FOLIAR APPLICATION OF BORON WITH COWDUNG AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN

MST. TAJRIN NEHAR

DEPARTMENT OF AGRONOMY

SHER-E- BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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BY

MST. TAJRIN NEHAR

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Approved by

Shimul Chandra Sarker	**Professor. Dr. Parimal Kanti Biswas**
Assistant professor	**Co-Supervisor**
Supervisor	

Professor. Dr. Tuhin Suvra Roy

Chairman

Examination committe

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka -1207

DEPARTMENT OF AGRONOMY

CERTIFICATE

*This is to certify that the thesis entitled "**FOLIAR APPLICATION OF BORON WITH COWDUNG AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN**" submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in AGRONOMY, embodies the result of a piece of bona-fide research work carried out by **MST.TAJRIN NEHAR**, REGISTRATION NO. **18-09268** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:

Dhaka, Bangladesh

Shimul Chandra Sarker
Assistant Professor
Supervisor
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

Dedicated To

My Beloved Parents

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FOLIAR APPLICATION OF BORON WITH COWDUNG AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN

ABSTRACT

A field experiment was conducted for evaluating the effect of organic and inorganic fertilizer with foliar application of boron on the growth and yield of mungbean at the research field of the Department of Agronomy, Sher-e- Bangla Agricultural University, Dhaka from March to June 2019. The experiment consisted of three levels of fertilizers *viz.,* F_1 : Recommended dose (RD) of NPK fertilizer, F_2: Recommended dose (RD) of cowdung, F_3: Half recommended dose of NPK fertilizer and half recommended dose of cowdung and Boron was applied by four levels *viz.,* B_1:100% RD as basal, B_2 : 80% RD as basal + 20% foliar spray (FS) of boron at pre flowering, B_3: 60% RD as basal + rest 40 % as foliar spray of boron at pre flowering, B_4: 40% RD as basal + 60 % as foliar spray at pre flowering stage. The experiment was set up in a split-plot design with three replications. Data recorded on the basis of plant height, leaves plant^{-1}, branches plant^{-1}, dry weight plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, pod length, seed yield, stover yield and biological yield were found statistically variable with treatments. The result revealed that treatment F_1(recommended NPK fertilizer) showed the highest plant height (55.00 cm), dry matter weight (8.23 g), Pod length (8.04 cm), number of pods plant^{-1} (19.43), seed yield (1.17 t ha^{-1}) and stover yield (3.8 t ha^{-1}). On the other hand, the highest dry weight plant^{-1} (4.40 g), 1000-seed weight (41.741g) and seed yield (1125.6 kg ha^{-1}) were recorded from B_3 (60% RD as basal + rest 40% as FS at PF). Result also showed that most of the treatment combinations gave the statistically similar results in case of seed yield where numerically the highest seed yield (1356.7 kg ha^{-1}) was recorded in F_1B_3. Numerically the highest stover yield (3.953 kg ha^{-1}) and Biological yield (5310.0 kg ha^{-1}) was recorded from F_1B_3.The combine application of organic and inorganic fertilizer influence the growth parameter of mungbean. It may be concluded that foliar spray of boron increase the yield of mungbean compare to basal application along with recommended dose NPK fertilizer

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ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
@	=	At the rate of
Agril.	=	Agricultural
Agron.	=	Agronomy
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
CV	=	Coefficient of Variance
cv.	=	Cultivar
cm	=	Centimeter
DAS	=	Days After Sowing
e.g.	=	exempli gratia(L) , for example
et al.,	=	And others
Etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
FS	=	Foliar Spray
Fig	=	Figure
g	=	Gram
LSD	=	Least Significant Difference
MS	=	Masters Of Science
m	=	meter Square
PF	=	Pre -Flowering
SAU	=	Sher-e-Bangla Agricultural Uuiversity
SRDI	=	Soil Resource Development Institute
RD	=	Recommended Dose
%	=	Percentage

CHAPTER I

INTRODUCTION

Pulses are known as the world's most essential food source after cereal crop. These are the main protein and energy sources of humans. Pulses play a significant role in rainfed agriculture and in average Bangladeshi diets. Pulses are cultivated three seasons in a years in Bangladesh. Pulses crops contains high protein, amino acid such as lysine, iso-leusine, valin and easily digestable components. Pulse fitswell in the existing cropping systems, due to its short duration, low input minimum require care and drought tolerant nature. A large number of pulse crops are grown in Bangladesh in respect of area and production(BBS.2005).

Mungbean (*Vigna radiata* L) is one of the important pulse crop grown in Bangladesh. It is famous to high protein content, good flavour and high digestibility. It is also known by several names such as golden gram, green gram, mung dal, mash bean and Chinese bean and many more. Generally mungbean is cultivated in two seasons of Bangladesh i.e. Rabi and kharif. It belongs to the family leguminosae and sub family Papilionaceae. Its life cycle is short, and it principally cultivated for human consumption for its edible seeds and high in protein. It's seed contains 24.7% protein, 0.6% fat, O.9% fibre and 3.7% ash (Potter and Hotchkiss, 1997). Among the pulses, it ranks third is area and production and first in highest price value and protein content. It improves fertility of soil through nitrogen fixation. The green plants are used as animal feed.

Average yield of mungbean in Bangladesh is very low, which is primarily due to substandard methods of cultivation, imbalance nutrition, poor plant protection measures and lack of high yielding varieties. Mungbean contributes 10-12% total pulse production in Bangladesh. This means the shortage is almost 80% of the total requirement. This shortage is due to lower yield (MOA, 2005). Mungbean is cultivated on an area of 261.4 thousand hectares with total grain production of 134.4 thousand tonnes and average yield of 482.63 kg ha-1 (Anonymous, 2003). The total production of mungbean in Bangladesh in 2011-2012 was 19,972 metric tons from an area of 20,117 hectors with average yield is about 0.98 t ha[1](BBS 2010).

Cultivation of mungbean can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through biological nitrogen fixation from the atmosphere. Its roots break the plough pan of puddled rice field and go deep in search of water and nutrients. Mungbean, and other pulse like cowpea and black gram are used as green manuring crop. There are many positive effects to use different organic and inorganic fertilizer use in mungbean cultivation. Mungbeans are highly responsive to organic and inorganic fertilizers. Mungbean growth, yield and quality can be improved by the balanced use of fertilizers and also by managing the organic manures properly. The low yield of mungbean besides other factors may partially be due to lack of knowledge about nutrition and modern production technology (Hassan *et al.*1997).

Recently, the use of organic materials as fertilizer for crop production has received attention for sustainable crop productivity (Tejada *et al* ,.2009). Organic fertilizer holds great promise as a source of multiple nutrients and ability to improve soil characteristics. Cowdung is an important source of organic fertilizer which is rich in essential nutrients. Cowdung is a good source of organic fertilizer and may play a vital role to improve soil fertility as well as supply micro and macronutrients for crop production. Proper management of it may reduce the need for chemical fertilizer, allowing the small farmers to reduce cost of the production. Mungbean yield and quality can be improved by the balanced use organic fertilizer properly.

Inorganic fertilizers are known as chemical fertilizer. Inorganic fertilizers are mainly nitrogenous, phosphorus and potassium fertilizer. Being leguminous in nature, mungbean needs low nitrogen but require optimum doses of other major nutrients as recommended. Nitrogen is required for the growth and development of the crops as essential plant nutrient which is the macro nutrient of plant. Urea fertilizer use as a inorganic fertilizer source of Nitrogen to enrich the soil fertility. Nitrogen plays a key role in mungbean production. It affects the vegetative growth, pod formation and ultimately seed yield. The important role of nitrogenous fertilizer in increasing mungbean yield has been widely recognized (Asad *et al*., 2004).

Phosphorus plays a remarkable role in plant physiological processes. It is an essential constituent of majority of enzymes which are of great importance in the transformation of energy in carbohydrate metabolism in different types of plants and is closely related in cell division. Potassium (K), as a third macronutrient required for plant growth after nitrogen and phosphorus. Pulse crops highly responsive to potassium application. Potassium (K) also play a vital role as essential plant nutrient in plant growth and sustainable crop production (Baligar *et al*., 2011). The grain yield of mungbean increased with increasing P_2O_5 up to 50 ka ha^{-1} (Hossain *et al*., 2011).The balance use of organic and inorganic fertilizer increase the growth and yield of mungbean. Mungbean is highly responsive to fertilizer and organic manures. Intregrated fertilizer management includes the use of organic, inorganic fertilizer and biological resources to sustain best yields, improve and keep the soil physical and chemicals properties and give crop nutrition (Hossain *et al.,*2018)

Boron ranks third among the micronutrient and has a chief role in plant cell wall and membrane constancy (Bassil *et al*., 2004). It increase the yield and growth of plants by increasing the leaf area expansion, 1000 seed weight, nodule formation, seed yield and biological yield. It Influences the major cellular functions and metabolic activities in plants and required for cell differentiation at all growing tips of plants where cell division is active. Due to B deficiency plants manifest restricted growth of terminal buds with necrosis, shortened internodes and lateral branching which gives the plants a bushy appearence. For maintaining production of higher yield of mungbean , organic and inorganic fertilizer and micronutrient B is play very important role . Foliar application of nutrients can increase the use of nutrients and reduce pollution by lowering the amount of fertilizer applied to the soil directly (Abdo-F, 2001). In addition, foliar nutrient feeding could have facilitated absorption of nutrient through root leading to the improvement of root growth and nutrient absorption (El-Fouly and El-Sayed, 1997). Foliar application of

B at vegetative stage may important role in mungbean growth, flowering and pod filling. So there is a great need for soil-based fertilizers and foliar application of boron.

Considering the above facts, the present work was carried out to examine the effect of organic and inorganic fertilizer and boron splitting on the growth and yield of mungbean with following objectives:

- To study the effect of organic and inorganic fertilizer on the growth and yield of mungbean.
- To evaluate the effect of basal and foliar application of boron on growth and yield of mungbean
- To know the foliar application of boron with cowdung and inorganic fertilizer on yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

Mungbean is an important pulse crop Bangladesh and including many other countries in the world. Application of cowdung and inorganic fertilizers with foliar application of boron has the positive effects on mungbean. Fertilizer is the important factor that maximize the growth, yield and quality of mungbean. Boron is an essential micro-nutrient, that's helps to plants growth and productivity. Many research works had been done on mungbean in different countries especially in the South Asian Countries for improvements its growth, yield quality, and variety development.

2.1 Effect of organic fertilizer on growth, yield attributes and yield

Organic fertilizer preserves the ecosystem. Symbiotic life forms are cultured ensuring weed and pest control and optimum soil biological activity, which maintain fertility. Organic fertilizer neither demands the use of synthetic fertilizers nor the harmful chemicals (pesticides & fungicides) for controlling weeds, insects and pests.

Bandani *et al*. (2014) found that bio-organic fertilizers can increase the quality and improve the sustainable agriculture. Organic fertilizer improves the plant height, number of branch and number of pods plant^{-1}.

Naeem *et al*. (2006) concluded that organic fertilizer on growth and yield of mungbean (*Vigna radiata* L. Organic fertilizers. were applied at the time of seed bed preparation. Among organic nutrient a source, poultry manure @ 3.5 t ha^{-1} was found the best followed by FYM @ 5 t ha^{-1}. Both varieties were equal in grain yield. Numbers of pods, number of seeds per pod, 1000 grain weight were also almost higher in organic fertilizer.

Anwar *et al*. (2018) conducted an experiment on the response of mungbean to organic sources (farmyard manure, poultry manure and crop residues @ 5 t ha^{-1}) and nitrogen levels (20, 25, 30 kg ha^{-1}) was carried at Agronomy Research Farm, The University of Agriculture, Peshawar and District Nowshera during summer 2015 . Among various organic sources applied, poultry manure produced maximum number of branches plant^{-1}, leaf area, fresh weight, dry matter, number of nodules plant^{-1}, number of pod plant^{-1} , number of seed pod^{-1}, thousand grains weight, biological yield, and grain yield.

Mahmub *et al.* (2016) data on different growth parameters and yield showed statistically significant variation for different levels of cowdung. The tallest plant, the highest number of leaves plant^{-1}, the highest number of branches plant^{-1}, the minimum number of days required for 1st flowering, the minimum number of days required for 80% pod maturity, the highest number of pods plant^{-1} , the highest number of seeds pod^{-1}.

Hossain *et al.* (2018) observed that the growth performance and development attributes of mungbean varieties were found significant with the combined effect of different organic manures. BARI Mung 6 performed the best performance with the application of vermicompost @ 2.5 t ha^{-1} with the recommended dose of fertilizer.

Bilkis *et al.* (2018) evaluated the field performance of different types of manures viz. cowdung, vermicompost, poultry manure and chemical fertilizers in potato-mungbean – T.aman rice cropping pattern. Integrated use of manures and fertilizers gave average yield in potato-mungbean -T.aman rice, cropping pattern respectively.

Rupa *et al.* (2014) found that 10 t ha^{-1} and inorganic fertilizer increase maximum number of pods , 1000-seed weight, biological yield and harvest index.

Jat *et al. (*2012) concluded that organic manures and biofertilizer proved to be better over untreated plot in respect of the growth , yield attributes and yield of mungbean. FYM increase the seed yield of mungbean.

Yaduv *et al. (*2016) reported that 5 t FYM ha^{-1} recorded significantly increase yield attributing characters (pod length, number of pods plant^{-1}, seed weight plant^{-1}, and 1000 seed weight) of mungbean.

Islam *et al*. (2016) found that the highest pod number, pod length, seed weight, were found vermicompost treatment. The highest yield of bush bean (2.98 ton ha^{-1}), yard long bean (2.22 ton ha^{-1}) were found in vermicompost treatment. It can be concluded that legumes grown with vermicompost produced the highest yield and yield attributes.

2.2Effect of inorganic fertilizer on growth, yield attributes and yield .

Rahman *et al*. (2002) reported that mungbean plant characters such as plant height, branches no of plants, pods $plant^{-1}$, seed pod^{-1}, 1000–seed weight and harvest index increased significantly due to the application of NPK fertilizers.

Ahmed *et al*.(2003) observed that to use NPK fertilizer at (50-100-50 Kg ha^{-1}) gave more number of pods $plant^{-1}$, 1000-seed weight , seed yield and protein content of mungbean.

Achkzai *et al*. (2012) investigate that different fertilizer levels significantly influenced most the growth attributes and yield of mungbean.

Aslam *et al*. (2010). Observed that the effect of organic and inorganic sources of phosphorus on the growth and yield of mungbean(*Vigna radiata* L.).

Chattha *et al*. (2017). reported that Nitrogen and phosphorus fertilizers have great importance for mungbean. The application of fertilizer 20:50 kg NP kg ha^{-1} substantially improve the growth of mungbean.

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

Abbas *et al*. (2011) investigate that the effects of potassium on growth and yield of mungbean under arid climate. Among different treatment (k_2SO_4@ 75 kg ha^{-1}) more prominent increase in yield and yield contributing parameters. Potassium fertilizer helped to improve the growth and yield of mungbean and play important role in maintaining soil fertility.

Patel and Parmer (1986) observed that increasing N fertilizer application to rainfed mungbean (V. radiata cv. Gujrat-1) from 0-45 kg ha^{-1} increase average seed yield from

0.83 to 0.94 t ha^{-1} and also increased protein content, plant height, number of branches $plant^{-1}$, pods $plant^{-1}$, seeds $plant^{-1}$ and 1000- seed weight.

Hossen *et al*. (2015) observed that longest pod(7.96cm), maximum seed pod^{-1}(9.70) and greater seed yield (1.85 t ha^{-1}) were obtained in 45 kg N ha^{-1} compared others N levels.

Gopala *et al.* (1993) found out the response of mungbean cultivars to a uniform dose of 20 ka N ha^{-1}. It increase the plant height, net assimilation rate, crop growth rate.

Bhuiyan *et al*. (2011) investigate the effect of integrated use of inorganic fertilizers on yield and nutrient uptake of T. Aus rice and mungbean in the Wheat-T. Aus/ Mungbean-T. Aman cropping pattern. The results showed that application of organic manure along with chemical fertilizers resulted in markedly higher uptake of nutrients. The application of NPK (HYG) fertilizers remarkably increased the crop yield. The lowest grain yield and the lowest nutrient uptake were noted in control plots receiving no fertilizer or manure.

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

Tariq *et al.* (2001) concluded that plant height and number of branches per plant were significantly increase by phosphorus and potassium application. Number of pods per plant, number of seeds per pod, 1000-seed weight and grain yields were increase by the application of phosphorus and potassium along with nitrogen. Application of P_2O_5 and K_2O each at 70 kg ha^{-1} along with N application at 30 kg ha^{-1} produced highest grain yield of 876.32 kg ha^{-1}

Ardesna *et al*. (1993) reported that mungbean seed yield increased with the application up to 20 kg N ha^{-1} as urea, phosphatic fertilizer.

Yein *et al.* (1981) found that applied inorganic fertilizer (NPK fertilizer) to mungbean which resulted in increase plant height. They also reported that application of various level of N, P, K fertilizers significantly increase the plant height.

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

Hossain *et al*. (2011) observed that the best level of potash fertilizer on growth and yield response of two mungbean (Vigna radiata L.) cultivars (Niab Mung-92 and Chakwal Mung-06) to different levels of potassium. The experiment was laid out in Randomized Complete Block Design with factorial arrangements and replicated thrice. Treatments were comprised of five levels of potash fertilizer (0, 30, 60, 90,120 Kg ha^{-1}). Different potassium levels significantly affected the seed yield and yield contributing parameters.

Mitra *et al*. (1999) reported that 1000 - seed weight of summer mungbean, might be maximized with application of rock phosphate (50 kg P_20_5 ha^{-1}).

Sardana and Verma (1987) conducted an expermiment in New Delhi, and reported that the application of nitrogen, phosphorus and potassium fertilizer in significant increase in plant height, pod number $plant^{-1}$, pod lenth in Mungbean.

Sachan *et al.* (2020) reported that 100% NPK fertilizers use in the mungbean cultivation recorded maximum plant height(65.61cm), number of branches Plant^{-1} (13.27), higher seed yield(1.83 t ha^{-1}), strover yield (2.99 t ha^{-1}) and harvest index.

2.2 Effect of boron on growth, yield attributes and yield

Quddus *et al.* (2011) found that the combine application of boron and zinc were observed superior to the application in both the years. Therefore, the combination of boron and zinc might be considered as suitable dose for mungbean cultivation in Bangladesh.

Chowdhury *et al*. (2010) proved that plant height, total dry matter; number of pods per plant, number of seeds per pod, 1000-seed weight and seed yield was enhanced with exogenous application of boron.

Dutta *et al*. (1984) started that application of B (1 kg ha^{-1}) in mungbean increased leaf area ratio, crop growth rate , number of branches plant$^{-1,}$ no of pod plant$^{-1,}$ 1000 seed weight and a decrease in chlorophyll content and net assimilation rate, but relative growth rate , total dry matter weight , and seed yield and some other growth rate were unaffected.

Mondal *et al.* (2012) reported that treatment combination boron at pre flowering and pod-filling irrigations with a foliar operation of 0.2% borax at the flowering stage listed a maximum yield of mung bean (898 kg ha$^{-1)}$ that was relatively higher than other combinations of treatment.

Mahadul and Reshma (2018) reported that the foliar application of boron showed significant increase in growth , yield, nutrient uptake and quality parameters of pulses and legumes.

Qumar *et al*. (2016) concluded that boron has many positive effect on growth and yield development of mungbean. Low level of boron causes of negative impact on growth, restricted root elongation of mungbean plant..

Renukadevi *et al*. (2002) concluded that soil applied boron boost up the seed yield and high protein contents in mungbean. Maximum seed yield (1082 kg ha^{-1}) as well as harvest index (18%) was noted in treatment 4kg ha^{-1} and 8kg ha^{-1} respectively.

Subedi and Yadev (2013) performed a field experiment to determine the effect of sodium molybdenum and boric acid as seed primer on production of mungbean.

Islam *et al*. (1999) Boron in an essential nutrients for cell division in the process of nodule formation, which is a potential source of N. Its deficiency induces male sterility.

Nabi *et al*.(2006) observed that the effect of boron on growth and production of mungbean. They explained a notable increase in height , leaf area and biomass production of mungbean by the application of boron. Result revealed that maximum leaf area , plant height , seeds per pod and 1000 seed weight was observed at 4 kg B ha^{-1}.

Shekhawat *et al*. (2012) concluded from experiment that boron and sulphur enhanced the yield, yield attributes and quality of mungbean.

Verma and Mishra (1999) carried out a pot experiment with mungbean cv. PDM 54; where boron was applied by seed treatment, soil application or foliar spraying. Increased production and growth parameters and seed yield per plant was observed when B was applied at the equivalent of 5 kg ha^{-1} during flowering.

Zaman *et al*. (1996) conducted an experiment on mungbean and observed that application of B(2 kg ha^{-1}) produced 23.37% higher 1000 seed weight over control.

Roy *et al.* (2011) carried out an experiment where foliar or soil plus foliar methods of B fertilization increased yield attributes including seed per pod, pod per plant, 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.

Singh *et al.* (2015) found that maximum number of plant height (67.57 cm) and maximum number of leaves (34.51) were recorded significantly higher over control at 60

Das with boron application at the rate of 200 ppm. Moreover seed yield and stover yield of mungbean was significantly with the application of boron.

Kalyani *et al.*(1993) concluded that the plant height , growth rate and leaf area index in pegion pea were increased significantly after foliar application of boron as boric acid at rate 200, 300 and 400ppm.

Kaiser *et al.*(2010) concluded that boron (5 kg ha^{-1}) has impressive effect on plant height , number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds per pod , weight of 1000-seed and yield of mungbean seed after completing their study in sandy loam boron deficient soil in Bangladesh.

Singh and singh(1984) observed that sings of boron toxicity in lentil plants first arose at rate 8ppm.The main main symptoms 12 are yellowing of the lower leaflets followed by browning and scorching.

CHAPTER III

MATERIALS AND METHOD

The experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University , Dhaka-1207 during the period from 28th March 2019 to June 2019 to study the effect of cowdung and inorganic fertilizer with foliar application of boron on the growth and yield of mungbean (BARI Mungbean-6).The details of the materials and methods have been presented below:

Description of the experimental sites:

3.1. Location

The field experiment was done from March 2019 to June 2019 at the agronomy farm at Sher-e –Bangla Agricultural University, Dhaka. The Experimental field is placed at 23^{o}46 N latitude and 90^{o} 22 E longitude at an elevation of 8.2 m above sea level belonging to the Madhupur Tract Agro-ecological Zone 'AEZ' BBS, 2012. The location of the experiment site has been shown in Appendix I.

3.2 Soil

The research field soil is slightly acidic with a low content of organic matter. The selected site was above flood level and sunlight was available during the experimental period with proper irrigation and drainage system.

3.3 Climate and Weather

The local climate is subtropical, with high temperatures and heavy rainfall during the kharip season (April-September) Low rainfall during the Rabi season (October–March). Information of the metrological information on air temperature, relative humidity, precipitation and sunshine during the experiment time were obtained from Bangladesh Weather station, Sher-e-Bangla Nagar**.**

3.4 Plant Materials

BARI Mungbean -6 is a variety of mungbean. It can be grows in Kharif-I, Kharif–II and Late Rabi Season. Plant Height become 40-45 cm. It was released in 2003. Tolerent to cercospora leaf spot and yellow mosaic virus. After flowering stage plant growth become stunted. 1000 seed weight 41.90 gram almost. Seed color deep green, large shape with smooth seed coat. Crop duration was 55-58 days.

3.5 Experimental treatments

The experiment was consisted of two factors as follows:

Treatments:

Factor A: Fertilizer levels-3

F_1= Recommended NPK as basal dose

F_2= Recommended dose of cowdung

F_3= 50 % NPK +50% cowdung

Factor B: Boron levels-4

B_1= 100% boron as basal
B_2= 80% boron as basal +20% boron foliar application at pre-flowering stage
B_3= 60% boron as basal +40% boron foliar application at pre-flowering stage
B_4 = 40% boron as basal +60%boron as foliar application at pre-flowering stage

3.6 Experimental design:

The two factors experiment was laid out in split–plot design with three replication of fertilizer was in main plot and boron in Sub plot. The experiment was consist of 12 treatments combinations. The treatment combination were allocated at random. There were 36 unit plots altogether in the experiment. The size of the each unit plot was 3 m×1.5 m. The distance between two blocks and plots were 0.5 m and plant to plant distance 10 cm.

3.7 Land preparation

Power tiller was used for the preparation of the experimental field. Then it was exposed to the sunshine for 5/6 days prior to the next plowing. Than the land was ploughed and cross –ploughed and deep ploughing was due to obtained good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of crop.

3.8 Fertilizer application:

The calculated entire amount of all fertilizers were applied during final plot preparation.

Inorganic fertilizer (Urea, TSP, MoP, Gypsum, organic fertilizer (cowdung) and Boric acid was applied as per treatment.

Table 1. Fertilizer Application

Fertilizer dose	**kg ha^{-1}**
Urea	45
TSP	90
MoP	40
Gypsum	55
Cowdung	8000
Boric acid	6

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Total Urea, TSP, MoP, Gypsum and cowdung were applied as basal dose. Boron was applied as boric as basal dose and rest amount were applied as foliar application at pre flowering stage as per treatment.

3.9 Sowing of seed in the field

Mungbean variety was sown in the experimental plot. Seeds were sown on 28 March, 2019. Row to row distance was 35 cm and plant to plant distance was 10 cm.

3.10 Intercultural operation

3.10.1 Thinning

Thinning is important for mungbean plants to grow well. Mungbean seeds were germinated 4-5 days after sowing. First thinning was done at 8-10 days and second thinning was done at 15 DAS to maintain the row to row distance of 35 cm and plant to plant distance 10 cm.

3.10.2 Weeding

Weeding is required because weeds are competitive plants as they reduce the useful crop yield by acquiring space, fertilizers and nutrients from the soil. Mungbean crop was weeded thrice during cultivation stages. First weeding was done at 12 days, second at 25 DAS and last weeding was done at 35 DAS.

3.10.3 Irrigation and drainage management

Mungbeans are particularly sensitive to waterlogging so good irrigation and drainage management is important. The crop was grown in kharif- I season when rainfall is likely to be occurred. So, two irrigation were given to the field. First irrigation was done at 20 DAS and second irrigation was done at 35 DAS.

3.10.4 Disease and pest management

The crops were infested by insects and diseases. These insects and diseases were controlled by applying proper insecticide. Ripcord 30ml/l was applied to control pod borer and diseases.

3.11 Harvesting and sampling

The crop was harvested from prefixed 1.0 m^2 areas. Before harvesting five plants were selected randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1m^2 area were harvested plot wise and were bundled separately, tagged and brought to the threshing floor.

3.12 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.13 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.14 Crop sampling and data collection

Data of the various mungbean parameters were collected from five randomly selected plant samples. Harvesting data were collected from 1m^2 of each the plot's. The harvested plants had been stored for yield. The sample plants were carefully removed from the soil with khurpi so that no seeds were dropped into the soil and then washed, dried on the ground and separated by hand from the pants. Finally, grain weights were taken at 12% moisture content on an individual plot basis and converted to kg ha^{-1}. Dry weight of stover yield has also been taken. Following data were reported to growth and yield parameters.

I) Plant height

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

II) Number of leaves plant^{-1}

The numbers of green leaves of mungbean present on each plant were counted manually from the five tagged plants at 15, 30, 45 DAS and at harvest. The average number of leaves plant^{-1} was calculated and expressed in number plant^{-1} basis.

III) Number of branches plant^{-1}

The total number of branches originating from the main stem was counted at 30, 45 DAS and harvest from five tagged plants. Average number of branches calculated and express and expressed as number of branches plant^{-1} basis.

IV) Number of pods plant^{-1}

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

V) Number of seeds pod^{-1}

Number of seed pod^{-1} from ten randomly selected pods from each plot were counted and averaged.

VI) Pod length (cm)

Pod length was measured in centimeter (cm) scale from randomly selected 10 pods. Mean value of them was recorded as treatment wise.

VII) Weight of 1000-seeds (g)

One thousand cleaned and dried seeds were counted randomly form 1m^2 area and weight by using a digital electric balance and the weight was expressed in gram.

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

The plants of the central 1.0 m^2 area plot were harvested for measuring seed yield. The seed were threshed from the plants, cleaned, dried and then weighed (kg ha^{-1}).

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

The stover of the harvested crop in each plot was sun dried to a constant weight. Then the stovers were weighted and thus the stover yield plot^{-1} was determined.Then transferred them in kg ha^{-1}.

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

Seed yield and stover yield together were considered as biological yield. The biological yield was calculated and recorded as kg ha^{-1}.

XI) Harvest index (%)

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

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

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the organic and inorganic fertilizer and boron and also their interaction. The mean values of all the characters were calculated and analysis of variance (ANOVA) was performed with the help of a computer package program MSTAT –C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

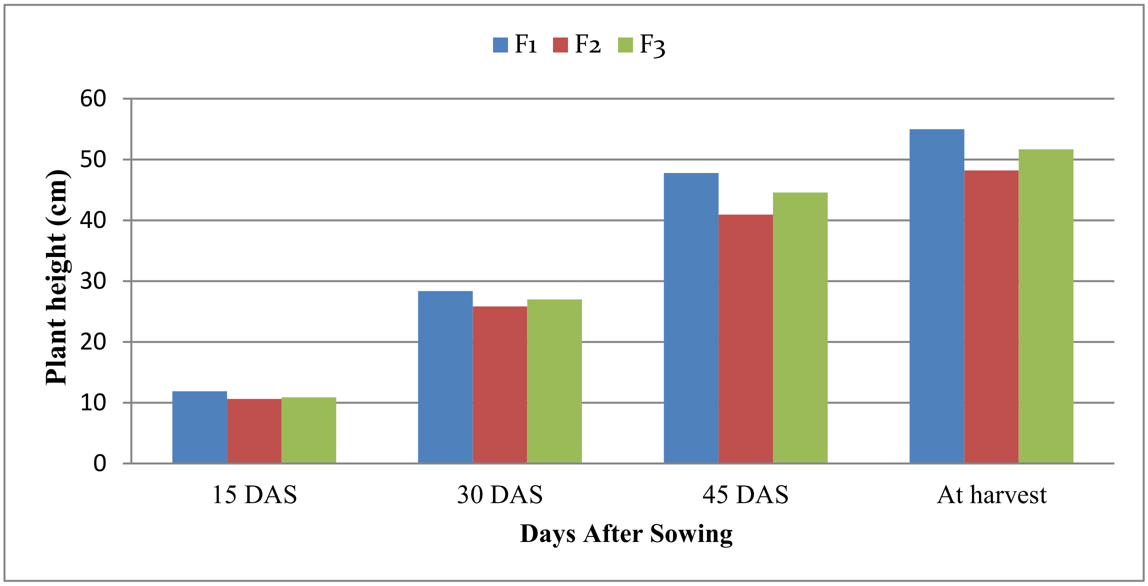
Application of boron along with different fertilizer play a vital role on the yield and yield attributes of many crops as like mungbean. The experiment was done to evaluate the effect of foliar application of boron with cowdung and inorganic fertilizer on growth and yield of mungbean. The data on different growth, yield contributing characters and yield were recorded to find out the best fertilizer management and suitable application of boron on mungbean. The analysis of varience in respect of all the characters under study has been presented in Appendix V-X. Experimental finding have been explained and discussed below with similar finding and references whenever possible.

4.1 Growth parameters

4.1.1. Plant height

Effect of cowdung and inorganic fertilizers

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. From this experiment, result revealed that there was significant effect of different fertilizer management on plant height of mungbean (Figure 1 and Appendix V). In that experiment result revealed that the highest plant height (11.89, 28.35, 47.75 and 55.00 cm at 15, 30, 45 DAS and, at harvest) was observed from the treatment of F_1 (Recommended NPK dose as basal). Whereas lowest plant height (10.61, 25.84, 40.96 and 48.19 cm at 15, 30, 45DAS and at harvest) was observed from the treatment of F_2 (Recommended dose of cowdung). Similar result was found by Yein et al. (1981). Bhuiyan *et al*. (2011) also found that the application of NPK fertilizer remarkably increase the plant height. Sultana *et al*.(2009) also found that basal dose of nitrogenous fertilizer increase the plant growth.

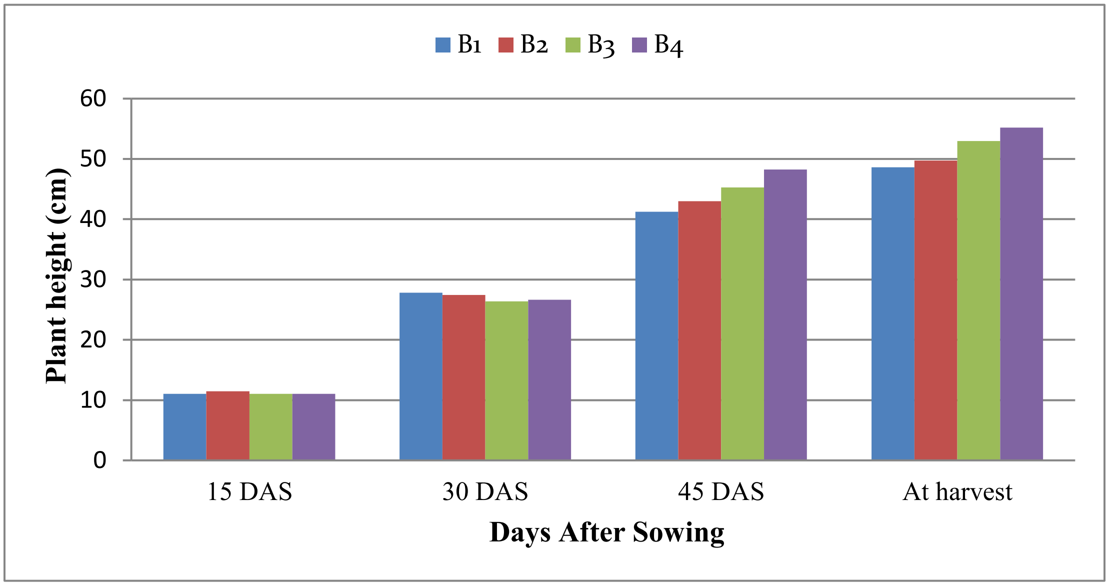


F_1 = Recommended NPK, F_2 = Recommended cowdung , F_3 = 50% cowdung + 50% NPK

Figure 1. Effect of cowdung and inorganic fertilizers on plant height of mungbean at different DAS ($LSD_{(0.05)}$= 0.459 , 0.802, 1.552 and 2.853 at 15, 30, 45 and at harvest respectively)

Effect of boron application

Mungbean plant height also differed considerably due to different treatment of boron on different days after sowing. Boron application on plant showed significant variation on plant height at different days after sowing in (Figure 2 and Appendix V). Result revealed that the highest plant height (11.45 cm at 15 DAS) was observed from the treatment of B_2, at 30 DAS, B_1 treatment showed highest plant height (27.80 cm) followed by B_2 (27.46 cm) which was also expressed statically similar result. At 45 DAS and, at harvest B_4 treatment showed highest plant height (48.24 cm and 55.20 cm). Whereas lowest plant height (11.012 cm at 15 DAS) was observed from the treatment of B_1 which was statistically similar with all others treatments except B_2 treatment, at 30 DAS, B_3 treatment showed lowest plant height (26.37 cm) followed by B_2 (26.61 cm) which was also expressed statically similar result. At 45 DAS and at harvest B_1 treatment showed lowest plant height (41.24 and 48.58 cm) which was statistically similar (49.73 cm) with B_2 treatment at harvest. Simillar findings was found by Chowdhury et al. (2010).



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF B_4=40%basal+60% foliar at PF

Figure 2.Effect of boron application on plant height of mungbean at different DAS ($LSD_{(0.05)}$= 0.358, 0.639, 1.213 and 1.918 at 15, 30, 45 and harvest respectively)

Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on plant height at different days after sowing (Table 2 and Appendix V). Result exhibit that highest plant height (12.19 cm) at 15 DAS was observed from the treatment combination of F_1B_3. Statically similar result (12.05, 12.03, 11.73 and 11.58 cm) also exhibited at 15 DAS from the combination of F_3B_2 followed by F_1B_1, F_1B_4, and F_1B_2 treatment combination. At 30 DAS the highest plant height (29.32 cm) was observed from the treatment combination of F_1B_1 which was statically similar with (29.153 cm) from F_1B_2 treatment combination. At 45 DAS and, at harvest highest plant height (53.07

and 58.23 cm) was observed from the treatment combination of F_1B_4 which was statically similar with (56.20 cm and 54.83cm) from F_1B_3 and F_3B_4 treatment combination at harvest. Whereas the lowest plant height (10.07 cm at 15 DAS was observed from the treatment combination of F_3B_1, Statistically similar result (10.36 cm, 10.41 cm, 10.49 cm and 10.733 cm) with F_2B_3, F_2B_4, F_3B_3, and F_2B_2 treatment combination were observed at 15 DAS. At 30 DAS lowest plant height (24.03 cm) was observed from the treatment combination of F_2B_4. At 45 DAS and at harvest lowest plant height (38.63 cm and 45.20 cm) was found with the treatment combination of F_2B_1 which was statistically similar with (40.00 and 45.967 cm) from F_2B_2 treatment combination, at 45 DAS and at harvest respectively.

Table 2. Interaction effect of cowdung and inorganic fertilizers with foliar application of boron on plant height(cm) of mungbean at different DAS

Treatment	Plant height (cm) at			
Combinations	15 DAS	30 DAS	45 DAS	Harvest
F_1B_1	12.03a	29.32a	43.55e-g	52.33c-e
F_1B_2	11.58a-c	29.15ab	46.00cd	53.23b-d
F_1B_3	12.19a	26.82d-f	48.40b	56.20ab
F_1B_4	11.73ab	28.08bc	53.06a	58.23a
F_2B_1	10.93cd	26.60d-f	38.63i	45.20h
F_2B_2	10.73de	26.11ef	40.00hi	45.96gh
F_2B_3	10.36de	26.60d-f	41.50gh	49.06e-g
F_2B_4	10.40de	24.02g	43.70d-f	52.53b-d
F_3B_1	10.07e	27.48cd	41.53f-h	48.23f-h
F_3B_2	12.04a	27.10c-e	42.93fg	50.00d-f
F_3B_3	10.48de	25.67f	45.90c-e	53.60bc
F_3B_4	11.03b-d	27.73cd	47.96bc	54.83a-c
$LSD_{(0.05)}$	0.620	1.107	2.101	3.322
CV (%)	3.25	2.39	2.76	3.75

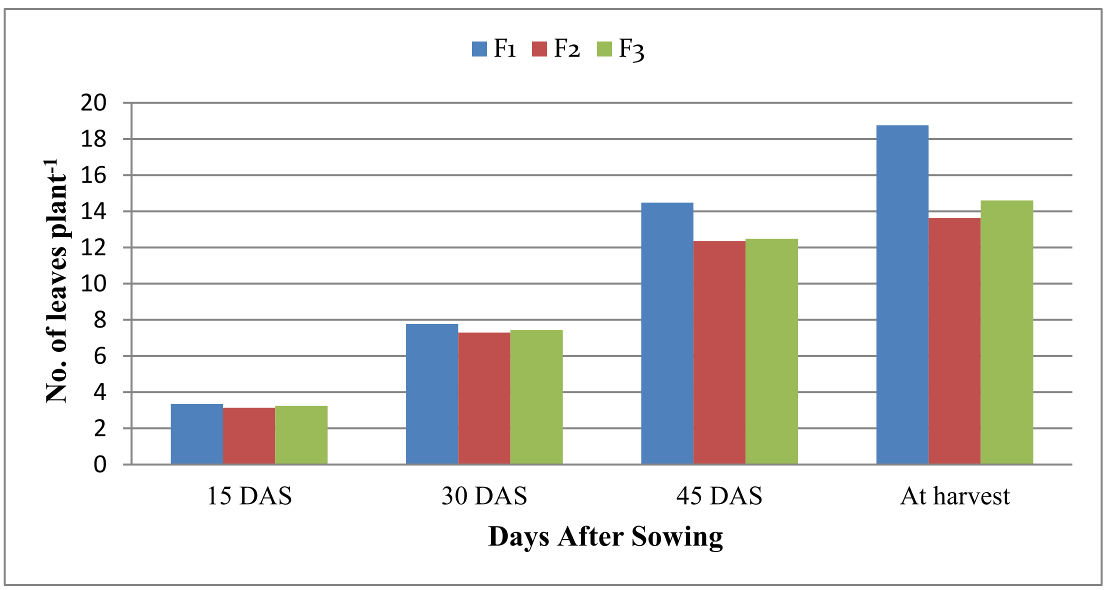
Note: F_1 = Recommended NPK, F_2 = Recommended cowdung, F_3 = 50% NPK + 50% cowdung

B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40% basal +60% foliar at PF

4.1.2 Number of leaves plant^{-1}

Effect of cowdung and inorganic fertilizers

Different fertilizer showed significant effect on number of leaves plant^{-1} (Figure 3 and Appendix VI). From the experiment result exhibited that the maximum number of leaves plant^{-1}(3.350, 7.77, 14.48 and 18.77 at 15, 30, 45 DAS) and at harvest respectively was observed from the treatment of F_1 which was statistically similar (3.25) with F_3 treatment at 15 DAS. Whereas lowest plant height (3.13,7.30, 12.35 and 13.63 at 15, 30, 45 DAS and at harvest) was observed from the treatment of F_2 which was statistically similar (7.43, 12.48 and 14.60 at 30, 45 DAS and, at harvest respectively) was observed from the treatment of F_3. Inorganic fertilizer increase the growth of mungbean than the organic fertilizer. Similar finding also found by Mahmud *et al.(*2016).

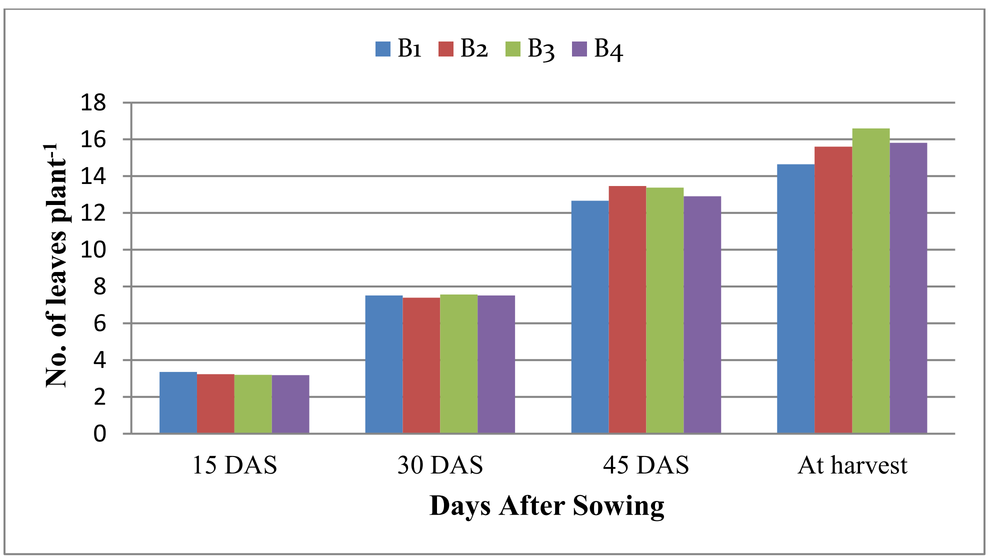


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung, F_3 = 50% cowdung + 50% NPK

Figure 3. Effect of cowdung and inorganic fertilizers on number of leaves plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.111, 0.182, 0.382 and 0.467 at 15, 30, 45 and at harvest respectively)

Effect of boron application

Boron application on plant showed significant variation on number of leaves plant^{-1} at different days after sowing (Figure 4 and Appendix VI). Result revealed that the maximum number of leaves plant^{-1} (3.35 at 15 DAS) was observed from the treatment of B_1, at 30 DAS B_3 treatment showed maximum number of leaves plant^{-1} (7.58) followed by B_1 (7.51) and B_4 (7.51) treatments which was also expressed statically similar result. At 45 DAS B_2 (Recommended dose of cowdung) treatment maximum number of leaves plant^{-1} (13.47) which was statistically similar (13.37) with B_3 treatment and, at harvest maximum number of leaves plant^{-1} (16.60) was found from B_3 treatment. Whereas number of leaves plant^{-1} (3.17 at 15 DAS) was observed from the treatment of B_4, at 30 DAS B_2 treatment showed lowest number of leaves plant^{-1} (7.40) at 45 DAS and at harvest respectively B_1 treatment showed lowest number of leaves plant^{-1} (12.66 and 14.64) which was statistically similar (12.91) with B_4 treatment at harvest. Foliar application of boron at the vegetative stage helps to increase the growth of mungbean.



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal+60% foliar at PF

Figure 4. Effect of boron application on number of leaves plant^{-1} of mungbean at different DAS (LSD$_{(0.05)}$= 0.090, 0.108, 0.308 and o.315 at 15, 30, 45 and at harvest respectively)

Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on number of leaves plant^{-1} of mungbean at different days after sowing (Table 3 Appendix VI). Result showed that the maximum number of leaves plant^{-1} at 15 and 30 DAS (3.47 and 7.93) was observed from the treatment combination of F_1B_1. Statically similar result (3.40, 3.40, 3.33 and 3.33) also exhibited at 15 DAS from the combination of F_1B_2 followed by F_2B_1, F_3B_3, and F_3B_4 treatment combination. At 45 DAS maximum number of leaves plant^{-1} (15.000) was observed from the treatment combination of F_1B_2 treatment combination and at harvest maximum number of leaves plant^{-1} (19.93) was observed from the treatment combination of F_1B_3 treatment combination. Whereas the lowest number of leaves plant^{-1} (2.93) at 15 DAS was observed from the treatment combination of F_2B_4 which was statistically similar result (3.0) with F_2B_3, treatment combination at 15DAS. At 30DAS lowest number of leaves plant^{-1} (7.13) was observed from the treatment combination of F_2B_2 which was statistically similar (7.26, 7.33, and 7.33) with F_2B_1 treatment combination followed by F_3B_2 and F_3B_1 at 30 DAS. At 45 DAS and at harvest, the lowest number of leaves plant^{-1} (11.73 and 12.87) was found with the treatment combination of F_2B_1 which was statistically similar with (12.00 and 12.26) from F_2B_4 and F_3B_1 treatment combination at 45 DAS and with (13.33) from F_3B_1 treatment combination at harvest respectively.

Table 3. Interaction effect of cowdung and inorganic fertilizer with foliar application of boron on number of leaves plant^{-1} of mungbean at different DAS

Treatment	Number of leaves at			
Combinations	15 DAS	30 DAS	45 DAS	Harvest
F_1B_1	3.46a	7.93a	14.00c	17.73c
F_1B_2	3.40ab	7.73b	15.00a	18.20c
F_1B_3	3.26b-d	7.66bc	14.66ab	19.93a
F_1B_4	3.26b-d	7.73b	14.26bc	19.20b
F_2B_1	3.40ab	7.26ef	11.73g	12.86g
F_2B_2	3.20cd	7.13f	12.66de	13.46f
F_2B_3	3.00ef	7.46cd	13.00d	14.40e
F_2B_4	2.93f	7.33de	12.00fg	13.80f
F_3B_1	3.20cd	7.33d-f	12.26e-g	13.33fg
F_3B_2	3.13de	7.33d-f	12.73de	15.13d
F_3B_3	3.33a-c	7.60bc	12.46d-f	15.46d
F_3B_4	3.33a-c	7.46c-e	12.46d-f	14.46e
$LSD_{(0.05)}$	0.1566	0.1875	0.5333	0.5455
CV (%)	2.81	1.46	2.37	2.03

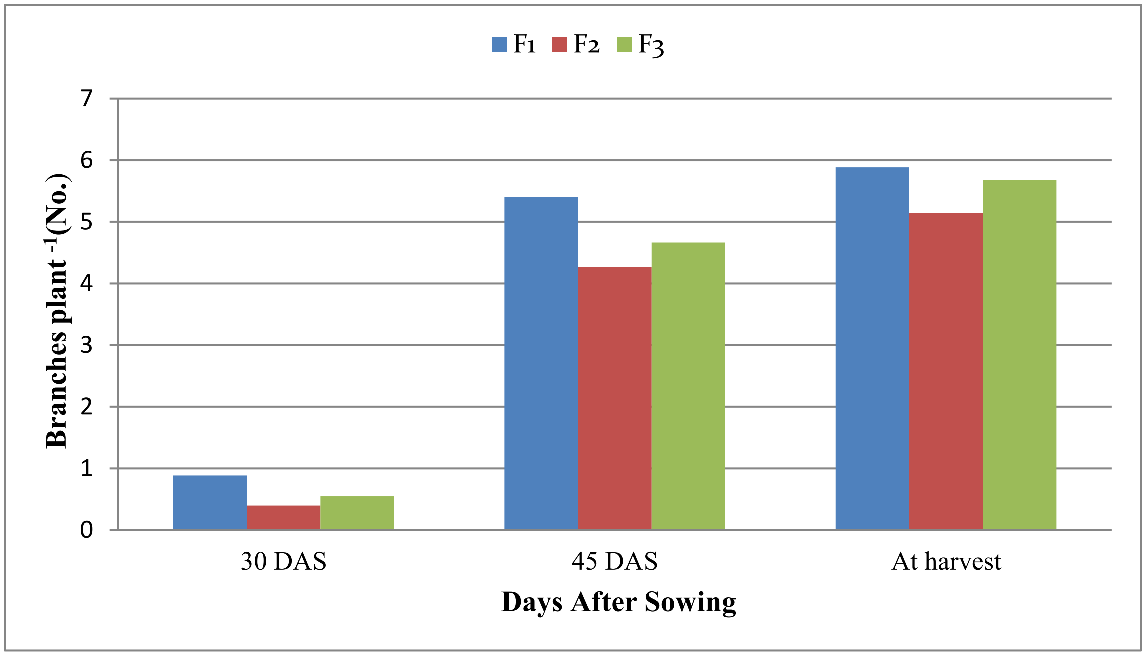
Note: F_1 = Recommended NPK, F_2 = Recommended cowdumg F_3 = 50 % cowdung + 50 % NPK,

B_1=100% basal, B $_2$=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

4.1.3 Number of branches plant^{-1}

Effect of cowdung and inorganic fertilizers

Different fertilizer management showed significant effect on number of branches plant^{1} of mungbean (Figure 5 and Appendix VII). From the experiment result exhibited that the maximum number of branches plant^{1} (0.88, 5.40 and 5.88) at 30, 45 DAS and at harvest respectively was observed from F_1 treatment. Whereas minimum branches plant^{1} (0.40, 4.2667 and 5.150 at 30, 45 DAS and, at harvest) was observed from F_2 treatment. Similar finding also found by Rahman *et al*. (2002) and Umer *et al*. (2001) that branches plant^{-1} of mungbean increase due to the application of NPK fertilizer.

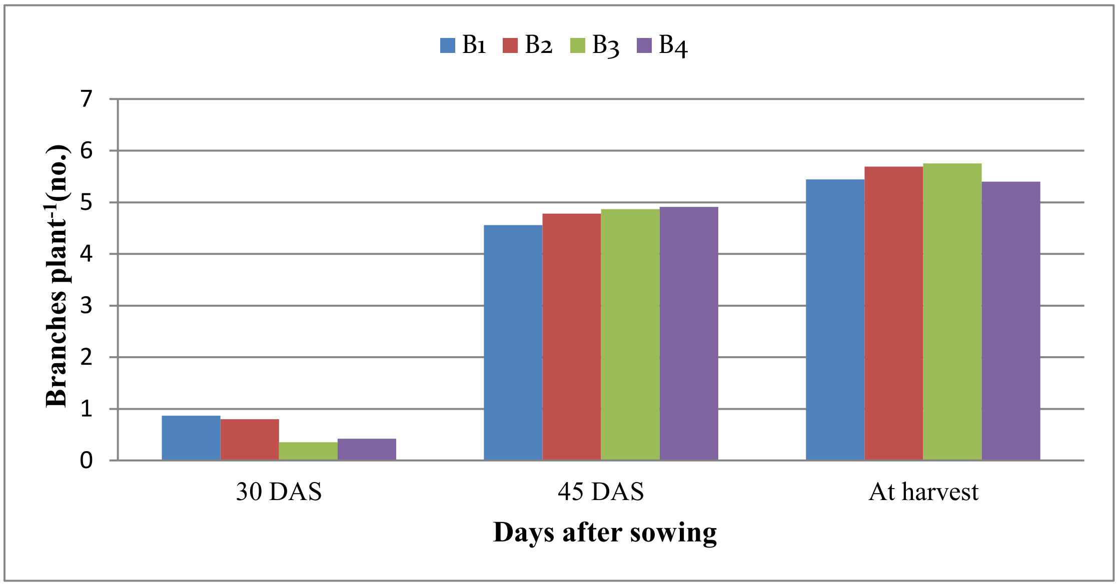


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung, F_3 = 50 % cowdung + 50 % NPK

Figure 5. Effect of cowdung and inorganic fertilizers on number of branches Plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$) = 0.036, 0.182 and 0.104 at 30, 45, and at harvest respectively)

1.3.2 Effect of boron application

Boron application on plant showed significant variation on number of branches plant^{-1} at different days after sowing (Figure 6 and Appendix VII). Result revealed that the maximum number of branches plant^{-1} (0.867 at 30 DAS) was observed from B_1 treatment, at 45 DAS B_4 treatment showed maximum branches plant^{-1} (4.91) followed by B_3 (4.86) and B_2 (4.77) treatments which was also expressed statically similar result. At harvest B_3 treatment showed maximum branches plant^{-1}(5.76) which was statistically similar (5.68) with B_2 treatment. Whereas minimum number of branches plant^{-1} (0.35 at 30 DAS) was observed from B_3 treatment, at 45 DAS B_1 treatment showed minimum branches plant^{-1} (4.55), and at harvest B_4 treatment showed minimum branches plant^{-1} (5.40) which was statistically similar (5.44) with B_1 treatment. Similar result was found Dutta *et al*. (1984) that application of boron in mungbean increase the number of branches plant^{-1}.



Note: B_1=100% basal , B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40% basal +60% foliar at PF

Figure 6. Effect of boron application on number of branches plant^{-1} of mungbean at different DAS (LSD$_{(0.05)}$ = 0.030, 0.143 and 0.148 at 30, 45 and at harvest respectively)

Interaction effect of cowdung and inorganic fertilizer with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on number of branches plant^{-1} of mungbean at different days after sowing (Table 4 and Appendix VII). Result represented that the maximum number of branches plant^{-1} at 30 DAS (1.40) was observed from the treatment combination of F_1B_1. At 45 DAS maximum number of branches plant^{-1}(5.66) was observed from the treatment combination of F_1B_4 treatment combination which was statistically similar (5.46 and 5.46) with F_1B_2 and F_1B_3 treatment combination and at harvest maximum number of branches plant^{-1} (6.26) was observed from the treatment combination of F_1B_3 treatment combination which was statistically similar (6.13) with F_3B_2 treatment combination. Whereas the minimum number of branches plant^{-1} (0.20) at 30 DAS was observed from the F_2B_3 treatment combination. At 45 DAS and at harvest minimum number of branches plant^{-1} (3.93 and 4.86) was observed from F_2B_1 treatment combination which was statistically similar (4.27) with F_2B_3 treatment combination at 45 DAS.

Table 4. Interaction effect of cowdung and inorganic fertilizers with foliar application of boron on number of branches plant^{-1} of mungbean at different DAS

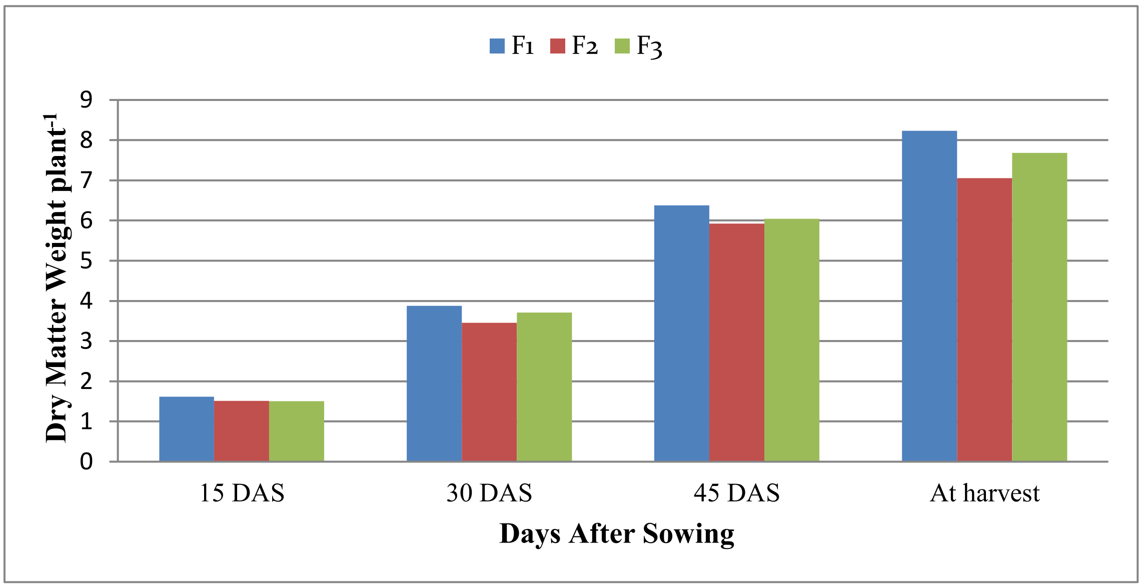
Treatment	Branch No Plant^{-1} at		
Combinations	30 DAS	45 DAS	Harvest
F_1B_1	1.40a	5.00b	5.80b
F_1B_2	1.13b	5.46a	5.80b
F_1B_3	0.46f	5.46a	6.26a
F_1B_4	0.53e	5.66a	5.66b
F_2B_1	0.53e	3.93f	4.86d
F_2B_2	0.46f	4.33de	5.13c
F_2B_3	0.20i	4.26e	5.26c
F_2B_4	0.40g	4.53cd	5.33c
F_3B_1	0.66d	4.73bc	5.66b
F_3B_2	0.80c	4.53cde	6.13a
F_3B_3	0.40g	4.86b	5.73b
F_3B_4	0.33h	4.53cde	5.20c
$LSD_{(0.05)}$	0.0517	0.2476	0.2557
CV (%)	4.93	3.02	2.68

Note: F_1 = Recommended NPK, F_2 = Cowdung Recommended F_3 = 50 % cowdung + 50% NPK, B_1=100% basal, B_2=80% basal +20% foliar at PF B_3= 60% basal +40% foliar at PF and B_4=40%basal +60%foliar at PF

4.1.4. Weight of dry matter (g)

Effect of cowdung and inorganic fertilizer

The production of total dry matter shows the potential of a crop. In case of different fertilizer application showed significant effect of dry matter weight plant^{1} on mungbean (Figure 7 and Appendix VIII). From the experiment result exhibited that the maximum dry matter weight plant^{1} (1.62, 3.88, 6.38 and 8.23g at 15, 30, 45 DAS and at harvest was observed from F_1 treatment. Whereas minimum dry matter plant[1] (1.50) at 15 DAS was observed from F_3(50% NPK and 50% cowdung) treatment at 30, 45 DAS and at harvest respectively, 3.46 g, 5.92 g, and 7.06 g dry matter weight plant^{-1} was observed from F_2 treatment .

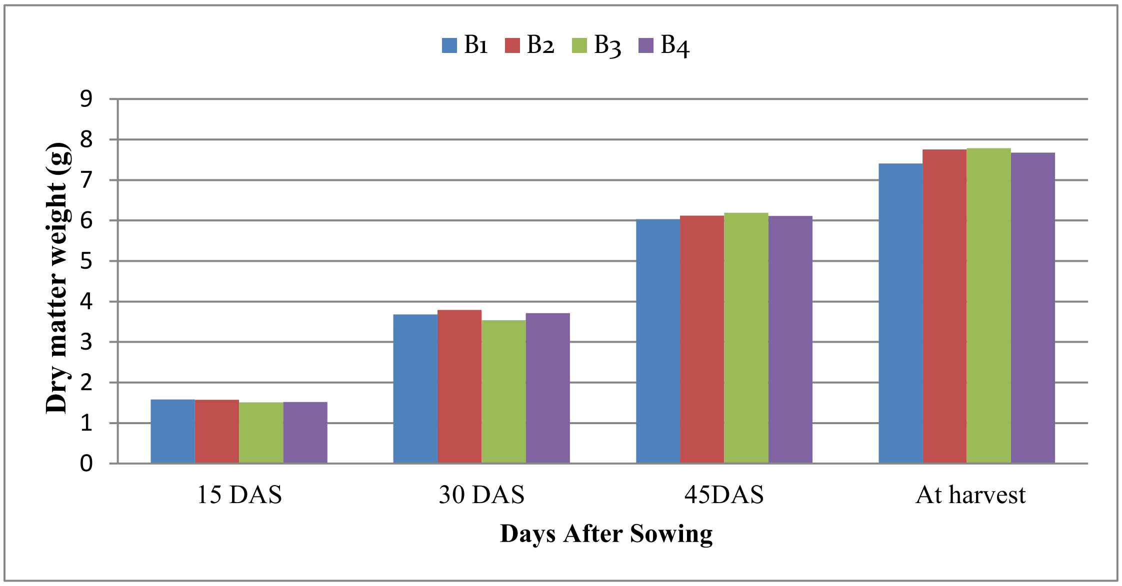


Note: F_1 = Recommended NPK, F_2 = Recommended Cowdung, F_3 = 50 % cowdung + 50% NPK

Figure 7. Effect of cowdung and inorganic fertilizers on dry matter weight plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$ = 0.046, 0.131, 0.087, and 0.291 at 15, 30, 45 and at harvest respectively).

Effect of boron application

Boron application on plant showed significant variation on dry matter weight plant^{-1} at different days after sowing (Figure 8 and Appendix VIII). Result showed that the maximum dry matter weight plant^{-1} (1.58 g at 15 DAS) was observed from B_1 treatment which was statistically similar (1.57 g) with B_2, at 30 DAS B_2 treatment showed maximum dry matter weight plant^{-1} (3.71 g) followed by B_4 treatment which was also expressed statically similar result. At 45 DAS and at harvest B_3 treatment showed maximum dry matter weight plant^{-1} (6.19 and 7.78 g) which was statistically similar all others treatment except B_1 treatment. Whereas minimum dry matter weight plant^{-1} (1.52 g and 3.54 (g) at 15 and 30 DAS) was observed from B_3 treatment which was statistically similar (1.51) with B_4 treatment at 15 DAS, at 30, 45 DAS and harvest minimum dry matter weight plant^{-1} 3.67, 6.04 and 7.41g was observed from B_1 treatment .



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 8. Effect of boron application on dry matter weight plant^{-1} at different DAS ($LSD_{(0.05)}$) = 0.041, 0.103, 0.095 and 0.143 at 15, 30, 45 and at harvest respectively).

Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on dry matter weight plant^{-1} of mungbean at different days after sowing (Table. 5 and Appendix VIII). Result exhibited that the maximum dry matter weight plant^{-1} at 15

DAS and 30 DAS (1.67 g and 4.05 g) was observed from the treatment combination of F_1B_2 which was statistically similar 1.64g with F_1B_1 at 15 DAS; with F_1B_4 (3.98 g) and F_1B_1 (3.97 g) at 30 DAS. At 45 DAS and harvest maximum dry matter weight plant^{-1} (6.62 and 8.50 g) was observed from the treatment combination of F_1B_3 which was statistically similar (8.32 g) with F_1B_2 treatment combination at harvest. Whereas the minimum dry matter weight plant^{-1} (0.20) at 30 DAS was observed from the F_2B_3 treatment combination. At 45 DAS and at harvest minimum dry matter weight plant^{-1} (3.93 and 4.86g) was observed from F_2B_1 treatment combination which was statistically similar (4.26 g) with F_2B_3 treatment combination at 45 DAS. Whereas the minimum dry matter weight plant^{-1} (1.45 g) at 15 DAS was observed from the F_3B_4 treatment combination which was statistically similar (1.47, 1.47, 1.49, 1.50 and 1.513g) with F_3B_3, F_2B_2, F_2B_3, F_2B_4 and F_3B_1 treatment combination respectively. At 30 DAS the minimum dry matter weight plant^{-1} (3.31 g) was observed from the F_3B_4 treatment combination which was statistically similar (3.39 and 3.48 g)with F_2B_4, and F_1B_3 treatment combination, at 45 DAS the minimum dry matter weight plant^{-1} (5.84 g) was observed from the F_2B_1 treatment combination which was statistically similar (5.88, 5.88 and 5.90 g)with F_3B_3, F_2B_2 and F_2B_4 treatment combination and at harvest minimum dry matter weight plant^{-1} (6.74 g) was observed from F_2B_1 treatment combination

Table 5. Interaction effect of cowdung and inorganic fertilizers with foliar application of boron on dry matter weight plant^{-1} of mungbean at different DAS

Treatment	Dry matter weight plant^{-1} (g) at			
Combinations	15 DAS	30 DAS	45 DAS	Harvest
F_1B_1	1.64ab	3.97ab	6.22cd	7.95cd
F_1B_2	1.66a	4.05a	6.25c	8.32ab
F_1B_3	1.57c-e	3.48f-h	6.62a	8.51a
F_1B_4	1.59bc	3.98ab	6.42b	8.15bc
F_2B_1	1.58b-d	3.51e-g	5.84g	6.74h
F_2B_2	1.47f	3.61d-f	5.88fg	7.19fg
F_2B_3	1.49f	3.31h	6.06de	7.20fg
F_2B_4	1.50ef	3.39gh	5.90e-g	7.08g
F_3B_1	1.51d-f	3.55e-g	6.04ef	7.53ef
F_3B_2	1.57b-e	3.71c-e	6.22c	7.75de
F_3B_3	1.47f	3.82bc	5.88fg	7.65de
F_3B_4	1.45f	3.75cd	6.02ef	7.79d
$LSD_{(0.05)}$	0.071	0.178	0.164	0.248
CV (%)	2.68	2.83	1.57	1.88

Note: F_1 = Recommended NPK, F_2 = Recommended cowdung , F_3 = 50% cowdung + 50% NPK,

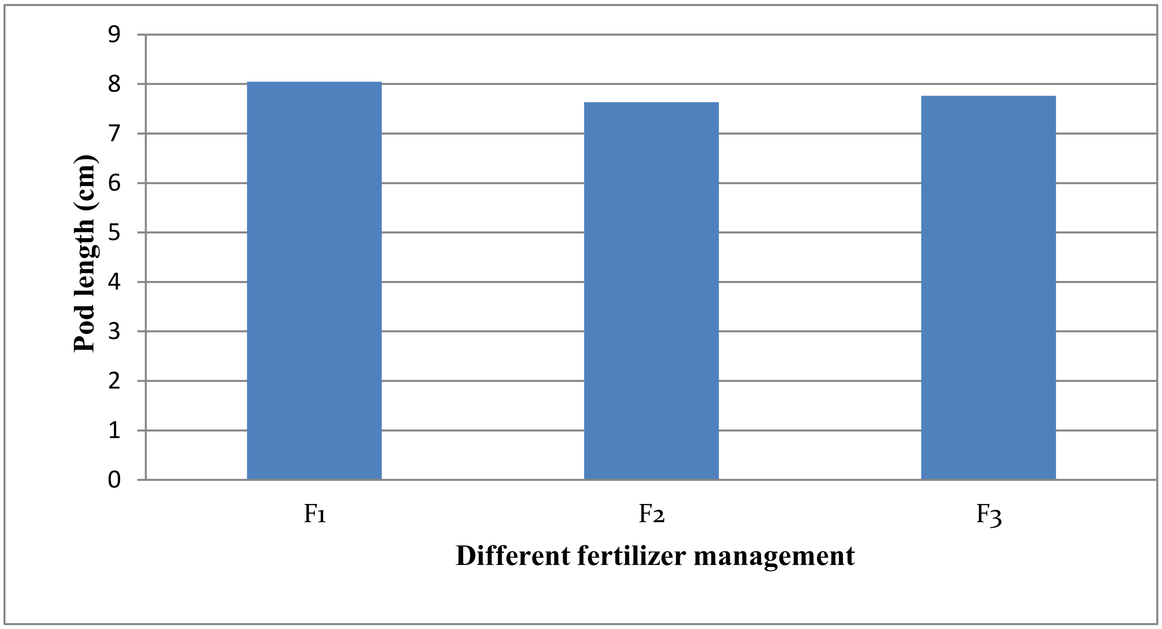
B_1= 100% basal, B_2= 80% basal +20% foliar at PF , B_3= 60% basal +40% foliar at PF and B_4= 40%basal +60% foliar at PF

4.2 Yield contributing parameters

4.2.1 Pod length (cm)

Effect of cowdung and inorganic fertilizers

Significant variation was observed on pod length of mungbean due to different fertilizer management (Figure 9 and Appendix IX). From the experiment result indicated that the maximum pod length (8.05 cm) was observed from F_1 treatment at harvest whereas minimum pod length (7.63 cm) was observed from F_2 treatmentat harvest which was statistically similar with F_3 (7.76cm) treatment at harvest.

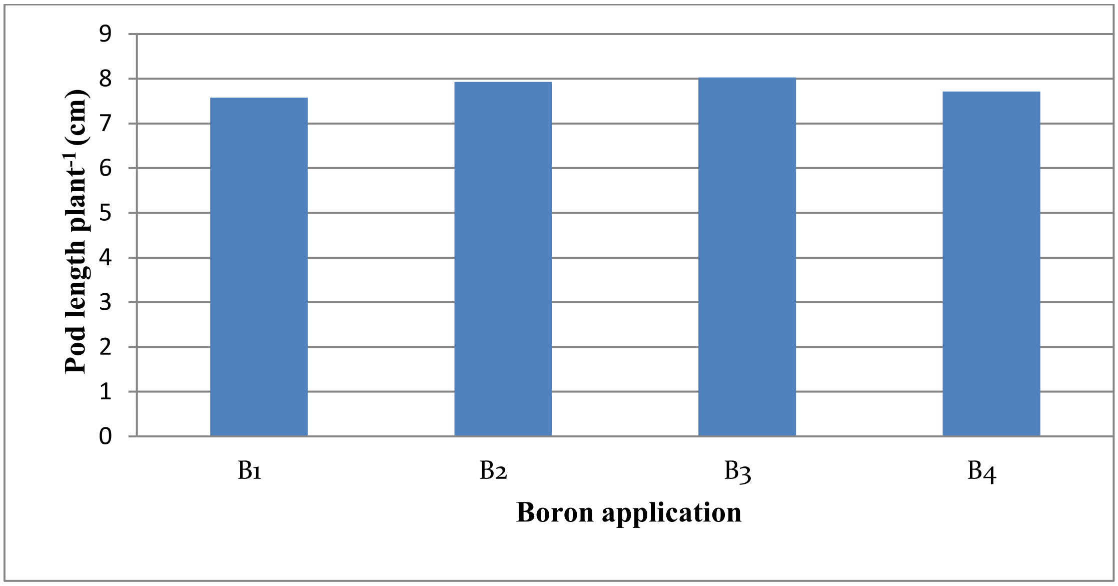


Note: F_1 = Recommended NPK, F_2 = Recommended Cowdung, F_3 = 50% cowdung + 50% NPK

Figure 9. Effect of cowdung and inorganic fertilizers on pod length of mungbean ($LSD_{(0.05)}$ = 0.125).

Effect of boron application

Boron application showed significant effect on pod length (cm) (Figure 10 and Appendix IX). The result indicated that the maximum pod length (8.02 cm) was observed from B_3 (60% Boron as basal + 40% Boron as foliar application at pre-flowering) at treatment which was statistically similar with (7.93 cm) B_2 treatment, whereas minimum pod length (7.58 cm) was observed from B_1 treatment which was statistically similar with (7.71 cm) B_4 treatment



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 10. Effect of boron application on pod length of mungbean ($LSD_{(0.05)}$ =0.176)

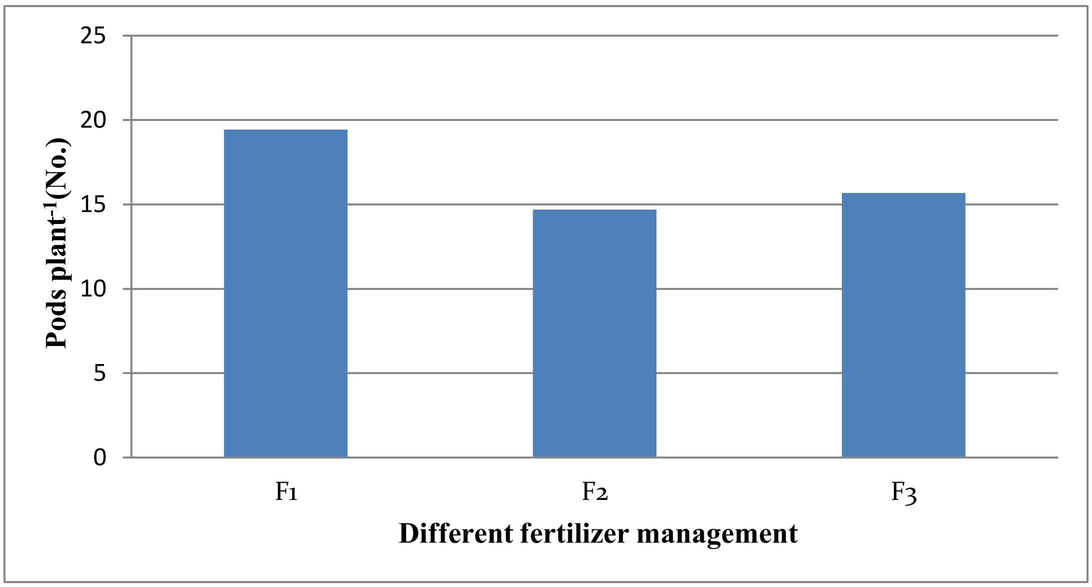
Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on pod length (cm) of mungbean (Table 6 and Appendix IX). From the experiment result showed that the maximum pod length plant^{-1} (8.32 cm) was observed from F_1B_3 treatment combination which was statistically similar (8.08 and 8.08 cm) with F_1B_4, and F_1B_2 treatment combination, whereas minimum pod length (7.42cm) was observed from F_2B_4 treatment combination which was statistically similar (7.48, 7.55, 7.63, and 7.70 cm) with F_2B_1, F_3B_1, F_3B_4, and F_1B_1 treatment combination.

4.2.2 Number of pods plant^{-1}

Effect of cowdung and inorganic fertilizers

Different fertilizer management showed significant effect on pods plant^{-1} (Figure 11 and Appendix IX). From the experiment result exhibited that the maximum pods plant^{-1} (19.43) was observed from F_1 treatment whereas minimum pods plant^{-1} (14.70) was observed from F_2 treatment.

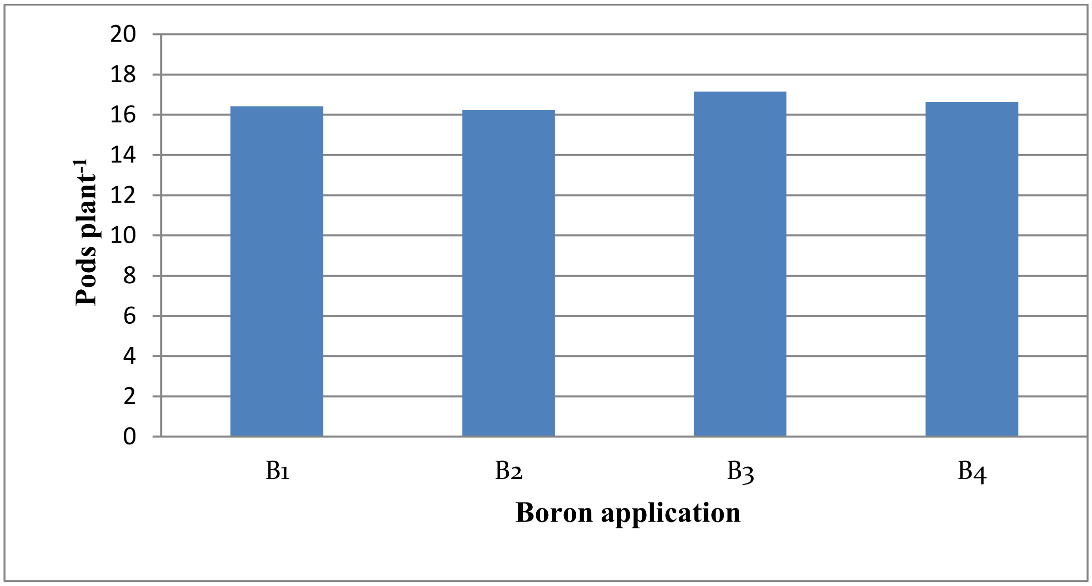


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung , F_3 = 50% NPK + 50% Cowdung

Figure 11. Effect of cowdung and inorganic fertilizers on number of pods plant^{-1} of mungbean ($LSD_{(0.05)}$ = 0.517)

Effect of boron application

Number of pods per plant of mungbean varied significantly due to different levels of boron application (Figure 12 and Appendix IX). In that experiment result found that the maximum pods plant^{-1} (17.15) was observed from B_3 (60% Boron as basal +40 % foliar spray at pre-flowering) whereas minimum pods plant^{-1} (16.22) was observed from B_2 (80% basal + 20 % boron as foliar spray at pre- flowering) which was statistically similar with all other treatments except B_3 treatment.



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 12. Effect of boron application on number of pods plant^{-1} of mungbean ($LSD_{(0.05)}$ = 0.404)

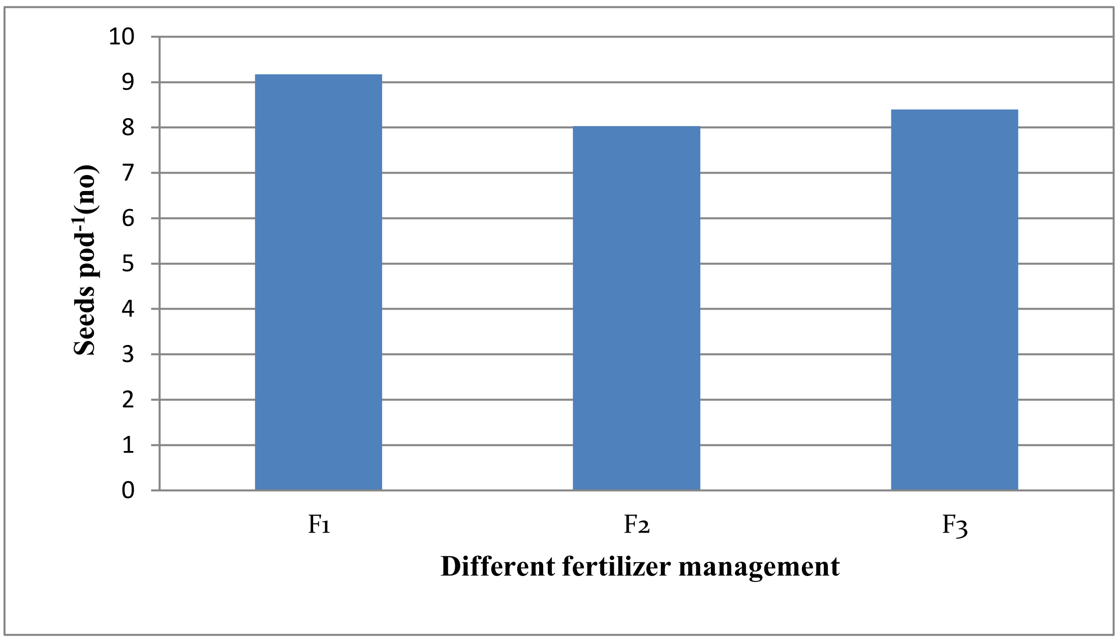
Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on pods plant^{-1} of mungbean (Table 6 and Appendix IX). From the experiment result showed that that the maximum pods plant^{-1} (19.86) was observed from F_1B_3 treatment combination which was statistically similar (19.40, 19.26 and 19.20) with F_1B_1, F_1B_2, and F_1B_4, treatment combination whereas minimum pods plant^{-1} (14.00) was observed from F_2B_2 treatment combination which was statistically similar (14.46) with F_2B_1 treatment combination.

4.2.3 Number of seeds pod $^{-1}$

Effect of cowdung and inorganic fertilizers

In terms of number of seeds pod^{-1} of mungbean, significant variation was observed due to different fertilizer treatment (Figure 13 and Appendix IX). Result revealed that the maximum seeds pod^{-1} (9.18) was observed from F_1 treatment whereas minimum seeds pod^{-1} (8.03) was observed from F_2 treatment seeds pod^{-1}. Similar result was founded by Hossen *et al*. (2015) and Umar *et al.* (2001) with the present study.

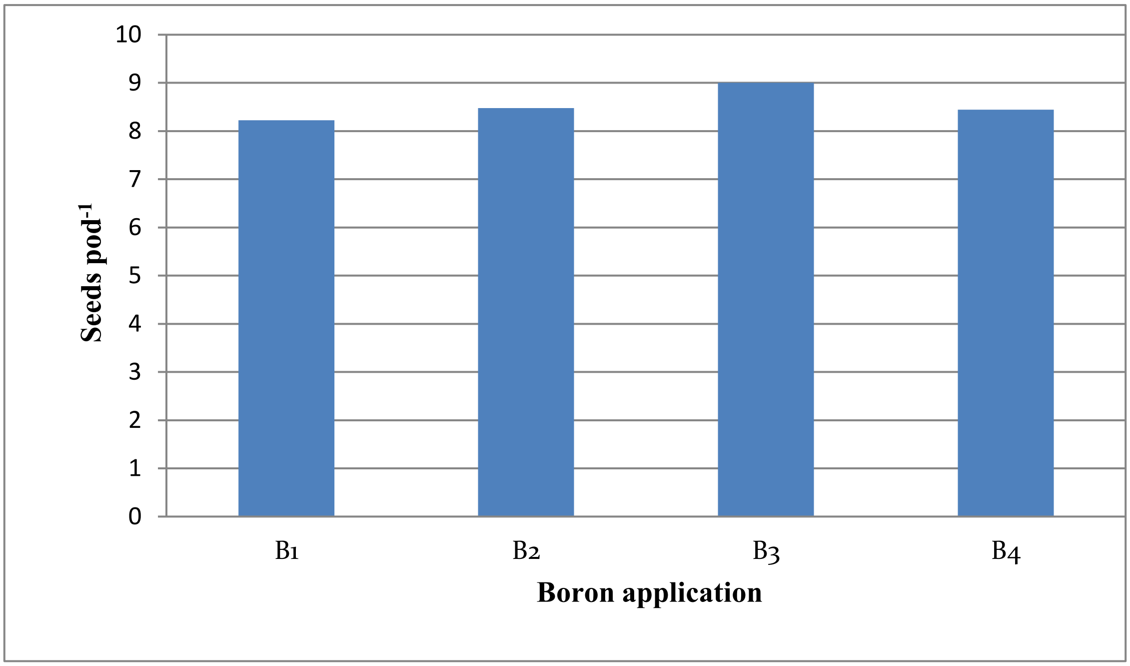


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung, F_3 = 50% NPK + 50% cowdung

Figure 13. Effect of cowdung and inorganic fertilizers on number of seed pod^{-1} of mungbean ($LSD_{(0.05)}$=0.351))

Effect of boron application

Significant variation was found by different levels of boron application for the number of seeds per pod^{-1} of mungbean (Figure 14 and Appendix IX). From the experiment result indicated that the maximum seeds pod^{-1} (9.00) was observed from B_3 treatment, whereas minimum seeds pod^{-1} (8.22) was observed from B_1 treatment which was statistically similar with all other treatments except B_3 treatment. Similar result was founded by Roy *et al.* (2011) with the present study.



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 14. Effect of boron application on number of seeds pod^{-1} of mungbean ($LSD_{(0.05)}$ = 0.282)

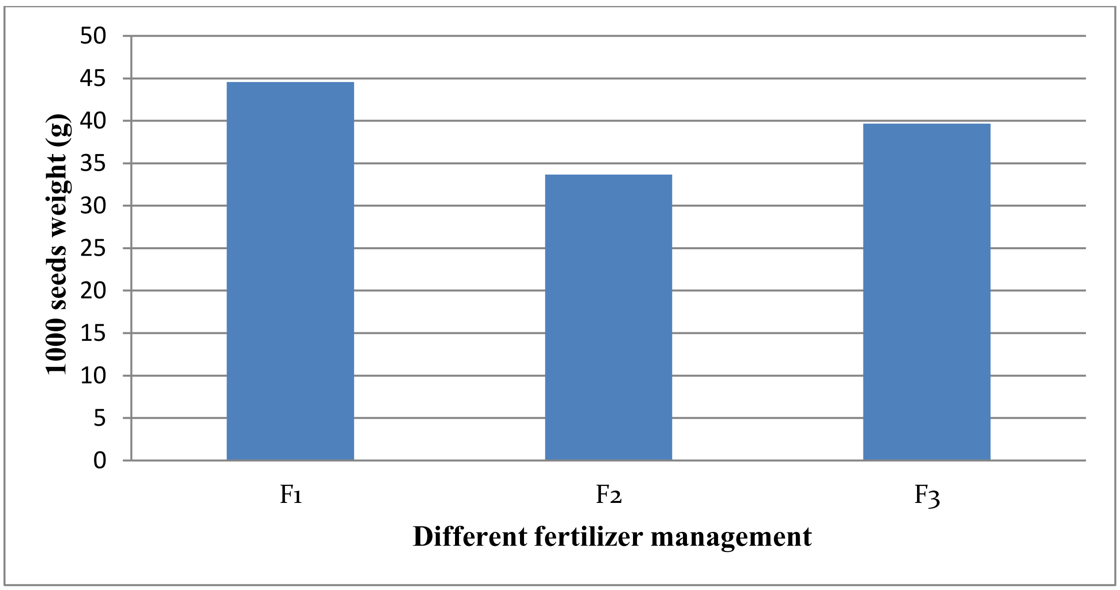
Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on seeds pod^{-1} of mungbean (Table 6 and Appendix IX). From the experiment result showed that the maximum seeds pod^{-1} (9.80) was observed from F_1B_3 treatment whereas minimum seeds pod^{-1} (7.73) was observed from F_2B_1 treatment combination which was statistically similar (7.80 and 7.93) with F_2B_4 and F_3B_1 treatment combination.

4.2.4 1000- seeds weight (g)

Effect of cowdung and inorganic fertilizers

Application of different fertilizer treatments showed significant effect on 1000-seeds weight of mungbean (Figure 15 and Appendix IX). From the experiment result exhibited that the maximum 1000-seeds weight (44.58 g) was observed from F_1 (Recommended NPK as basal dose) treatment whereas minimum 1000 seeds weight (33.66) was observed from F_2 (Recommended dose of cowdung) treatment. Similar result also observed by Rupa *et al.* (2014)



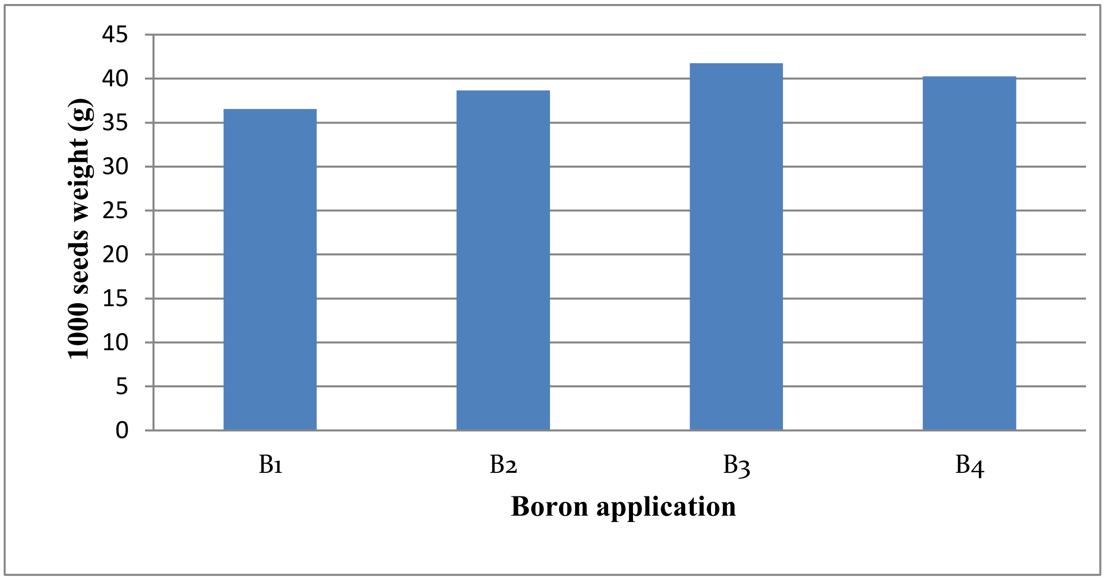
F_1 = Recommended NPK, F_2 = Recommended cowdung , F_3 = 50% NPK + 50% cowdung

Figure 15. Effect of cowdung and inorganic fertilizers on 1000- seeds weight of mungbean ($LSD_{(0.05)}$= 2.06)

Effect of boron application

Different treatment of boron showed significant effect on 1000-seeds weight of mungbean (Figure 16 and Appendix IX). Result found that the maximum 1000-seeds weight (41.74 g) was observed from B_3 treatment, whereas minimum 1000-seeds weight

(36.56 g) was observed from B_1 treatment. Boron increase the yield contributiong character of mungbean. Similar result also recorded by Singh *et al*. (2015).



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal + 40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 16. Effect of boron application on 1000-seed weight of mungbean ($LSD_{(0.05)}$=1.617)

Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertlizer management and boron application showed significant variation on 1000-seeds weight of mungbean (Table 6 and Appendix IX). From the experiment result showed that that the maximum 1000 seeds weight (46.67 g) was observed from F_1B_3 treatment which was statistically similar (46.00 g) with F_1B_4 treatment combination where as minimum 1000-seeds weight (30.33 g) was observed from F_2B_1 treatment combination.

Table 6. Interaction effect of cowdung and inorganic fertilizers with foliar application of boron on yield contributing characters of mungbean

Treatment	Yield Contributing characters			
Combinations	Pod length(cm)	Number of pods plant^{-1}	Seeds pod^{-1}	1000- seed weight(g)
F_1B_1	7.70-f	19.40a	9.00b	41.33de
F_1B_2	8.08a-c	19.26a	8.76bcd	44.33bc
F_1B_3	8.32a	19.86a	9.80a	46.66a
F_1B_4	8.08ab	19.20a	9.13b	46.00ab
F_2B_1	7.48f	14.46de	7.73g	30.33j
F_2B_2	7.79c-e	14.00e	8.26d-f	32.66i
F_2B_3	7.83b-e	15.13cd	8.33c-e	36.66gh
F_2B_4	7.41f	15.20c	7.80fg	35.00h
F_3B_1	7.55ef	15.40c	7.93e-g	38.00fg
F_3B_2	7.92b-d	15.40c	8.40c-e	39.00e-g
F_3B_3	7.93b-d	16.46b	8.86bc	41.88cd
F_3B_4	7.63d-f	15.46c	8.40c-e	39.77d-f
$LSD_{(0.05)}$	0.305	0.700	0.488	2.269
CV(%)	2.28	2.46	3.33	3.36

Note: F_1 = Recommended NPK, F_2 = Recommended cowdung F_3 = 50 % NPK + 50 % cowdung,

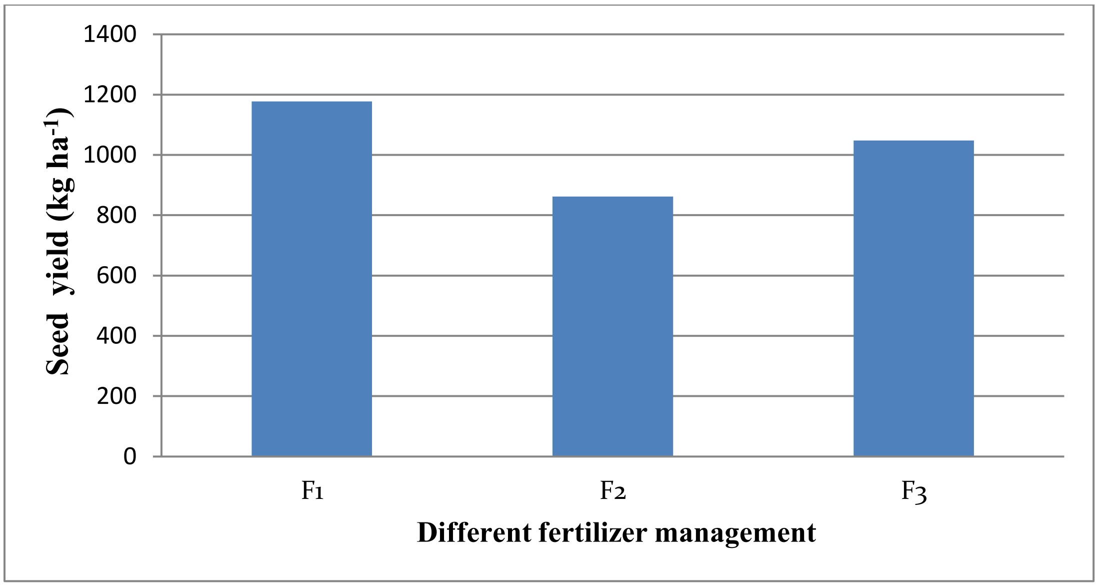
B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF.

4.3 Yield

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

Effect of cowdung and inorganic fertilizers

Different levels of fertilizer application showed significant effect on seed yield (kg ha^{-1}) of mungbean (Figure 17 and Appendix X). From the experiment result showed that the maximum grain yield (1177.80 kg ha^{-1}) was observed from F_1 treatment whereas minimum grain yield (861.70 kg ha^{-1}) was observed from F_2 treatment. Recommended dose of inorganic fertilizer (NPK) increase the growth and yield of mungbean than organic fertilizer. For this reason F_1 (Recommended dose of NPK) treatment gave the highest seed yield. And many research revealed that inorganic fertilizer increase the yield of mungbean. Similar finding was also found by Hossen *et al*. (2015) and Sanchan *et al*. (2020).

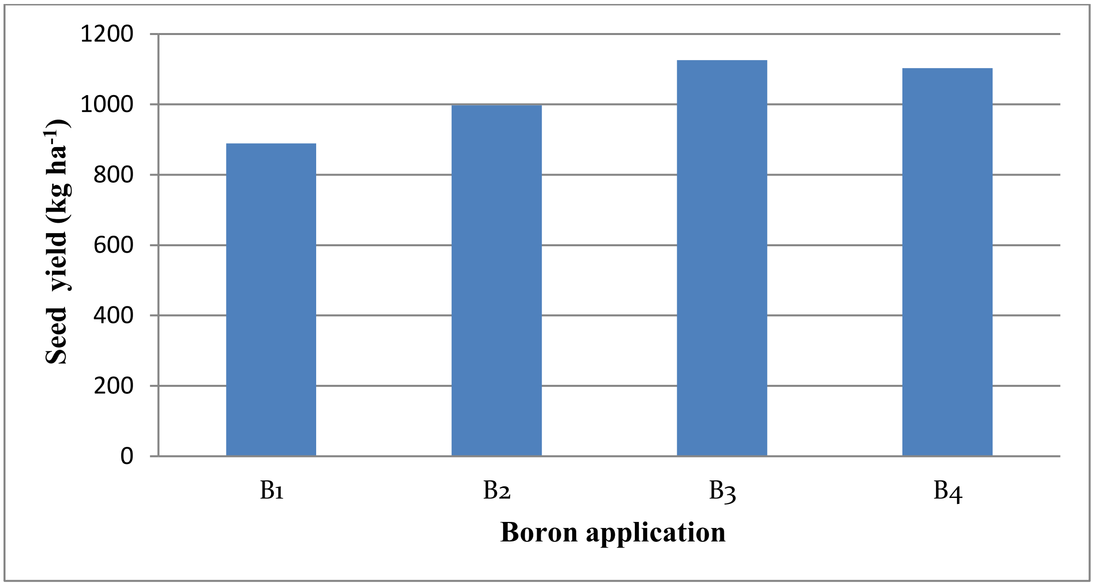


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung, F_3 = 50% cowdung + 50% NPK

Figure 17. Effect of cowdung and inorganic fertilizers on seed yield of mungbean ($LSD_{(0.05)}$ = 51.736)

Effect of Boron application

Boron application showed significant effect on seed yield of mungbean (Figure 18 and Appendix X). From the experiment result exhibited that the grain yield weight (1125.60 kg ha^{-1}) was observed from B_3 treatment which was statistically similar (1103.30 kg ha^{-1}) with B_4 treatment , whereas minimum grain yield (889.30 kg ha^{-1}) was observed from B_1 treatment. At the vegetative stage of mungbean foliar application of boron helps to increase higher seed yield. Similar finding was found by Mondol *et al*. (2012) that foliar application of boron increase seed yield.



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 18. Effect of boron application on seed yield of mungbean ($LSD_{(0.05)}$ = 40.432).

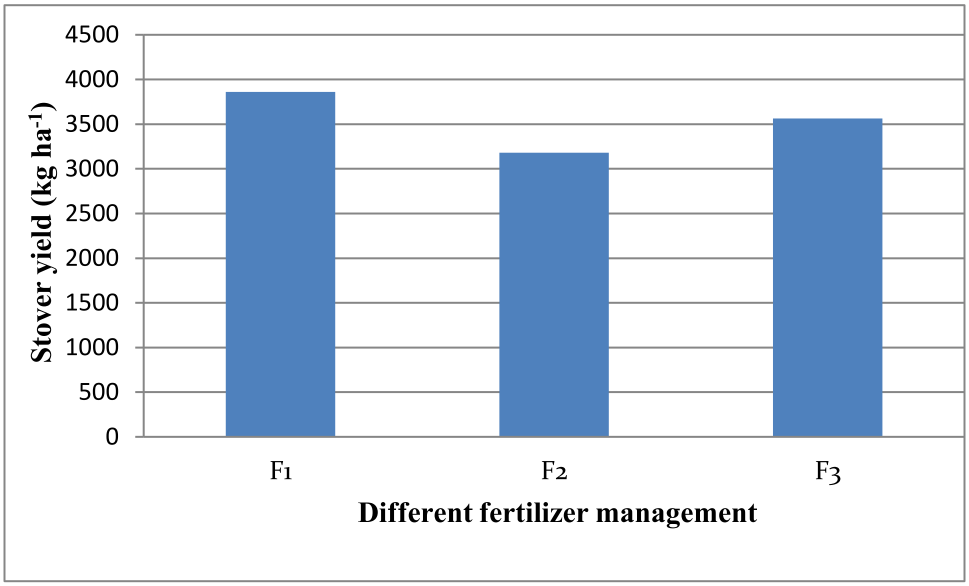
Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on seed yield of mungbean (Table 7 and Appendix X). From the experiment result showed that the maximum seed yield weight (1356.70 kg ha^{-1}) was observed from F_1B_3 treatment which was statistically similar (1310.00 kg ha^{-1}) with F_1B_4 treatment combination whereas minimum seed yield weight (756.70 kg ha^{-1}) was observed from F_2B_1 treatment combination.

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

Effect of cowdung and inorganic fertilizers

Application of different levels of fertilizer management showed significant variation on stover yield (kg ha^{-1}) of mungbean (Figure 19 and Appendix X). Result showed that the highest stover yield (3862.50 kg ha^{-1}) was observed from F_1 treatment whereas lowest stover yield (3180.00 kg ha^{-1}) was observed from F_2 treatment. The use of NPK fertilizer, increase the higher seed yield as well as stover yield. Similar result was founded by anwar *et al.* (2018) with the present study.

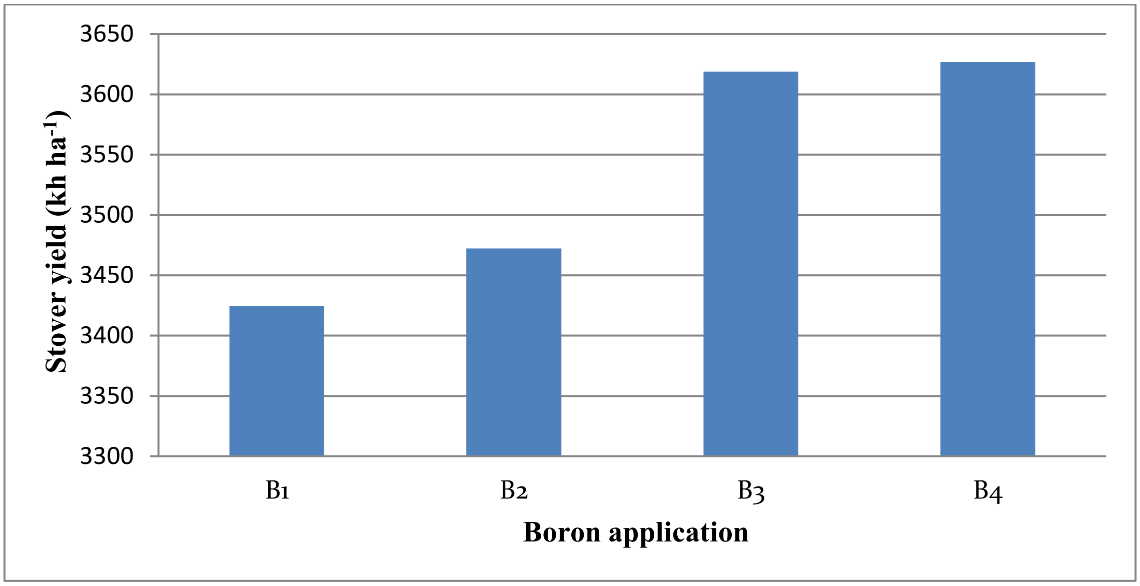


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung , F_3 = 50 % NPK + 50% cowdung

Figure 19. Effect of cowdung and inorganic fertilizers on stover yield (kg ha^{-1}) of mungbean ($LSD_{(0.05)}$= 103.470)

Effect of boron application

Boron application showed significant effect on stover yield of mungbean (Figure 20 and Appendix X). From the experiment result exhibited that the stover yield (3626.70 kg ha^{-1}) was observed from B_4 (40% boron as basal + rest 60% as FS at PF) treatment which was statistically similar (3618.90 kg ha^{-1}) with B_3 (60% boron as basal + rest 40% as FS at PF) treatment, whereas minimum stover yield (3424.40 kg ha^{-1}) was observed from B_1 (100% boron as basal) treatment. Boron is an important micronutrients that helps to plant growth and increase the yield of pulses and legumes.



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 20. Effect of boron application on stover yield of mungbean ($LSD_{(0.05)}$= 80.865)

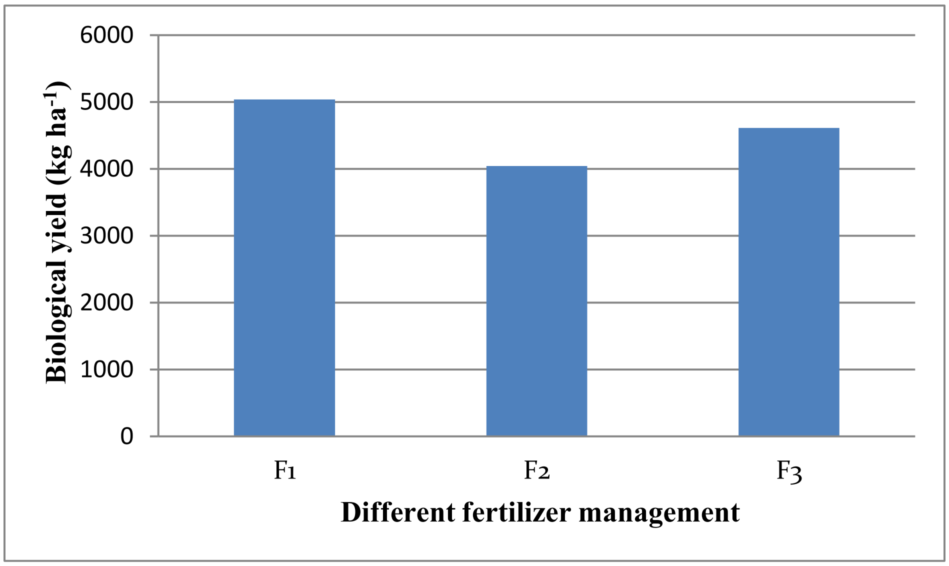
Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on stover yield of mungbean (Table 7 and Appendix X). From the experiment result showed that the maximum stover yield (3990.00 Kg ha^{-1}) was observed from F_1B_4 treatment which was statistically similar (3953.30 kg ha^{-1}) with F_1B_3 treatment combination whereas minimum stover yield (3073.30 kg ha^{-1}) was observed from F_2B_2 treatment combination which was statistically similar (3090.00 kg ha^{-1}) with F_2B_1 treatment combination.

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

Effect of cowdung and inorganic fertilizers

Different fertilizer management showed significant effect on biological yield of mungbean (Figure 21 and Appendix X). From the experiment result revealed that the maximum biological yield (5040.30 kg ha^{-1}) was observed from F_1 treatment whereas minimum biological yield (4041.70 kg ha^{-1}) was observed from F_2 treatment.

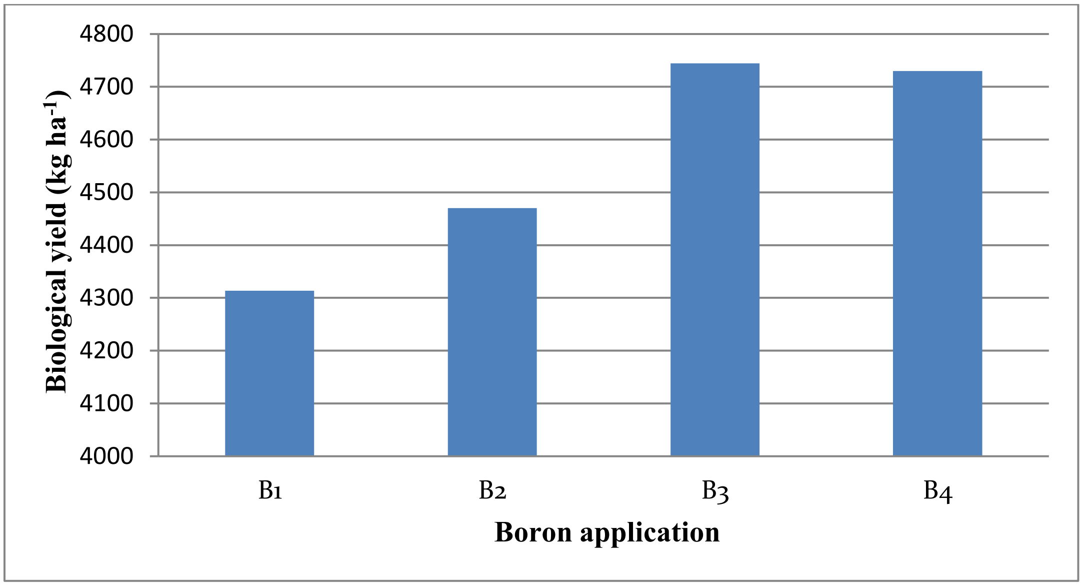


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung , F_3 = 50% cowdung + 50% NPK

Figure 21. Effect of cowdung and inorganic fertilizers on biological yield (kg ha^{-1}) of mungbean ($LSD_{(0.05)}$= 190.790)

Effect of boron application

Boron application showed significant effect on biological yield of mungbean (Figure 22 and Appendix X). From the experiment result exhibited that the biological yield (4744.40 kg ha^{-1}) was observed from B_3 treatment which was statistically similar (4730.00 kg ha^{-1}) with B_4 treatment, whereas minimum biological yield (4313.80 kg ha^{-1}) was observed from B_1 treatment.



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 22. Effect of boron application on biological yield (kg ha^{-1}) of mungbean (LSD$_{(0.05)}$= 153.96)

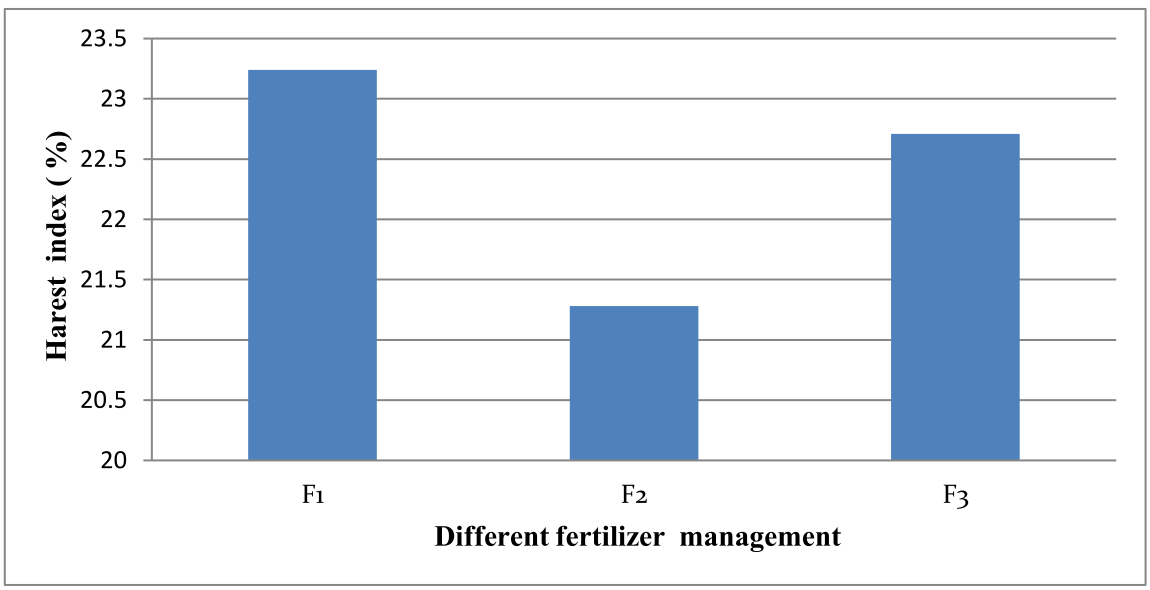
Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on biological yield of mungbean (Table 7 and Appendix X). From the experiment result showed that the maximum biological yield (5310.00 kg ha^{-1}) was observed from F_1B_3 treatment which was statistically similar (5300.00 kg ha^{-1}) with F_1B_4 treatment combination whereas minimum biological yield (3846.70 kg ha^{-1}) was observed from F_2B_1 treatment combination which was statistically similar (3903.30 kg ha^{-1}) with F_2B_2 treatment combination.

4.3.4 Harvest index (%)

Effect of cowdung and inorganic fertilizers

Harvest index is an important measurement of yield performance of crops. The harvest index was found significant due to different treatment of fertilizer application (Figure 23 and Appendix X). From the experiment result exhibited that the maximum harvest index (23.24 %) was observed from F_1 (Recommended dose of NPK fertilizer) treatment which was statistically similar (22.71%) with F_3 treatment whereas minimum harvest index (21.28 %) was observed from F_2 treatment. Inorganic fertilizer increase biological yield and harvest index. Combine use of organic and inorganic fertilizer also gave the highest harvest index of crops. Abbas *et al.* (2011) found the similar result that different combination of organic and inorganic fertilizers significantly affected the seed yield as well as harvest index.

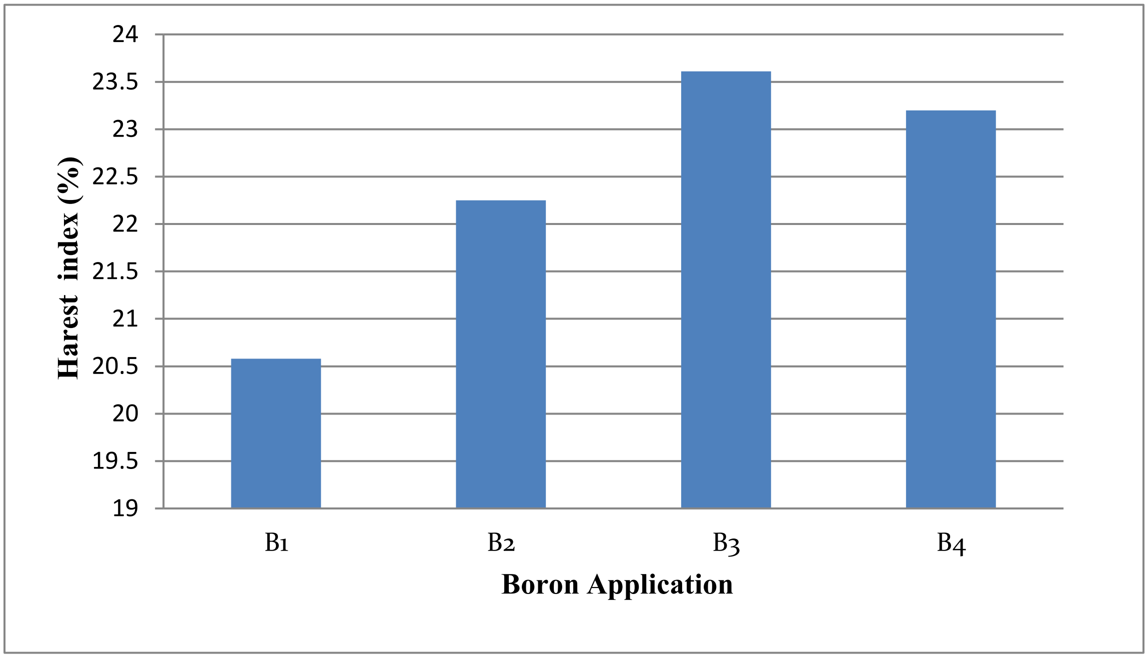


Note: F_1 = Recommended NPK, F_2 = Recommended cowdung, F_3 = 50% NPK + 50 % cowdung

Figure 23. Effect of cowdung and inorganic fertilizer on harvest index of mungbean ($LSD_{(0.05)}$= 0.654)

Effect of boron application

Boron application showed significant effect on harvest index (%) of mungbean (Figure 24 and Appendix X). From the experiment result exhibited that the harvest index (23.61%) was observed from B_3 treatment which was statistically similar (23.20 %) with B_4 treatment, whereas minimum harvest index (20.58 %) was observed from B_1 treatment



Note: B_1=100% basal, B_2=80% basal +20% foliar at PF, B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

Figure 24. Effect of boron application on harvest index of mungbean ($LSD_{(0.05)}$= 0.639)

Interaction effect of cowdung and inorganic fertilizers with foliar application of boron

Interaction of different fertilizer management and boron application showed significant variation on harvest index of mungbean (Table 7 and Appendix X). From the experiment result showed that the maximum harvest index (25.55 %) was observed from F_1B_3 treatment which was statistically similar (24.72) with F_1B_4 treatment combination whereas minimum harvest index (19.66) was observed from F_1B_1 treatment combination which was statistically similar (19.67 %) with F_2B_2 treatment combination.

Table 7. Interaction effect of cowdung and inorganic fertilizers with foliar application of boron on yield of mungbean

Treatment	Yield			
Combinations	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
F_1B_1	904.7fg	3696.7bc	4601.4c	19.66e
F_1B_2	1140.0b	3810.0b	4950.0b	23.03b
F_1B_3	1356.7a	3953.3a	5310.0a	25.55a
F_1B_4	1310.0a	3990.0a	5300.0a	24.72a
F_2B_1	756.7h	3090.0g	3846.7f	19.67e
F_2B_2	830.0g	3073.3g	3903.3f	21.26d
F_2B_3	960.0ef	3266.7f	4226.7de	22.71b
F_2B_4	900.0fg	3290.0f	4190.0e	21.48cd
F_3B_1	1006.7de	3486.7e	4493.3cd	22.40b-d
F_3B_2	1023.3de	3533.3de	4556.7c	22.46bc
F_3B_3	1060.0cd	3636.7cd	4696.7bc	22.56bc
F_3B_4	1100.0bc	3600.0c-e	4700.0bc	23.41b
$LSD_{(0.05)}$	70.031	140.060	266.670	1.107
CV (%)	3.97	2.31	3.41	2.88

Note: F_1= Recommended NPK, F_2 = Recommended cowdung , F_3 = 50 % NPK + 50 % Cowdung ,

B_1=100% basal, B_2=80% basal +20% foliar at PF , B_3= 60% basal +40% foliar at PF and B_4=40%basal +60% foliar at PF

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka during the period from March to June 2019 to study foliar application of boron with cowdung and inorganic fertilizer on growth and yield of mungbean. The variety BARI Mung 6 was used as the test crop. The experiment was laid out in a split-plot design in two factors with three replications comprising 36 plots. Fertilizer used as a factor A and Boron used as factor B. There are three levels of fertilizer *viz*.,F_1= Recommended dose of NPK fertilizer,F_2= Recommended dose of cowdung, F_3= 50% NPK fertilizer and 50% cowdung and four levels of Boron *viz.,*B_1= Control (Recommended dose as control 100% basal dose), B_2= (80% recommended dose as basal + Rest 20% as foliar spray at pre flowering), B_3 = (60% RD as basal + Rest 40% as FS at PF), B_4 = (40% RD as basal + Rest 60% as FS at PF). The study was aimed at finding out the most effective combination of treatment of mungbean under organic and inorganic fertilizer with Boron.

From the result it was observed that the highest plant height (11.88cm, 28.34cm, 47.75cm, 55cm at 15, 30, 45, and at harvest respectively), leaves plant^{-1}(3.35, 7.76, 14.48, 18.76 at 15, 30, 45, and at harvest respectively), branches plant^{-1} (0.88, 5.40, 5.88 at 30, 45, and at harvest respectively), highest dry matter weight plant^{-1} (1.62g, 3.87g, 6.38g, 8.23g at 15,30,45 and at harvest respectively), pod plant^{-1} (19.43), dry matter weight (8.50 g), pod length(8.04 cm), seed pod^{-1} (9.17), 1000- seed weight (44.58 g), seed yield (1177.8 kg ha^{-1}) stover yield (3862.50 kg ha^{-1}), biological yield(5040.30 kg ha^{-1}) were recorded from the F_1 treatment. Where the F_2 treatment gave the shortest plant height (10.60cm, 25.84cm, 40.95cm, 48.19cm at 15, 30, 45, and at harvest respectively), lowest number leaves plant^{-1} (3.13, 7.30, 12.35, 13.63 at 15, 30, 45, and at harvest respectively), lowest number branches plant^{-1} (0.40, 4.26, 5.15 at 30, 45 and at harvest respectively) and lowest dry matter weight (1.51g, 3.45g, 5.92g, 7.05g at 15, 30, 45 DAS and at harvest respectively), numbers of pods plant^{-1}(7.63), 1000–seed weight(33.66), seed pod^{-1}(8.03) grain yield(861.7 kg ha^{-1}), stover yield(3180.0 kg ha^{-1}), biological yield(4041.7 kg ha^{-1}), and harvest index(21.282%) at harvest respectively.

Different growth and yield parameters of mungbean were also significantly influence by the use of different levels of boron application. It was found that the highest plant height (11.45cm, 27.45cm at 15 at 30 DAS) in B_2 treatment. But at 45DAS and at harvest the highest plant height (48.24cm and 55.20 cm respectively) observed in B_4 treatment. The highest number of leaves plant^{-1}(3.35) at 15 DAS in treatment $B_{1,}$ and at 30DAS, 45DAS, and at harvest (7.57, 13.37, 16. respectively) were recorded from treatment B_3. The highest number of branch (0.86) at 30 DAS in B_1 treatment and at 45 DAS and at harvest (4.86 and 5.75 respectively) recorded from B_3 treatment. The highest dry matter weight plant^{-1}(1.57g 3.79g at 15 to 30 DAS respectively) in B_2 treatment, and at 45 DAS and at harvest (6.19g and 7.78g respectively) found from treatment B_3 . Highest pod plant^{-1} (17.15), Seed pod^{-1} (9.0), 1000-seed weight (40.44 g), seed yield(1125.6 kg ha^{-1}), biological Yield(4744.4 kg ha^{-1}), harvest index (23.61%) were recorded as B_3 respectively The smallest plant height (11.01cm at 15 DAS)found from B_1 treatment and at 30 DAS the smallest plant height 26.36)found from B_3 treatment and at 45 DAS and at harvest smallest plant height (48.24 and 48.58 cm) recorded from B_4 treatment. The lowest number of leaves plant^{-1} (3.17) at 15 DAS found from treatment $B_{4,}$ and at 30 DAS lowest number of leaves (7.40) observed from B_2 treatment. At 45 DAS and at harvest lowest number of leaves (12.66 and 14.64 respectivelty) recorded fromB_1 treatment. The lowest branches no plant^{-1} (0.35) at 30 DAS found from B_4 treatment and at 45 DAS and at harvest lowest branches number plant^{-1}(4.55 and 5.44 respectively).The lowest dry matter weight plant^{-1}(1.51) at 15 DAS from B_4 treatment3 and at 30 DAS, 45 DAS and at harvest lowest dry matter weight plant^{-1}(3.54, 6.03 and 7.41 respectively) found from B_1 treatment. The lowest pods plant^{-1} (16.42), pod length (7.58 cm), seed pod (8.22), seed yield (919.30 kg ha $^{-1}$), biological yield (4392.20 kg ha^{-1}), harvest index (21.88%) are recorded as B_1 treatment respectively. Due to the application as basal dose and foliar spray of boron, there are some variation in the growth parameters. Foliar spray of boron increase the growth and yield of mungbean as well as many other pulses crops.

Effect of organic and inorganic fertilizer and boron application also significantly affect the growth, as well as yield contributing characters and yield of mungbean. The interaction result had significantly different from others treatment. The highest plant height observed (12.19cm) in F_1B_3 treatment at 15 DAS, and (29.32cm) in F_1B_1 at 30 DAS, and (53.06cm) in F_1B_4 treatment at 45 DAS. The highest number of leaves Plant^{-1} (3.46 and 7.93) in F_1B_1 treatment at 15 and 30 DAS respectively, and (15.00) in F_1B_2 at 45 DAS. The highest branch number plant^{-1}(1.40) in F_1B_1 treatment at 30DAS and (5.46 and 6.26) in F_1B_3 treatment at 45 and at harvest respectively. The highest dry matter weight (1.66g and 4.05g) in F_1B_2 treatment in 15 DAS and 30 DAS respectively and (6.62g) in F_1B_3 at 45 DAS. Whereas the lowest plant height (10.07cm) at 15 DAS was observed from the treatment combination of F_3B_1. Statistically similar result (10.36cm, 10.41cm, 10.49 and 10.73cmwith F_2B_3, F_2B_4 , F_3B_3 and F_2B_2 combination were observed at 15 DAS. At 30 DAS lowest plant height (24.03cm) was observed from treatment combination F_2B_4 and (38.63cm) in F_2B_1 at 45 DAS. The lowest leaves plant^{-1} (2.93) from the treatment combination F_2B_4 was statistically similar with (3.0) with F_2B_3 at 15 DAS, and (7.13) found from F_2B_2 at 30 DAS which was statistically similar (7.26, 7.33 and 7.33) with F_2B_1, F_3B_2 and F_3B_1 respectively. At 45 DAS the lowest leaves plant^{-1}(11.73) found from treatment combination F_2B_1. The lowest branch number (0.20) was observed at 30 DAS from treatment combination F_2B_3. At 45 DAS and at harvest the lowest branch number (3.93 and 4.86) observed from the treatment combination F_2B_1. The lowest dry matter weight (1.45 g) at 15 DAS was observed from F_3B_4 and (3.32 g) at 30 DAS from the treatment combination F_3B_4 and (5.84 g and 6.74 g) at 45 and at harvest from the treatment combination F_2B_1. The highest number of pods plant^{-1} (8.32) was recorded from F_1B_3, and the lowest (7.40) was recorded from treatment combination (F_2B_1). The highest number of seeds per pod (9.80) was recorded from F_1B_3 combination and lowest (7.73) was found from F_2B_1. The maximum seed yield, stover yield and biological yield (1356.70 kg ha$^{-1,}$ 3953.30 kg ha^{-1}, 5310.0 kg ha^{-1}) was recorded from F_1B_3 and the lowest (756.70 kg ha^{-1}, 3090.00 kg ha^{-1}, 3846.70 kg ha^{-1}) was recorded from (F_2B_1). From the result the highest harvest index (25.54%) was recorded from F_1B_3 and the lowest harvest index (19.67%) was recorded from F_2B_1 treatment respectively. It can be concluded from the discussion that the effect of organic and inorganic fertilizer and boron levels had influenced the production, growth and yield of mungbean.

Finally the study should be conducted at different pulse growing areas of Bangladesh for the evaluation and justification at different agro-ecological zones (AEZs) to improvement of mungbean

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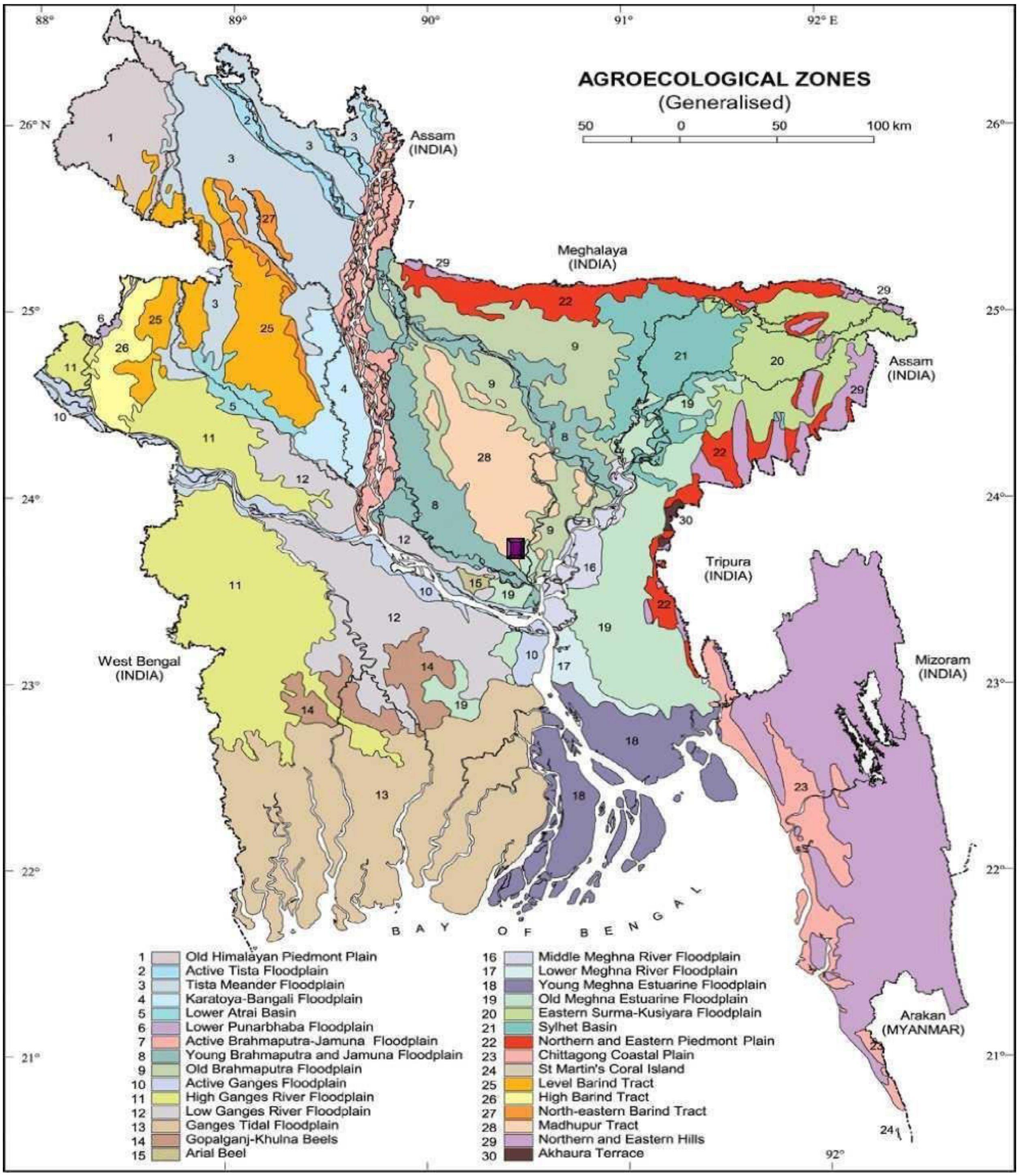
APPENDICES

Appendix 1: Experimental site showing in the map under the present study



Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
PH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

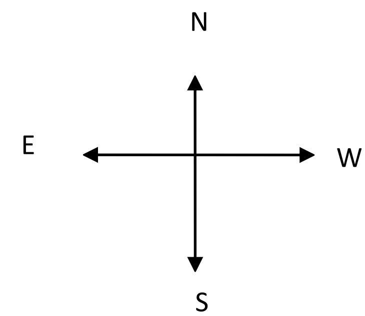
Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March, 2019 to July, 2019

Month and year	RH (%)	Air temperature (^{0}C)			Total rainfall (mm)
		Max.	*Min.*	*Mean*	
March, 2019	38.44	35.20	21.00	28.10	62
April, 2019	56.26	35.65	23.65	29.65	185
May, 2019	71.20	34.80	25.70	30.25	342
June, 2019	76.90	32.75	25.26	29.05	336

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

Appendix IV: Experimental layout



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R_1		R_1		R_3	
F_1B_1	F_2B_3	F_1B_2	F_2B_4	F_3B_2	F_1B_4
F_1B_2	F_2B_4	F_1B_3	F_2B_1	F_3B_3	F_1B_1
F_1B_3	F_3B_1	F_1B_4	F_3B_2	F_3B_4	F_3B_2
F_1B_4	F_3B_2	F_1B_1	F_3B_3	F_3B_1	F_3B_3
F_2B_1	F_3B_3	F_2B_2	F_3B_4	F_1B_2	F_3B_4
F_2B_2	F_3B_4	F_2B_3	F_3B_1	F_1B_3	F_3B_1

Layout: Split plot design,
Plot size:3m×1.50m,
Between Plot:o.5m ,
Between block o.75 m

Factor A:Fertilizer

F_1=Recommended dose of NPK fertilizer

F_2=Recommended dose of Cowdung

F_3=50 % NPK +50 % cowdung

Factor B: Boron

B_1=Recommended dose as basal,

B_2= 80 % B as Basal+20% as FS at PF

B_3=60% B as Basal+40% B as FS at PF,

B_4= 40% B as Basal + 60% as FS at PF

AppendixV. Effect of cowdung and inorganic fertilizers with foliar application of boron on plant height of mungbean

Mean square of plant height at					
Source	Df	15 DAS	30 DAS	45 DAS	At harvest
Replication (A)	2	0.06429	0.2500	0.750	2.583
Fertilizer (B)	2	5.36080*	18.9590*	138.756*	139.080*
Error (a)	4	0.16387	0.5000	1.875	6.333
Boron (C)	3	0.41606*	4.1651*	82.626*	82.042*
B×C	6	1.11028*	3.4351*	3.053*	0.966*
Error (b)	18	0.13068	0.4167	1.500	3.750
Total	35				

*: Significant at 0.05 level of probability

AppendixVI . Effect of cowdung and inorganic fertilizers with foliar application of boron on leaves plant^{-1} of mungbean

Mean square of number of leaves plant^{-1} at					
Source	Df	15 DAS	30 DAS	45 DAS	At harvest
Replication (A)	2	0.00583	0.01083	0.0633	0.0700
Fertilizer (B)	2	0.14111*	0.69333*	17.1378*	89.2933*
Error(a)	4	0.00958	0.02583	0.1133	0.1700
Boron (C)	3	0.05630*	0.04889*	1.3048*	5.8341*
B×C	6	0.06852*	0.04889*	0.2059*	0.4963*
Error (b)	18	0.00833	0.01194	0.0967	0.1011
Total	35				

*: Significant at 0.05 level of probability

Appendix VII. Effect of cowdung and inorganic fertilizers with foliar application of boron on dry matter weight plant^{-1} of mungbean

Mean square of dry matter weight plant^{-1} at					
Source	Df	15 DAS	30 DAS	45 DAS	At harvest
Replication (A)	2	0.00184	0.00583	0.00583	0.03083
Fertilizer (B)	2	0.04581*	0.53505*	0.67643*	4.16502*
Error(a)	4	0.00166	0.01333	0.00583	0.06583
Boron (C)	3	0.01153*	0.09782*	0.03592*	0.26332*
B×C	6	0.00503*	0.09994*	0.07761*	0.04130*
Error (b)	18	0.00172	0.01083	0.00917	0.02083
Total	35				

*: Significant at 0.05 level of probability

Appendix VIII. Effect of cowdung and inorganic fertilizers with foliar application of boron on branches plant^{-1} of mungbean

Mean square of branches plant^{-1} at				
Source	Df	30 DAS	45 DAS	At harvest
Replication (A)	2	0.00066	0.01083	0.02333
Fertilizer (B)	2	0.73444*	3.96444*	1.72444*
Error(a)	4	0.00103	0.02583	0.00833
Boron (C)	3	0.60593*	0.22519*	0.27963*
B×C	6	0.11370*	0.14074*	0.24741*
Error (b)	18	0.00091	0.02083	0.02222
Total	35			

*: Significant at 0.05 level of probability

Appendix IX. Effect of cowdung and inorganic fertilizers with foliar application of boron on yield contributing characters of mungbean

Mean square of yield contributing characters					
Source	Df	**Pod Length**	**Number of pods/plant**	**Seeds/pod**	**1000 seed weight**
Replication (A)	2	0.03083	0.0833	0.05083	1.333
Fertilizer (B)	2	0.53889*	74.8678*	4.07694*	358.694*
Error(a)	4	0.05708	0.2083	0.09583	3.333
Boron (C)	3	0.23365*	1.4500*	0.97657*	42.991*
B×C	6	0.10605*	0.3122*	0.16880*	2.769*
Error (b)	18	0.04833	0.1667	0.08083	2.667
Total	35				

*: Significant at 0.05 level of probability

Appendix X. Effect of cowdung and inorganic fertilizers with foliar application of boron on yield characters of mungbean

Mean square of yield					
Source	Df	**Grain Yield**	**Stover yield**	**Biological yield**	**Harvest index**
Replication (A)	2	833	3333	15833	0.5833
Fertilizer (B)	2	302964*	1404786*	3011980*	12.2996*
Error(a)	4	2083	8333	28333	0.3333
Boron (C)	3	105990*	94807*	394686*	16.3374*
B×C	6	23921*	6271*	45893*	4.6864*
Error (b)	18	1667	6667	24167	0.4167
Total	35				

*: Significant at 0.05 level of probability