed yield in mungbean. The results revealed that two rounds of foliar spray of 0.05% ammonium molybdate solution at 25 and 40 DAS increased seed yield by 9.02% (1269.50 kg ha^{-1}) over water spray (1164.50 kg ha^{-1}). Combined inoculation of seeds with *Rhizobium* + *Azotobacter* + PSB (1629 kg ha^{-1}) and *Rhizobium* + PSB remarkably increased the seed yield due to better nodulation along with improvement in growth and yield attributes. The effect of interaction between foliar spray and seed inoculation on seed yield was found significant.

A field experiment was conducted by Patra and Bhattacharya (2009) in kharif (rainy) season in a sandy loam soil (mixed hyperthermic paleudalfs) at Jhargram, Paschim Medinipur in the Red and Laterite zone of West Bengal to investigate the effect of four levels of boron and three levels of molybdenum on growth and yield of Mungbean, Boron, molybdenum and their combined application significantly improved all the growth and yield attributing characters of Mungbean. The synergistic influence of these two micronutrients helped augmenting growth and yield of the crop.

Rizk and Abdo (2001) conducted two field experiments to investigate the response of mungbean with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used in those investigations. Zn (0.2 or 0.4 g l-1), Mn (1.5 or 2.0 g l-1), B (3.0 or 5.0 g l-1) and a mixture of Zn, Mn, and B (0.2, 1.5 and 3.0 g l-1, respectively), in addition to distilled water as control were sprayed once at 35 days after sowing (DAS). The obtained results could be summarized in the following: Generally, cultivar VC-1000 surpassed cultivar V-2010 in yield and its components as well as in the chemical composition of seeds with exception in 100-seed weight and phosphorus percentage in seeds. All treatments increased significantly, yield and its components especially Zn (0.2 g l-1) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mungbean cultivars in both seasons. Among the treatments of micronutrients, B gave the highest percentage of crude protein.

2.5 Effect of foliar spray of boron

Gowthami and Rao (2014) carried out an experiment to evaluate the effect of foliar application of potassium, boron and zinc on growth and seed yield of soybean. They observed that foliar application of potassium nitrate @ 2 % + boric acid @ 50 ppm + zinc sulphate @ 1 % (T_7) at 30 and 60 DAS was found to be superior in increasing plant height, number of branches, number of leaves, leaf area, total drymatter, number of pods per plant, test weight and seed yield followed by potassium nitrate @ 2 % + boric acid @ 50 ppm at 30 and 60 DAS (T_4), boric acid @ 50 ppm + zinc sulphate @ 1 % at 30 and 60 DAS (T_6) and potassium nitrate @ 2 % + zinc sulphate @ 1 % at 30 and 60 DAS (T_5) where as minimum results were found in control.

Moghazy *et al.* (2014) carried out an experiment to evaluate the influence of a foliar application with boron and five levels of combinations between compost manure and mineral nitrogen fertilizer as well as their interaction on growth, yield and chemical composition of pea. They found that foliar spray for improving quality and increasing yield with boron (boric acid 17 % B) at 50 ppm and application of nitrogen fertilizer in compost form at 2.5 ton fed^{-1} and inorganic N- fertilizer at 60 kg fed^{-1} in pea field were the most effective treatment.

Ali and Mahmoud (2013) carried out an experiment to evaluate the effect of B and Zn foliar application in mungbean on seed yield and yield components under sandy soil conditions. Foliar spray by B, Zn and their interaction had a significant ($p \leq 0.05$) effect on number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000 seed weight traits in the two growing seasons. The maximum seed yields ha^{-1} (2000 and 2030 kg ha^{-1} in first and second seasons, respectively) were found when mungbean plants sprayed with 150 ppm B and 500 ppm Zn with no significant differences between this interaction and obtained seed yield from sprayed mungbean plants with 150 ppm B and 400 ppm Zn in the two growing seasons. This is to be logic since the highest values of yield components and consequently seed yield ha^{-1} gained with the same interaction.

Pandey and Gupta (2013) conducted an experiment to study the effect of foliar application of B on reproductive biology and seed quality of black gram. Black gram was grown under controlled sand culture condition at deficient and sufficient B levels. After 32 days of sowing B deficient plants were sprayed with three concentrations of B (0.05%, 0.1% and 0.2% borax) at three different stages of reproductive development. Foliar spray at all the three concentrations and at all stages increased the yield parameters like number of pods, pod size and number of seeds formed $plant^{-1}$. Foliar B application also improved the seed yield of black gram.

Quddus *et al.* (2011) conducted an experiment to evaluate the effect of foliar application of Zn and B on the yield and yield contributing characters of mungbean and to find out the optimum dose of Zn and B for yield maximization. There were four levels of Zn (0, 0.75, 1.5, and 3.0 % ha^{-1} and B

(0, 0.5, 1.0, and 2 % ha^{-1}) along with a blanket dose of N_{20} P_{25} K_{35} S_{20} kg ha^{-1}. Among the treatments, the highest plant height 47.8 cm and 44.0 cm were recorded with Zn level 1.5 % ha^{-1} in the year of 2008 and 2009, respectively, which were statistically identical with T4 treatment (3.0 % Zn ha^{-1}) for both the years, but statistically significant to others.

Roy *et al.* (2011) carried out an experiment where foliar or soil plus foliar methods of B fertilization increased yield attributes including seed pod^{-1}, pod $plant^{-1}$, 1000 seed weight, both seed and straw yield and uptake of B in green gram over control irrespective of genotypes. The maximum increase in all parameters studied was found in the soil plus foliar application method.

Valenciano *et al.* (2010) stated that Spain is the main chickpea producing country in Europe, despite there are few studies on micronutrient application to chickpea. The response of chickpea to the foliar applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils in northwest Spain from 2006 to 2008 following a factorial statistical pattern (5×2×2) with three replications. Five concentrations of Zn (0, 1, 2, 4 and 8 mg Zn pot^{-1}), two concentrations of B (0 and 2 mg B pot^{-1}), and two concentrations of Mo (0 and 2 mg Mo pot^{-1}) were added to the pots. Chickpea resulted to the Zn, B and Mo applications. There were differences between soils. The mature plants fertilized with Zn, with B and with Mo had a greater total dry matter production.

Eichert and Goldbach (2010) observed that the application of foliar formulations nocturnal or diurnal showed no significant differences in foliar B absorption on lychee leaves. But, subsequent translocation of foliar applied B out of the treated leaflet was significantly higher after nocturnal versus diurnal application. During night time stomatal closure may limit the transpiration flow and improve the rate of B distribution from the point of application. Recent publications showed increased B distribution via phloem, after foliar application, in relation to the interruption of the transpiration stream.

Manonmani and Srimathi (2009) conducted an experiment to study the effects of the foliar application of ZnSO4 (1.0%; T_1), Borax (1.0%; T_2), FeSO4 (1.0%; T_3), MnSO4 (1.0%; T_4), Na_2MoO_4 (1.0%; T_5), DAP [Diammonium phosphate] (2.0%; T_6), urea (1.0%; T_7) and KCl (1.0%; T_8) on blackgram (cv. APK 1) seed yield and quality were studied in Bhavanisagar, Tamil Nadu, India. DAP, followed by urea, resulted in the greatest germination (92 and 88%) and vigour index (3690 and 3256). The resultant seeds were stored under ambient conditions (28+2°C and 70+5% relative humidity) for 12 months. Treatment with DAP and urea maintained the storability of seeds, which were characterized by high germination rates (74 and 70%) and vigour index (2088 and 1820), up to 10 months of storage, whereas the control seeds maintained their viability only up to 8 months of storage.

Dixit and Elamathi (2007) concluded that foliar application of B (0.5%) in green gram increased the plant height (32.26 cm), number of nodules plant^{-1} (30.8) and dry weight plant^{-1} (12.90 g).

Tahlooth *et al.* (2006) carried out two field experiments to evaluate the effect of foliar application of Zn, K or B on growth, yield and yield contributing characters and some chemical constituents of mungbean plants grown under water stress conditions. Irrespective to water stress, foliar application of Zn, K, or B significantly increased all the yield contributing characters compared with control plants. Potassium foliar application had the greatest stimulatory effect on pods number plant^{1}, pods dry weight, number of seeds pod^{1}, seeds dry weight plant^{1}, seed index and seed yield kg fed^{1}.

Nassar (2005) conducted an experiment to study the effect of foliar application of B, Zn, Mn and Fe on the seed and pod yields of groundnut as well as on the nutrient, oil and protein content of seeds. Boron was applied at rates of 75, 150 and 300 mg litre^{-1} as boric acid, whereas Zn, Mn and Fe were applied at rates of 150, 300 and 600 mg litre^{-1} in EDTA from. Foliar spraying with 600 mg Fe, 600 mg Zn, 300 mg Mn and 150 mg B litre^{-1} gave the highest seed and pod yields.

Bhattacharya *et al.* (2004) concluded that foliar application of B and Mo improved yield by 38% for greengram and 50% for blackgram over the control. An economic evaluation of each treatment revealed that the complete treatment was most profitable in greengram. However, NPK plus B returned the highest profits in blackgram as marginal yield gains obtained with Mo could not support the current added cost.

Torun *et al.* (2001) suggested that foliar application of different micronutrients (B, Mn, Mo and Cu) equally or more effective as soil application by different research. They reported that foliar application could be used effectively to overcome the problem of micronutrients deficiency in subsoil. Leiw (1988) have reported increase in crop production due to micronutrients application. Salam (2004) found that foliar application of B increased the plant growth, leaf area index, and root length and root nodules of bean.

Verma and Mishra (1999) conducted a pot experiment with mungbean cv. PDM 54, boron was applied for seed treatment, soil application (basally or at flowering) or foliar spraying. It increased yield and growth parameters with the best results in terms of seed yield plant^{-1} when the equivalent of 5 kg borax ha^{-1} was applied at flowering stage.

Saha *et al*. (1996) carried out a field trial in pre-Kharif seasons at Pundibari, India, yellow sarson was given 0, 2.5 or 5.0 kg borax and 0, 1 or 2 kg ha^{-1} of sodium molybdate was applied in soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer green gram. In both years green gram seed yield was highest with a combination of 5 kg borax + 2 kg sodium molybdate. Soil application gave higher yields than foliar or soil + foliar application.

From above discussion it was concluded that foliar application of different fertilizer at different stage improving the growth and yield contributing character of field crops.

CHAPTER III

MATERIALS AND METHODS

The present research work was conducted at the Agronomy Farm, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from March, 2016 to May, 2016. Brief descriptions of soil, climate, materials and methods that are used in the experiment have been presented in this chapter.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at 90°22′ E longitude and 23°4l′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28.

3.2 Climatic condition

The experimental area was under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September). Details of weather data in respect of temperature (^{0}C), rainfall (mm) and relative humidity (%) for the study period was collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207 (Appendix I).

3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract under the AEZ no. 28 and Tejgoan soil series. The soil was sandy loam in texture with pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in (Appendix II).

3.4 Planting material

Seeds of mungbean variety namely BARI Mung-5 and BARI Mung-6 were used for the experiment. The seeds were collected from BARI (Bangladesh Agricultural Research Institute), Joydebpur, Gazipur. Characteristics of BARI Mung-5 and BARI Mung-6 are described below:

3.4.1 BARI Mung-5

BARI Mung-5 was used as planting material. BARI Mung-5 was released and developed by BARI in 1997. Plant height of the cultivar ranges from 40 to 45 cm. It is resistant to *Cercospora* leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 55 to 60 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1700 kg ha-1. The seeds of BARI mung-5 for the experiment were collected from BARI, Joydebpur Gazipur. The seeds were large shaped, deep green and free from mixture of other seeds, weed seeds and extraneous materials.

3.4.2 BARI Mung-6

BARI Mung-6 was used as planting material. BARI Mung-6 was released and developed by BARI in 2003. Plant height of the cultivar ranges from 40 to 45 cm. It is resistant to *Cercospora* leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 55 to 58 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1800 kg ha-1. The seeds of BARI Mung-6 for the experiment were collected from BARI, Joydebpur, Gazipur. The seeds were large shaped, deep green and free from mixture of other seeds, weed seeds and extraneous materials.

3.5 Treatment of the Experiment

The experiment consists of two factors *viz*. varieties and fertilizer management**.** Details of factors and their combined effects are given bellow:

Factor A: Variety – 2 varieties

1) V_1 = BARI Mung-5
2) V_2 = BARI Mung-6

Factor B: Fertilizer management – 8 levels

1) T_1 = Recommended fertilizer (RF)
2) T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
3) T_3 = RF + Urea (2%) FS at FI
4) T_4 = RF + Boron (1%) FS at FI
5) T_5 = RF + Urea (2%) + Boron (1%) FS at FI
6) T_6 = Urea (2%) FS at FI
7) T_7 = Boron (1%) FS at FI
8) T_8 = Urea (2%) + Boron (1%) FS at FI

Therefore the treatment combinations were given below:

V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_5, V_1T_6, V_1T_7, V_1T_8, V_2T_1, V_2T_2, V_2T_3, V_2T_4, V_2T_5, V_2T_6, V_2T_7, V_2T_8

3.6 Design of the experiments

The experiment was laid out in Split-Plot Design with three replications. varieties were assigned in the main plot and fertilizer management in sub-plot. Two factors were used in the experiments *viz*. varieties of mungbean and eight levels of fertilizer management.

3.7 Layout of the field experiment

The experimental area was first divided into three blocks. Each block was divided into 16 plots for the treatment combinations. Therefore, the total no. of plots was 48. Thereafter 16 treatment combinations were assigned to each block as per design of the experiment. The size of the unit plot was 2.1m × 2.4m. A distance of 30 cm between the rows and 10 cm between the plants were maintained and each unit plot. The distance maintained between two plots was 1m and between blocks was 1.5m. The layout of experiment field is presented in Fig. 1.

3.8 Details of the field operations

The particulars of the cultural operations carried out during the experiment are presented below:

3.8.1 Growing of crops

3.8.1.1 Seed collection

The seeds of the test crop i.e., BARI Mung-5 and BARI Mung-6 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.8.2. Preparation of the main field

The plot selected for the experiment was opened in the first week of March, 2016 with a power tiller, and was exposed to the sun for a week, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

Treatments:

Factor A: Variety

V_1 = BARI Mung-5

V_2 = BARI Mung-6

Factor B: Fertilizer management

T_1 = RF + Foliar spray (FS) of water at flower initiation (FI)

T_2 = RF + Urea (2%) FS at FI

T_3 = RF + Boron (1%) FS at FI

T_4 = RF + Urea (2%) + Boron (1%) FS at FI

T_5 = Urea (2%) FS at FI

T_6 = Boron (1%) FS at FI

T = Urea (2%) + Boron (1%) FS at FI

T_8 = RF + Foliar spray (FS) with water at flower initiation (FI)

Experiment layout:

Plot size = 2.4m×2.1m, Plot to plot distance = 1 m, Block to block distance = 1.5m

Total land size = 18.60m × 24.10m. Replication = 3

R_1		R_2		R_3	
V_1T_1	V_2T_5	V_2T_7	V_1T_3	V_2T_8	V_1T_5
V_1T_2	V_2T_6	V_2T_8	V_1T_4	V_2T_1	V_1T_6
V_1T_3	V_2T_7	V_2T_1	V_1T_5	V_2T_2	V_1T_7
V_1T_4	V_2T_8	V_2T_2	V_1T_6	V_2T_3	V_1T_8
V_1T_5	V_2T_1	V_2T_3	V_1T_7	V_2T_4	V_1T_1
V_1T_6	V_2T_2	V_2T_4	V_1T_8	V_2T_5	V_1T_2
V_1T_7	V_2T_3	V_2T_5	V_1T_1	V_2T_6	V_1T_3
V_1T_8	V_2T_4	V_2T_6	V_1T_2	V_2T_7	V_1T_4

Fig. 1. Layout of the experiment field

3.8.3. Fertilizers and manure application

Different fertilizers were applied according to the following doses:

Manure and Fertilizer	Recommended doses of fertilizer (Rate ha^{-1}) (BARI, 2015)	Fertilizer application According to the treatment combination (Rate ha^{-1})
Cowdung	10 ton	10 ton
Urea	40-50 kg	As per treatment
TSP	80-85 kg	85 kg
MoP	30-35	35 kg
Gypsum	50 kg	50 kg
Boric acid	1 kg	As per treatment

3.8.4. Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the mungbean**.**

3.8.4.1. Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.8.4.2. Weeding

Several weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), 2nd and 3rd weeding was done at 35 and 50 DAS, respectively.

3.8.4.3. Plant protection

The plots were infested by caterpillar, which was successfully controlled by applying Basudin 10G at the rate of 16.8 kg ha^{-1}. There was no disease infestation on the crop.

3.9 Harvesting, threshing and cleaning

The crop was finally harvested at full maturity on 14 May, 2016 to 20 May, 2016 and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of mungbean seed. Fresh weight of grain and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The stover was sun dried and the yields of grain and stover $plot^{-1}$ were recorded and converted to t/ha.

3.10 Collection of data

Data were collected on the following parameters

A. Growth parameters

1) Plant height (cm)
2) Leaves $plant^{-1}$(no.)
3) Branches $plant^{-1}$(no.)
4) Above ground dry matter content $plant^{-1}$(g)
5) Nodules $plant^{-1}$(no.)

B. Yield contributing parameters

1) Pods $plant^{-1}$(no.)
2) Pod length(cm)
3) seeds pod^{-1}(no.)
4) Weight of 1000-seeds(g)

C. Yield parameters

1) Seed yield (kg ha^{-1})
2) Stover yield (kg ha^{-1})
3) Biological yield (kg ha^{-1})
4) Harvest index (%)

3.11Procedure of recording data

3.11.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at 15, 30, 45 DAS and harvest. Data were recorded from 5 plants from each plot and average plant height $plant^{-1}$ was recorded as per treatment. The height was measured from the ground level to the tip of the plant by a meter scale.

3.11.2 Leaves $plant^{-1}$ (no.)

Number of leaves $plant^{-1}$ was counted at the harvesting time. Leaves number $plant^{-1}$ were recorded by counting all leaves from each plant of each plot and mean was calculated. Data were recorded at 15, 30, 45 DAS and at harvest.

3.11.3 Branches $plant^{-1}$ (no.)

The number of branches $plant^{-1}$ was counted at 15, 30, 45 DAS and harvest. Data were recorded from 5 plants from each plot and average number of branches plant-1 was recorded as per treatment.

3.11.4 Above ground dry matter content $plant^{-1}$ (g)

Five plants were collected randomly from each plot at 15, 30, 45 DAS and harvest. Fresh plant samples from each plot were put into envelop and placed in oven maintained at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final dry weight of the sample was taken and recorded in gram.

3.11.5 Nodules plant^{-1} (no.)

Five plants from each plot was uprooted carefully with soil at 15, 30 and 45 DAS then washed out with water and make clean. The number of nodules plant^{-1} was observed and counted from each plot and average number of nodules plant^{-1} was recorded as per treatment.

3.11.6 Pods plant^{-1} (no.)

Numbers of total pods of 10 plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis.

3.11.7 Pod length (cm)

Pod length was taken from randomly selected 10 pods and the mean length was expressed on pod^{-1} basis.

3.11.8 Seeds pod^{-1} (no.)

The number of seeds pods^{-1} was recorded randomly from selected pods at the time of harvest. Data were recorded as the average of 10 pods from each plot.

3.11.9 Weight of 1000-seeds (g)

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

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

The seeds collected from 5.04 (2.1 m ×2.4 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in kg ha^{-1}.

3.11.11Stover yield (kg ha^{-1})

The stover collected from 5.04 (2.1 m ×2.4 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in kg ha^{-1}.

3.11.12 Biological yield (kg ha^{-1})

Biological yield was calculated by the following formula

Biological yield = Seed yield + Stover yield

3.11.13 Harvest index (HI) (%)

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{HI (\%)} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Stover yield)}} \times 100$$

3.12 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprised presentation and discussion of the results obtained from the study on the Impact of added foliar spray of urea and boron on growth and yield of mungbean varieties. The analyses of variance (ANOVA) of the data on different growth parameters and yield of mungbean are presented in Appendix III-IX. The results have been presented and discussed in the different tables and graphs and possible interpretations are given under the following headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of variety

Statistically non-significant variation was recorded due to different variety of mungbean in terms of plant height at 15, 30, 45 DAS and harvest (Appendix III). The tallest plant (16.86, 40.41, 47.66 and 49.27 cm, respectively) was found from V_2 (BARI Mung-6) whereas the shortest plant (16.83, 39.74, 46.72 and 47.77 cm, respectively) was observed from V_1 (BARI Mung-5) at 15, 30, 45 DAS and harvest, respectively (Fig.2). Variety plays an important role in producing longest plant of mungbean because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Tripathi *et al*. (2012), Kumar *et al*. (2009) and Raj and Tripathi (2005) reported significant varieties plant heights due to varietal differences .

4.1.1.2 Effect of fertilizer management

Plant height of mungbean at 15, 30, 45 DAS and harvest showed statistically significant variation due to fertilizer management in respect of foliar spray of urea and boron (Appendix III). Results revealed that the tallest plant at the four stages (19.37, 46.10, 57.36 and 58.42 cm, at 15, 30, 45 DAS and harvest respectively) was recorded from T_3 (RF + Urea 2% FS at FI) which was statistically different from all other treatments followed by T_1 (Recommended fertilizer; RF), T_2 (RF + Foliar spray; FS of water at flower initiation; FI) and T_5 (RF + Urea 2% + Boron 1% FS at FI). The shortest plant (15.08, 29.50, 34.47 and 37.74 cm, at 15, 30, 45 DAS and harvest respectively) was observed from T_7 (Boron 1% FS at FI)followed by T_6 (Urea 2% FS at FI) and T_8 (Urea 2% + Boron 1% FS at FI) (Fig. 3). These are an agreement with those of Ali *et al*. (1990), Mondal and Gaffer (1983), Gaffer and Razzaque (1983), who have reported that different levels of nitrogen significantly increased plant height. Tahir *et al*. (2013) also reported that boron at 4 kg ha^{-1} significantly increased plant height in mungbean. Zaman *et al*. (1996) observed that application of B (2 kg ha^{-1}) significantly increased 23.57% higher plant height of mungbean over control.

4.1.1.3 Combined effect of variety and fertilizer management

Combined effect of varieties and fertilizer management through foliar spray of urea and boron showed significant differences on plant height at 15, 30, 45 DAS and harvest (Appendix III). It was found that the tallest plant (19.57, 47.17, 58.83 and 59.97 cm, at 15, 30, 45 DAS and harvest respectively) was recorded from the treatment combination of V_2T_3 followed by V_1T_3, while the shortest plant (15.03, 29.20, 33.77 and 34.90 cm, at 15, 30, 45 DAS and harvest respectively) was found from V_1T_7 followed by V_2T_6 and V_2T_7 (Table 1).

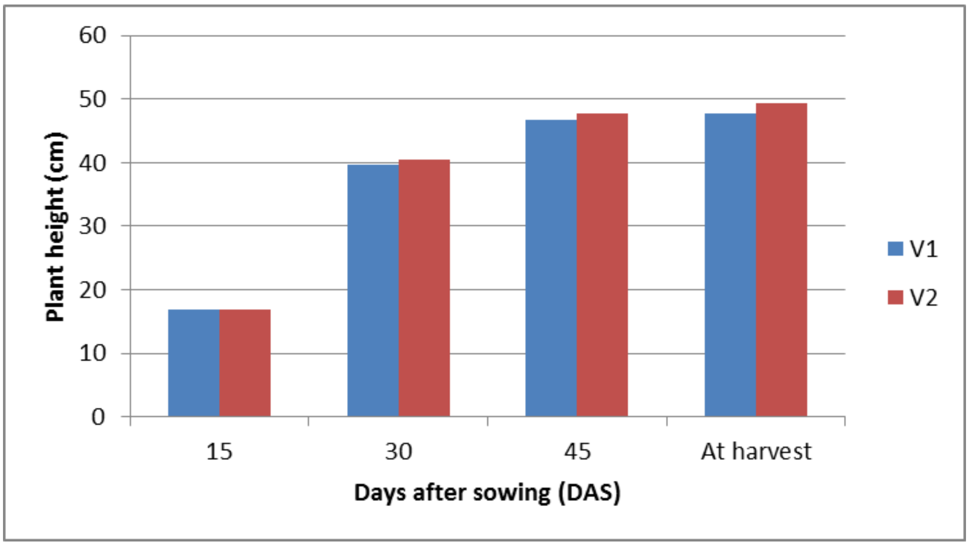

Fig. 2. Combined effect of varieties on plant height (cm) of mungbean at different growing period (SE = NS, NS, NS and NS at 15, 30, 45 DAS and harvest respectively)

V_1 = BARI Mung-5, V_2 = BARI Mung-6

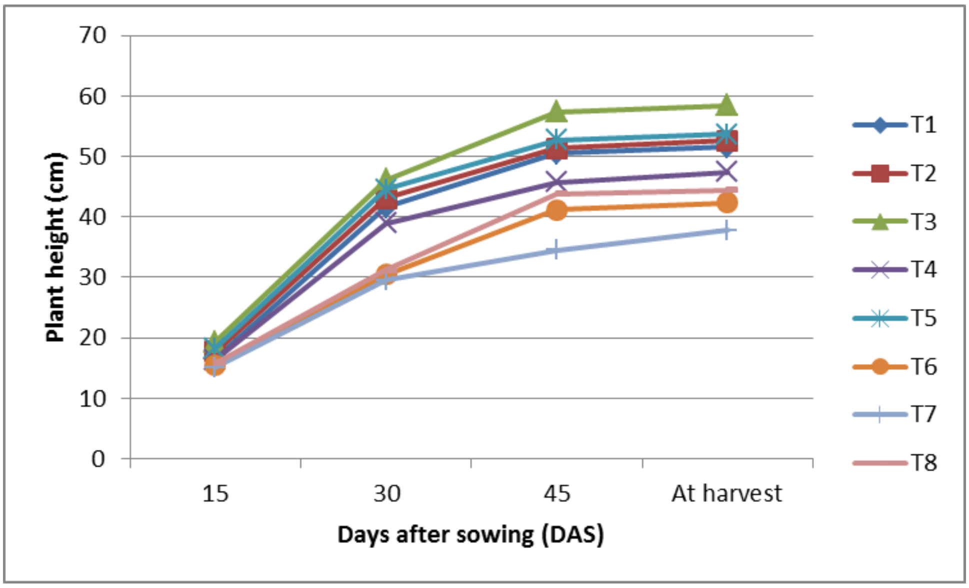

Fig. 3. Combined effect of urea and boron on plant height (cm) of mungbean at different growing period (SE = 0.520, 0.746, 1.215 and 1.104 at 15, 30, 45 DAS and harvest respectively)

T_1 = Recommended fertilizer (RF)

T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)

T_3 = RF + Urea (2%) FS at FI

T_4 = RF + Boron (1%) FS at FI

T_5 = RF + Urea (2%) + Boron (1%) FS at FI

T_6 = Urea (2%) FS at FI

T_7 = Boron (1%) FS at FI

T_8 = Urea (2%) + Boron (1%) FS at FI

Table 1. Combined effect of variety at added foliar application of urea and boron on plant height (cm) of mungbean.

Treatment	Plant height (cm) at			
	15 DAS	30 DAS	45 DAS	Harvest
V_1T_1	16.53 de	41.03 e	49.73 c	51.23 d
V_1T_2	18.03 c	43.20 cd	51.37 c	52.67 cd
V_1T_3	19.17 ab	45.03 b	55.87 b	56.87 b
V_1T_4	16.40 e	38.43 f	44.67 e	45.90 f
V_1T_5	18.13 c	44.47 bc	51.50 c	52.87 cd
V_1T_6	15.67 ef	30.70 gh	43.23 e	43.73 f
V_1T_7	15.03 f	29.20 i	33.77 h	34.90 h
V_1T_8	15.67 ef	30.87 gh	43.60 e	44.00 f
V_2T_1	16.60 de	42.20 de	51.23 c	51.83 d
V_2T_2	17.47 cd	43.00 d	51.33 c	52.57 cd
V_2T_3	19.57 a	47.17 a	58.83 a	59.97 a
V_2T_4	16.40 e	39.47 f	46.87 d	48.87 e
V_2T_5	18.47 bc	44.67 b	53.90 b	54.47 c
V_2T_6	15.27 f	30.33 g-i	39.17 f	40.87 g
V_2T_7	15.13 f	29.83 hi	35.97 g	40.57 g
V_2T_8	16.00 ef	31.63 g	44.00 e	45.00 f
SE	0.980	1.364	3.287	2.151
CV(%)	5.375	5.283	6.119	8.317

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI
V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.2 Leaves plant^{-1}(no.)

4.1.2.1 Effect of variety

Statistically non-significant variation was found due to different variety of mungbean in terms of leaves plant^{-1} at 15, 30, 45 DAS and harvest (Appendix IV). The highest leaves plant^{-1} (4.19, 8.56, 9.77and 9.68, at 15, 30, 45 DAS and harvest respectively) was found from V_2 (BARI Mung-6) whereas the lowest leaves plant^{-1} (4.11, 8.43, 9.63 and 9.49 at 15, 30, 45 DAS and harvest respectively) was observed from V_1 (BARI Mung-5) (Fig. 4). Significant variation was observed by Tripathi *et al*. (2012) on leaf area of mungbean influenced by different variety.

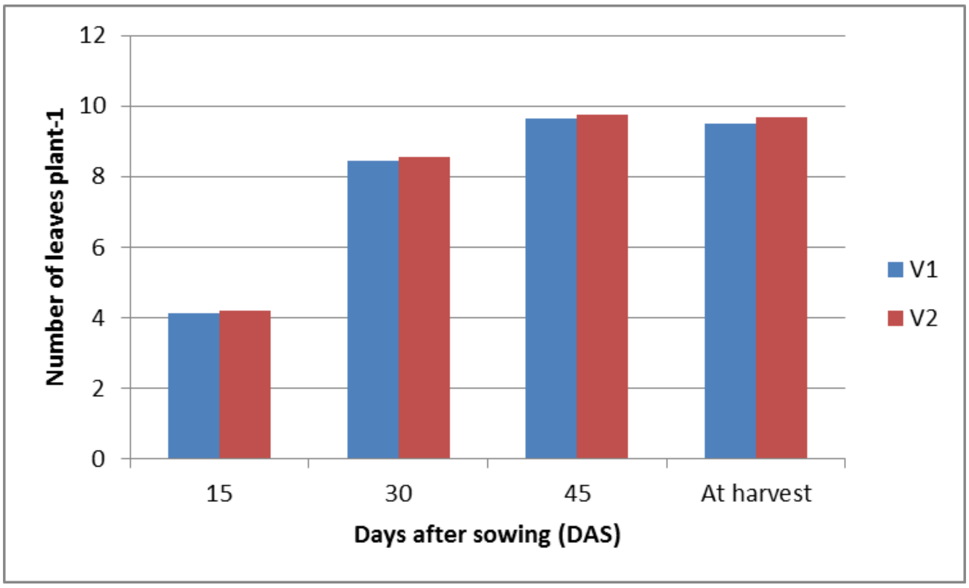

Fig. 4. Combined effect of different varieties on leaves plant^{-1} (no.) of mungbean at different growing period (SE = NS, NS, NS and NS at 15, 30, 45 DAS and harvest respectively)

V_1 = BARI Mung-5, V_2 = BARI Mung-6

4.1.2.2 Effect of fertilizer management

Leaves plant^{-1} of mungbean at all growth stages except 15 DAS showed statistically significant variation due to fertilizer management in respect of foliar spray of urea and boron (Appendix IV). Results revealed that the highest leaves plant^{-1} (9.95, 11.30 and 11.20 at 30, 45 DAS and harvest respectively) was recorded from T_3 (RF + Urea 2% FS at FI) which was statistically similar with T_5 (RF + Urea 2% + Boron 1% FS at FI) at 45 DAS and harvest.The lowest leaves plant^{-1} (7.40, 8.62 and 8.35 at 30, 45 DAS and harvest respectively) was observed from T_7 (Boron 1% FS at FI) which was closely followed by T_6 (Urea 2% FS at FI) and T_8 (Urea 2% + Boron 1% FS at FI) at the time of harvest (Fig. 5). Similar result was also found by Achakzai *et al*. (2012) in terms of nitrogen application on leaves of mungbean. Dutta *et al*. (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased leaves plant^{-1}.

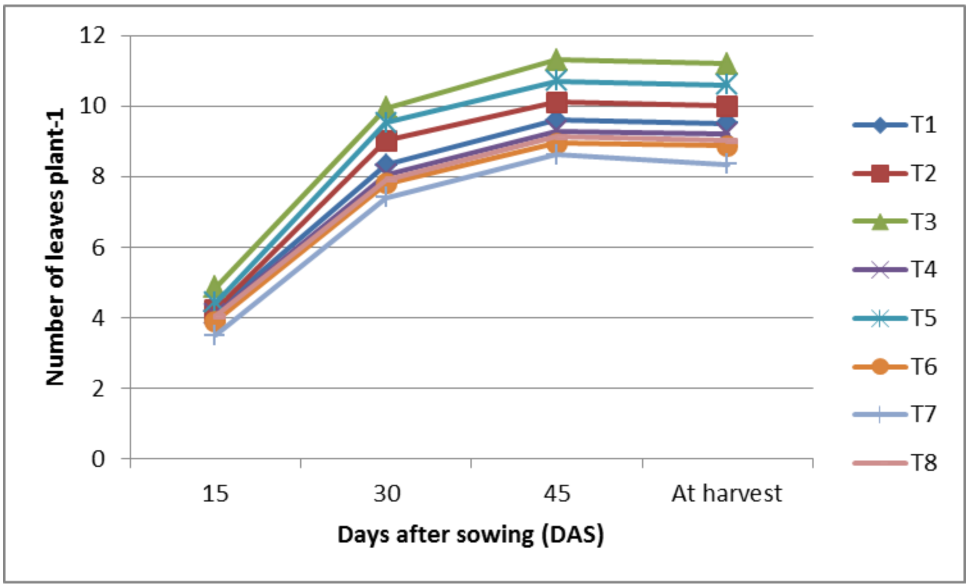

Fig. 5. Combined effect of urea and boron on leaves plant^{-1} (no.) of mungbean at different growing period (SE = 0.263, 1.132, 2.018 and 2.104 at 15, 30, 45 DAS and harvest respectively)

T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.2.3 Combined effect of variety and fertilizer management

Combined effect of varieties and fertilizer management through foliar spray of urea and boron showed significant differences on leaves plant^{-1} at all growth stages except 15 DAS (Appendix IV). It was found that the highest leaves plant^{-1} (10.10, 11.40 and 11.30 at 30, 45 DAS and harvest respectively) was recorded from the treatment combination of V_2T_3 which was statistically identical with V_1T_3 (9.83, 11.10 and 11.00 at 30, 45 DAS and harvest respectively) and closely followed by V_2T_5. The lowest leaves plant^{-1} (7.40, 8.60 and 8.13 at 30, 45 DAS and harvest respectively) was found from V_1T_7 which was closely followed by V_2T_7 at all growth stages (Table 2).

Table 2. Combined effect of variety at added foliar application of urea and boron on leaves plant^{-1} (no.) of mungbean

Treatment	Leaves plant^{-1}(no.) at			
	15 DAS	30 DAS	45 DAS	Harvest
V_1T_1	4.17	8.17 cd	9.43 ef	9.37 ef
V_1T_2	4.23	9.03 b	10.20 cd	10.10 cd
V_1T_3	4.67	9.83 a	11.10 a	11.00 a
V_1T_4	4.07	8.00 cd	9.17 fg	9.10 e-g
V_1T_5	4.33	9.27 b	10.50 bc	10.30 bc
V_1T_6	3.93	7.87 de	9.03 fg	8.93 fg
V_1T_7	3.47	7.40 e	8.60 g	8.13 h
V_1T_8	4.03	7.90 de	9.10 fg	9.00 fg
V_2T_1	4.20	8.47 c	9.77 de	9.63 de
V_2T_2	4.20	9.00 b	10.10 cd	10.00 cd
V_2T_3	5.07	10.10 a	11.40 a	11.30 a
V_2T_4	4.10	8.10 cd	9.40 ef	9.33 ef
V_2T_5	4.50	9.77 a	10.90 ab	10.80 ab
V_2T_6	3.87	7.73 de	8.87 fg	8.80 fg
V_2T_7	3.53	7.40 e	8.63 g	8.57 gh
V_2T_8	4.07	7.97 cd	9.13 fg	9.03 fg
SE	NS	2.319	4.226	4.116
CV(%)	4.876	4.638	6.019	5.439

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI

V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.3 Branches plant^{-1}(no.)

4.1.3.1 Effect of variety

Variety of mungbean showed statistically significant variation in terms of branches plant^{-1} at 45 DAS and harvest but at 15 and 30 DAS non-significant variation was found (Appendix V). Results revealed that the highest branches plant^{-1} (2.24 and 2.50 at 45 DAS and harvest respectively) was found from V_2 (BARI Mung-6) whereas the lowest branches plant^{-1} (2.10 and 2.31 at 45 DAS and harvest respectively) was observed from V_1 (BARI Mung-5) (Fig. 6). The results obtained from the present findings was similar with the findings of Parvez *et al*. (2013) and Muhammad *et al*. (2006) and they found significant variation due to different varieties regarding branches plant^{-1}. Parvez *et al*. (2013) observed that with a study, BARI Mung-6 showed the highest branches plant^{-1} compared to Binamoog-4, Binamoog-6 and Binamoog-8.

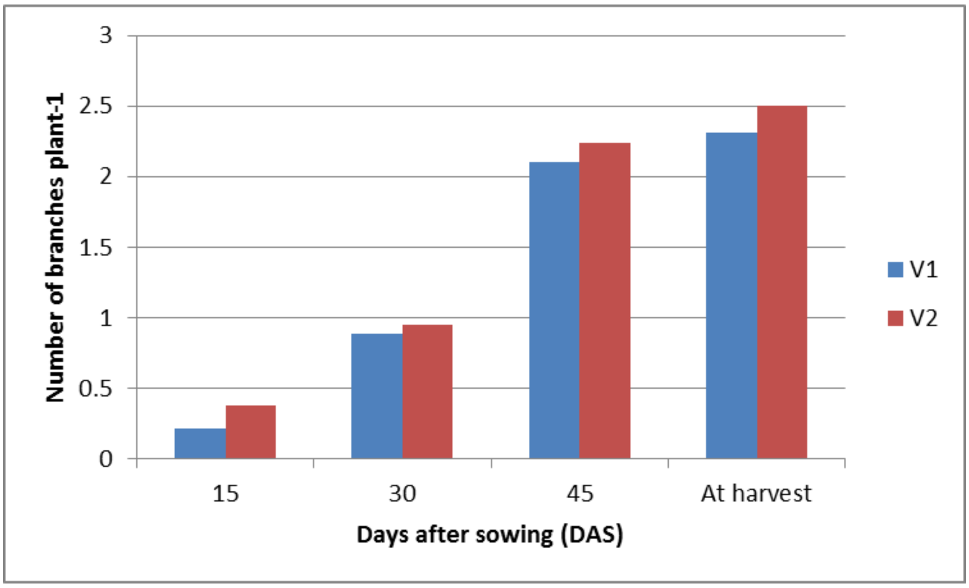

Fig. 6. Combined effect of different varieties on branches plant^{-1}(no.) of mungbean at different growing period (SE = NS, NS, 0.148 and 0.132 at 15, 30, 45 DAS and harvest respectively)

V_1 = BARI Mung-5, V_2 = BARI Mung-6

4.1.3.2 Effect of fertilizer management

Branches $plant^{-1}$ of mungbean at 15 DAS showed statistically non-significant variation but at 30, 45 DAS and harvest showed significant variation due to fertilizer management in respect of foliar spray of urea and boron (Appendix V). Results showed that the highest branches $plant^{-1}$ (1.33, 3.75 and 4.35 at 30, 45 DAS and harvest respectively) was recorded from T_3 (RF + Urea 2% FS at FI) followed by T_5 (RF + Urea 2% + Boron 1% FS at FI) at 45 DAS and harvest. The lowest branches $plant^{-1}$ (0.50, 1.13 and 1.27 at 30, 45 DAS and harvest respectively) was observed from T_7 (Boron 1% FS at FI) which was statistically similar with T_6 (Urea 2% FS at FI) (Fig. 7). Azadi *et al*. (2013) found that highest branches $plant^{-1}$ was obtained at 150 kg/ha urea. Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased branches $plant^{-1}$.

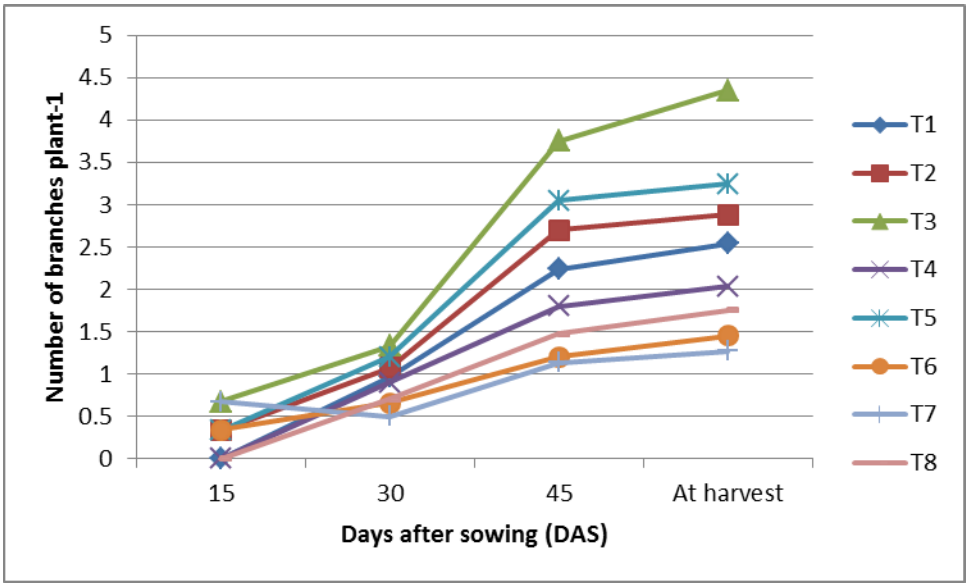

Fig. 7. Combined effect of urea and boron on branches $plant^{-1}$(no.) of mungbean at different growing period (SE = 0.167, 0.214, 0.253 and 0.354 at 15, 30, 45 DAS and harvest respectively)

T_1 = Recommended fertilizer (RF)

T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)

T_3 = RF + Urea (2%) FS at FI

T_4 = RF + Boron (1%) FS at FI

T_5 = RF + Urea (2%) + Boron (1%) FS at FI

T_6 = Urea (2%) FS at FI

T_7 = Boron (1%) FS at FI

T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.3.3 Combined effect of variety and fertilizer management

Combined effect of varieties and fertilizer management through foliar spray of urea and boron showed significant differences branches plant^{-1} at all growth stages (Appendix V). It was found that the highest branches plant^{-1} (1.00, 1.40, 3.97 and 4.63 at 15, 30, 45 DAS and harvest respectively) was recorded from the treatment combination of V_2T_3 followed by V_1T_3. The lowest branches plant^{-1} (0, 0.47, 1.13 and 1.27 at 30, 45 DAS and harvest respectively) was found from V_1T_7 which was statistically identical with V_2T_7 and closely followed by V_1T_6, V_1T_8, V_2T_6 and V_2T_8 (Table 3).

Table 3. Combined effect of variety at added foliar application of urea and boron on branches plant^{-1}(no.) of mungbean

Treatment	Branches plant^{-1}(no.) at			
	15 DAS	30 DAS	45 DAS	Harvest
V_1T_1	0.00 d	0.93 cde	2.07 ef	2.47 de
V_1T_2	0.33 c	1.07 bc	2.80 cd	2.93 cd
V_1T_3	0.33 c	1.27 ab	3.53 ab	4.07 b
V_1T_4	0.00 d	0.87 c-e	1.67 f-h	1.90 fg
V_1T_5	0.33 c	1.13 a-c	2.97 b-d	3.20 c
V_1T_6	0.00 d	0.67 ef	1.27 gh	1.47 gh
V_1T_7	0.00 d	0.47 f	1.13 h	1.27 h
V_1T_8	0.00 d	0.67 ef	1.33 gh	1.70 f-h
V_2T_1	0.00 d	1.00 b-d	2.40 de	2.60 de
V_2T_2	0.33 c	1.07 bc	2.60 c-e	2.83 cd
V_2T_3	1.00 a	1.40 a	3.97 a	4.63 a
V_2T_4	0.00 d	0.93 c-e	1.93 e-g	2.13 ef
V_2T_5	0.33 c	1.27 ab	3.13 bc	3.27 c
V_2T_6	0.67 b	0.65 ef	1.15 h	1.43 gh
V_2T_7	0.00 d	0.53 f	1.13 h	1.28 h
V_2T_8	0.00 d	0.73 d-f	1.60 f-h	1.80 f-h
SE	0.355	0.386	0.584	0.618
CV(%)	4.116	5.614	7.319	6.118

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI
V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.4Above ground dry matter content plant^{-1}(g)

4.1.4.1 Effect of variety

Statistically significant variation was found due to different variety of mungbean in terms of above ground dry matter content plant^{-1} at 30, 45 DAS and harvest (Appendix VI).Above ground dry matter content plant^{-1} at 15 DAS showed non-significant variation between the varieties (Appendix VI). Results showed that the highest above ground dry matter content plant^{-1} (11.23, 15.58 and 22.40g at 30, 45 DAS and harvest respectively) was found from V_2 (BARI Mung-6) whereas the lowest dry matter content plant^{-1} (10.94, 15.34 and 22.15 g at 30, 45 DAS and harvest respectively) was observed from V_1 (BARI Mung-5) (Fig. 8). Kumar *et al*. (2009), Muhammad *et al*. (2006) and Rahman *et al*. (2005) found significant variations on above ground dry matter content plant^{-1} due to different varieties of mungbean.

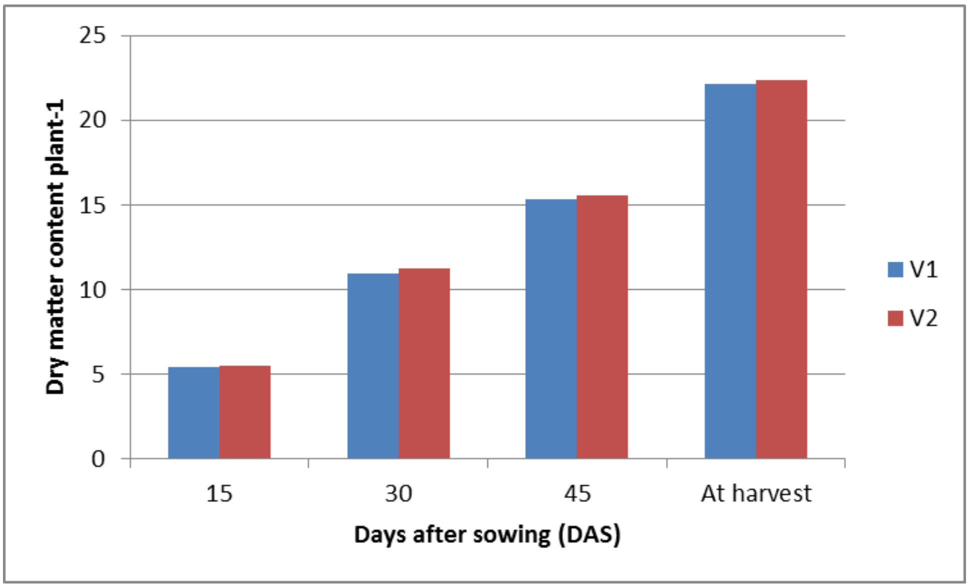

Fig. 8. Combined effect of different varieties on above ground dry matter content plant^{-1}(g) of mungbean at different growing period (SE = NS, 0.684, 0.586 and 0.539 at 15, 30, 45 DAS and harvest respectively)

V_1 = BARI Mung-5, V_2 = BARI Mung-6

4.1.4.2 Effect of fertilizer management

Above ground dry matter content plant^{-1} of mungbean at 30, 45 DAS and harvest showed statistically significant variation but at 15 DAS showed statistically non-significant variation due to fertilizer management in respect of foliar spray of urea and boron (Appendix VI). Results revealed that the highest above ground dry matter content plant^{-1} (13.25, 18.41 and 25.27 g at 30, 45 DAS and harvest respectively) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_3 (RF + Urea 2% FS at FI) and T_4 (RF + Boron 1% FS at FI). The lowest above ground dry matter content plant^{-1} (8.42, 12.31 and 18.99 g at 30, 45 DAS and harvest respectively) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) (Fig. 9).

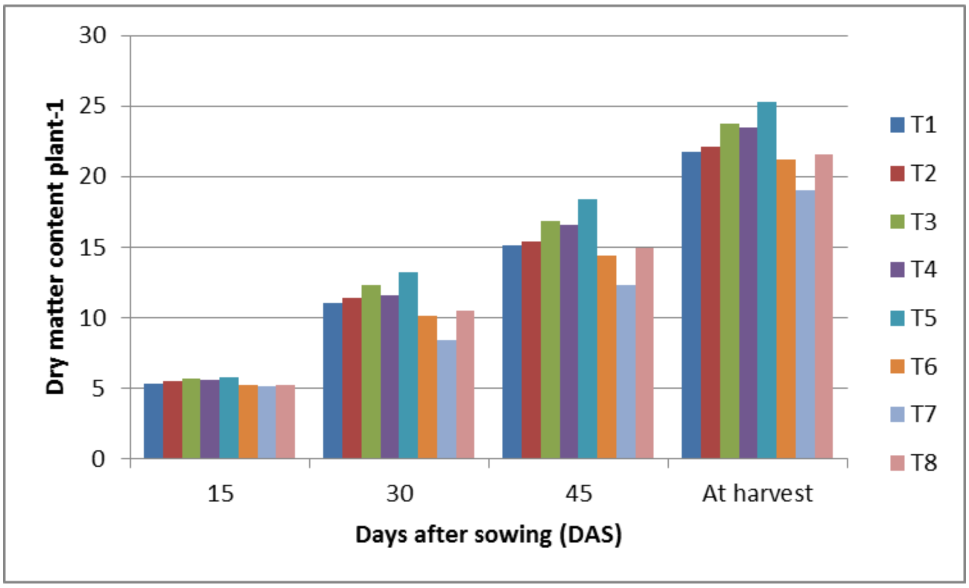

Fig. 9. Combined effect of urea and boron on above ground dry matter content plant^{-1}(g) of mungbean at different growing period (SE = 0.352, 1.533, 1.212 and 1.326 at 15, 30, 45 DAS and harvest respectively)

T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.4.3 Combined effect of variety and fertilizer management

Combined effect of varieties and fertilizer management through foliar spray of urea and boron showed significant differences on above ground dry matter content plant^{-1} at all growth stages except 15 DAS (Appendix VI). It was found that the highest above ground dry matter content plant^{-1} (5.75, 13.54, 18.64 and 25.52 g at 15, 30, 45 DAS and harvest respectively) was recorded from the treatment combination of V_2T_5which was statistically identical with V_1T_5 (5.75, 12.95, 18.17 and 25.02g at 15, 30, 45 DAS and harvest respectively) followed by V_1T_3, V_1T_4, V_2T_3 and V_2T_4. The lowest dry matter content plant^{-1} (5.12, 8.34, 11.88 and 18.21 g at 15, 30, 45 DAS and harvest respectively) was found from V_1T_7 followed by V_2T_7 (Table 4).

Table 4. Combined effect of variety at added foliar application of urea and boron on above ground dry matter content plant^{-1}(g) of mungbean

Treatment	Above ground dry matter content plant^{-1}(g) at			
	15 DAS	30 DAS	45 DAS	Harvest
V_1T_1	5.32	11.05 bc	15.01 de	21.66 cd
V_1T_2	5.56	11.43 b	15.57 cd	22.33 c
V_1T_3	5.71	11.73 b	16.75 b	23.64 b
V_1T_4	5.59	11.60 b	16.52 bc	23.39 b
V_1T_5	5.75	12.95 a	18.17 a	25.02 a
V_1T_6	5.23	10.11 c	14.64 de	21.38 cd
V_1T_7	5.12	8.34 d	11.88 f	18.21 f
V_1T_8	5.25	10.29 c	14.94 de	21.58 cd
V_2T_1	5.36	11.05 bc	15.18 de	21.86 cd
V_2T_2	5.51	11.39 b	15.31 de	21.98 cd
V_2T_3	5.74	12.90 a	16.91 b	23.79 b
V_2T_4	5.63	11.60 b	16.67 b	23.63 b
V_2T_5	5.78	13.54 a	18.64 a	25.52 a
V_2T_6	5.22	10.09 c	14.21 e	21.03 d
V_2T_7	5.20	8.50 d	12.73 f	19.77 e
V_2T_8	5.29	10.75 bc	14.95 de	21.62 cd
SE	NS	2.347	2.468	3.118
CV(%)	4.311	6.642	6.371	8.436

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI
V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.1.5 Nodules plant^{-1}(no.)

4.1.5.1 Effect of variety

Statistically non-significant variation was found due to different variety of mungbean in terms of nodules plant^{-1} at 30, 45 DAS and harvest (Appendix VII). But results showed that the highest nodules plant^{-1} (42.54, 54.13 and 64.50 at 30, 45 DAS and harvest respectively) was found from V_2 (BARI Mung-6) whereas the lowest nodules plant^{-1} (41.46, 53.21 and 63.67 at 30, 45 DAS and harvest respectively) was observed from V_1 (BARI Mung-5) (Table 5).Tripathi *et al*. (2012) and Muhammad *et al*. (2006) found that production of nodules plant^{-1} differed significantly due to different varieties.

4.1.5.2 Effect of fertilizer management

Nodules plant^{-1} of mungbean at all growth stages showed statistically significant variation due to fertilizer management in respect of foliar spray of urea and boron (Appendix VII). Results revealed that the highest nodules plant^{-1} (65.17, 76.67 and 87.33 at 30, 45 DAS and harvest respectively) was recorded from T_3 (RF + Urea 2% FS at FI) which was statistically identical with T_5 (RF + Urea 2% + Boron 1% FS at FI) at harvest (83.17). The lowest nodules plant^{-1} (22.50, 34.67 and 44.33 at 30, 45 DAS and harvest respectively) was observed from T_7 (Boron 1% FS at FI) which was closely followed by T_6 (Urea 2% FS at FI) and T_8 (Urea 2% + Boron 1% FS at FI) at all growth stages (Table 5). Tahir *et al*. (2013) found that boron at 4 kg ha^{-1} significantly increased nodules plant^{-1} (13.33).

4.1.5.3 Combined effect of variety and fertilizer management

Combined effect of varieties and fertilizer management through foliar spray of urea and boron showed significant differences on nodules plant^{-1} at all growth stages (Appendix VII). It was found that the highest nodules plant^{-1} (67.33, 79.33 and 88.33 at 30, 45 DAS and harvest respectively) was recorded from the treatment combination of V_2T_3 which was statistically similar with V_1T_3 and V_2T_5. The lowest nodules plant^{-1} (20.33, 32.00 and 41.33 at 30, 45 DAS and harvest respectively) was found from V_1T_7 followed by V_1T_6, V_1T_8, V_2T_6 and V_2T_7 (Table 5).

Table 5. Combined effect of variety at added foliar application of urea and boron on nodules plant^{-1} (no.) of mungbean

Treatment	Nodules plant^{-1} (no.) at		
	30 DAS	45 DAS	Harvest
Effect of variety			
V_1	41.46	53.21	63.67
V_2	42.54	54.13	64.50
SE	NS	NS	NS
CV(%)	4.352	4.581	6.214
Effect of fertilizer management			
T_1	42.67 c	54.50 c	63.17 c
T_2	52.17 b	63.34 b	72.67 b
T_3	65.17 a	76.67 a	87.33 a
T_4	38.34 c	50.34 c	61.50 c
T_5	57.00 b	69.00 b	83.17 a
T_6	27.83 d	39.50 de	49.50 de
T_7	22.50 e	34.67 e	44.33 e
T_8	30.34 d	41.33 d	51.00 d
SE	3.371	3.012	3.694
CV(%)	6.369	8.419	9.772
Combined effect of variety and fertilizer management			
V_1T_1	41.67 de	54.33 e	63.00 e
V_1T_2	55.00 b	66.00 cd	75.67 c
V_1T_3	63.00 a	74.00 ab	86.33 ab
V_1T_4	38.00 e	50.00 e	61.00 e
V_1T_5	56.67 b	69.00 bc	82.33 b
V_1T_6	28.33 fg	40.00 f	49.67 f
V_1T_7	20.33 h	32.00 g	41.33 g
V_1T_8	28.67 fg	40.33 f	50.00 f
V_2T_1	43.67 d	54.67 e	63.33 e
V_2T_2	49.33 c	60.67 d	69.67 d
V_2T_3	67.33 a	79.33 a	88.33 a
V_2T_4	38.67 de	50.67 e	62.00 e
V_2T_5	57.33 b	69.00 bc	84.00 ab
V_2T_6	27.33 fg	39.00 f	49.33 f
V_2T_7	24.67 gh	37.33 fg	47.33 f
V_2T_8	32.00 f	42.33 f	52.00 f
SE	6.449	5.387	7.286
CV(%)	6.369	8.419	9.772

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI

V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.2 Yield contributing parameters

4.2.1 Pods plant^{-1}(no.)

4.2.1.1 Effect of variety

Pods plant^{-1} of mungbean showed statistically significant variation due different variety of mungbean (Appendix IX). The highest pods plant^{-1} (21.08) was observed from V_2 (BARI Mung-6) and the lowest pods plant^{-1} (20.86) was observed from V_1 (BARI Mung-5) (Table 6). Similar results were found by Parvez *et al*. (2013), Kumar *et al*. (2009), Raj and Tripathi (2005), Shamsuzzaman *et al*. (2004), Madriz-Isturiz and Luciani-Marcano (2004) and Brar *et al*. (2004). They found that variety had significant effect on pods plant^{-1} of mungbean.

4.2.1.2 Effect of fertilizer management

Statistically significant variation was recorded for pods plant^{-1} due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that significantly the highest pods plant^{-1} (25.37) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) showed highest result are followed from T_3 (RF + Urea 2% FS at FI) and T_4 (RF + Boron 1% FS at FI). The lowest pods plant^{-1} (15.13) was observed from T_7 (Boron 1% FS at FI). Razzaque *et al*. (2015) indicated that increasing applied nitrogenous upto 60 kg N ha^{-1} increased pods plant^{-1}. Rajender *et al.* (2002) found that pods per plant increased with increasing N rates up to 30 kg N ha^{-1}. Tahir *et al*. (2013) found that boron at 4 kg ha^{-1} significantly increased number of pods plant^{-1}. Dutta *et al*. (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased pod plant^{-1}.

4.2.1.3 Combined effect of variety and fertilizer management

Pods plant^{-1} was significantly influenced by combined effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest pods plant^{-1} (25.89) was recorded from the treatment combination of V_2T_5 followed by V_1T_5. The lowest pods plant^{-1} (14.97) was found from V_1T_7 which statistically identical with V_2T_7, V_1T_6 and V_2T_6 (Table 7).

4.2.2 Pod length (cm)

4.2.2.1 Effect of variety

Pod length of mungbean showed statistically non-significant variation due different variety of mungbean (Appendix IX). Numerically highest pod length (8.68 cm) was observed from V_2 (BARI Mung-6) and the lowest pod length (8.49 cm) was observed from V_1 (BARI Mung-5) (Table 6). Madriz-Isturiz and Luciani-Marcano (2004) found significant differences in the values of pod length due to cultivars differences.

4.2.2.2 Effect of fertilizer management

Statistically significant variation was recorded for pod length due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest pod length (9.73 cm) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_3 (RF + Urea 2% FS at FI) where the lowest pod length (7.54 cm) was observed from T_7 (Boron 1% FS at FI) which was statistically identical with T_6 (Urea 2% FS at FI) followed by T_8 (Urea 2% + Boron 1% FS at FI) (Table 6).Azadi *et al*. (2013) observed that the highest pod length (7.5 cm) was obtained from 150 kg/ha urea.

4.2.2.3 Combined effect of variety and fertilizer management

Pod length of mungbean was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest pod length (10.40 cm) was recorded from the treatment combination of V_2T_5 followed by V_1T_3, V_1T_5 and V_2T_3. The lowest pod length (7.53 cm) was found from V_1T_7 which was statistically identical with V_1T_6, V_2T_6 and V_2T_7 followed by V_1T_8 and V_2T_8 (Table 6).

4.2.3 Seeds pod^{-1}(no.)

4.2.3.1 Effect of variety

Seeds pod^{-1} of mungbean showed statistically non-significant variation due different variety of mungbean (Appendix IX). But results showed that the highest seeds pod^{-1} (10.04) was observed from V_2 (BARI Mung-6) and the lowest seeds pod^{-1} (9.94) was observed from V_1 (BARI Mung-5) (Table 6). Different variety had significant variation on producing capacity of seeds pod^{-1}

and this was supported by the findings of Raj and Tripathi (2005), Shamsuzzaman *et al*. (2004), Madriz-Isturiz and Luciani-Marcano (2004) and Brar *et al*. (2004).

4.2.3.2 Effect of fertilizer management

Statistically significant variation was recorded for pod^{-1} due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest seeds pod^{-1} (10.43) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) which was statistically identical with T_3 (RF + Urea 2% FS at FI) and statistically similar with T_2 (RF + Foliar spray; FS of water at flower initiation; FI) and T_4 (RF + Boron 1% FS at FI). The lowest seeds pod^{-1} (9.21) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) and T_8 (Urea 2% + Boron 1% FS at FI) (Table 6). Razzaque *et al*. (2015) indicated that increasing applied nitrogenous upto 60 kg N ha^{-1} increased seeds pod^{-1}. Malik *et al.* (2003) showed similar findings. Islam and Sarkar (1993) found higher seeds pod^{-1} of mustard due to application of B @ 1.5 kg ha^{-1}.

4.2.3.3 Combined effect of variety and fertilizer management

Seeds pod^{-1} of mungbean was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest seeds pod^{-1} (10.46) was recorded from the treatment combination of V_2T_5 which was statistically similar with V_1T_3, V_1T_5 and V_2T_3. The lowest seeds pod^{-1} (8.89) was found from V_1T_7 followed by V_2T_7 (Table 6).

4.2.4 Weight of 1000-seeds (g)

4.2.4.1 Effect of variety

Weight of 1000-seeds of mungbean showed statistically significant variation due different variety of mungbean (Appendix IX). It was found that the highest 1000 seed weight (52.25 g) was observed from V_2 (BARI Mung-6) and the lowest 1000 seed weight (51.82 g) was observed from V_1 (BARI Mung-5)

(Table 6). Raj and Tripathi (2005) found significantly varies 1000 seed weight due to varietal differences.

4.2.4.2 Effect of fertilizer management

Statistically significant variation was recorded for 1000 seed weight due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest 1000 seed weight (55.67 g) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_2 (RF + Foliar spray; FS of water at flower initiation; FI), T_3 (RF + Urea 2% FS at FI) and T_4 (RF + Boron 1% FS at FI). The lowest 1000 seed weight (47.33 g) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) (Table 6). Zaman *et al.* (1996) observed that application of B (2.0 kg ha^{-1}) produced 23.37% higher 1000 seed weight of mungbean over control. Rajender *et al.* (2002) showed 1000-seed weight increased with increasing N rates.

4.2.4.3 Combined effect of variety and fertilizer management

Weight of 1000-seeds was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest 1000 seed weight (56.67 g) was recorded from the treatment combination of V_2T_5 followed by V_1T_5. The lowest 1000 seed weight (47.33 g) was found from V_1T_7 which was statistically identical with V_2T_7 followed by V_1T_6 and V_2T_6 (Table 6).

Table 6. Combined effect of variety at added foliar application of urea and boron on pods plant^{-1} (no.), pod length (cm),Seeds pod^{-1}(no.) and Weight of 1000-seeds(g)of mungbean

Treatment	Pods plant^{-1}(no.)	Pod length (cm)	Seeds pod^{-1}(no.)	Weight of 1000-seeds(g)
Effect of variety				
V_1	20.86 b	8.49	9.94	51.82 b
V_2	21.08 a	8.68	10.04	52.25 a
SE	1.314	NS	NS	1.322
CV(%)	4.116	3.014	3.581	4.083
Effect of fertilizer management				
T_1	20.76 d	8.64 bc	9.97 bc	52.00 c
T_2	22.20 c	8.75 bc	10.16 ab	53.33 b
T_3	24.20 b	8.98 b	10.31 a	54.00 b
T_4	23.34 b	8.80 bc	10.25 ab	53.33 b
T_5	25.37 a	9.73 a	10.43 a	55.67 a
T_6	18.08 e	7.76 d	9.77 c	49.67 d
T_7	15.13 f	7.54 d	9.21 d	47.33 e
T_8	18.70 e	8.50 c	9.84 c	51.33 c
SE	2.876	1.617	1.065	3.258
CV(%)	7.522	4.314	5.361	6.884
Combined effect of variety and fertilizer management				
V_1T_1	20.57 g	8.58 c	9.86 e	51.33 e
V_1T_2	22.64 e	8.76 bc	10.22 bcd	53.33 cd
V_1T_3	24.01 cd	8.95 b	10.29 ab	54.00 bc
V_1T_4	23.21 de	8.78 bc	10.23 bcd	53.30 cd
V_1T_5	24.84 b	9.05 b	10.39 ab	54.67 b
V_1T_6	18.19 hi	7.81 d	9.83 e	50.00 f
V_1T_7	14.97 j	7.53 d	8.89 g	47.33 g
V_1T_8	18.45 hi	8.47 c	9.80 e	51.33 e
V_2T_1	20.94 g	8.70 bc	10.07 d	52.67 d
V_2T_2	21.76 f	8.74 bc	10.10 cd	53.40 cd
V_2T_3	24.39 bc	9.01 b	10.32 ab	54.00 bc
V_2T_4	23.47 d	8.81 bc	10.26 bc	53.37 cd
V_2T_5	25.89 a	10.40 a	10.46 a	56.67 a
V_2T_6	17.96 i	7.70 d	9.70 e	49.33 f
V_2T_7	15.29 j	7.55 d	9.52 f	47.37 g
V_2T_8	18.95 h	8.52 c	9.85 e	51.30 e
SE	4.110	2.316	2.012	6.119
CV(%)	7.522	4.314	5.361	6.884

NS = Non-significant

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI

V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

4.3 Yield parameters

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

4.3.1.1 Effect of variety

Seed yield ha^{-1} of mungbean showed statistically significant variation due different variety of mungbean (Appendix IX). It was found that the highest seed yield ha^{-1} (810.58kg) was observed from V_2 (BARI Mung-6) and the lowest seed yield ha^{-1} (783.58kg) was observed from V_1 (BARI Mung-5) (Table 7). The results of the present study on seed yield ha^{-1} was supported by the findings of Ali *et al*. (2014), Parvez*et al*. (2013), Rasul *et al.* (2012) and Muhammad *et al*. (2006). They observed that variety had significant effect on seed yield.

4.3.1.2 Effect of fertilizer management

Statistically significant variation was recorded for seed yield ha^{-1} due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest seed yield ha^{-1} (1121.00kg) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_3 (RF + Urea 2% FS at FI). The lowest seed yield ha^{-1} (526.70kg) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) (Table 7).Razzaque *et al*. (2015) found that increasing applied nitrogenous fertilizer increased yield of mungbean upto 60 kg N ha^{-1}.Azadi *et al.* (2013) found that the highest seed yield of 8.9 grams per square meter was obtained at 150 kg/ha urea. Tahir *et al*. (2013) found that boron application at 4 kg ha^{-1} significantly increased seed yield (1200 kg ha^{-1}).

4.3.1.3 Combined effect of variety and fertilizer management

Seed yield ha^{-1} was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest seed yield ha^{-1} (1159.00kg) was recorded from the treatment combination of V_2T_5 followed by V_1T_5. The lowest seed yield ha^{-1} (501.70kg) was found from V_1T_7 followed by V_2T_7 (Table 7).

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

4.3.2.1 Effect of variety

Stover yield ha^{-1} of mungbean showed statistically significant variation due different variety of mungbean (Appendix IX). It was found that the highest stover yield ha^{-1} (1273.35 kg) was observed from V_2 (BARI Mung-6) and the lowest stover yield ha^{-1} (1271.04 kg) was observed from V_1 (BARI Mung-5) (Table 7). Varietal performance showed significant variation on stover yield which was supported by the findings of Parvez *et al*. (2013) and Hossain and Solaiman (2004).

4.3.2.2 Effect of fertilizer management

Statistically significant variation was recorded for stover yield ha^{-1} due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest stover yield ha^{-1} (1467.00 kg) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_3 (RF + Urea 2% FS at FI). The lowest stover yield ha^{-1} (1058.00 kg) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) (Table 7). Mahajan *et al*. (1994) found that soil application of B (0.5 kg ha^{-1}) increased seed yield significantly of groundnut.

4.3.2.3 Combined effect of variety and fertilizer management

Stover yield ha^{-1} was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest stover yield ha^{-1} (1472.00 kg) was recorded from the treatment combination of V_2T_5 which was statistically identical with V_1T_5 (1462.00 kg ha^{-1}) followed by V_2T_3. The lowest stover yield ha^{-1} (1044.00 kg) was found from V_1T_7 followed by V_2T_7 (Table 7).

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

4.3.3.1 Effect of variety

Biological yield ha^{-1} of mungbean showed statistically significant variation due different variety of mungbean (Appendix IX). It was found that the highest biological yield ha^{-1} (2083.93 kg) was observed from V_2 (BARI Mung-6) and the lowest biological yield ha^{-1} (2054.62 kg) was observed from V_1 (BARI Mung-5) (Table 7). Varietal performance showed significant variation on biological yield which was supported by the findings of Parvez *et al*. (2013) and Hossain and Solaiman (2004).

4.3.3.2 Effect of fertilizer management

Statistically significant variation was recorded for biological yield ha^{-1} due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest biological yield ha^{-1} (2588.00 kg) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_3 (RF + Urea 2% FS at FI). The lowest biological yield ha^{-1} (1584.70 kg) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) (Table 7). Mahajan *et al*. (1994) found that soil application of B (0.5 kg ha^{-1}) increased biological yield significantly of groundnut.

4.3.3.3 Combined effect of variety and fertilizer management

Biological yield ha^{-1} was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest biological yield ha^{-1} (2631.00 kg) was recorded from the treatment combination of V_2T_5 followed by V_1T_5 (2545.00 kg ha^{-1}). The lowest biological yield ha^{-1} (1545.70 kg) was found from V_1T_7 followed by V_2T_7 (1624.70 kg) (Table 7).

4.3.4 Harvest index (%)

4.3.4.1 Effect of variety

Harvest index of mungbean showed statistically significant variation due different variety of mungbean (Appendix IX). It was found that the highest harvest index (38.34%) was observed from V_2 (BARI Mung-6) and the lowest harvest index (37.64%) was observed from V_1 (BARI Mung-5) (Table 7).Shamsuzzaman *et al*. (2004) and Riaz *et al*. (2004) also showed similar findings with present study and they found that harvest index differed significantly due to different varieties.

4.3.4.2 Effect of fertilizer management

Statistically significant variation was recorded for harvest index due to fertilizer management in respect of foliar spray of urea and boron (Appendix IX). Results revealed that the highest harvest index (43.31%) was recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI) followed by T_3 (RF + Urea 2% FS at FI). The lowest harvest index (33.21%) was observed from T_7 (Boron 1% FS at FI) followed by T_6 (Urea 2% FS at FI) (Table 7). Mahajan *et al*. (1994) found that soil application of B (0.5 kg ha^{-1}) increased harvest index significantly of groundnut.

4.3.4.3 Combined effect of variety and fertilizer management

Harvest index was significantly influenced by interaction effect of varieties and fertilizer management through foliar spray of urea and boron (Appendix IX). It was found that the highest harvest index (44.05%) was recorded from the treatment combination of V_2T_5 which followed by V_1T_5. The lowest harvest index (32.45%) was found from V_1T_7 followed by V_2T_7 (Table 7).

Table 7. Combined effect of variety at added foliar application of urea and boron on yield parameters (seed yield, stover yield, biological yield and harvest index,) of mungbean

Treatment	Seed yield ha^{-1} (kg)	Stover yield ha^{-1} (kg)	Biological yield (kg)	Harvest index (%)
Effect of variety				
V_1	783.58 b	1271.04 b	2054.62 b	37.64 b
V_2	810.58 a	1273.35 a	2083.93 a	38.34 a
SE	5.428	8.385	12.271	2.634
CV(%)	6.187	8.172	7.389	5.884
Effect of fertilizer management				
T_1	734.30 e	1257.00 e	1991.30 e	36.88 e
T_2	809.20 d	1307.00 d	2116.20 d	38.24 d
T_3	1033.00 b	1434.00 b	2467.00 b	41.88 b
T_4	893.50 c	1360.00 c	2253.50 c	39.63 c
T_5	1121.00 a	1467.00 a	2588.00 a	43.31 a
T_6	595.70 g	1119.00 g	1714.70 g	34.75 f
T_7	526.70 h	1058.00 h	1584.70 h	33.21 g
T_8	662.70 f	1175.00 f	1837.70 f	36.05 e
SE	15.614	17.339	22.162	4.114
CV(%)	11.527	13.632	12.264	10.266
Combined effect of variety and fertilizer management				
V_1T_1	717.70 j	1245.00 i	1962.70 j	36.57 fg
V_1T_2	826.30 g	1319.00 f	2145.30 g	38.52 d
V_1T_3	1016.00 d	1427.00 c	2443.00 d	41.59 b
V_1T_4	857.30 f	1348.00 e	2205.30 f	38.87 d
V_1T_5	1083.00 b	1462.00 a	2545.00 b	42.56 b
V_1T_6	616.30 m	1155.00 l	1771.30 m	34.79 hi
V_1T_7	501.70 p	1044.00 n	1545.70 p	32.45 j
V_1T_8	650.30 l	1168.00 k	1818.30 l	35.76 gh
V_2T_1	751.00 i	1268.00 h	2019.00 i	37.19 ef
V_2T_2	792.00 h	1295.00 g	2087.00 h	37.95 de
V_2T_3	1051.00 c	1442.00 b	2493.00 c	42.16 b
V_2T_4	929.70 e	1372.00 d	2301.70 e	40.38 c
V_2T_5	1159.00 a	1472.00 a	2631.00 a	44.05 a
V_2T_6	575.00 n	1082.00 m	1657.00 n	34.70 hi
V_2T_7	551.70 o	1073.00 m	1624.70 o	33.97 i
V_2T_8	675.00 k	1182.00 j	1857.00 k	36.34 fg
SE	28.750	31.366	42.541	6.119
CV(%)	11.527	13.632	12.264	10.266

In a column, figures, bearing same letter(s) do not differ significantly at 5% level of significance

V_1 = BARI Mung-5
T_1 = Recommended fertilizer (RF)
T_2 = RF + Foliar spray (FS) of water at flower initiation (FI)
T_3 = RF + Urea (2%) FS at FI
T_4 = RF + Boron (1%) FS at FI
V_2 = BARI Mung-6
T_5 = RF + Urea (2%) + Boron (1%) FS at FI
T_6 = Urea (2%) FS at FI
T_7 = Boron (1%) FS at FI
T_8 = Urea (2%) + Boron (1%) FS at FI

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the research field, Sher–e- Bangla Agricultural University, Dhaka, during the period from March 2016 to May 2016 to study the impact of added foliar spray of urea and boron on growth and yield of mungbean varieties .The experiment consists of two varieties *viz*. V_1 = BARI Mung-5 and V_2 = BARI Mung-6 and eight levels of fertilizer management *viz*. T_1 = Recommended fertilizer (RF), T_2 = RF + Foliar spray (FS) of water at flower initiation (FI), T_3 = RF + Urea (2%) FS at FI, T_4 = RF + Boron (1%) FS at FI, T_5 = RF + Urea (2%) + Boron (1%) FS at FI, T_6 = Urea (2%) FS at FI, T_7 = Boron (1%) FS at FI and T_8 = Urea (2%) + Boron (1%) FS at FI. The experiment was laid out in split-plot design with three replications. The size of the unit plot was 2.1 m × 2.4 m. The distance maintained between two plots was 1m and between blocks was 1.5m. The date of the seed sowing was 15 March, 2016 and the crop was harvested on 16 May, 2016. Harvesting was done manually from each plot. Data were recorded on different growth and yield and yield contributing parameters.

Different growth, yield and yield contributing parameters were significantly influenced by the varieties of mungbean. In terms of growth parameters, the variety V_2 (BARI Mung-6) gave the tallest plant (16.86, 40.41, 47.66 and 49.27 cm, respectively), highest leaves plant^{-1} (4.19, 8.56, 9.77and 9.68, at 15, 30, 45 DAS and harvest respectively), highest branches plant^{-1} (2.24 and 2.50 at 45 DAS and harvest respectively), highest above ground dry matter content plant^{-1} (11.23, 15.58 and 22.40 g at 30, 45 DAS and harvest respectively) and highest nodules plant^{-1} (42.54, 54.13 and 64.50 at 30, 45 DAS and harvest respectively) where V_1 (BARI Mung-5) gave the shortest plant (16.83, 39.74, 46.72 and 47.77 cm, respectively), lowest leaves plant^{-1} (4.11, 8.43, 9.63 and 9.49 at 15, 30, 45 DAS and harvest respectively), lowest branches plant^{-1} (2.10 and 2.31 at 45 DAS and harvest respectively), lowest dry matter content plant^{-1} (10.94, 15.34 and 22.15 g at 30, 45 DAS and harvest respectively) and lowest nodules plant^{-1} (41.46, 53.21 and 63.67 at 30, 45 DAS and harvest respectively). In terms of yield and yield contributing parameters, the highest pods plant^{-1} (21.08), pod length (8.68 cm), seeds pod^{-1} (10.04), 1000 seed weight (52.25 g), seed yield (810.58 kg ha^{-1}), stover yield (1273.35 kg ha^{-1}), biological yield (2083.93 kg ha^{-1}) and harvest index (38.34%) were obtained from V_2 (BARI Mung-6) where the lowest pods plant^{-1} (20.86), pod length (8.49 cm), seeds pod^{-1} (9.94), 1000 seed weight (51.82 g), seed yield (783.58 kg ha^{-1}), stover yield (1271.04 kg ha^{-1}), biological yield (2054.62 kg ha^{-1}) and harvest index (37.64%) were also obtained from V_1 (BARI Mung-5).

Different growth and yield parameters of mungbean were also significantly influenced by different fertilizer management practices. It was found that the tallest plant (19.37, 46.10, 57.36 and 58.42 cm, at 15, 30, 45 DAS and harvest respectively)the highest leaves plant^{-1} (9.95, 11.30 and 11.20 at 30, 45 DAS and harvest respectively), the highest branches plant^{-1} (1.33, 3.75 and 4.35 at 30, 45 DAS and harvest respectively) and the highest nodules plant^{-1} (65.17, 76.67 and 87.33 at 30, 45 DAS and harvest respectively) were recorded from T_3 (RF + Urea 2% FS at FI) but the highest above ground dry matter content plant^{-1} (13.25, 18.41 and 25.27 g at 30, 45 DAS and harvest respectively), the highest pods plant^{-1} (25.37), pod length (9.73 cm), seeds pod^{-1} (10.43), 1000 seed weight (55.67 g), seed yield (1121.00 kg ha^{-1}), stover yield (1467.00 kg ha^{-1}), biological yield (2588.00 kg ha^{-1}) and harvest index (43.31%) were recorded from T_5 (RF + Urea 2% + Boron 1% FS at FI). On the other hand, the shortest plant (15.08, 29.50, 34.47 and 37.74 cm, at 15, 30, 45 DAS and harvest respectively),the lowest leaves plant^{-1} (7.40, 8.62 and 8.35 at 30, 45 DAS and harvest respectively), the lowest branches plant^{-1} (0.50, 1.13 and 1.27 at 30, 45 DAS and harvest respectively), the lowest above ground dry matter content plant^{-1} (8.42, 12.31 and 18.99 g 30, 45 DAS and harvest respectively), the lowest nodules plant^{-1} (22.50, 34.67 and 44.33 at 30, 45 DAS and harvest respectively), the lowest pods plant^{-1} (15.13), pod length (7.54 cm), seeds pod^{-1} (9.21), 1000 seed weight (47.33 g), seed yield (526.70 kg ha^{-1}**), s**tover yield

(1058.00 kg ha^{-1}), biological yield (1584.70 kg ha^{-1}) and harvest index (33.21%) were obtained from T_7 (Boron 1% FS at FI)

Different growth and yield parameters of mungbean were also significantly influenced by the interaction of different variety and fertilizer management practices. Results revealed that the tallest plant (19.57, 47.17, 58.83 and 59.97 cm, at 15, 30, 45 DAS and harvest respectively), the highest leaves $plant^{-1}$ (10.10, 11.40 and 11.30 at 30, 45 DAS and harvest respectively), the highest branches $plant^{-1}$ (1.00, 1.40, 3.97 and 4.63 at 15, 30, 45 DAS and harvest respectively) and the highest nodules $plant^{-1}$ (67.33, 79.33 and 88.33 at 30, 45 DAS and harvest respectively) were recorded from the treatment combination of V_2T_3 but the highest above ground dry matter content $plant^{-1}$ (5.75, 13.54, 18.64 and 25.52 g at 15, 30, 45 DAS and harvest respectively), the highest pods $plant^{-1}$ (25.89), pod length (10.40 cm), seeds pod^{-1} (10.46), 1000 seed weight (56.67 g), seed yield (1159.00 kg ha^{-1}), stover yield (1472.00 kg ha^{-1}), biological yield (2631.00 kg ha^{-1}) and harvest index (44.05%) were recorded from the treatment combination of V_2T_5. Again, the shortest plant (15.03, 29.20, 33.77 and 34.90 cm, at 15, 30, 45 DAS and at harvest respectively),the lowest leaves $plant^{-1}$ (7.40, 8.60 and 8.13 at 30, 45 DAS and harvest respectively), the lowest branches $plant^{-1}$ (0, 0.47, 1.13 and 1.27 at 30, 45 DAS and harvest respectively),the lowest above ground dry matter content $plant^{-1}$ (5.12, 8.34, 11.88 and 18.21 g at 15, 30, 45 DAS and harvest respectively), the lowest nodules $plant^{-1}$ (20.33, 32.00 and 41.33 at 30, 45 DAS and at harvest respectively), The lowest pods $plant^{-1}$ (14.97), pod length (7.53 cm), seeds pod^{-1} (8.89), 1000 seed weight (47.33 g), seed yield (501.70 kg ha^{-1}), stover yield (1044.00 kg ha^{-1}), biological yield (1545.70 kg ha^{-1}) and harvest index (32.45%) were found from the treatment combination of V_1T_7.

Based on the experimental results, it may be concluded that

1. Varietal differences at added foliar application of urea and boron showed significant variations in yield and yield attributes of mungbean.
2. BARI Mung-6 along with fertilizer management practice T_5 (RF + Urea 2% + Boron 1% FS at FI) seemed to be suggestive for getting higher yield in mungbean.

Recommendations

Such study may be conducted at different growing areas of Bangladesh for justification of the treatment variability towards improvement of the crop.

CHAPTER VI

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APPENDICES

Appendix I. Monthly records of air temperature, relative humidity, total rainfall and sunshine during the period from March to May 2016

Year	Month	Air temperature (°C)			Relative humidity (%)	Total Rainfall (mm)	Sunshine (Hours)
2016	March	32.5	26.9	29.7	73.5	4.0	233.2
2016	April	34.6	29.2	31.9	71.6	3.0	210.5
2016	May	33.6	24.6	29.1	66.5	3.0	218.1

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (μ g/g)	:	18.49
Exchangeable K (μ g/g)	:	0.07
Available S (μ g/g)	:	20.82
Available Fe (μ g/g)	:	229
Available Zn (μ g/g)	:	4.48
Available Mg (μ g/g)	:	0.825
Available Na (μ g/g)	:	0.32
Available B (μ g/g)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix III. Analysis of variance of the data on plant height of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of plant height			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	0.501	3.683	1.396	3.538
Factor A	1	NS	NS	NS	NS
Error	2	0.121	0.115	0.167	7.750
Factor B	7	1.441**	13.828*	3.917*	8.902*
AB	7	0.185**	3.381**	4.162*	7.148*
Error	28	0.281	3.525	4.025	3.051

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IV. Analysis of variance of the data on leaves plant^{-1} of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of leaves plant^{-1}(no.)			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	1.012	2.33	1.222	3.113
Factor A	1	NS	NS	NS	NS
Error	2	1.115	0.137	0.340	0.105
Factor B	7	2.246*	8.25**	2.326*	9.41**
AB	7	0.155*	2.229*	5.104**	6.65*
Error	28	0.189	2.664	3.501	3.771

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Analysis of variance of the data on branches plant^{-1} of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of branches plant^{-1}(no.)			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	0.154	0.015*	0.944	0.627
Factor A	1	NS	NS	3.618*	5.500*
Error	2	1.142	7.552	8.319	7.113
Factor B	7	13.54*	9.797*	10.89**	8.605*
AB	7	8.473**	2.340*	9.409*	12.96*
Error	28	0.111	1.170	1.167	2.0039

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Analysis of variance of the data on above ground dry matter content plant^{-1} of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of above ground dry matter content plant^{-1}			
		15 DAS	30 DAS	45 DAS	Harvest
Replication	2	2.023	1.294	2.291	2.027
Factor A	1	NS	2.642*	4.144*	2.081*
Error	2	0.226	4.117	6.308	6.814
Factor B	7	NS	9.900*	6.043*	3.623*
AB	7	NS	7.742*	8.685*	8.005*
Error	28	0.022	3.823	3.047	2.165

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Analysis of variance of the data on nodules plant^{-1} of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of nodules plant^{-1}(no.)		
		30 DAS	45 DAS	At harvest
Replication	2	3.202	4.087	4.046
Factor A	1	12.81*	16.704 *	10.404*
Error	2	6.663	9.577	8.214
Factor B	7	10.781*	17.241*	14.610*
AB	7	8.693*	9.465*	12.646**
Error	28	3.304	2.029	3.013

NS = Non-significant   * = Significant at 5% level   ** = Significant at 1% level

Appendix VIII. Analysis of variance of the data on yield contributing parameters of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of yield contributing parameters			
		pods plant^{-1} (no.)	Pod length (cm)	seeds pod^{-1} (no.)	Weight of 1000-seeds
Replication	2	1.293	1.024	0.294	3.044
Factor A	1	1.142*	NS	NS	6.464*
Error	2	0.636	1.129	7.624	2.654
Factor B	7	1.018*	2.623*	11.90*	9.610*
AB	7	0.684**	0.515**	6.742*	9.634**
Error	28	0.217	0.263	0.821	3.012

NS = Non-significant   * = Significant at 5% level   ** = Significant at 1% level

Appendix IX. Analysis of variance of the data on yield contributing parameters of mungbean as influenced by Combined effect of variety and foliar spray

Source of variation	Degrees of freedom	Mean square of yield parameters			
		Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield(kg ha^{-1})	Harvest index (%)
Replication	2	2.007	3.023	4.027	1.204
Factor A	1	104.345*	116.220*	126.280*	2.622*
Error	2	11.476	14.119	18.133	6.621
Factor B	7	216.83*	207.77*	311.74*	9.910*
AB	7	315.742*	231.208**	242.207**	7.542*
Error	28	11.061	13.022	14.023	1.833

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

PLATES

Plate 1: Preparing land for seed sowing

Plate 2: Mungbean plant after germination

Plate 3: Vegetative stage of mungbean

Plate 4: Nodule data collection

Plate 5: Flowering stage and foliar application

Plate 6: Reproductive stage

Plate 7: Harvesting stage and Harvested Pod