COMPARATIVE VARIETAL RESPONSE OF BUSHBEAN TO ORGANIC AND INORGANIC BASED NITROGEN MANAGEMENT

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CERTIFICATE

This is to certify that the thesis titled, "**COMPARATIVE VARIETAL RASPONSE OF BUSHBEAN TO ORGANIC AND INORGANIC BASED NITROGEN MANAGEMENT**" submitted to the **Dept. of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in Soil Science** embodies the result of a piece of bona fide research work carried out by **TASLIMA AKHTER, Registration No. 05-1601** 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 by the Author.

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DEDICATED TO

MY

BELOVED

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ABSTRACT

A field experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka (Madhupur Tract, AEZ 28), during the *rabi* season from November 2011 to February 2012 to study the comparative varietal response of bushbean to organic and inorganic based nitrogen management on BARI bush bean. The two factors experiment were consisted of two bush varieties such as BARI bush-1 (V_1) and BARI bush-2 (V_2) as level factor A and five levels of inorganic and organic sources of N including control (without any N) *viz.* inorganic N @ 90 kg ha^{-1} (T_1), inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1} (T_2), inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1} (T_3), organic N @ 90 kg ha^{-1} (T_4) and control treatment (T_5) as level factor B. Responses of variety were significantly influenced on different growth and yield characters of the study were stover yield did not vary significant. Of the two varieties, BARI bush-1 determined the greater performance on flowers (13.33 plot^{-1}), pods plot^{-1} (543.3), pod weight (138.26 g plant^{-1} and 6040.0 g plot^{-1}), pod yield (12.08 t ha^{-1}) than that of other variety BARI bush-2. However, BARI bush-2 attained the tallest plant (39.43 cm) and maximum branches (14.40 plant^{-1}) than BARI bush-1. Varietal effect also responsed significantly on soil nutrient content except N and K content where BARI bush-1 had higher than BARI bush-2. Similarly, organic and inorganic based N also responsed significantly among the whole growth and yield characters and also on soil nutrient content of C, P and S whereas treatment T_3 had highly efficient than that of other N doses among the whole characters. As a result, tallest plant (42.00 cm), maximum branches (15.50 plant^{-1}), flowers (10.50 plant^{-1}), pods (553.8 plot^{-1}), pod yield (13.08 t ha^{-1}), stover yield (5.91 t ha^{-1}) were obtained in T_3. In contrast, C, P and S content had higher in T_3 (0.672%, 17.49 and 22.00 ppm, respectively) than that of other N. Combined effect between varieties and N doses had also significant on whole growth, yield and nutrient content except nutrient content of N and K whereas treatment combination of V_1T_3 showed superior results on flowers production (14.50 plant^{-1}), pod (606.45 plot^{-1}), pod yield (13.28 t ha^{-1}), stover yield (6.05 t ha^{-1}) than that of other combinations. Above investigated results indicated that the variety BARI bush-1 (V_1) and 50 kg inorganic + 40 kg organic N ha^{-1} (T_3) would be suitable variety and appropriate N dose for obtaining the better growth and higher yield as well as the treatment combination of V_1T_3 would be highly beneficial for higher production of bush bean.

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ABBREVIATIONS

AEZ	=	Agro-Ecological Zone
Agric.	=	Agriculture
Agril.	=	Agricultural
ANOVA	=	Analysis of variance
ANOVA	=	Analysis of variance
BARC	=	Bangladesh Agricultural Researcher Council
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
CRD	=	Completely randomized design
DAS	=	Days after sowing
FAO	=	Food and Agriculture Organization
LSD	=	Least significant difference
RCBD	=	Randomized Complete Block Design
7Viz.	=	Namely

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Bush bean *(Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family Leguminosae and sub family papiolionaceae is reported to be a native of Central and South America (Swaider *et al,* 1992). French bean synonyms common bean, bush bean, kidney bean, snap bean, haricot bean and navy bean (*Phaseolus vulgaris* L.) commonly known as rajmash in India, is an important legume (Sarangi and De, 2010). It is also known as pinto bean, green bean, raj bean, pole bean, wax bean, string bean and bonchi (Duke, 1983; Salunkhe *et al* 1987; Tindall, 1988). It is domesticated in Mexico, Peru and Colombia about 8000 years ago (Schoonhoven and Voysest, 1991). It is widely cultivated in tropics, sub tropics and temperate regions. In India and most of the tropical Asia, it is a major vegetable crop where indigenous pulses are also preferred (Adams, 1985). It is widely cultivated in the temperate and subtropical regions and also in many parts of the tropics (Perseglove, 1987). French beans are grown intensively in five major continental areas: Eastern Africa, North and Central America, South America, Eastern Asia and Western and South Eastern Europe, However Brazil is the largest bush bean producing country in the world.

According to the recent FAOSTAT statistics, bush bean including other related species of the genus Phaseolus occupied 1.5 million hectare by the year 2012 of the world's cropped area and production of dry pods was about 20.28 million tones with an average yield of 132.82 thousand kg acre^{1} (FAOSTAT, 2013). It is not a new crop in our country and is cultivated in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country rather in a limited scale. Recently cultivation of bush bean is gaining popularity in Bangladesh mainly because of its demand as a commodity for export. It is estimated that the different varieties were cultivated in about 43 thousand acres of land whereas the total production of 95 thousand tons with an average yield of 2216 kg per acre during 2010–2011 (BBS, 2012).

Immature green pods are marketed fresh, frozen or canned. The dry seeds also may be used as pulses for human consumption or animal feed. After harvest, plants can be fed to cattle, sheep and horses. Its edible pods supply protein, carbohydrate, fat, fiber, thiamin, riboflavin, Ca and Fe (Shanmugavelu, 1989) and the seed contains significant amount of thiamin, niacin, folic acid as well as fiber (Rashid, 1993). In Bangladesh, bush bean is mainly used as green vegetable. Recently the feasibility of cultivating this crop in different parts of Bangladesh has been started in a small scale (Rashid, 1993). Because of high nutritive value, good taste and wide range of use, the popularity of French bean is increasing day by day in Bangladesh. As a legume, roots of French bean root system has nodules with nitrogen fixing bacteria. It can also be used as a green manuring crop and included in the crop rotation system in the field to improve soil fertility status. French bean *(Phaseolus vulgaris* L.) is an important legume vegetable grown during *rabi* season for its tender green pods with high protein, calcium and iron contents. The Bangladesh Agricultural Research Institute (BARI) has developed two potential French bean varieties. Plant density and soil fertility are the two important factors of crop production.

French bean or bush bean is a short durated crop and thus, yield ha^{-1} is comparatively high. It can fit well in intercropping with other crops such as wheat, maize, sunflower and sugarcane. Various problems, however, hamper bush bean production in Bangladesh. Fertilizer specially nitrogenous and phosphatic are the most critical input for increasing crop production and had been recognized as the key element for agricultural development (Mukhopadhyay *et al,* 1986). Bush bean shows high yield potential, but unlike other leguminous crops it does not nodulate with the native *rhizobia* (Ali and Kushwaha, 1987). For this reason, high dose of nitrogenous fertilizer or inoculation with effective stain of Rhizobium is required to exploit the yield potential of this crop.

Gupta et al (1996) observed that french bean responded up to 120 kg N ha^{-1} and there were 57.2% increase in yield over control. The hilly areas of Bangladesh, where the soil is light in texture and comparatively low temperature prevails during the winter season with less rainfall has been found suitable for french bean cultivation (Mozumdar et al. 2003). French bean is gaining popularity in the north eastern parts, particularly as a vegetable crop. The present experiment was taken to identify suitable location specific variety. Nitrogen is of vital importance for plant growth due to being a part of amino acid, protein, enzymes and chlorophyll molecule (Devlin and Witham, 1986). Many investigators reported that increasing NPK application improved the plant growth, yield and green pod quality of snap bean (Singer *et al.*, 2000, Saxena *et al.*, 2003, Hafez *et al.*, 2004, Abdel-Mawgoud *et al.*, 2005, Souza *et al.*, 2008, and El-Bassiony *et al.*, 2010). All vegetative growth parameters were gradually and significantly increased by increasing the level of nitrogen fertilizer application (Asmaa *et al.*, 2010). Insufficient available N leads to reduced growth, reduced light interception, limited yield and early crop senescence. On the other hand, excessive available N can result in reduced and delayed yield and reduced dry matter content (Kleinkopf *et al.*, 1981). El-Tohamy *et al* (2009) reported the possibility of using slow release N fertilizer such as Ensyabine to maximize growth, yield and quality of bean plants grown under new-reclaimed sandy nitrogen. Nitrogen is necessary for its vegetative growth & development. However, excessive or under dose of nitrogen can affect the growth & yield. An optimum amount of nitrogen is necessary to produce maximum yield of good quality bush bean. A detailed and systemic study is needed to find out the requirements of nitrogen for maximizing the yield of bush bean in Bangladesh. Considering the above situation, the present investigation was undertaken with the following specific objectives-

Objectives:

i. To investigate the performance of bush bean cultivars and inorganic and organic based N regarding to growth, yield and nutrient content of studied soil under AEZ-28;
ii. To identify the suitable bush bean cultivar on the aspect of growth and yield of bush bean
iii. To find out the optimum doses of inorganic and organic based N for obtaining the higher yield of bush bean;
iv. To select the most effective interaction effect between bush bean cultivar and N doses regarding to growth and yield of bushbean.

CHAPTER II

REVIEW
OF
LITREATURE

CHAPTER II
REVIEW OF LITREATURE

Bush bean *(Phaseolus vulgarris* L.) is one of the most important legume vegetables in the world. Researches on various aspects of its production technology have been carried out worldwide. Many research works have been done in different parts of the world to study the effect of nitrogen and phosphorus on the growth and yield of bush bean. It has been recently introduced in Bangladesh. However, very few research works have been carried on bush bean production under Bangladesh conditions. Some of the important findings related to the present study are reviewed in this chapter.

2.1 Responses of variety on growth and yield of bush bean

Present experiment was conducted with 16 genotypes of French bean (*Phaseolus vulgaris* L.) from various sources in a randomized block design with three replications at G.B. Pant University of Ag. & Tech, Hill Campus Ranichauri, Uttarakhand in the temperate midhills of Himalayas (Rana and Arvind, 2012). In this experiment data were recorded on plant height, days to 50% flowering, pod length and width, fresh pod weight, number of pickings and yield. Early flowering was recorded in Contender (42.33 days) and IIHR-909 (42.33 days) followed by Arka Komal (43 days) and maximum pod length was noticed in Arka Komal with 16.20 cm. The green pod yield was maximum in IIHR-909 (130.00 q ha^{-1}) followed by CH-808 (123.33 q ha^{-1}) and MFB-2 (114.07 q ha^{-1}).

Kamanu *et al.* (2012) reported that the variety Serengeti had higher shoot dry weight than Amy. Variety Serengeti had significantly higher extra fine pod yield than Amy in all inorganic fertilizer regimes. The two varieties were not significantly different in extra fine pod yield in the control plots. However, variety Serengeti had higher pod yields than Amy in both first and second season.

Kazemi *et al.* (2012) reported that between two cultivars, Shekofe had significant different with Danshekadeh cultivar and it obtained 188.59 cm plant height. Shokofa cultivar had indeterminate growth compared with Danshekadeh cultivar, thus it obtained high plant height. In spite of lack of cultivar effect on branch numbers, it observed that Shokofa cultivar had more number of branches than Danshekadeh cultivar. Number of pods plant^{-1} had not significant effect by cultivar. In spite of no difference in pods plant^{-1} between cultivars, it observed that Shokofa cultivar had higher pods plant^{-1} than Danshekadeh cultivar. Number of grains plant^{-1} had significant differences by cultivar where Shokofa cultivar had more grains plant^{-1} (173.6) than Danshekadeh. As shown, no significant difference observed between cultivars where Shokofa cultivar obtained highest 1000-grains weight 33.3g while grain yield also affected significantly by cultivar and Shokofa cultivar had higher grain yield (258.8 kg ha^{-1}) than Danshekadeh. Data also indicated that Shokofa cultivar had higher yield than Danshekadeh due to higher number of pods plant^{-1}, number of grains plant^{-1} and more 1000 grains weight. Biological yield was not significantly affected by cultivar. However, Shokofa cultivar had the highest biological yield (5681.3 kg ha^{-1}). Harvest index was significantly affected by cultivar and the cultivar Shokofa had higher harvest index than Danshekadeh. It is seem in Shokofa that it can preserved more photosynthetic matter and thus can delivered more photosynthetic matters to grain because all organs acted more yield components and more dry matter. It is also as source at late growth period due to its high yield.

Safapour *et al.* (2011) studied to investigate the effect of biological fertilizers on beans yield and yield components. A field study was conducted during spring and summer 2010 in agricultural experimental station of Arak Islamic Azad University. Three beans varieties Goli (indeterminate), Sayad (Semi determinate) and Derakhshan (determinate) were used. Mycorrhiza fungi including no inoculation and *Glomus intraradices* and three levels of *Rhizobium phaseoli* (no application, strain *Rb*116 and strain *Rb*133) were used. Interaction between Mycorrhiza, *Rhizobium* and cultivars on yield and yield components showed highest seed yield (2664 kg ha^{-1})

and biological yield (6333 kg ha^{-1}) in treatment of inoculation Goli variety with both mycorrhiza (*Glomus intarardices*) and *Rhizobium* strain *Rb*133, respectively. The lowest yield (1172 kg ha^{-1}) was obtained in treatment not using Mycorrhiza fungi and Rhizobium bacteria with variety Derakhshan.

Ngueguim *et al.* (2011) reported that there were significant differences among genotypes for seed yield in this study. Line KNX-114 significantly out-yielded the control variety. All the exotic lines yielded above the control variety, GLP-190, although not always significantly. Mean seed yield per plot was 210.5 g which surpassed the check variety, but not significantly (P>0.05). There were no significant differences among the genotypes for stand count 10 days after planting. The weight of 100 seeds ranged from 21.7 to 40.1 g, and there were significant differences among the genotypes. Mean seed yield was 287.8 g, which did not surpass the check variety PH 201. There were, however, significant differences among genotypes for seed yield. Line TY 3396-12 tended to out-yield the control variety, PH 201, though not significantly (P>0.05). There were significant differences among the genotypes for stand count 10 days after planting, but these seemed not to have influenced grain yield in the same manner. The weight of 100 seeds ranged from 16.7 to 42.2 g, and there were significant differences among the genotypes. There were significant differences among genotypes for stand count 10 days after planting, but these seemed not to have influenced grain yield in the same manner. The weight of 100 seeds ranged from 17.6 to 48.9 g, and there were significant differences among the genotypes.

Two field experiments were carried out for the two successive growing seasons of 2004 and 2005 in a silt clay loam soil at the Experimental Farm of the Faculty of Agriculture, Ain Shams University, Qalubia Governorate, Egypt. Growth parameters of bean varieties in the two experimental seasons of 2004 and 2005 are examined by El-Noemani *et al.* (2010). Data showed that growth parameters i.e. plant height, branches no., leaves no., pods no., leaves area, stem dry weight and total plant dry weight in two seasons, as well as leaves and roots dry matter in the second season were significantly affected by bean varieties. With regard to the dry weight of pods, there were no significant differences between the two varieties in the two growing seasons. Moreover, differences between varieties in dry weight of leaves and roots did not reach the level of significance in the first season. It is worthy to mention that Paulista variety exhibited its superiority in all aforementioned growth characters. Contrarily, in both growing seasons Bronco variety showed its inferiority against Paulista variety in the same regard.

A field experiment was conducted by Dahmardeh *et al.* (2010) where the results indicated that var. 3514 was the shortest and Algazayeri was the highest, though plant height did not show significant difference at cultivars Regarding the tested cultivars, the data indicated that Algazayeri cultivar produced the highest number of pods plant^{-1} (5.7), whereas Barekat cultivar produced the lowest number of pods plant^{-1} (3.2). The results showed that cultivars were greatly different in the number of their seeds pod^{-1}. Shami cultivar showed the lowest seed pod^{-1} and Barekat cultivar showed the highest seed pod^{-1}. With regard to the cultivars effect, the results showed that Algazayeri cultivar had the heaviest seed weight plant^{-1} compared to other cultivars (29.8 g) and Shami cultivar had the lightest seed weight plant^{-1} compared to other cultivars (22 g). With regard to cultivars, the results showed that Algazayeri cultivar produced the highest seed yield (2.53 t ha^{-1}), because this cultivar had the highest number of pods plant^{-1}. The results showed that Algazayeri cultivar produced the highest values of biological yield (3.65 t ha^{-1}) where no significant difference was observed due to Barekat and Shami cultivars. Superiority of this cultivar may be due to their advantages in plant height and number of pods.

The present study was conducted to investigate the effect of different nitrogen levels (0, 25, 50 kg ha^{-1}) on forage yield and quality of three cluster bean cultivars namely; cluster bean 2/1, BR-90 and BR-99 by Ayub *et al.* (2010). The variety BR-99 produced significantly higher forage yield (63.00 t ha^{-1}), crude protein contents

(16.63 %) and lower ash contents than cultivars cluster bean and BR-90. Significant difference was also observed among cultivars regarding green forage and dry matter yield, plant height, no. of leaves and leaf area plant^{-1}.

Sarangi and De (2010) reported that the pod length was significantly highest (16.35 cm) in the variety selection-9, which was at par with Contender (15.86 cm). Mean pod circumference was highest in the variety Anupam (0.88 cm) which was at par with Contender (0.87 cm), Pusa Parvati (0.81 cm) and Selection-9 (0.79 cm). The days to first harvest varied from 50 days in case of variety Selection-9 to 59 days in case of variety Kentuky Wonder. Highest mean pod yield of 747.92 g m^{-2} was observed in the variety Contender, whereas the variety Kentuky Wonder produced the lowest pod yield of 96.77 g m^{-2}. The number of pod m^{-2} was also highest (111.97) in the variety Contender and lowest in the variety Kentuky Wonder (16.35 m^{-2}). The number of seeds pod^{-1} was highest (7.77) in Kentuky Wonder, which was significantly superior over all other varieties studied.

Noor-e-Alam Siddiqui (2010) reported that the genotype BB-9 gave the highest seed yield (1.89 t ha^{-1}) and BARI Jharsheem-1 gave the lowest seed yield (1.14 t ha^{-1}). The genotype BARI Jharsheem-1 gave the highest green pod yield (12.40 t ha^{-1}) and BB-15 gave significantly the lowest green pod yield (10.92 t ha^{-1}).

The data on the effect of varieties, plant density, and nitrogen levels on the yield attributers and pod yield have been presented by Moniruzzaman *et al.* (2009). There was no significant difference in two varieties (BARI bush bean-I and BAR! bush bean-2) with respect to branches plant^{-1}, pod length, and number of green pods plant^{-1}. However, the plant height, pod width, and green pod weight plant^{-1} were significantly higher in BARI bush bean-I as compared to BARI bush bean-2. BARI bush bean-I gave significantly higher yield than BARI bush bean-2.

A field study was conducted by Singh *et al.* (2009) to assess the effect of nitrogen doses on growth and parameters of French bean varieties during *kharif* 2006-07 and 2007-08. Among the varieties, the variety CH-812 produced the highest average green pod yield plot^{-1} which was significantly different with other varieties, simultaneously this variety revealed early flowering (37.19 days). This variety was most suitable for early picking of green pods and higher green pods yield. Variety CH-812 also recorded highest number of pods per plant, pod diameter, number of green seeds per pod and green pod yield per plant. Variety Pant Anupam recorded the highest pod weight and green pods per plant. Variety VL-65 recorded the highest number of branches per plant and pod length. On the other hand two varieties CHFB-2 and Swarn Priya were found late flowering and low yielding. The individual performances of the varieties regarding days revealed that variety Pant Anupam showed the highest range for days to 50% flowering under three nitrogen applications whereas two varieties CHFB-2 and HUR-137 showed low range.

Chandrashekhar (2008) reported that the twenty seven collections of broad bean (*Vicia faba* L.) were studied for their relative performance for seed yield per plant, protein content of dry seeds and some agronomic traits. The best performance in terms of maximum seed yield plant^{-1} was exhibited by EC 284374 (53.81 g), EC 284375 (42.74 g) and Palampur Local 3 (42.64 g). High protein content was obtained in lines JV1 (26.69 %), JV5 (26.25 %) and EC 284347 (26.23 %).

The field experiment was conducted by Pawar *et al.* (2007) during rabi season of 2003-2004. The four varieties namely HPR -35, PDR- 14, HUR - 15 and VL- 63 were allotted to the main blocks randomly in each replication and three spacing (plant densities) i.e. 30 x 10 cm (3.33 lakh plants ha^{-1}), 45 x 10 cm (2.22 lakh plants ha^{-1}) and 45 x 15 cm (1.48 lakh plants ha^{-1}) were allotted randomly in each sub block. The growth performance were recorded in terms of plant height, number of leaves, leaf area, number of branches plant^{-1} at various growth stages with an interval of 20 days from 30 days onwards after sowing up to harvest . Similarly yield attributes *viz.*, number of pods plant^{-1}, weight of pods plant^{-1}, number of grains pods^{-1}, number of grains plant^{-1}, weight of grains plant^{-1} and 100 grain weight were recorded. However, the varieties V_3 and V_4 recorded at par plant height. Similar trend was observed in respect of branches per plant and functional leaves. The significantly highest number of branches plant^{-1} (6.63) and functional leaves plant^{-1} (3.36) was recorded under the variety V_2 over the other treatments. Amongst the four varieties, variety V_2 (PDR-14) was significantly superior over the rest of the treatments in yield attributes. The yield attributes were on par under the varieties V_3 and V_4. The variety V_1 was significantly inferior. The variety V_2 (PDR-14) recorded significantly superior grain yield (13.41 q ha^{-1}), biological yield (44.62 q ha^{-1}) and straw yield (31.14 q ha^{-1}) over all other varieties. The yield data recorded under the variety V_2 and V_3 were at par and significantly superior over the variety V_1.

Abdel-Mawgoud *et al.* (2005) reported that snap bean varieties in both season significantly differed in their vegetative growth parameters. Plant height and number of leaves recorded the lowest values with cv. Julia. Meanwhile the highest values of the two parameters were recorded in cvs. Royal Nel and Coby for plant height and number of leaves, respectively. As for number of branches, the highest values were recorded with cvs. Coby and Duel followed by Royal Nel. In both seasons, results also clarified that cv. Royal Nel gave the highest fresh and dry weights followed by cv. Coby. However, cv. Julia gave the lowest values of vegetative growth parameter. Coby cultivar recorded the highest pod yield and the lowest yield was recorded with cv. Royal Nel. Early and exportable yields showed the same pattern of total yield and were about 10 and 71% of total yield, respectively. Number of days until harvesting was not significantly affected by the cultivars in both seasons. Pod length was the highest in cv. Royal Nel, which was significantly the longest compared to all other cultivars meanwhile cv. Coby recorded the shortest pods. Royal Nel and Coby cultivars recorded the highest values of pod diameters compared to the other cultivars.

Roy (2004) studied to characterize different plant parameters of twenty seven bush bean (*Phaseolus vulgaris* L.) genotypes for yield improvement of this crop. Genotypes varied from 34.33 to 54.67 days to initiate 50% flowering. They differed remarkably in producing seed yield plant^{-1} (g) and the difference in yield was attributed mainly due to variation in yield components. Pods number plant^{-1} was the highest in BB 15 (22.64) followed by BB 3, and the lowest in BB 26 (2.9). The highest number of seeds pod^{-1} was obtained from BB 3 (5.74) while BB 22 (1.84) was the least. 100-seed weight was the maximum in BB 19 (34.87 g) and BB 3 (11.13 g) had the minimum. Based on seed yield plant^{-1}, the 27 genotypes were grouped as i) high yielder (3 genotypes viz. BB 3, BB 9, BB 15), which produced >12.0 g plant^{-1}, ii) medium yielder (7 genotypes) which produced > 8.0 g but < 12.0 g plant^{-1} and iii) low yielder (17 genotypes) those produced < 8.0 g plant^{-1}.

Sardana *et al.* (2000) reported that different varieties are recommended for different regions. While PDR 14 (Uday) is the most suited variety in north-eastern plains during winter season, VL 63 gives higher yield in central zone during winters and in the hills when grown in summer rainy season.

Anjanappa *et al.* (2000) reported that the Arka Komal recorded the higher plant height (52.70 cm) followed by Burfi Stringless (48.36 cm) and Selection-11 (47.92 cm) and lowest was in Local (43.99 cm) during kharif season. In rabi season, Selection-11 recorded the maximum plant height (56.88 cm), followed by Arka Komal (54.45 cm) and Burfi Stringless (50.07 cm). The local recorded the lowest plant height of 45.89 cm in pooled data Arka Komal registered a maximum plant height of 53.57 cm, followed by Selection-11 and Burfi Stringless (52.40 cm and 49.22 cm, respectively) and minimum of 44.94 cm was in Local. Significantly higher number of primary branches was in Arka Komal (5.22) where as it was lowest with Burfi Stringless. In pooled statistically analysis Arka Komal recorded significantly higher number of primary branches (5.24) where as it was lowest with Local (4.07). In kharif season Arka Komal recorded significantly higher dry weight of pods (21.86 g 1000 g^{-1} of fresh weight) as compared to Burfi Stringless but it was on par with Local and Selection-11 (16.87 and 15.88 g 100 g^{-1} fresh weight, respectively). Similar trend was also noticed in rabi season. But hte pooled data was non significant. Significant variation in pod yield were recorded for both the seasons and also poled data due to varieties. Significantly higher pod yield (21.90 t ha^{-1}) was recorded in Arka Komal, followed by Selection-11 (19.38 t ha^{-1}). Significantly lower yield was recorded in Local (11.76 t ha^{-1}) and was on par with Burfi Stringless (13.10 t ha^{-1}).

Roy and Parthasarathy (1999) screened six varieties of French bean namely Tender crop, Stringless cluster, Canadian wonder, Meghalaya dwarf (bush types), Meghalaya pole and Manipuri (pole types) for yield parameters. Maximum number of branches $plant^{-1}$ were observed with Stringless (5.44), maximum number of pods $plant^{-1}$ Chandrashekhar with Canadian wonder (15.64) whereas, variety Tender crop recorded maximum seed yield (79.57 q ha^{-1}).

2.2 Effect of nitrogen on growth and yield of bush bean

Nitrogen is one of the most essential elements for crop any production. It encourages vegetative growth and increases leaf areas of plants, which helps hi photosynthetic activity. It stimulates root growth and development of the plant. Furthermore it helps in uptake of other nutrients from the soil. Both excess and under doses of nitrogen hampered the yield. So for higher yield judicious amount of nitrogen should be applied.

Kamanu *et al.* (2012) reported that the application of inorganic fertilizer depressed nodule numbers and nodule dry weight. DAP-CAN and DAP-NPK inorganic fertilizer application regimes increased shoot dry weight DAP-CAN applied on variety Serengeti had higher extra fine yield than the control. Application of 91 kg N ha^{-1} as DAP-CAN on Serengeti had the highest total pod yield and profit margin, compared to CAN, DAP-CAN-NPK and DAP-NPK regimes.

Eric Simonne *et al.* (2012) reported that adequate nitrogen (N) and irrigation management are critical to optimize the yield of a shallow-rooted vegetable crop like snap bean (*Phaseolus vulgaris* L.). The study was conducted on a Blanton-

Foxworth-Alpin complex sandy soil in fall 2007 and spring 2008. 'Bronco' bush snap beans were fertilized with a total of 0, 40, 80, 120, 160, or 200 lb acre^{-1} (0, 45, 90, 134, 179, 224 kg ha^{-1}) N rates with three identical applications at planting, first trifoliate leaf, and first flower bud. Plots consisted of four, 40-ft (12.2 m) long rows with the two middle rows harvested. In both years, the marketable pod yield response to N rate was quadratic and maximum pod yield for both fall 2007 and spring 2008 occurred near the current recommended N rate.

El-Awadi *et al.* (2011) reported that the application of nitrogen fertilizer at recommended dose (100 %) increasing significantly the vegetative growth criteria (i.e. plant length, leaves number plant^{-1}, number of branches plants^{-1} and fresh and dry weight of leaves plant^{-1}) in the two seasons. While the lowest values of the vegetative growth criteria was obtained with the application of nitrogen at 35% of recommended dose. The highest yield, pod length and pod weight were recorded by using 100 % N. On the contrary, the lowest total yield of snap bean and pod weight as well as pod length was found by using 35% N.

The present study was conducted to investigate the effect of different nitrogen levels (0, 25, 50 kg ha$_{-1}$) on forage yield and quality of three cluster bean 2/1 cultivars namely; cluster bean 2/1, BR-90 and BR-99 by Ayub *et al.* (2010). The experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during 2008. The experiment was laid out in randomized complete block design (RCBD) with factorial arrangements having three repeats. The application of nitrogen significantly increased the forage yield and maximum yield (63.70 kg ha^{-1}) was recorded at 50 kg ha^{-1}. The increase in yield was mainly due to greater plant height, number of leaves and leaf area plant^{-1} and number of branches plant^{-1}. The quality parameters like crude protein, crude fibre, total ash and dry matter percentage were also increased significantly by nitrogen application over control.

Noor-e-Alam Siddiqui (2010) were evaluate the effects of applied nitrogen and phosphorus on growth, yield and nutrient uptake in bush bean genotypes. The first experiment was conducted with three genotypes of bush bean (BARI Jharsheem-1, BB-9 and BB-15) and four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}). Nitrogen levels exerted significant influence on plant growth and yield in bush bean genotypes. Plant height, number of primary branches $plant^{-1}$, LAI, TDM and CGR increased progressively with the increased level of N up to 150 kg ha^{-1} in BARI harsheem-1 and up to 100 kg N ha^{-1} in the genotypes BB-9 and BB-15. Nitrogen levels had significant effect on days to maturity. The highest level of N delayed maturity in the genotypes. Nitrogen levels had significant influence on CGR, RGR and NAR. BARI Jharsheem-1 had greater allocation of dry mass (73.75%) at harvest into its reproductive part than the genotypes BB-9 (62.86%) and BB-15 (61.39%). Nitrogen levels had significant effect on yield. Pods $plant^{-1}$, seeds pod -1 , pod length, seed yield $plant^{-1}$, 100-seed weight, seed yield and green pod yield increased up to 150 kg N ha^{-1} in BARI Jharsheem-1 and up to 100 kg N ha^{-1} in the genotypes BB-9 and BB-15.

A field experiment on French bean was conducted in Old Brahmaputra Floodplain Soil of Jamalpur and Grey Terrace Soil of Joydebpur during 2005-2006 to find out the optimum rates of N and P for yield maximization by Sen *et al.* (2010). Four levels of nitrogen (0, 100, 150 and 200 kg ha^{-1}) and 3 levels of phosphorus (0, 40 and 60 kg ha^{-1}) were used in the experiment. Nitrogen and phosphorus alone significantly influenced the pod yield of French bean. Among the N levels, the highest pod yield (13.33 t ha^{-1} at Jamalpur and 14.68 t ha^{-1} at Joydebpur) were obtained with 150 kg N ha^{-1}.

Rahman *et al.* (2009) reported that the application of different fertilizer packages increased pod yield significantly over control plot and the highest pod yield was obtained with T_3 treatment where soil test based fertilizer was applied. The three years average pod yield of Bush bean was generally higher with application of different fertilizer doses (T_2-T_6), varying from 0.74 to 1.07 t ha^{-1}, compared to that obtained with no fertilization (0.56 t ha^{-1}). The pod production in farmers doses (T_6) vas relatively low (0.74 t ha^{-1}), which was 31% lower than that obtained with T_3 treatment. The yield recorded from BARC recommended fertilizer dose (T_2) also gave better yield (0.86 t ha^{-1}) than that with farmers doses in T_6 treatment. Pod yield due to T_3 treatment increased by 24% as compared to T_2.

Moniruzzaman *et al.* (2009) reported that the plant height and branches $plant^{-1}$ increased with increasing level of N. Pod length, pod width, number of green pods $plant^{-1}$ and green pod weight $plant^{-1}$ were found highest at 120 kg N ha^{-1}. Higher values of plant height and number of branches $plant^{-1}$ with 120 kg N ha^{-1} resulted in better growth and development of plants, thus leading to the maximum pod size (pod length x width), more number of green pods $plant^{-1}$ and green pod weight $plant^{-1}$. The maximum pod yield (27.8 t ha^{-1}) was obtained from the application of 120 kg N ha^{-1} and it was minimum (15.9 t ha^{-1}) in control (No) treatment. Higher yield for 120 kg N ha^{-1} fertilization was contributed by higher values for yield attributes compared to the lower dose (60 kg N ha^{-1}). Plant height, number of green pods $plant^{-1}$, green pod weight $plant^{-1}$ and green pod yield ha^{-1} were significantly influenced by variety x nitrogen. The maximum plant height (48.8 cm) was obtained from V_1N_2 treatment combination whereas, the highest number of green pods $plant^{-1}$ was found from V_2N_2 treatment. The treatment V_1N_2 produced the highest green pod weight $plant^{-1}$ (96.5 g) and green pod yield (30.0 t ha^{-1}).

A field study was conducted by Singh *et al.* (2009) to assess the effect of nitrogen doses on growth and parameters of French bean varieties during *kharif* 2006-07 and 2007-08. The crop sown with 180 kg nitrogen application gave significantly higher green pod yield than the crop sown with 120 and 80 kg nitrogen application. Further significantly higher green pod yield was recorded with the application of 120 kg ha^{-1} N than 80 kg N application. Green pod yield was significantly reduced with low nitrogen application (80 kg ha^{-1}). All growth and yield characters revealed significantly different response with changing level of nitrogen application. Reduction in number of branches $plant^{-1}$, number of pods plant^{-1}, pod diameter, pod length, number of green seeds per pod and 10- pod weight were responsible for lower green pod yield with low nitrogen application (80 kg/ha). Highest number of branches plant^{-1}, number of pods plant^{-1}, pod diameter, pod length, number of green seeds pod^{-1} and 10-pod weight were recorded with 180 kg ha^{-1} N application. Days to 50% flowering and plant height were the highest with 180 kg ha^{-1} N application, and decreased with reduced level of N application. These results indicated that higher doses of nitrogen enhance the vegetative growth resulting taller plants and delayed flowering. It indicated that variety Pant Anupam was highly responsive for higher dose of nitrogen application in comparison to other varieties. All the varieties revealed higher green pod plot^{-1} with 180 kg N application but the highest response was shown by variety CHFB-2 (3.35 kg plot^{-1}) with high dose of N application. Two varieties IIHR-909 and Pant Anupam showed the least response and rest of the varieties revealed almost equal response to high dose of N application. It was observed that varieties early in flowering recorded higher green pod yield plot^{-1} under all three N application regimes and the varieties late in flowering showed reverse trend in green pod yield. Therefore early flowering varieties would be most useful in hilly areas of Jammu and Kashmir for higher green pod yield.

A greenhouse pot experiment was conducted by Kovacs *et al.* (2008) to investigate the effects of nitrogen (N) and sulphur (S) fertilization on the yield of garden bean (Phaseolus vulgaris L.). Four levels of nitrogen (0.36, 0.66, 0.96, 1.27 g pot^{-1} as NH_4NO_3 and $NH_4H_2PO_4$) in combination with three levels of S (0.23, 0.46, 0.92 g pot^{-1} as K_2SO_4) were tested as treatments. Results indicated that significant response to yield was observed for N and S application. N fertilization significantly increased the total fresh and dry weight of bean pods, but the highest N doses delayed the ripening of bean. The fresh pod weights of first harvest were much higher in all plots than in the case of pods of second harvest. The pod weights of first harvest ranged 102.73 - 165.93 g pot^{-1}, in the second harvest ranged 2.38 – 54.95 g pot^{-1} and the total yield of pods ranged 140.8 – 185.5 g pot^{-1}, respectively. In the first harvest the highest fresh yield of pods (176.3 g pot^{-1}) was produced by applying the highest N and S doses, and in the second harvest by applying the N_4 nitrogen and S_2 sulphur levels. The fresh and dry weights of straw ranged between 108.3-130.9 g pot^{-1}, and 25.8-29.7 g pot^{-1}, respectively. The highest fresh weight of byproduct was measurable in pots having the maximum nitrogen level, N_4 and S_2 doses.

A field experiment on French bean taking the variety BARI Jhar Shim-2 was conducted with five levels of Nitrogen (0, 40, 80, 120 and 160 kg N ha^{-1}) and four levels of each of phosphorous (0, 40, 80 and 120 kg P2O5 ha^{-1}), potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) and sulfur (0, 10, 20 and 30 kg S ha^{-1}), three levels of each of zinc (0, 4 and 8 kg Zn ha^{-1}) and boron (0, 1 and 1.5 kg B ha^{-1}) by Moniruzzaman *et al*. (2008). Yield and yield components of French bean were significantly influenced by different fertilizer treatments containing macro and micronutrients separately. Results showed significant effect of fertilizers on plant height, number of branches and leaves $plant^{-1}$, pod length, number of green pods and pod weight $plant^{-1}$ and green pod yield during both years. The highest pod yield of 23.14 t ha^{-1} (average of 2005-2006 and 2006-2007) was obtained with 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung ha^{-1} that was closely followed by 120-80-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung ha^{-1}. The response equations indicated an optimum level of 138.6 kg N, 131.5 kg P_2O_5, 63.4 kg K_2O and 17.4 kg S ha^{-1} for higher green fruit yield of French bean.

Hossain (2007) studied on the effect of nitrogen and molybdenum on the growth and yield of bush bean (*Phaseolus vulgares* L.) cv. BARI Jhar Sheem-1. The treatments consisted of 5 (five) levels of N (0, 40, 80, 120 and 160 kg ha^{-1}) designated as N_0, N_{40}, N_{80}, $N_{120}$and N_{160}, respectively and 3 (three) levels of Mo (0, 0.5 and 1.0 kg ha^{-1}) designated as Mo_0, Mo_{05}, and Mo10, respectively. There was a positive impact of each nutrient and their interaction on number of effective branches $plant^{-1}$, population m^{-1} number of green pod $plant^{-1}$, pod length, diameter of pod, number of seed pod^{-1}, pod yield plot^{-1}, seed yield plot^{-1} and 1000-seed weight, green pod yield, seed yield and straw yield with increasing the rate of nitrogen and molybdenum, all these parameters increased up to N_{120} and $Mo_{0.5}$. The highest green pod yield (18.00 t ha^{-1}) and seed yield (3.10 t ha^{-1}) was obtained from N_{120}. The highest green pod yield (12.88 t ha^{-1}) and seed yield (2.50 t ha^{-1}) was obtained from M00.5The maximum pod yield (18.50 t ha^{-1}) and seed yield (3.50 t ha$^{-1)}$ was attained in $N_{120}Mo_{05}$ treatment.

Slaton *et al.* (2007) reported that the fresh green bean yields ranged from 9,189 to 11,702 lb/acre among treatments with an overall average of 10,407 lb/acre. Statistical analysis with the Fisher's Protected LSD multiple mean comparison indicated no significant yield or green bean size differences among treatments at the 0.10 probability level. However, single-degree-of-freedom contrasts used to compare selected treatments showed that green beans receiving no N (the unfertilized control) yielded less (P=0.0261) than green beans receiving 73 lb N/acre (NH_4NO_3 and Urea Base Programs) and the NH_4NO_3 base program plus foliar fertilization (P=0.0378), but produced similar yields as green beans receiving the Base N rate plus additional N (P=0.1458). Addition of extra N did not benefit green bean yield or size.

Kikuti *et al.* (2005) studied the effects of different levels of N (0, 70, 140and 210 kg ha^{-1}, urea source) and P_2O_5 (0, 100, 200 and 300 kg ha^{-1}) triple super phosphate source on the bean. The initial and final stands of the plants, grain productivity and the utilization efficiency in response to N and of P_2O_5 treatments were evaluated. The N and k association resulted in small bean plant population and the P lessened that effect. The productivity was increased in response to N and P_2O_5 levels higher than those recommend for bean crop.

Bildirici *et al* (2005) conducted an experiment during 2001 and 2002 to determine the effects of bacterial *(Rhizobium phaseoli)* inoculation, N fertilizers (0, 20, 40, 60 kg N ha^{-1}) on field bean. Nitrogen fertilizer exerted a significant and positive effect on pod number, grain yield and raw protein proportion, whereas no significant effect was observed on seeds pod^{-1} and 1000-seed weight. On the other hand, bacterial inoculation exerted a significant and positive effect on pod number plant^{-1} and grain yield.

Abdel-Mawgoud *et al.* (2005) reported that all the recorded vegetative growth parapets responded significantly and positively to increasing the level of mineral fertilizer (NPK) application as shown in both seasons. The total, early and exportable yield gradually and significantly increased in both seasons. There was no significantly difference between their and fourth levels of NPK concerning these parameters. Increasing the level of mineral fertilizers application significantly increased number of days to harvesting, pod quality, i.e. pod length, thickness and fiber content not significantly affected by the level of NPK application. On the contrary, protein and carbohydrates contents significantly increased with increasing the level of NPK fertilizer application.

The effects of N (0, 20, 40 and 60 kg ha^{-1}) and P (0, 30, 60 and 90 kgP_2O_5 ha^{-1}) on the seed yield of pea cv. Arkel and french bean *[Phaseolus vulgaris]* were investigated in Uttar Pradesh, India during 2002-03 (Lal, 2004). Nitrogen at 40 kg ha^{-1} was optimum for obtaining the maximum pea and bean seed yields. Seed yield of both crops increased with increasing P rates up to 60 kg ha^{-1}.

Prajapati *et al,* (2004) conducted an experiment in Sardar Krushinagar, Gujarat, India, to study nutrient uptake and yield of french bean as affected by weed control methods and nitrogen levels (0, 40, 80 and!20 kg ha^{-1}). Among the N rates, 120 kg ha^{-1} recorded the greatest N uptake (56.70 kg ha^{-1}), P uptake (18.47 kg ha^{-1}), K uptake (37.34 kg ha^{-1}), grain yield (1091.77 kg ha^{-1}), straw yield (1932.35 kg ha^{-1}), protein yield (228.39 kg ha^{-1}), net returns (10816 rupees ha^{-1}), and benefit cost ratio (1: 2.44).
Ram-Gopal *et al.* (2003) investigated the effects of irrigation (0.5, 0.7 and 0.9 W CPE^{-1}) and nitrogen rates (50, 100 and 150 kg ha^{-1}), with or without 5 t farmyard manure (FYM) ha^{-1}, on the yield and water use of french bean *(Phaseolus vulgaris)*

in a field experiment conducted in Faizabad, Uttar Pradesh, India. Plant height, number of branches plant^{-1}, dry matter plant^{-1}, grain yield, consumptive use of water and water use efficiency increased with increasing irrigation and N rates and with the addition of FYM.

Dhanjal *et al.* (2003) conducted a field experiment in Uttar Pradesh, India. With treatments consisted of 3 french bean *(P. vulgaris)* cultivars (IIUR 87, PDR 14 and VL 63), 3 planting densities (250x103, 333x103 and 500x103 plants ha^{-1}) and 3 N levels (0, 60 and 320 kg ha^{-1}). Leaf area index and crop growth rate was highest at 500x103 plants ha^{-1}, whereas dry weight plant^{-1}, net assimilation rate and relative growth rate in general were the highest at 250x103 plants ha^{-1}. Increasing levels of N with 120 kg N ha^{-1} increased dry weight, leaf area index, crop growth rate and relative growth rate, but net assimilation rate increased up to 60 kg N ha^{-1} only.

Chandel *et al.* (2002) conducted a field experiment to determine the effect of different nitrogen levels (0, 40, 80, 120 kg ha^{-1}) and *Rhizobium* inoculation (control, HURR-3, and Raj-2) on crop yield, nitrogen uptake and crop quality of french bean cv. HUR-137 in Varanasi, Uttar Pradesh, India. The yield components, crop and protein yield significantly increased with increasing nitrogen levels and the highest values were registered with 120 kg N ha^{-1} during both years. *Rhizobium* inoculation increased crop yield over the control. Strain Raj-2 produced significantly higher grain and protein yield compared to HURR-3.

A two-year experiment was conducted during 1995-97 with 5 nitrogen levels (0, 30, 60, 90 and 120 kg ha^{-1}) to study their impact on the growth, yield attributes, yield and economics of french bean *(Phaseolus vulgaris* cv. PDR 14) under late-sown conditions of eastern Uttar Pradesh, India (Singh and Verma 2002). They showed that the highest rates of nitrogen (120 kg ha^{-1}) resulted in the highest plant height, branches per plant, pods per plant, seeds pod^{-1}, 100-seed weight, grain yield (21.19 q ha^{-1} with 120 kg N ha^{-1}) and straw yields (29.76 q ha^{-1} with 120 kg N).

A field experiment was conducted by Vishwakarma *et al.* (2002) to determine the response of two french bean *(Phaseolus vulgaris)* cultivars (Holland 84 and PDR 14) to different nitrogen application rates (0, 30, 60, 90 kg ha^{-1}) on sandy loam soil in Varanasi, Uttar Pradesh, India. Both cultivars showed differential performance for growth and yield attributes. Holland 84 was the tallest; whereas PDR 14 recorded the highest dry matter production $plant^{-1}$ as well as pods $plant^{-1}$, grains pod^{-1}, grains $plant^{-1}$, pod length and 100-grain weight. The growth, yield attributes and yield (grain and stover) increased with increasing rates of nitrogen up to 90 kg ha^{-1}.

A field experiment was conducted by Farkade *et al.* (2002) in Maharshtra, India to determine the effect of N:P fertilizers at 60:45, 90:75 and 120:75 kg ha^{-1} on *Paseolus vulgaris* cultivars. The yield and growth characters in creased with increasing N:P fertilizer level and the highest value (15.93 q ha^{-1}) was observed at 120:75 kg ha^{-1}.

Rejesh and Singh (2001) carried out a field experiment in India to evaluate the effects of N (80, 160 and 240 kg ha^{-1}) and S (0, 20, 40 and 60 kg ha^{-1}) on the nutrient uptake and grain yield of french bean *(Phaseolus vulgaris* cv. HUR 137). The highest grain yield (2091kg ha^{-1}) straw yields (3331kg ha^{-1}), total N uptake (90.70 kg ha^{-1}) and S uptake (6.58 kg ha^{-1}) were recorded at N level of 240 kg ha^{-1} and sulphur (S) at 40 kg ha^{-1} recorded the highest grain yield (1811 kg ha^{-1}) total N uptake (77.45 kg ha^{-1}) and S uptake (6.06 kg ha^{-1}).

Dhanjal *et al.* (2001) conducted a field experiment in Uttar Pradesh, India to study the effects of crop density (500 000, 333 000, or 250 000 plants ha^{-1}) and N (0, 60, or 120 kg ha^{-1} applied at sowing) on the yield and yield components of P. *vulgaris* cultivars. The lowest crop density (250 000 plants ha^{-1}) gave the highest values of growth and yield components, except the plant height which was highest under 500 000 plants ha^{-1}. The highest seed and stover yields were recorded under medium crop density (333 000 plants ha^{-1}). The increase in N rate gave the corresponding improvement in yield and yield components.

Chaudhari *et al.* (2001) conducted an experiment in Nagpur, India to study the nutrient management of French bean. They reported that application of nitrogen significantly increased the plant height; pod number and grain yield plant^{-1} of french bean. They recommended fertilizer dose of 90kg N ha^{-1}.

Vargas *et al.*, (2000) showed that N fertilizer decreased nodulation at both sites, but increased grain yield at site 1 but not at site 2, indicating that the response to inoculation and N fertilization depends on the cropping history. When bean was cultivated for the first time, indigenous populations of rhizobia were low and high yields were accomplished solely with seed inoculation, with no further response to N fertilizer. In contrast, previous cultivation of bean increases soil Rhizobia, preventing nodule formation by inoculated strains, and N fertilizer might be necessary for maximum yield. A significant interaction effect between N fertilizer and inoculation was detected for zero-group distribution only at site 2, with N fertilizer decreasing nodule occupancy by the inoculated strain and increasing the occurrence of indigenous strains.

Tewari and Singh (2000) conducted a field trial in Uttar Pradesh, India to determine the optimum and economical dose of nitrogen (0, 40, 80. 120 or 160 kg N ha^{-1}) for better growth and seed yield of French bean. Plant height, number of branches and length of pod increased with successive increase in the doses of nitrogen. Application of 120 kg N ha^{-1} produced significantly higher number of pods plant^{-1}, weight of seeds plant^{-1}, number of seeds pod^{-1} and seed yield, whereas 160 kg N ha^{-1} significantly reduced seed yield.

Teixeira *et al.* (2000) conducted a field experiment to study the effect of sowing density (6, 10, 14 and 18 seeds m^{-2}) and N levels (0, 50, 100 and 150 kg N ha^{-1}), on *P. vulgaris* cv. Grain yield increased with increasing N rates, resulting in increased numbers of pods plant^{-1}, seeds pod^{-1} and 100-seed weight. This effect, however, was influenced by seasons and sowing densities. An increase in sowing density reduced the number of pods plant^{-1}, and in the absence of N fertilizers increased the grain yield. An increase in sowing density also reduced weed infestation during harvest.

Singh and Singh (2000) carried out a field trial in India with different nitrogen levels (0, 40, 80 or 120 kg N ha^{-1}) on yield and yield components of French bean They observed that seed yield and 1000-seed weight increased with the increasing rate of N.

Guriqbal *et al.*, (2000) conducted a field trial at Ludhiana in 1993/94, P. vulgaris was grown with or without seed inoculation with Rhizobium combined with different N fertilizer treatments. Inoculation and 40 + 30 + 30 kg N ha^{-1} or inoculation + 40 + 30 kg N gave the highest seed yields of 1046-1048 kg ha^{-1}, compared to 574 kg in controls. Inoculation alone did not significantly increase yield, and supplementary spraying of fertilized treatments with 2% urea had no significant benefit

Ghosal *et al.* (2000) conducted a field trial in Bihar, India to study the effect of varying N rates (0, 40, 80, 120 and 160 kg N ha^{-1}) and times of application on the growth and yield of French bean. They observed that nitrogen at the rate of 160 kg N ha^{-1} resulted significantly the highest values for number of pods plant^{-1}, weight of pods plant^{-1} grain yield and straw yield.

Daba and Haile (2000) carried out a field experiment in Ethiopia on French bean cv. Red Wolaita, Ex Rico-2, A-376 and A-250. Seeds were inoculated with mixture CIAT *Rhizobium* isolates 384, 274, 632 and 23 kg N ha^{-1} was applied to the soil. They reported that *Rhizobium* inoculation and N significantly increased grain yield, nodule number and dry matter yield.

Vieira *et al,* (1998) showed that N applied as a side dressing increased equally the total amount of N in the pods. A 10% increase in the seed N concentration was obtained with foliar application of Mo, while N applied as a side dressing had no effect on seed N concentration. An average increase of 41% in N export to the seeds was obtained by either Mo or N as side dressing. Nitrogen applied at sowing or Rhizobia inoculation had no effect on the characteristics evaluated 74 days after plant emergence. Plants that received either Mo as foliar spray or as side dressed N had similar yields.

Nandan and Prasad (1998) conducted a field trial at Pusa, Bihar to study yield and water use efficiency of *P. vulgaris* cv. Uday where 6 irrigation treatment and 3 N treatments (40, 80 or 120 kg N ha^{-1}). Seed yield in the first year was highest (1.311 ha^{-1}) when given 3 irrigations at 25, 50 and 75 days after sowing, But in the second year the highest yield of 1.35 t ha^{-1} was obtained when irrigated at a 0.8 IW: CPE [irrigation water: cumulative pan evaporation] ratio. Yield and water use efficiency increased with increasing N rate in both the years.

In a field trial conducted at India Lakhaoti, and Rana *et al.* (1998) found that *Phaseolus vulgaris* seed and straw yields increased significantly with each increment in N rate in both the seasons. The mean increase in seed yields with 120 kg N ha^{-1} compared with 0, 40 and 80 kg N ha^{-1} was 66.6, 21.7 and 7.0% respectively. Growth and yield parameters generally followed the same trend.

In a field experiment during the rainy seasons of 1993/94 and 1994/95 at Rahuri, Maharashtra, India, *P.* vulgaris cv. Waghya was irrigated at flowering and/or branching and was given 0, 40, 80 or 120 kg N ha^{-1} (Wani *et al.,* 1998). Yield and yield component (pod weight $plant^{-1}$) values increased with increasing N rate and were highest with irrigation at 75 mm CPE.

Gajendra and Singh (1998) stated that application of 120kg N ha^{-1}, 90 kg P_2O_5 ha^{-1} and 45 kg K_2O ha^{-1} gave higher grain yield of French bean. Durge *et al*, (1997) stated that the highest yield of French bean (957kg ha^{-1}) was obtained with 150 kg N ha^{-1}. Calvache *et al*. (1997) found a significant increase in seed yield, pod number $plant^{-1}$, number of seeds pod^{-1} and harvest index in French bean through increased nitrogen application.

An experiment was carried out in Uttar Pradesh, in India by Baboo *et al*. (1998) to study the response of French bean to applied nitrogen. Seed yield was increased with the increase of nitrogen and it was higher with 120kg N $ha^{-1'}$. Singh *et al*. (1996) investigated the response of French bean to spacing and nitrogen levels. They reported that seed yield increased with up to 120 kg N and 30×10 cm spacing.

Sharma *et al*. (1996) studied the effect of N fertilizer (0, 40, 80 and 120 kg N ha^{-1}) and timing of application on the growth and yield of French bean. They observed that increasing level of N significant increase in seed yield, number and weight of pods $plant^{-1}$ and number of seeds pod^{-1} up to 120 kg N ha^{-1}. However, in the case of seed yield, pod length and 100 seed weight, variation for 80 and 120 kg N ha^{-1} were not significant. They also reported that application of N in three equal splits gave higher seed yield attributes in French bean.

Koli *et al*. (1996) conducted an experiment in Maharashtra, India to study the influence of row spacing, plant densities and nitrogen levels on yield of French bean. Results revealed that pod yield was highest with 60 kg N ha^{-1} and at the density of 3, 33,333 plants ha^{-1} (yield 1.41 t) and the row spacing of 30 cm (yield 1.13 t ha^{-1}).

Dahatonde and Nalamwar (1996) studied the effects of nitrogen and irrigation on the yield of French bean. A significant increase in seed yield due to N fertilizer was observed with 90 kg N ha^{-1}. Application of 120 kg N ha^{-1} did not result in any further increase in yields compared to 90 kg N ha^{-1}.

Verma and Saxena (1995) reported that the growth and yield *of P. vulgaris.* in response of 0, 60 or 120 kg ha^{-1} each of N as urea. Seed yields were the highest with 120 kg N ha^{-1}.

A field experiment was conducted by Bagal and Jadhav (1995) to find out the effects of nitrogen and *Rhizobium* on the yield and nutrient uptake by French bean. Seeds were inoculated with *Rhizobium phaseoli* or uninoculated and the crop was given 0. 12.5, 25 or 37.5 kg N ha^{-1}. Seed yield and total P uptake increased up to 25 kg N ha^{-1}, whereas total N and K uptake increased up to 37.5 kg ha^{-1}.

Negi and Shekhar (1993) conducted a field trail in Himachal Pradesh, India to study the response of French bean genotypes to nitrogen. They used *Phaseolus vulgaries* cv. Katrain 1, Him 1, 64 and B_6 and 0-90 kg N ha^{-1} and observed that seed yield was the highest in B_6 (1.99 t ha^{-1}) and lowest in Katrain 1 (1.45 t ha^{-1}) and that increased up to 60kg N ha^{-1}.

Carranca *et al.* (1993) conducted an experiment on *Phaseolus vulgaris* cv. *Martingal* plants on a heavy alluvial soil supplied with 20, 80, 140 or 200 kg N ha^{-1}. Fertilizer treatment did not significantly affect pod yield, N uptake or crop quality. At the end of the growing cycle nitrate accumulation in the soil was observed at the highest N application rates. The lowest N rate (20 kg ha^{-1}) was sufficient to obtain the yields >10 000 kg ha^{-1} without decreasing the pod quality for deep freezing. Seasonal variations affected yield, pod N content and most quality characteristics with significantly, except for N content in tops and pod alcohol-insoluble solid content.

Dahatonde *et al.* (1992) conducted an experiment to study the effects of irrigation regimes, pan evaporation ratio and nitrogen levels on the growth and yield of French bean. They obtained higher grain yield of 0.92 t ha^{-1} with 3 irrigations. In case of nitrogen fertilization, the highest grain yield of 0.88 t ha^{-1} was found with 120 kg N ha^{-1}. Different levels of nitrogen showed significant differences in seed yield and dry matter production in French bean and nitrogen up to 60 kg N ha^{-1} were optimum (Leelavathi *et al.*, 1991).

Bhatnagar *et al.* (1992) conducted a field trial at Rajastan, India to find out the effect of nitrogen on French bean during winter. Nitrogen was applied at 20, 40 or 60 kg ha^{-1}. They reported that seed yield and nitrogen uptake in seed increased but crude protein percentage decreased with increasing nitrogen rate.

Parthiban and Thamburaj (1991) recorded increased grain yield with nitrogen fertilization up to 50 kg N ha^{-1}. Number of pods and grain yield $plant^{-1}$ increased significantly with nitrogen fertilization over the control. Moraghan *et al,* (1991) found that there was a response to N application up to 150 Ib at one of the irrigated sites, but the seed yields of the rainfed crops tended to be depressed by N application. Rhizobium inoculation increased seed yields at one of the rainfed sites at all N fertilizer rates. Application of N had little effect on grain-N concentration.

Leelavathi *et al* (1991) reported that the seed yield and dry matter production in French bean were increased up to 60 kg N ha^{-1}. Bengtsson (1991) conducted an experiment on *P. vulgaris* with 0, 30 or 60 kg N ha^{-1}. N generally increased seed yield, 1000-seed weight and seed protein. The number of root nodules was significantly increased due to inoculation.

Singh *et al.* (1990) reported that N fertilization and irrigation French bean increased the number of pods $plant^{-1}$ and 1000 seed weight with increase in nitrogen level. Hegde and Srinivas (1990) worked on the water relation and nutrient in French bean and observed that nitrogen application increased green pod yield, nutrient uptake and water use efficiency but had no marked effect on water relation and canopy temperature.

A field experiment was carried out by Srinivas and Naik (1990) at Bangalor, India to investigate the growth, yield and nitrogen uptake by vegetable French bean as influenced by nitrogen and phosphorus fertilizers. Nitrogen was applied at 0, 40, 80, 120 and 160 kg ha^{-1}. They observed that application of nitrogen increased plant growth, nutrient uptake and yield of green pods.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

An experiment was conducted at the research field in Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2011to March 2012 to study the comparative varietal response of bushbean to organic and inorganic based nitrogen management. This section for convenience of presentation has been divided into various sub-sections such as experimental site, soil and climatic condition, experimental materials, land preparation, experimental design, fertilizer application, seed sowing, intercultural operations, harvesting and threshing, data collection, statistical analysis etc.

3.1 Experimental site

The experimental field is located at 90.335° E longitude and 23.774° N latitude at an elevation of 1 (one) meter above the seas level (Iftekhar & Islam, 2004).

3.2 Soil

The soil of the experimental field belongs to the Tejgaon Soil Series of the Madhupur Tract under Agro ecological Zone (AEZ-28) (UNDP and FAO, 1988). The General Soil Type of the experimental field is Deep Red-Brown Terrace Soil. Topsoil is silty clay loam in texture. Organic matter content was very low (›1.0%) and soil pH varies from 5.8-6. The land was above flood level and well drained. The initial morphological, physical and chemical characteristics of soil are presented in the Table 1.

Figure: View of the experimental field.

Figure: View of the experimental plot.

3.3 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year (Biswas, 1987). The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991). The average maximum temperature is 30.39°C and average minimum temperature is 19.19°C.

Table:1.The morphological, physical and chemical properties of the experimental land

Morphological characteristics

Constituents	Characteristics
Location	Field Laboratory, Department of Soil Science, SAU, Dhaka
Soil Series	Tejgaon
Soil Tract	Madhupur
Land type	High
General soil type	Slightly acidic in nature with low organic matter content
Agro-ecological zone	"AEZ-28" of Madhupur Tract
Topography	Fairly level
Soil type and colour	Deep Red Brown Terrace Soil
Drainage	Moderate
Depth of inundation	Above the flood level
Drainage condition	Well drained

Physical properties of the soil

Constituents	Results
Particle size analysis	
Sand (%) (0.0-0.02 mm)	29.04
Silt (1%) (0.02-0.002 mm)	41.80
Clay (%) (<0.002 mm)	29.16
Soil textural class	Silty clay loam
Colour	Dark grey

Result obtained from the mechanical analysis of the initial soil sample done in the Soil Resources Development Institute (SRDI), Dhaka.

Chemical composition of the initial soil (0-15 cm depth)

Constituents	Results
Soil pH	5.8
Organic matter (%)	›1.0
Total nitrogen (%)	0.06
Available phosphorus (ppm)	25
Exchangeable potassium (meq/100g soil)	0.24

The mean air temperature during the cropping season varied between 19.19°c (in January 2012)to 24.94°c(in March 2012).The experiment was done during the *rabi* season. Temperature during the cropping period ranged between 13.46 C to 30.93°C. The humidity varies from 73.57 to 87.55%. The day length was 10.5-11.0 hours only and there was no rainfall from the beginning of the experiment to harvesting. The monthly average temperature, humidity, bright sunshine, solar radiation of the site during the experimental work is enclosed in Table 2.

Table2.Monthly air temperature, rainfall, relative humidity and sunshine hours during the growing season (November 2011 to March 2012)

Month	Year	*Air temperature (^{O}C)			**Rainfall (mm)	*Relative humidity (%)	** Sunshine (hrs)
		Maximum	Minimum	Average			
November	2011	29.63	16.67	23.51	00.00	83.10	265.8
December	2011	25.52	15.70	20.61	00.00	87.55	142.8
January	2012	24.92	13.46	19.19	Trace	86.16	160.4
February	2012	28.77	15.33	22.05	Trace	73.57	223.4
March	2012	30.93	18.95	24.94	18.1	75.16	202.1
Average		27.95	16.02	22.06	6.03	81.11	198.9

* Monthly average and ** Monthly total

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

3.4 Experimental materials

3.4.1 Planting materials

Two varieties of bush bean were used as level factor A in the experiment which was as follows. The seeds of the varieties were collected from the Horticultural Research Center (HRC) of BARI, Joydebpur, Gazipur.

Factor A: Two varieties of bush bean

V_1: BARI bush-1

V_2: BARI bush-2

3.4.2 Treatments of the experiment

The experiment was undertaken to study the effects of five different levels of inorganic and organic based nitrogen including control on the growth and yield of bush bean and also on nutrient content of soil. These five treatments were as follows :

Factor B: five levels of inorganic and organic based nitrogen

T_1: inorganic N @ 90 kg ha^{-1} from urea.

T_2: inorganic N(urea)@70 kg ha^{-1} +organic N(cowdung) @ 20 kg ha^{-1}

T_3: inorganic N(urea) @ 50 kg ha^{-1} + organic N(cowdung) @ 40 kg ha^{-1}

T_4: organic N @ 90 kg ha^{-1} from cowdung.

T_5: control (without inorganic and organic N)

**considering decomposed cowdung contain 0.1% N_2 (dry basis)

3.5 Layout and design of the experiment

The two factors experiment was laid out in the randomized completely block design (RCBD) with three replications. The experimental plot was first divided into three blocks where each block used as replication. Each block was consisted of 10 unit plots. Thus the total number of plots was 30. Different combinations of bush bean varieties and nitrogen levels were assigned randomly to each block as per design of the experiment. The size of the unit plot was 2.5 m x 2.0m. The distance between the plot and the block were 50 cm and 100 cm, respectively.

3.6 Land preparation and fertilizer application

The land was opened with a tractor on 09 November 2011. Thereafter, it was ploughed and cross-ploughed several times with a power tiller. Each ploughing was followed by laddering to break the clods and to level the land. During land preparation, weeds and other stubbles of the previous crop were collected and removed from the land. These operations were done to bring the land for a good tilth condition. Irrigation channels were also made before sowing. All weeds and stubbles were removed and the land was finally prepared through addition of the inorganic and organic based N as per treatment.

3.7 Sowing of seeds

Seeds of BARI bush bean-1 and BARI bush bean-2 were sown on 22 November, 2011 following spacing 30 cm x 10 cm in line sowing . Two seeds were sown in each hill at a depth of 5.0 cm and the seeds were covered with fine soil by hand. Immediate after sowing irrigation was done. Surrounding of the experimental plots three rows of beans were sown as the boarder crop to protect the experimental crops from grazing by animals.

3.8 Intercultural operations

3.8.1 Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedling of about 15 cm height were transplanted from border rows with roots plunged 5 cm below the soil in the hills in the evening and then watering was done to protect the seedling from wilting. All gaps were filled up within two weeks after germination of seeds.

3.8.2 Thinning of seedlings

After 15 days of sowing one healthy plant hill^{-1} was kept and remaining one was plucked.

3.8.3 Weeding

The experimental plots were kept weed free by hand weeding.

3.8.4. Irrigation

Four irrigations were given throughout the growing period by a water can. The first irrigation was given at 15 days after sowing (DAT) and the next three at 15 days interval after the 1st irrigation.

3.8.5 Pest management

a) Insect pests

At the early stage of growth, some plants were attacked by insect Aphids and at the flowering and fruit setting stage attacked by white fly. Malathion 57 EC, and Ripcord were sprayed at the rate of 2ml/ litre at an interval of 15 days.

b) Diseases

Some plots were attacked by bean common Mosaic virus (BDMV) which *is* an important disease of bush bean-2 and root rot are found on experimental plot. The affected plants were removed from the plots to control Mosaic virus and Cupravit 7 gm L^{-1}, Ridomil Gold 2gm L^{-1} were sprayed to control further infestation of root rot. Insect vector of mosaic virus (white fly) was controlled by applying insecticides.

3.9 Harvesting

Immature green pods were harvested at lender stage, suitable for use as vegetable. At harvest, pods were nearly full size, with the seeds still small (about one quarter developed) with firm flesh (Swaider *et* al., 1992). First harvesting was done at 45 days after sowing (DAS). Again the pods were harvested at 15 days interval.

3.10 Collection of data

Five plants were randomly selected from the middle rows in each plot to avoid the border effect. Data were recorded from the sample plants during the course of experiment. The details of data recording are given below-

3.10.1 Plant height (cm)

The plant height was recorded at harvest by placing a meter scale from ground level to the tip of the largest leaf. Plant height of five randomly sample plants were recorded and mean was calculated in centimeter (cm).

3.10.2 Number of branch plant^{-1}

Number of branches plant^{-1} was recorded at harvest where all the primary and secondary branches were developed from each plant.

3.10.3. Number of flowers plant^{-1}

Number of flower plant^{-1} was counted randomly from early flowering.

3.10.4. Number of pods plot^{-1}

The number of pods was recorded from the sample plants and the average number of pods produced per plant was recorded at the time of final harvest.

3.10.5. Length of pod (cm)

Five pods from each randomly selected plant were measured using a scale and the mean value was calculated which was expressed in centimeter (cm).

3.10.6.Weight of pods plant^{-1} and plot^{-1} (g)

Pods were weighed on the basis of plot and their average weight was taken in gram (g). Average weight of pods plot^{-1} data was further calculated into pods weight plant^{-1} on the basis of total weight of pods (g plot^{-1}) divided into total plants plot^{-1}.

3.10.7 Pod yield (t ha^{-1})

Green pods were harvested from ten sample plants of each plot at four days interval and their total weight was recorded. Harvesting was done for four times and their weight was recorded in each unit plot from the plant population and expressed in kilogram (kg). The green pod yield per plot was finally converted to yield per hectare and expressed in ton (t).

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

After harvesting the plants, fruits were removed from plants and then those plants were sun-dried. After sun-dried the stover weight was recorded as per treatment with the help of a balance. Stover yield was converted to g.

3.11. Collection and analysis of soil sample

Soil samples were collected at 0-5 cm soil depths after the harvesting of crop from five locations of the experimental land. These samples were mixed together made a composite sample and analyzed for organic carbon, total nitrogen, available phosphorus, exchangeable potassium and available sulphur.

3.11.1 Organic carbon (%)

Walkley estimated soil organic carbon and Black's Wet oxidation Method as outlined by Jackson (1973).

3.11.2 Total nitrogen (%)

Total nitrogen in the soil sample was determined by the Micro Kjeldhal method (Page *et al.,* 1982) .The procedure was - digestion of soil sample by cone. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

3.11.3 Available phosphorus (ppm)

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pll 8.5 (Olsen *et al,* 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black, 1965).

3.11.4 Exchangeable potassium (meq 100 g^{-1} soil)

Exchangeable potassium in the soil samples was extracted in the normal ammonium acetate at pH 7.0 (Black, 1965) and was determined by using a flame photometer.

3.11.5 Available sulphur (ppm)

Available sulphur in the soil samples was determined by extracting the soil sample with 0.15%CaCl solution(Page et al 1982).The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by a spectrophotometer at 420nm wavelength.

3.12 Statistical Analysis

The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program by Completely Randomized Block Design (RCBD) (Russel, 1986). The analyses of variance for various crop characters and also for nutrient concentration were done following the principle of F-statistics. The mean values for all the parameters were calculate and the analysis of variance for the characters was accomplished by Duncan's Multiple Range Test (DMRT) and the significance of difference between pair of means was tested by the Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

CHAPTER - IV

RESULTS

AND

DISCUSSIONS

CHAPTER - IV
RESULTS AND DISCUSSIONS

The experiment was conducted to observe the effects of organic and inorganic based of nitrogen on the growth and yield of BARI bush bean. The results have been shown in various Tables, Figures and discussed under following headings.

4.1 Effect of varieties, nitrogen levels and their combinations on yield and yield attributing traits of bush bean

4.1.1 Effect of varieties

Plant height

Among the yield and yield contributing characters, plant height is one of the most efficient character for getting the higher yield of bush bean and also a key of higher straw yield incase of the tallest plant significantly influence the straw yield of bush bean. Analysis of variance data on the performance of variety significantly influence on plant height at harvest in this study (Fig. 1). Between two varieties, BARI bush-2 produced significantly the tallest plant (39.43 cm) than that of the variety BARI bush-1 (38.53cm) at harvest, respectively. These results revealed that, the variation in plant height was observed due to the variation in genetic variability and adaptability with the studied area. Similar findings were also obtained by Rana and Arvind, 2012 who found that the variation in plant height was indicated by the differentiation of genotypic characters and their genetic makeup also. Similar findings were also obtained by Kamanu *et al.* (2012), Safapour *et al.* (2011), El-Noemani *et al.* (2010) and many other scientists. Besides, the climatic and soil condition of studied area were favourable for better growth of Shakorkura. It was alsogetting proper soil nutrient for its higher growth as well as the tallest plant was recorded compare other varieties.

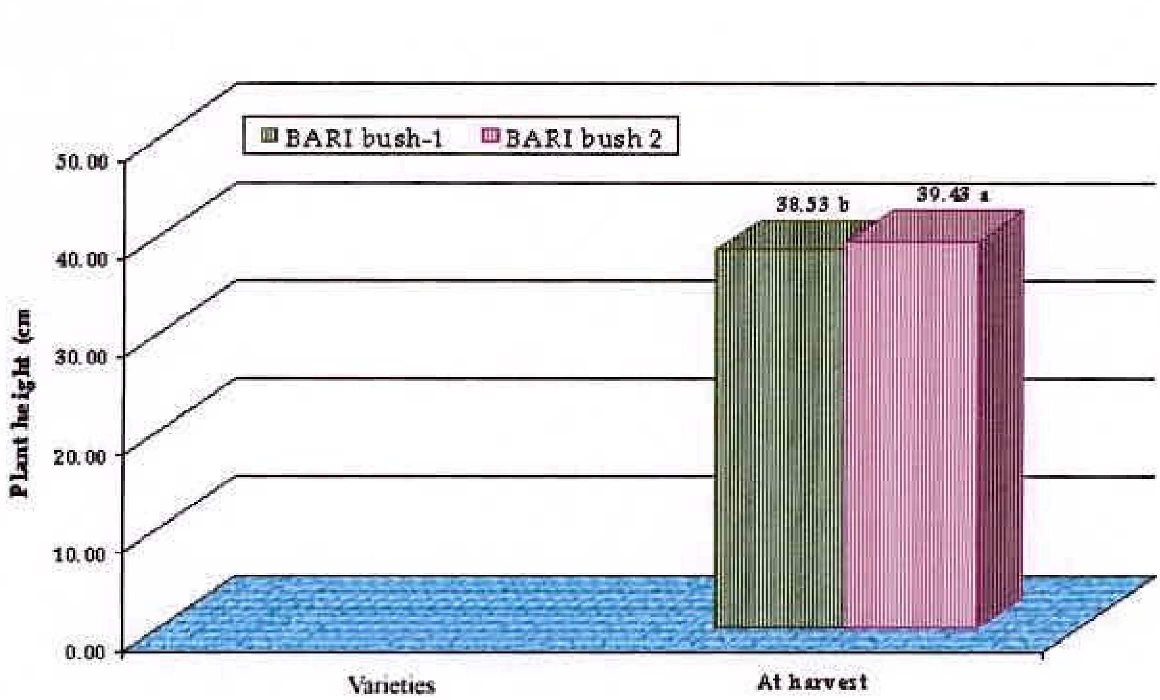

Fig. 1. Effect of varieties on plant height at harvest. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

Number of branches plant^{-1}

Statistical analysis of the data on number of branches plant^{-1} differed significantly among the genotypes (Fig. 2). From the Fig. 2, it was appeared that the branch production plant^{-1} had maximum (14.40) in BARI bush–2 than that of the variety BARI bush-1 (10.80). These results are fully agreed with the findings of El-Noemani *et al.* (2010) who also found that the branch production in the second season were significantly affected by bean varieties.

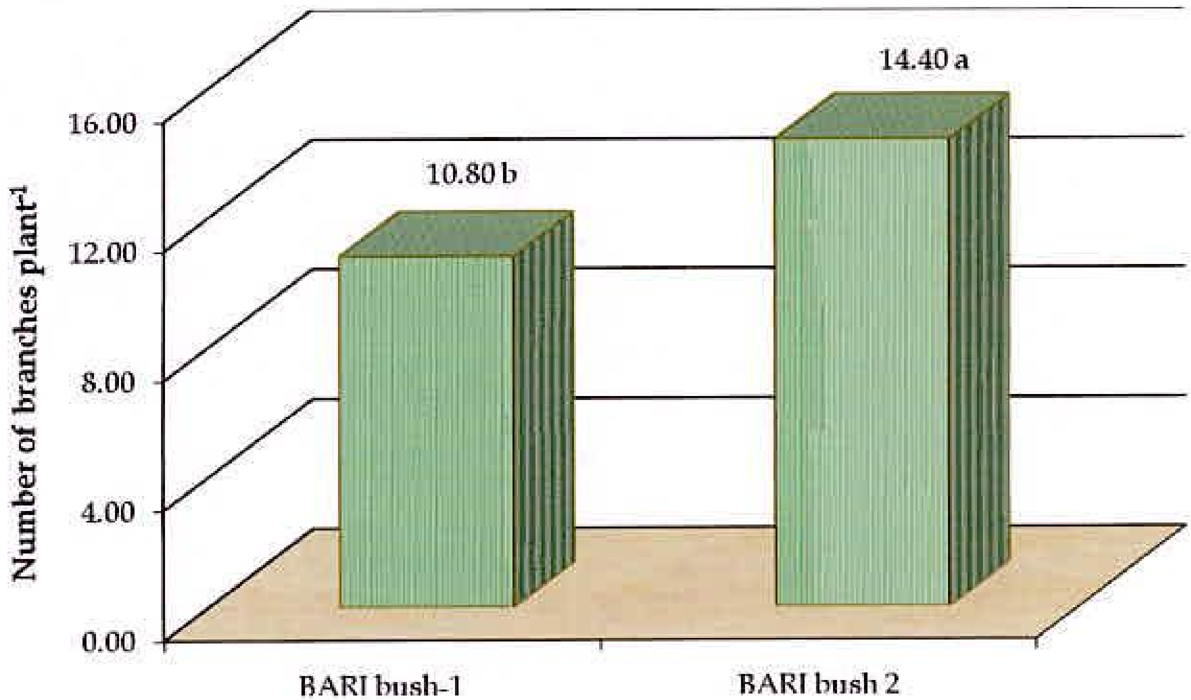

Fig. 2. Effect of varieties on number of branches plant^{-1} at harvest. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

Number of flowers plant^{-1}

Number of flowers plant^{-1} was significantly affected by the main effect of bush bean varieties in this study while number of flowers plant^{-1} data was recorded at 50% flowering stage (Fig. 3). The maximum number of flowers plant^{-1} (13.33) was recorded from the variety BARI bush-1 while another variety BARI bush-2 observed the minimum number of flowers plant^{-1} (6.30) which might be due to the proper soil nutrient achieved. This also might be due to the climatic condition and the regional adaptability was favourable for BARI bush-1 than BARI bush-2.

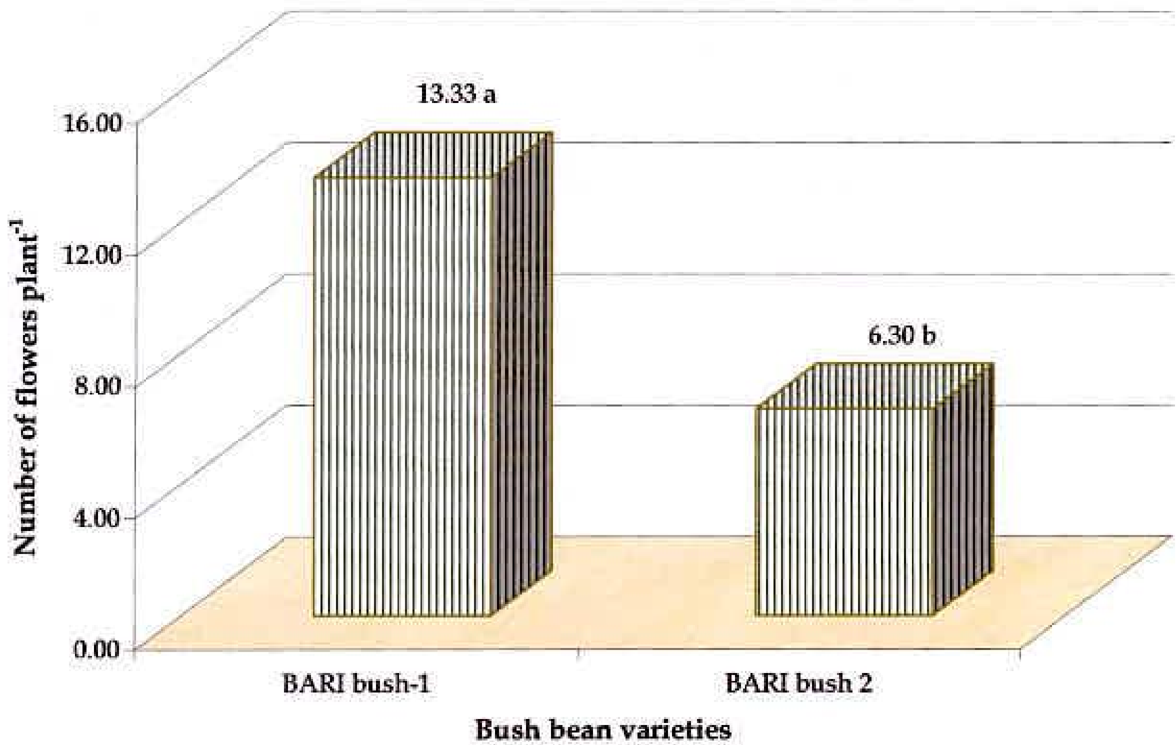

Fig. 3. Effect of varieties on number of flowers plant^{-1} at harvest. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

Number of pods plot^{-1}

Main effect of bush bean varieties was significantly influenced on the production of pods plot^{-1} at maturity (Table 3). From the Table 3, it was found that the variety BARI bush-1 produced significantly the maximum pods plot^{-1} (543.3) while the variety BARI bush-2 noticed significantly the minimum pods plot^{-1} (389.5). Similar agreement was also obtained by El-Noemani *et al.* (2010) who reported that pods no.of pods was significantly affected by bean varieties. Similar findings was also obtained by Dahmardeh *et al.* (2010), Sarangi and De (2010), Ayub *et al.* (2010) and many other researchers of our country.

Pod length

Length of pod showed significant difference between two varieties of bush bean in this study (Fig.4). Between two varieties, BARI bush-1 produced significantly the longest pod (13.72 cm) and BARI bush-2 observed the shortest pod (11.94 cm). This result was found might be due to the variation in the genetic make of the studied two varieties. Rana and Arvind, (2012) also found similar results where they reported that the maximum pod length was noticed in Arka Komal with 16.20 cm than other varieties. Similar results were also found by Sarangi and De (2010) and they found that pod length was significantly highest (16.35 cm) in the variety selection-9, which was at par with Contender (15.86 cm). Similarly, Dahmardeh *et al.* (2010) reported that the pod length significantly affected by the cultivars where Algazayeri cultivar produced the highest number of pods plant^{-1} (5.7) than that of other varieties. Ayub *et al.* (2010), Moniruzzaman *et al.* (2009) also reporte

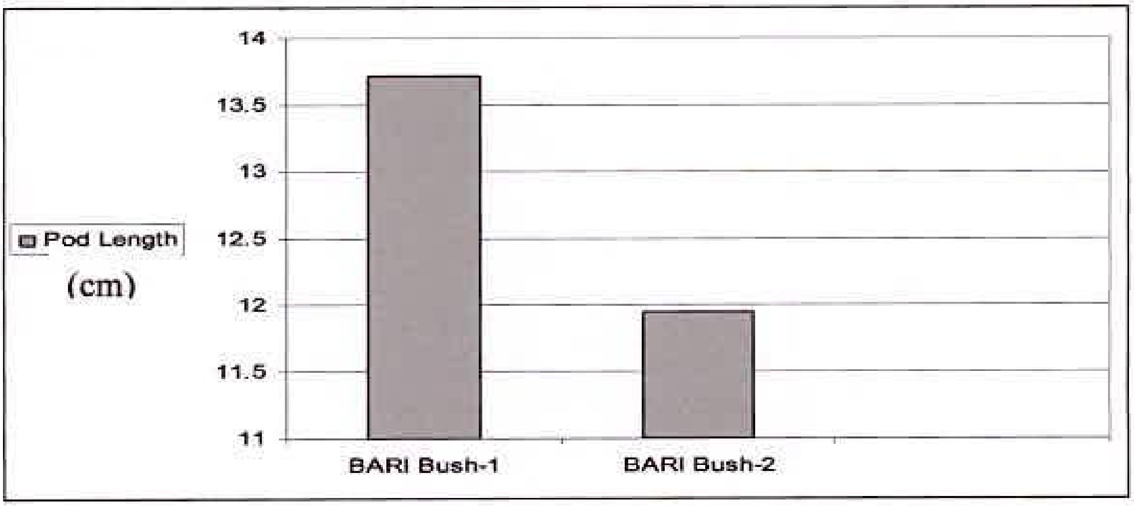

Fig. 4. Effect of varieties on pod length at harvest. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

Weight of pods plant^{-1}

Analysis of variance data on weight of pods plant^{-1} showed significant difference between two bush bean varieties in this study (Table 3). Weight of pods plant^{-1} had higher (138.26 g) in BARI bush-1 and lower (107.32 g) in BARI bush-2 which might be found due to the dissimilarity in the characteristics of the studied bush bean varieties. Similar results were also found by Sarangi and De (2010) and they found that highest mean pod yield of 747.92 g m^{-2} was observed in the variety Contender, whereas the variety Kentuky Wonder produced the lowest pod yield of 96.77 g m^{-2}. Noor-e-Alam Siddiqui (2010), Moniruzzaman *et al.* (2009) and many other scientists reported the similar results.

Weight of pods plot^{-1}

A significant variation was found due to the main effect of varieties regarding to weight of pods plot^{-1} (Table 3). Weight of pods plot^{-1} had higher (6040.0 g) in BARI bush-1 while BARI bush-2 observed the lowest weight of pods plot^{-1} (5456.66g). The variation in pod weight was found due to the variation of the genetic make up of the studied varieties. Similarly, Sarangi and De (2010) found that the highest mean pod yield of 747.92 g m^{-2} was observed in the variety Contender, whereas the variety Kentuky Wonder produced the lowest pod yield of 96.77 g m^{-2}. Noor-e-Alam Siddiqui (2010), Moniruzzaman *et al.* (2009) and many other scientists reported the similar results.

Pod yield

Pod yield data was also significantly influenced between the studied bush bean varieties(Table 3). Of the two bush bean varieties, BARI bush-1 produced significantly the higher yield of pod (12.08t ha^{-1}) than BARI bush-2 (10.09tha^{-1}). Between two varieties, BARI bush-1 produced significantly the higher pod yield which might be found due to the variation of the genetic make up of the varieties and also the variation of the adaptability range. Besides, BARI bush-1 had highly effective than BARI bush-2 to accumulate the soil nutrient of the study area. Rana and Arvind, (2012) reported the similar observation in his study where they found that the green pod yield was maximum in IIHR-909 (130.00 q ha^{-1}) followed by CH-808 (123.33 q ha^{-1}) and MFB-2 (114.07 q ha^{-1}). Similarly, Sarangi and De (2010) found that the highest mean pod yield of 747.92 g m^{-2} was observed in the variety Contender, whereas the variety Kentuky Wonder produced the lowest pod yield of 96.77 g m^{-2}. Noor-e-Alam Siddiqui (2010), Moniruzzaman *et al.* (2009) and many other scientists reported the similar results.

Table 3. Effect of varieties on yield contributing characters of Bush bean

Varieties	Number of pods $plot^{-1}$	Weight of pods (g $plant^{-1}$)	Weight of pods (g $plot^{-1}$)	Pod yield (t ha^{-1})
BARI bush-1	543.3	138.26	6040.00	12.08
BARI bush-2	389.5	107.32	5456.66	10.90
F-test	**	**	**	**
CV%	**3.26**	**4.72**	**13.07**	**20.63**

In a column figures having similar letter(s) do not differ significantly
**= Significant at 5% level of probability

Stover yield

The data on stover yield did not differ significantly between two varieties of bush bean in this study (Fig. 5). These results revealed that the variety BARI bush-1 and BARI bush-2 showed statistically identical stover yield (4.91 and 4.85t ha^{-1}, respectively). Similarly, Pawar *et al.* (2007) found that the varietals effect had significant on stover yield while the variety V_2 (PDR-14) recorded significantly superior stover yield (31.14 q ha^{-1}) over all other varieties.

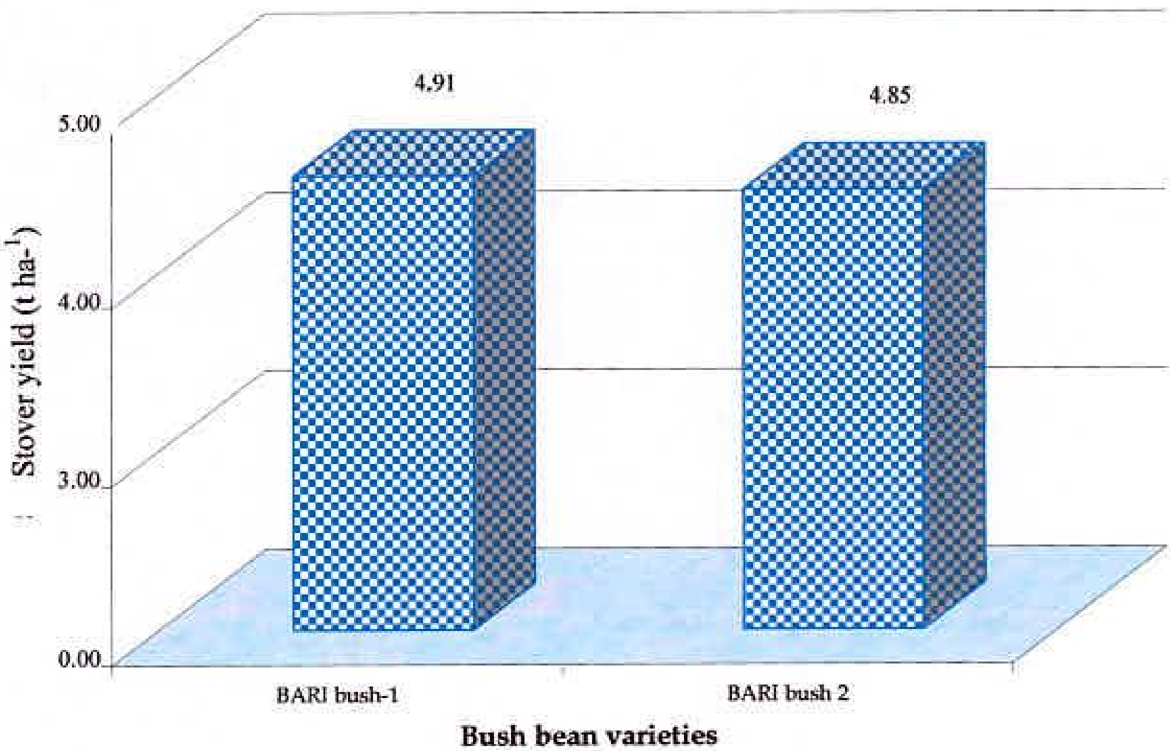

Fig. 5. Effect of varieties on stover yield at harvest. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

4.1.2 Effect of inorganic and organic based N levels

Plant height

Different levels of nitrogen exhibited significant variation in respect of plant height at harvest (Table 4). Inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1} (T_3) recorded the tallest plant of bush bean (42.00 cm) and the shortest plant (34.33 cm) was observed from the untreated plot of organic and inorganic N (T_5: control treatment) at final harvest . Ayub *et al.* (2010) reported the similar observation where they found that the application of nitrogen significantly increased the plant height and 50 kg ha^{-1} N recorded the tallest plant.

Similarly, Noor-e-Alam Siddiqui (2010) reported that nitrogen application affected significantly on plant height while 150 kg ha^{-1} was more effective than other doses of N. This result is in full agreement with Moniruzzaman *et al.* (2009), Singh *et al.* (2009), Hossain (2007) and many other scientists showed that the highest rates of nitrogen (120 kg ha $^{-1}$) resulted in the highest plant height.

Number of branches plant^{-1}

Number of branches plant^{-1} data was recorded at harvest and data was presented in table indicated significant difference among the levels of organic and inorganic based N. From the Tab. 4, it was found that the maximum number of branches plant^{-1} (15.50) was found from the treatment T_3 (inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1}) while control treatment (without organic or inorganic N) observed the minimum branches plant^{-1} (11.00). Similarly, Noor-e-Alam Siddiqui (2010) reported that nitrogen application affected significantly on branch production while 150 kg ha^{-1} was more effective than other doses of N. This result is in full agreement with Moniruzzaman *et al.* (2009), Hossain (2007) and many other scientists who found that the N application @ 120 kg ha $^{-1}$ had highly efficient on branch production.

Number of flowers plant^{-1}

Number of flower plant^{-1} was affected significantly at 5% level of probability due to the effect of different doses of organic and inorganic based N (Table.4). Among the treatments, the maximum number of flowers plant^{-1} (10.50) was observed in inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1} (T_3) which was statistically identical (10.50) with inorganic N fertilizer application @ 90 kg ha^{-1} (T_1). It was also statistically followed (6.58 and 9.66) by the treatment T_2 (inorganic N fertilizer @ 70 kg ha^{-1} and organic N fertilizer @ 20 kg ha^{-1}) and T_4 (inorganic N fertilizer @ 90 kg ha^{-1}), respectively while the minimum number of flowers $plant^{-1}$ (8.83) was observed in control or without organic and inorganic N fertilizer (T_5) whereas treatment T_2 and T_4 were also statistically identical.

Table 4: Effect of different doses of inorganic and organic based N on plant height, branches $plant^{-1}$ and flowers $plant^{-1}$ of Bush bean

Treatment	Plant height (cm) at harvest	Number of branches $plant^{-1}$	Number of flowers $plant^{-1}$
T_1	39.08 c	12.00 b	10.50 a
T_2	39.00 c	12.17 b	9.58 ab
T_3	42.00 a	15.50 a	10.50 a
T_4	40.50 b	12.33 b	9.67 ab
T_5	34.33 d	11.00 c	8.83 b
F-test	**	**	*
CV%	**2.83**	**4.78**	**9.18**

In a column figures having similar letter(s) do not differ significantly
*= Significant at 5% and **= Significant at 1% level of probability
T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)
In a column figures having similar letter(s) do not differ significantly
**= Significant at 5% level of probability

No. of pods plot^{-1}

The number of pods plot^{-1} in observing with different levels of nitrogen was found to be significant at 1% level of probability (Table 5). The maximum number of pods plot^{-1} (553.8) was produced from the treatment T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}). On the contrary, the control treatment (T_5) produced the minimum number of pods plot-^{1} (386.25) (Table 5). It may be due to adequate supply of nitrogen to develop pod bearing branches. This result is in full agreement with Singh *et al*. (2009) who reported that higher number of pods plant^{-1} was recorded in 180 kg ha^{-1} N application. Moniruzzaman *et al*. (2008) also reported that there was a significant effect of N fertilizers on pods production plant^{-1} whereas the maximum pod plant^{-1} was obtained with 120-120 60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung ha^{-1}.

Pod length

Effect of different doses of organic and inorganic based nitrogen influenced significantly in respect of pod length (Table 5). From the Table 5, it was found that the length of pod increased significantly due to increasing dose of organic nitrogen fertilizer along with inorganic fertilizer. The longest pod of bush bean (14.00 cm) was found in the crop grown with the inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1} while inorganic N fertilizer @ 70 kg ha^{-1} along with organic N fertilizer @ 20 kg ha^{-1} observed the statistically identical length of pod (13.40 cm). The shortest pod (11.33 c) was observed from the control (0 kg organic and inorganic N ha^{-1}) treatment which was statistically differed from other treatments (Table 5). This result is in full agreement with Moniruzzaman *et al*. (2009). He reported that pod length was significantly influenced by higher dose of nitrogen. Singh *et al.* (2009) also found significant variation in pod length regarding to N application.

Weight of pods plant^{-1}

A significant influence was observed in respect of pod weight plant^{-1} at different levels of organic and inorganic nitrogen (Table 5). The highest pod weight plant^{-1} (153.66 g) was obtained from the treatment T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) while control treatment (T_5) observed the lowest pods weight plant^{-1} (97.0 g) whereas both treatment were statistically differed from other N treatments (Table5). It was clearly observed that there was a positive effect of nitrogen on the pod weight plant-^{1}. The result is similar to that of Ayub *et al.* (2010) who found that 50 kg N ha^{-1} took significantly the higher pods weight plant^{-1}. Similar findings were also obtained by Hossain (2007), Shamima (2005) and many other scientists.

Weight of pods plot^{-1}

Effect of different doses of organic and inorganic based N fertilizer showed significant different regarding to weight of pods plot^{-1} (Table.5). Among the organic and inorganic based N treatments, the highest weight of pods plot^{-1} (6546.0 g) was obtained from the treatment T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) and the lowest weight of pods plant^{-1} (4423.0 g) was recorded from the without inorganic and organic based N (control treatment) (Table.5). It was clearly observed that there was a positive effect of nitrogen on the pod weight plant^{-1}. The result is similar to that of A field study was conducted by Singh *et al.* (2009) who found that the 10-pod weight were recorded with 180 kg ha^{-1} N application than that of other N doses. Moniruzzaman *et al.* (2008) also reported that yield and yield components of French bean were significantly influenced by different fertilizer treatments containing macro and micronutrients separately whereas the highest pod yield of 23.14 t ha^{-1} was obtained with 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung ha^{-1}.

Pod yield

The results indicated that nitrogen had profound effect on pod yield while application of N had highly significant on pod production (Table 6). Among the N treatments, the maximum pod yield (13.08 t ha^{-1}) was obtained from the application of inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1} and the minimum pod yield (8.84 t ha^{-1}) in control (without organic and inorganic N). This result revealed that the pod yield increased with increasing doses of organic nitrogen up to 20 kg ha^{-1} while rest amount of N was used as inorganic based N. This result was found which might be due to higher branch production, longest pod, higher pod diameter and pods $plant^{-1}$ enhance the total pod yield. This result is in full agreement with Singh *et al.* (2009) who reported that reduction in number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod diameter, pod length, number of green seeds per pod and 10- pod weight were responsible for lower green pod yield with low nitrogen application (80 kg/ha). Similarly, Kovacs *et al.* (2008) found significant difference on pod production.

Table.5. Effect of different doses of inorganic and organic based N on yield contributing characters of Bush bean

Treatment	Number of pods plot^{-1}	Pod length (cm)	Weight of pods (g plant^{-1})	Weight of pods (g plot^{-1})
T_1	481.35b	12.72 b	105.84 c	5557 c
T_2	451.5 c	13.40 a	108.84c	5829 b
T_3	553.8 a	14.00 a	153.66a	6546 a
T_4	443.85 c	12.72 b	118.66b	5965 b
T_5	286.25d	11.33 c	97.0 d	4423 d
F-test	**	**	**	**
CV%	**3.26**	**4.09**	**4.72**	**13.07**

In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)

Stover yield

A significant variation was experienced in respect of stover yield due to different levels of organic and inorganic based N (Table. 6). Among the N treatments, the maximum stover yield (5.91 t ha^{-1}) was recorded from the treatment T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) which was statistically differed from other organic and inorganic N. On the other hand, the minimum stover yield (4.53 t ha^{-1}) was found from the control treatment while inorganic N @ 90 kg ha^{-1} (T_1), organic N @ 90 ha^{-1} (T_4) were produced statistically identical minimum stover yield (4.62 and 4.61 t ha^{-1}, respectively). Similarly, Kamanu *et al.* (2012) reported that the inorganic fertilizer application 91 kg N ha^{-1} as DAP-CAN had the highest stover yield. Eric Simonne *et al.* (2012), Ayub *et al.* (2010) and so many researcher were found significant variation in grain yield.

Singh and Verma (2002) showed that the highest rates of nitrogen (120 kg ha "') resulted in the highest stover yield with 120 kg N ha"[1]. Similar opinion was also

forward by Vishwakarma *et al.* (2002).

Table 6.Effect of different doses of inorganic and organic based N on yield contributing characters of Bush bean.

Treatment	Pod yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)
T_1	11.10 c	4.62 c
T_2	11.64c	4.74 b
T_3	13.08 a	5.91 a
T_4	11.92b	4.61 c
T_5	8.84d	4.53d
F-test	**	**
CV%	**20.63**	**10.72**

In a column figures having similar letter(s) do not differ significantly
**= Significant at 1% level of probability

T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)

4.1.3 Combined effect between varieties and inorganic and organic based N levels

Plant height

Combined effect between bush bean varieties and different levels of organic and inorganic based nitrogen exhibited significant variation regarding to plant height (Table7). From the Table7, treatment combination of V_2T_3 (inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1}) recorded the tallest plant (42.67 cm) at harvest while it was statistically followed by the treatment combination of V_1T_3 (inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1}) and V_2T_4 (organic N @ 90 kg ha^{-1}) whereas treatments combination of V_1T_3 and V_2T_4 were statistically identical at harvest. The shortest plant (34.00 cm) was found from the variety BARI bush-1 under control treatment (V_1T_5) which was also statistically identical (34.67 cm) with the similar N treatment of the variety BARI bush-2 (V_2T_5). The present study was similar in agreement of Noor-e-Alam Siddiqui (2010) who fond that plant height increased with the increased level of N up to 150 kg ha^{-1} in BARI jarsheem-1.

Number of branches plant^{-1}

Combined effect of the studied bush bean varieties and different doses of organic and inorganic N fertilizer significantly was influenced on number of branches plant^{-1}(Table 7). Among the treatment combinations, interaction treatment of V_2T_3 (inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1}) recorded the maximum branches plant^{-1} (16.33) which was statistically differed from other treatment combinations. The variety BARI bush-1 under control treatment (V_1T_5) observed the minimum branches plant^{-1} (9.00) which was also statistically differed from other treatment combinations.

However, it was statistically close with the treatment combinations of V_1T_1 and V_1T_2 (both similar branches plant^{-1} 10.00) where V_1T_1 and V_1T_2 were statistically close (Table 5). The present study was similar in agreement of Noor-e-Alam Siddiqui (2010) who fond that number of primary branches plant^{-1} increased progressively with the increased level of N up to 150 kg ha^{-1} in BARI harsheem-1. Moniruzzaman *et al.* (2009) also reported the similar findings branch production was significantly influenced by variety × nitrogen whereas the maximum branches plant^{-1} was obtained from V_1N_2 treatment combination. Similar result was also found by Singh *et al.* (2009).

Number of flowers plant^{-1}

Analysis of variance data on number of flower plant^{-1} affected significantly due to the combined effect of varieties and different doses of organic and inorganic based N (Table 7). Among the treatment combinations, the maximum number of flowers plant^{-1} (14.50) was observed in V_1T_3 (inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1}) while it was statistically close (14.00 and 13.00) with the similar variety in both 90 kg ha^{-1} organic and inorganic N fertilizer treatments (V_1T_1 and V_1T_4, respectively) whereas V_1T_1 and V_1T_4 were statistically close. On the other hand, the minimum number of flowers plant^{-1} (5.00) was taken from the variety BARI bush-2 under control treatment which was also statistically followed (6.33 and 6.50) by the similar variety in 90 kg ha^{-1} organic fertilizer (V_2T_4) and 50 kg inorganic + 40 kg organic N ha^{-1} (V_2T_3), respectively whereas V_2T_4 and V_2T_3 were also statistically identical.

Table 7.Combined effect between varieties and different doses of inorganic and organic based N on morphological characters of Bush bean

Treatment combinations	Plant height at harvest(cm)	Number of branches plant^{-1}	Number of flowers plant^{1}
V_1T_1	40.00 bc	10.00 de	14.00 ab
V_1T_2	37.33 d	10.00 de	12.50 b
V_1T_3	41.33 ab	14.67 b	14.50 a
V_1T_4	40.00 bc	10.33 d	13.00 ab
V_1T_5	34.00 e	9.00 e	12.67 b
V_2T_1	38.17 cd	14.00 bc	7.00 c
V_2T_2	40.67 b	14.33 b	6.66 c
V_2T_3	42.67 a	16.33 a	6.50 cd
V_2T_4	41.00 ab	14.33 b	6.33 cd
V_2T_5	34.67 e	13.00 c	5.00 d
F-test	*	**	**NS**
CV%	**2.83**	**4.78**	**9.18**

V_1: BARI bush-1
V_2: BARI bush-2

T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)
In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

No. of pods plot^{-1}

A highly significant variation was also obtained by the combined effect between varieties and N fertilizer (Table 8). The maximum number of pods plot^{-1} (606.45) was produced from the treatment combination of V_1T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) and it was statistically identical (450.0) with the treatment combination of V_1T_5

(control treatment). On the contrary, the variety BARI bush-2 under control treatment (V_2T_5) produced significantly the minimum number of pods plot^{-1} (322.5) which was statistically differed from other combinations (Table 8). It may be due to adequate supply of nitrogen to develop pod bearing branches. This result is in full agreement with Moniruzzaman *et al.* (2009) reported that pod production was significantly influenced by variety vs nitrogen whereas the highest number of green pods plant^{-1} was found from V_2N_2 treatment. The treatment V_1N_2 produced the highest green pod weight plant^{-1} (96.5 g) and green pod yield (30.0 t ha^{-1}).

Pod length

Combined effect of varieties and different doses of organic and inorganic based nitrogen fertilizer influenced significantly regarding to pod length (Table 8). From the Table 8, it was observed that the length of pod increased significantly due to increasing dose of organic nitrogen fertilizer along with inorganic fertilizer for both varieties. As a result, the longest pod (15.00 cm) was found in those BARI bush-1 crops grown under inorganic N fertilizer @ 50 kg ha^{-1} and organic N fertilizer @ 40 kg ha^{-1} (V_1T_3) while BARI bush-1 also grown under inorganic N fertilizer @ 70 kg ha^{-1} along with organic N fertilizer @ 20 kg ha^{-1} (V_1T_2) observed the statistically close length of pod (14.50 cm). The shortest pod (10.50 cm) was observed from the variety BARI bush-2 under control treatment (0 kg organic and inorganic N ha^{-1}) which was statistically differed from other treatment combinations (Table 8). This result is in full agreement with Singh *et al.* (2009) who reported that the interaction effect between varieties and N application had significant on pod length where Pant Anupam was highly responsive for higher dose of nitrogen application.

Weight of pods plant^{-1}

Weight of pods plant^{-1} also affected significantly due to the combined effect between varieties and application of N fertilizer (Table 8). The highest pod weight plant^{-1} (163.66 g) was obtained from the treatment combination of V_1T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) which was statistically identical (157.0 g) with similar variety under 90 kg ha^{-1} organic fertilizer treatment (V_1T_4). The lowest pods weight plant^{-1} (77.34 g) was found from the variety BARI bush-2 under control treatment (V_2T_5) which was statistically differed from other treatment combinations (Table 8). It was clearly observed that there was a positive effect of nitrogen on the pod weight plant^{-1}. The result is similar to that of Noor-e-Alam Siddiqui (2010) who found that green pod yield increased up to 150 kg N ha^{-1} in BARI Jharsheem-1 and up to 100 kg N ha^{-1} in the genotypes BB-9 and BB-15.

Weight of pods plot^{-1}

Weight of pods plot^{-1} was also significantly affected at 1% level of probability due to the effect of varieties and different doses of organic and inorganic based N fertilizer(Table 8). Among the treatment combinations, the highest weight of pods plot^{-1} (6642.0 g) was obtained from the treatment combination of V_1T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) which was statistically differed from other treatment combinations. The lowest pods weight plot^{-1} (4026.0 g) was found from the variety BARI bush-2 under control treatment (V_2T_5) which was statistically identical with the treatment combinations of V_2T_4 (5490.0 g), V_2T_2 (5638.0 g), V_2T_1 (5180.0 g) and V_1T_5 (4820.0 g) (Table 8). It was clearly observed that there was a positive effect of nitrogen on the pod weight plant^{-1}. The result is similar to that of This result is in full agreement with the findings of Moniruzzaman *et al.* (2009) who reported that pod production was significantly influenced by variety vs nitrogen whereas the treatment V_1N_2 produced the highest green pod weight plant^{-1} (96.5 g) and green pod yield (30.0 t ha^{-1}). Similarly, Singh *et al.* (2009) reported that all the varieties revealed higher green pod plot^{-1} with 180 kg N application but the highest response was shown by variety CHFB-2 (3.35 kg plot^{-1}). Similar findings was also obtained by Noor-e-Alam Siddiqui (2010).

Pod yield

Significant difference was found by the combined effect of bush bean varieties and different levels of N in respect of pod production (Table 9). As a result, the maximum pod yield (13.28 t ha^{-1}) was taken from the variety BARI bush-1 while inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1} was applied. Similarly, the minimum pod yield (8.04 t ha^{-1}) was in BARI bush-2 under control (without organic and inorganic N) which was statistically followed by the treatment combinations of V_2T_4 (10.98 t ha^{-1}), V_2T_2 (11.26 t ha^{-1}), V_2T_1 (10.36 t ha^{-1}) and V_1T_5 (9.64 t ha^{-1}) whereas treatment combinations of V_2T_4, V_2T_2, V_2T_1 and V_1T_5 were statistically identical (Table 9). This result revealed that the pod yield increased with increasing doses of organic nitrogen up to 20 kg ha^{-1} for both bush bean varieties while rest amount of N was used as inorganic based N. This result is in full agreement with Kamal (2007). He reported that pod yield increased with increasing doses of organic nitrogen up to 20 kg ha^{-1} while rest amount of N was used as inorganic based N. Similar opinion was also put forward by Moniruzzaman *et al.* (2009) who reported that pod production was significantly influenced by variety vs nitrogen whereas the treatment V_1N_2

produced the highest green pod weight plant^{-1} (96.5 g) and green pod yield (30.0 t ha^{-1}). Similar result was also obtained by Singh *et al.* (2009).

Table 8. Combined effect of varieties and different doses of inorganic and organic based N on yield contributing characters of Bush bean

Treatment combinations	Number of pods plot^{-1}	Pod length (cm)	Weight of pods (g plant^{-1})	Weight of pods (g plot^{-1})
V_1T_1	602.5 a	13.00 c	120.34 d	5934.0 d
V_1T_2	547.5 b	14.50 ab	133.66 c	6020.0 d
V_1T_3	606.45 a	15.00 a	163.66 a	6642.0 a
V_1T_4	540.0b	13.93 b	157.0a	6440.0 c
V_1T_5	450.0 d	12.17 cd	116.66d	4820.0 f
V_2T_1	361.05 e	12.43 c	91.34e	5180.0 f
V_2T_2	355.5e	12.31 cd	84.00ef	5638.0 e
V_2T_3	501.0c	13.00 c	143.66 b	6450.0 b
V_2T_4	347.5e	11.50 d	80.34 f	5490.0 e
V_2T_5	322.5 f	10.50 e	77.34g	4026.0 g
F-test	**	*	**	**
CV%	**3.26**	**4.09**	**4.72**	**13.07**

V_1: BARI bush-1
V_2: BARI bush-2

T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)

In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

Stover yield

A significant variation was examined in respect of stover yield due to the combined effect between bush bean varieties and different levels of organic and inorganic based N fertilizer (Table 9). Among the treatment combinations, the maximum stover yield (6.05 t ha^{-1}) was recorded from the treatment combination of V_1T_3 (inorganic N fertilizer @ 50 kg ha^{-1} along with organic N fertilizer @ 40 kg ha^{-1}) which was statistically differed from other treatment combinations. On the other hand, the minimum stover yield (4.50 t ha^{-1}) was found from the treatment combination of V_1T_5 (control treatment) which was closely followed by the variety BARI bush-2 under control treatment (V_2T_5), organic N @ 90 kg ha^{-1} (V_2T_4), inorganic N @ 90 ha^{-1} (V_2T_1) (4.55, 4.55 and 4.59 t ha^{-1}, respectively) were these three treatment combinations were statistically identical.

Table 9. Combined effect of varieties and different doses of inorganic and organic based N on yield characters of Bush bean

Treatment combinations	Pod yield (t ha^{-1})	Stover yield (t ha^{-1})
V_1T_1	11.86 ef	4.65 d
V_1T_2	12.04d	4.66 cd
V_1T_3	13.28 a	6.05 a
V_1T_4	12.88c	4.66 cd
V_1T_5	9.64f	4.50 e
V_2T_1	10.36ef	4.59 de
V_2T_2	11.26ef	4.80 c
V_2T_3	12.90b	5.76 b
V_2T_4	10.98 ef	4.55 de
V_2T_5	8.04 g	4.55 de

F-test	**	**
CV%	**20.63**	**10.72**

V_1: BARI bush-1
V_2: BARI bush-2
T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)

In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

4.2 Effect of varieties, nitrogen levels and their combinations on exchangeable nutrient content of the studied soils

4.2.1 Main effect of varieties

Organic carbon content (%)

Percentage of organic carbon content varied significantly due to the main effect of varieties in this study (Table 10). Between two varieties, organic carbon content had highly increase (0.64%) in the plot of BARI bush-1 and it was comparatively lower (0.61%) in the plot of BARI bush-2 while the organic matter carbon content of initial soil was less than 1.0%

Total nitrogen content (%)

Nitrogen content did not differ significantly between two varieties in case of the N content were statistically identical between them (Table 10). However, the total nitrogen value of the initial soil was 0.06%.

Phosphorus content (ppm)

Available phosphorus of the studied soil was presented in the table 10 which was significantly influenced by the effect of varieties . The highest value of available phosphorus obtained (16.64 ppm) in the plot of BARI bush-1 while the plot of BARI bush-2 recorded the lowest available phosphorus (16.19 ppm) of studied soil whereas the available phosphorus of initial soil was (25ppm).

Potassium content (ppm)

Potassium content of the studied soil varied due to the effect of varieties (Table 10). The highest potassium content (0.23 meq $100g^{-1}$) was obtained from the plot of variety BARI bush-1 while comparatively lower potassium content (0.20 meq $100g^{-1}$) was found from the plot of variety BARI bush-2. However, the potassium content of initial soil was (0.24 meq $100g^{-1}$).

Sulphur content (ppm)

Sulphur content of the studied soil was significantly influenced by the bush bean varieties (Table 10). Between two varieties, BARI bush-1 plot recorded the maximum sulphur content (21.61 ppm) than BARI bush-2 plot (16.42 ppm) in the studied soil whiles the sulphur content of initial soil was (25.0 ppm).

Table 10. Effect of varieties on Carbon, total N, available P, exchangeable K and available S contents of post harvest soils

Varieties	C (%)	N	P	K(meq/100g)	S(ppm)
BARI bush-1	0.64 a	0.063	16.64 a	0.23 a	21.61 a
BARI bush-2	0.61 b	0.063	16.19 b	0.20 b	16.42 b
F-test	**	**NS**	**	**NS**	**
CV%	**0.61**	**0.065**	**20.20**	**0.27**	**25.87**

In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

4.2.2 Main effect of inorganic and organic based N levels

Organic carbon content (%)

Analysis of variance data on organic carbon (%) was significantly influenced by the effect of different doses of organic and inorganic based N (Table 11). Among the organic and inorganic based N doses, carbon content range was 0.51 to 0.68 where the maximum carbon content was observed in the treatment T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}) and minimum carbon content was recorded in the treatment T_5 (control or without organic and inorganic based N). However, organic N @ 90 kg ha^{-1} (T_4) noticed the statistically higher identical carbon (0.668%) and it was closely followed by inorganic N @ 70 kg ha^{-1} and organic N @ 20 kg ha^{-1} (T_2) (0.651%).

Nitrogen content (%)

Nitrogen content of the studied soil did not vary significant due to the effect of different doses of organic and inorganic based nitrogen application (Table 11). However, the nitrogen content was varied from 0.054 to 0.069% which were from the treatment T_5 (control) and T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}), respectively but they were statistically identical.

Phosphorous content (ppm)

Statistically significant variation was also observed in phosphorous content in the studied soil when different doses of nitrogen were applied (Table 11). The P content ranged from 14.89 to 17.49 ppm. Among the different doses of nitrogen, the highest phosphorous content (17.49 ppm) was recorded in the treatment T_3 (inorganic N @ 50 kg ha^{-1} along with organic N @ 40 kg ha^{-1}) which was significantly differed from other N treatments. In contrast, the lowest phosphorous content (14.89 ppm) was recorded in the T_5 treatment where no organic or inorganic nitrogen was applied.

Potassium content (ppm)

Exchangeable Potassium content of the studied soil did not differ significantly due to the application of different doses of organic and inorganic based N (Table 11). As a result, all the treatments of N were statistically identical among them regarding to potassium content.

Sulphur content (ppm)

A highly significant variation was observed in available sulphur content of the studied soil due to the application of different doses of organic and inorganic N (Table 11). Among the organic and inorganic N application, the maximum sulphur content (22.00 ppm) was found from the treatment T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}) while control treatment (T_5) minimum sulphur content (15.00 ppm).

Table 11. Effect of inorganic and organic based N on Carbon, total N, available P, exchangeable K and available S contents of post harvest soils

Fertilizer	C (%)	N(%)	P(ppm)	K(meq/100g)	S(ppm)
T_1	0.618 b	0.062	16.54 c	0.20	15.75 c
T_2	0.651 ab	0.065	16.01 d	0.21	16.28 c
T_3	0.681 a	0.069	17.49 a	0.23	22.00 a
T_4	0.668 a	0.064	17.16 b	0.21	20.20 b
T_5	0.516 c	0.054	14.89 e	0.17	15.00 d
F-test	**	**NS**	**	**NS**	**
CV%	**0.61**	**0.065**	**20.20**	**0.27**	**25.87**

T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)
In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

4.2.3 Combined effect between varieties and inorganic and organic based N levels

Organic carbon content (%)

A significant variation was found due to the combined effect of bush bean varieties and different doses of organic and inorganic based N (Table 12). Among the treatment combinations, the carbon content range was 0.49 to 0.68% where the maximum carbon content was observed in the treatment combinations of V_1T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}) which was statistically identical with the treatment combinations of V_2T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}), V_1T_4 (organic N @ 90 kg ha^{-1}), V_2T_4 (organic N @ 90 kg ha^{-1}) and V_1T_2 (inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}) (0.68, 0.67, 0.66 and 0.66%, respectively). The minimum carbon content was recorded in the treatment combination of V_2T_5 (control or without organic and inorganic based N).

Nitrogen content (%)

Nitrogen content of the studied soil did not vary significant due to the combined effect between bush bean varieties and application of different doses of organic and inorganic based nitrogen (Table 12). These results revealed that all the treatment combinations were statistically identical regarding to nitrogen content.

Phosphorous content (ppm)

Analysis of variance data regarding to available phosphorus content was significantly influenced by the combined effect of varieties and N content (Table 12). Among the treatment combinations, the P content ranged was from 14.80 to 17.99 ppm whereas the highest phosphorous content (17.99 ppm) was recorded from the treatment combination of V_1T_3 (inorganic N @

50 kg ha^{-1} along with organic N @ 40 kg ha^{-1}) and the lowest phosphorous content (14.80 ppm) was recorded from the treatment combination of V_2T_5 (without any N).

Potassium content (ppm)

Exchangeable Potassium content of the studied soil did not vary significantly due to the combined effect of varieties and application of organic and inorganic based N (Table 12). As a result, all the treatment combination between varieties and N doses were produced statistically identical potassium content.

Sulphur content (ppm)

Available Sulphur content of the studied soil showed significant difference at 1% level of probability by the combined effect between varieties and application of organic and inorganic N (Table 12). From the Table 12, it was found that the available sulphur content range was 15.00 to 22.00 ppm while the maximum sulphur content (22.00 ppm) was found from the treatment combination of V_2T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}) and the lowest S content (15.01 ppm) was found in V_2T_5. However, the results of V_2T_5 were statistically identical with V_1T_5.

Table 12. Carbon, total N, available P, exchangeable K and available S contents of post harvest soils

Treatment combinations	C (%)	N (%)	P (ppm)	K (meq/100g)	S (ppm)
V_1T_1	0.643 ab	0.061	16.43 f	0.21 ab	16.00 f
V_1T_2	0.660 a	0.064	15.99 g	0.22 b	16.66 e
V_1T_3	0.686 a	0.067	17.99 a	0.23 a	22.01 a
V_1T_4	0.673 a	0.065	17.82 b	0.20 c	20.40 c
V_1T_5	0.543 cd	0.057	14.99 h	0.18 d	15.02 h
V_2T_1	0.593 bc	0.064	16.65 d	0.19d	15.50 g
V_2T_2	0.643 ab	0.067	16.02 g	0.20 c	15.90g
V_2T_3	0.676 a	0.071	16.99 c	0.22 b	22.00 b
V_2T_4	0.663 a	0.063	16.49 e	0.21ab	20.01 d
V_2T_5	0.490 d	0.051	14.80 i	0.16 e	15.01 h
F-test	**	**NS**	**	**NS**	**
CV%	**0.61**	**0.065**	**20.20**	**0.27**	**25.87**

V_1: BARI bush-1
V_2: BARI bush-2

T_1: Inorganic N @ 90 kg ha^{-1}
T_2: Inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}
T_3: Inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}
T_4: Organic N @ 90 kg ha^{-1}
T_5: control (without inorganic and organic N)

In a column figures having similar letter(s) do not differ significantly
NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

From the above investigated results of the present study, it was appeared that the studied bush bean varieties and application of inorganic and organic N fertilizer singly or their combined significantly influenced on most of the growth and yield characters as well as nutrient content of studied soil at studied region. Whereas, BARI bush-1 and inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1} singly or their combination were more significant on most of the growth and yield characters of bush bean due to the genetic differences of the studied varieties and also the variation of organic and inorganic N fertilizer doses. So, the variety BARI bush-1 and 50 kg inorganic N ha^{-1} + 40 kg organic N ha^{-1} would be suitable variety and appropriate doses of inorganic and organic based N for obtaining the better growth and higher yield.

CHAPTER - V
SUMMARY
AND
CONCLUSIONS

CHAPTER - V

SUMMARY AND CONCLUSIONS

The present experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from November 2011 to March 2012 to study on the performance of growth, yield and yield contributing traits as influenced by two bush bean cultivars along with five levels of organic and inorganic based N that are suitable to cultivate at the Madhupur track under AEZ-28. So, therefore, the present research work consists of two sets of treatments; the first set comprised of two bush bean cultivars *viz.* BARI bush bean-1 (V_1) and BARI bush bean-2 (V_2) and the second set consisted of five different levels of organic and inorganic based nitrogen *viz.* inorganic N @ 90 kg ha^{-1} (T_1), inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1} (T_2), inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1} (T_3), organic N @ 90 kg ha^{-1} (T_4) and control treatment (T_5). The seeds of both varieties were collected from the HRC, BARI, Joydebpur, Gazipur on 15 November, 2011. The size of each unit plot was 5 m^2 (2.5m x 2m) and the seeds of bush bean were sown on 22 November, 2011. Data were recorded on various growth and yield attributing traits. The sample plants were randomly selected from each plot to recorded data on green pod and seed yield and yield contributing characteristic. The experiment was laid out in two factors design with four replications and analysis was done by the MSTAT-C package program under Randomized Completely Block Design (RCBD) method whereas means were adjudged by DMRT at 5% level of probability.

The results of the study revealed that most of the growth and yield contributing parameters were significantly affected by the bush bean cultivars except stover yield where higher performances were obtained by BARI bush bean-1 than that of BARI bush bean-2. However, BARI bush bean-2 recorded the tallest plant (39.433 cm) at harvest, maximum branches (14.40 plant^{-1}) than BARI bush bean-1 (38.533 cm, and 10.80 plant^{-1}). Among other parameters, BARI bush bean-1 showed greater results than BARI bush-2 such as flowers (13.33 plant^{-1}), pods (543.3 plot^{-1}), pod length (13.72 cm), pod weight (138.26 g plant^{-1} and 6040.00 g plot^{-1}), pod yield (12.08t ha^{-1}), were obtained in BARI bush bean-1 while lower performance of these characteristics were found by BARI bush bean-2 (6.33 plant^{-1}, 389.5plot^{-1}, 11.95 cm, 107.32 g plant^{-1} and 5456.66 g plot^{-1}, 10.90 t ha^{-1}.) Stover yield did not differ significantly for both cultivars. Nutrient content of carbon (C), nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) of the studied soil after harvest were also determine where C, P and S were significant and N and K were not significant. As a result, both cultivars showed statistically similar N and K content while BARI bush bean-1 produced more C (0.641%), P (16.64 ppm) and S (15.01 ppm) than that of BARI bush bean-2 (0.61%, 16.19 ppm and 15.00 ppm, respectively).

Similarly, whole of the growth and yield contributing parameters were significantly affected by the organic and inorganic based N. There was an increasing significant response on most of the parameters to the increasing levels of organic nitrogen up to 40 kg N ha^{-1} and decreasing of inorganic nitrogen from 90 to 50 kg ha^{-1}. So, the treatment T_3 (inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1}) showed the higher result on plant height (42.00 cm) at harvest, respectively, branches (15.50 plant^{-1}), flowers (10.50 plant^{-1}), pods (553.8 plot^{-1}), pod length (14.00 cm), pod weight (153.66 g plant^{-1} and 6546.0 g plot^{-1}), pod yield (13.08 t ha^{-1}), stover yield (5.91 t ha^{-1}), while inorganic N @ 90 kg ha^{-1} (T_1) was statistically identical to flowers production (10.50 plant^{-1}) and treatment T_2 (inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1}) was statistically identical to pod length (13.40 cm). In contrast lower results of these parameters such as plant height (34.33 cm) at harvest, respectively, branches (11.00 plant^{-1}), flowers (8.83 plant^{-1}), pods (386.25plot^{-1}), pod length (11.33 cm), pod weight (97.0g plant^{-1} and 4423.0 g plot^{-1}), pod yield (8.84 t ha^{-1}), stover yield (4.53 t ha^{-1}), were found by control or untreated inorganic or organic N while statistically identical lower stover yield were found with both recommended dose (90 kg ha^{-1}) of organic (T_4) or inorganic N (T_1) (4.61 and 4.62 t ha^{-1}, respectively). Application of organic and inorganic based N also significantly influenced on C, P and S content but N and K content did not vary significant whereas C, P and S content had higher (0.672%, 17.49 and 22.00 ppm, respectively) in treatment T_3 and lower in control (0.517%, 11.89 and 15.01 ppm, respectively).

Interaction effect between cultivars and different doses of N was significantly influenced among the whole parameters of growth and yield while nutrient content of C, P and S were significant and N and K were non significant. Among the interactions, cultivar BARI bush bean-1 and inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1} (V_1T_3) recorded maximum flowers (14.50 plant^{-1}), pods (606.45 plot^{-1}), longest pod (15.00 cm), pod weight (163.66 g plant^{-1} and 6642.0 plot^{-1}), pod yield (13.28t ha^{-1}), stover yield (6.05 t ha^{-1}) while BARI bush bean-2 under control treatment noticed the lowest results on flowers (5.00 plant^{-1}), pods (322.5plot^{-1}), longest pod (10.50 cm), pod weight (77.34 g plant^{-1} and 4026.0 plot^{-1}) and pod yield (8.04 t ha^{-1}) but control treatment of BARI bush bean-1 took the lowest result on stover yield (4.50 t ha^{-1}) . However, cultivar BARI bush bean-2 and inorganic N @ 70 kg ha^{-1} + organic N @ 20 kg ha^{-1} (V_2T_3) recorded the tallest plant (42.67 cm) at harvest, respectively and maximum branches (16.33 plant^{-1}). Nutrient content of N and K of the studied soil were statistically identical among the interactions while C and P content had higher (0.687% and 17.99 ppm) in V_1T_3 and S content had higher(22.01ppm) in V_2T_3 whereas statistically identical C content were found in V_2T_3 (0.677 %), V_1T_4 (0.673%), V_2T_4

(0.663 %) and V_1T_2 (0.660 %). In contrast, the lowest content of C, P and S were found in V_2T_5 (0.490%, 14.80 and 15.00 ppm, respectively) while statistically equal lower S content (15.01 ppm) was obtained in V_1T_5.

From the above results investigation, it could be summarized that the organic and inorganic based N would be highly efficient than organic or inorganic recommended doses of N due the proper nutrient content, higher N-fixation, better photosynthesis were accumulated by organic and inorganic N combination than recommended N. As a result, inorganic @ 50 kg and organic N @ 40 kg ha^{-1} showed understanding superiority than that of other inorganic or organic based N doses and also over control. Besides, between two bush bean cultivars, BARI bush bean-1 perform better than that of BARI bush bean-2 regarding to growth, yield and nutrient content of the studied soil that might be due to the higher adaptability with the studied area at Dhaka, Bangladesh under AEZ-28 that might also be due to their genetic variance. So, therefore, the cultivar BARI bush bean-1 and inorganic N @ 50 kg ha^{-1} + organic N @ 40 kg ha^{-1} alone or their combinations would be suitable cultivar, appropriate organic + inorganic N and most effective interaction for obtaining the higher yield of bush bean.

CHAPTER VI
REFERENCES

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Abdel-Mawgoud, M.A.R., EL-Desuki, M., Salman, S.R. and Abou-Hussein, S.D. 2005. Performance of some snap bean varieties as affected by different levels of mineral fertilizers. J. Agron., 4(3): 242-247.

Adams, M. W., 1985, Common bean (*Phaseolus vulgaris* L.). In : Summerfield RJ, Roberts EH, eds. *Gr. Leg. Cr.,* London, UK, Collins, 433-476.

Ali, M. and Kushwaha, B.L. 1987. Cultivation of rabi rajmash in plains. *Indian Farming* 31(2): 20-23.

Anjanappa, M., Shiva Reddy, N., Krishnappa, K.S., Murali, K.and Pitchaimuthu, M. 2000. Performance of French bean varieties under Southern dry region of Karnataka. Karnataka J. Agric. Sci., 13(2): 503-505.

Asmaa, R. Mahmoud, M. EL-Desuki and Mona, M. Abdel-Mouty, 2010. Response of snap bean plants to boi-fertilizer and nitrogen level application. Inter. J. of Academic Res., 2(3): 179-183.

Ayub, M., Tahir, M., Nadeem, M.A., Zubair, M.A., Tariq, M. and Ibrahim, M. 2010. Effect of nitrogen applications on growth, forage yield and quality of three cluster bean varieties. Pak. J. Life Soc. Sci., 8(2): 111-116.

Baboo. R., Rana, N.S. and Pantola, P. 1998. Response of French bean to nitrogen and phosphorus. Ann. Agri. Res. 19(1): 81-82.

Bagal, P.K. and Jadhav, A.S. 1995. Effects of nitrogen and *Rhizobium* on composition French bean. J. Maharashtra Agril. Univ. 20(1): 53-55.

BBS. 2012. Annual Agricultural Statistics 2010–11. Summary crop statistics and crop indices. Bangladesh Bureau of Statistics, Statistic Division, Ministry of Planning, Government people's Republic of Bangladesh, Dhaka, pp. 39. Online available at http://www.bbs.gov.bd/WebTestApplication/ userfiles/Image/ArgYearBook11/Chapter-2.pdf.

Bengtsson, A. 1991. Field experiments with inoculation and nitrogen fertilization of kidney beans *(Phaseolus vulgaris* L.). Swedish-Journal-of-Agricultural-Research. 21(2): 63-66.

Bhatnagar, G.S., Powal, M.K. and Nagawati, G.C. 1992. Effect of nitrogen and mixtalol of french bean during winter. Indian J. Agril. Sci. 62 (4) : 280-281.

Bildirici, N. and Yilmaz, N. 2005. The effects of different nitrogen and phosphorus doses and bacteria inoculation *(Rhizobium phaseoli)* on the yield and yield components of field bean *(Phaseolus vulgaris* L.). Journal-of-Agronomy. 4(3): 207-215.

Biswas, P.K. 1987. A study on the relative merits of mixed cropping under two levels of irrigations. M.Sc. Thesis. Department of Agronomy, Bangladesh Agricultural University, Mymensingh. p. 18

Black, C.A. 1965. Methods of Soil Analysis. Part 1 and 11. Amer. Soc. Agron. Inc. Publisher, Madison, Wisconsin, USA. pp. 545- 567.

Calvache, A.M., Reicheardt, K., Malavotta, E. and Bacchi, O.O.S. 1997. Effect of water stress and nitrogen efficiency in bean. Scientia Agricola. 54(3): 232-240 [Cited fromHort. Abs. 68(1): 53-55

Carranca, C.F, Ferreira, A., Andrada, L., Fernandes, M.L., Ferreira, M.E. and Fragoso, M.A.C. 1993. Nitrogen fertilization of Phaseolus vulgaris for freezing. National Agronomy Research Station, INIA, Quinta do Marques, 2780 Oeiras, Portugal. Optimization-of-plant-nutrition:-refereed-papers-from-the-Eighth-International-Colloquium-for-the-Optimization-of-Plant-Nutrition,-31-August-8-September-1992,-LisborvPortugal. 429-433 .

Chandel, R.S., Singh, R, Singh, R.S. and Singh, O.N. 2002. Influence of nitrogen levels and *Rhizobium* inoculation on yield, quality and nitrogen uptake of French bean (Phaseolus vulgaris L.). Research on Crops. 3(3): 524-528.

Chandrashekhar S.S. 2008. Morphological and molecular characterization and effect of sowing dates and seed pelleting on seed production of French bean (*Phaseolus vulgaris* L.). Ph.D. Dissertation, Dept. of Seed Science and Technology, College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad- 580 005.

Chaudhari, C.S., Mendhe, S.N., Pawar, W.S., Lngole, A.S. and Nikam, R.R. 2001. Nitrogen management in French bean. J. Soil and Crops. 11(1): 137-139.

Daba, S. and Haile, M.. 2000. Effects of *Rhiozbium* inoculant and nitrogen fertilizer on yield and nodulation of common bean. J. Plant Nutrition. 23(5): 581-591.

Dahatonde, B.N. and Nalamwar, R.V. 1996. Effect of nitrogen and irrigation levels on yield and water use of French bean. Indian J. Agron. 41(2): 265-268.

Dahatonde, B.N., Tukhede, A.B. and Kale, M.R. 1992. Purpose of French bean *(Phaseolus vaugaris* L.) to irrigation regimes and nitrogen levels. Indian J. Agron. 37(4): 835-837.

Dahmardeh, M., Ramroodi, M. and Valizadeh, J. 2010. Effect of plant density and cultivars on growth, yield and yield components of faba bean (*Vicia faba* L.). African J. Biotech., 9(50): 8643-8647.

Devlin, R.M. and Witham, F.H. 1986. Plant Physiology. 4th ed. CBS Publishers and Distributors, 485, Jain Bhawan, Shadhara, Delhi, 110032 (India).

Dhanjal, R., Prakash, O.M. and Ahlawat, I.P.S.. 2001. Response of french bean *(Phaseolus vulgaris)* varieties to plant density and nitrogen application. Indian J.Agron. 46(2): 277-281.

Dhanjal, R., Prakash, O.M. and Ahlawat, I.P.S. 2003. Physiological variations hi French bean *(Phaseolus vulgaris)* cultivars as affected by plant density and nitrogen. Indian J. Plant Physio. 8(1): 34-37.

Duke, J.A. 1983. Hand Book of Legumes of World Economic Importance (Second Edi.) Plenum Press, New York. p. 341.

El-Awadi, M.E., El-Bassiony, A.M., Fawzy, Z.F. and El-Nemr, M.A. 2011. Response of Snap Bean *(Phaseolus vulgaris* L) Plants to Nitrogen

Fertilizer and Foliar Application with Methionine and Tryptophan]. Nat. and Sci., 9(5): 87-94.

El-Bassiony, A.M., Fawzy, Z.F., Abd El-Baky, M.M.H. and Asmaa Mahmoud, R. 2010. Response of snap bean plants to mineral fertilizers and humic acid application. Res. J. of Agric. and Biol. Sci., 6(2): 169-175.

El-Noemani, A.A., El-Zeiny, H.A., El-Gindy, A.M., El-Sahhar, E.A. and El-Shawadfy, M.A. 2010. Performance of some Bean (*Phaseolus vulgaris* L.) varieties under different irrigation systems and regimes. Australian J. Basic App. Sci., 4(12): 6185-6196.

El-Tohamy, W.A., Ghoname; A.A., Riad, G.S. and Abou-Hussein, S.D. 2009. The Influence of slow release fertilizer on bean plants (*Phaseolus vulgaris* L.) grown in sandy soils. Austr.J. of Basic and Applied Sci., 3(2): 966-969.

Eric Simonne, Guodong Liu, Aparna Gazula, Bob Hochmuth, Linda Landrum, Debbie Gast, Lei Lani Davis, Wandalaughlin, Randi Randell, Macebauer, Chrisvann, Carolyn Saft and Elena Toro. 2012. Yield response of overhead irrigated snap bean to nitrogen rates. Proc. Fla. State Hort. Soc. 125:174–181.

FAOSAT. 2011. Production Report. Food and Agriculture Organization Statistics Division. 29 Oct. 2011.

FAOSTAT. 2013. Food and Agriculture Organization Statistics Division. Annual Agricultural Statistics report 2012-13., Online available at http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

.

Farkade, B.K. and Pawar, W.S. 2002. Growth performance and yield of French bean varieties as influenced by different fertilizer levels. Indian J. Aric. Sci. 12{1): 142-144.

Gajendra, S. and Singh, T.P. 1988. Effect of moisture regimes and fertility levels on growth, yield and water use of French bean *(Phaseolus valgari).* Indian J.Agron., 44(2): 389-391.

Ghosal, S., Singh, O.N. and Singh, R.P. 2000. Effect of rate and time of application of nitrogen on growrth and productivity of French bean. Legume Res., 23(2): 110-113.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. 2nd Edn. John Willey and Sons, New York. pp. 97-411.

Gupta, P.K., Singh, K., Singh, U.N., Singh, R.N. and Bohra, J.S. 1996. Effect of moisture regime and fertility level on growth, yield, nutrient turnover and moisture use by French bean (*Phaseolus vulgaris).* 66(6): 343-347.

Guriqbal, S., Sakhon, H.S. and Singh, G. 2000. Effect of nitrogen and Rhizobium inoculation on the productivity of dry bean *(Phaseolus vulgari)*

Hafez, M. Magda and Asmaa Mahmoud, R., 2004. Response of snap bean (*Phaseolus vulgaris,*L.) to nitrogen fertilizer source. Annals of Agric. Sci., Mashtohor, 42(1): 261 270.

Hedge, D.M. and Sriniva. 1989. Effect of irrigation and nitrogen on growth, yield and water use of French bean. J. Agron., 34(2): 180-184.

Hossain, M.K. 2007. Effect of nitrogen and molybdenum application on the growth and yield of bush bean (phaseolus vulgaris l.). MS thesis, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka. pp. 1-106.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall. Inc. N. J., USA. p. 46.

Kamanu, J.K., Chemining'wa, G.N., Nderitu, J.H. and Ambuko, J. 2012. Growth, yield and quality response of snap bean (Phaseolus vulgaris L.) plants to different inorganic fertilizers applications in central Kenya. J. App. Biosci., 55: 3944– 3952.

Kazemi, E., Naseri, R., Karimi, Z. and Emami, T. 2012. Variability of grain yield and yield components of white bean (*Phaseolus vulgaris* L.) cultivars as affected by different plant density in Western Iran. American-Eurasian J. Agric. & Environ. Sci., 12(1): 17-22.

Kikuti, H., MJ.B. Andrade, J.G. Carvalho, and A.R. Morais. 2005. Nitrogen and phosphorus in the cultivated variety bean BRS MG Talisma (Phaseolus vulgaris L.). J. Indian Soc. Soil Sci

Kleinkopf G.E., Westermannn, D.T. and Dwelle, R.B. 1981. Dry matter production and nitrogen utilization by six potato cultivars. Agron. J. 73: 799-802.

Koli, B.D., Akasheand, V.B. and Shaikh, A.A. 1996. Effect of row spacing, plant density and N - level on the yield and quality of French bean. PKV Res. J. 20(2) 174-175.

Kovács, A.B., Vágó, I. and Kremper, R., 2008. Growth and yield responses of Garden bean *(Phaseolus vulgaris* l.*)* to nitrogen and sulphur fertilization. Analele Universităţii din Oradea, Fascicula: Protecţia Mediului, Vol. XIII: 69-75

Lal. 2004. Effect of nitrogen and phosphorus on seed yield of pea *(Pisum sativum* L.) and French bean *(Phaseolus vulgaris* L.). Progres. Horti. 36(1): 150-151.

Leelavathi, G.S.W.S., Subbaiah, G.V. and Pillai, R.N. 1991. Effect of different levels of nitrogen on the yield of greengrass *(Vigna radiata* L.Wilezek) . AndhraAgril.J., 38(1): 93-94.

Moniruzzaman, M., Halim, G.M.A. and Firoz, Z.A. 2009. Performances of French bean as influenced by plant density and nitrogen application. Bangladesh J. Agril. Res., 34(1): 105-111

Moniruzzaman, M., Islam, M.R. and Hasan, J. 2008. Effect of N P K S Zn and B on yield attributes and yield of french bean in south eastern hilly region of Bangladesh. J. Agric Rural Dev., 6(1&2): 75-82.

Moraghan, J.T., Lamb, J.A. and Albus, W. 1991. Nitrogen fertilizer requirement of navy beans in the Northern Great Plains. Journal-of-Production-Agriculture. 1991,4:2,204-208.

Mozumder, S.N., Moniruzzaman, M., Islam, M.R. and Alam, S.N. 2003. Effect of planting time and spacing on the yield performance of bush bean (*Phaseolus vulgaris L.*) in the eastern hilly area of Bangladesh. *Legume Res* 26(4): 242-247.

Mukhopadhyay, D., Ewunus, M. and Haque, MM. 1986. Response of Major Crop to Balanced Fertilizer Application. DAE and FAO Publ. Field Document No. 5. p. 1.

Nandan, R. and Prasad, U.K. 1998. Effect of nitrogen and Irrigation on growthand seed yield of french bean *(Phaseolons vulgaries).* Indian J. Agron. 43(3): 5

Negi, S.C. and Shekhar, J. 1993. Response of French bean genotypes to nitrogen Indian J. Agron., 38(2): 321-322.

Ngueguim, M., Mékontchou, T., Fobasso, M. and Nounamo, L. 2011. Influence of time of planting on yield and grain quality of bean genotypes grown on an Andosol in the Western Highlands of Cameroon. African Crop Sci. J., 19(4): 247 – 254.

Noor-e-Alam Siddiqui, M. 2010. Response of bush bean to applied nitrogen and phosphorus. Ph.D. Dissertation, Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, I.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. US Dept. Agron, Cire. p. 939.

CHAPTER VII
APPENDICES

APPENDICES

Appendix I. The morphological, physical and chemical properties of the experimental land

Morphological characteristics

Constituents	Characteristics
Location	Field Laboratory, Department of Agronomy, SAU, Dhaka
Soil Series	Tejgaon
Soil Tract	Madhupur
Land type	High
General soil type	Slightly acidic in reaction with low organic matter content
Agro-ecological one	"AEZ-28" of Madhupur Tract
Topography	Fairly level
Soil type and colour	Deep Red Brown Terrace Soil
Drainage	Moderate
Depth of inundation	Above the flood level
Drainage condition	Well drained

Physical properties of the soil

Constituents	Results
Particle size analysis	
Sand (%) (0.0-0.02 mm)	29.04
Silt (1%) (0.02-0.002 mm)	41.80
Clay (%) (<0.002 mm)	29.16
Soil textural class	Silty clay loam
Colour	Dark grey
Consistency	Grounder

Result obtained from the mechanical analysis of the initial soil sample done in the Soil Resources Development Institute (SRDI), Dhaka.

Chemical composition of the initial soil (0-15 cm depth)

Constituents	Results
Soil pH	5.8
Organic matter (%)	<1.0
Total nitrogen (%)	0.06-0.7
Available phosphorus (ppm)	27
Exchangeable potassium (me/100 g soil)	0.12

Methods of analysis

Texture	Hydrometer methods
pH	Glass electrode pHmeter method
Organic carbon	Walkely-Black method
Total N	Modified kjeldhal method
Soluble P	Olsen method ($NAHCO^3$)
Exchangeable K	Flame photometer method (Ammonium)
Available sulphur	****

Result obtained from the mechanical analysis of the initial soil sample done in the Soil Resources Development Institute (SRDI), Dhaka.

Appendix II. Monthly air temperature, rainfall, relative humidity and sunshine hours during the growing season (November 2012 to March 2013)

Month	Year	*Air temperature (°C)			**Rainfall (mm)	*Relative humidity (%)	** Sunshine (hrs)
		Maximum	Minimum	Average			
November	2011	29.63	16.67	23.51	00.00	83.10	265.8
December	2011	25.52	15.70	20.61	00.00	87.55	142.8
January	2012	24.92	13.46	19.19	Trace	86.16	160.4
February	2012	28.77	15.33	22.05	Trace	73.57	223.4
March	2012	30.93	18.95	24.94	18.1	75.16	202.1
Average		27.95	16.02	22.06	6.03	81.11	198.9

* Monthly average and ** Monthly total

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

Appendix III. Analysis of variance (mean square) for morphological characters of bush bean

Source of variation	Degrees of freedom	Mean square for				
		Plant height at different days after sowing		Number of branches plant^{-1}	Weight of plant (g)	Number of flowers plot^{-1}
Replication	2	1.808		0.400	0.307	0.433
Factor A	1	6.075*		97.200**	318.176**	371.008**
Factor B	4	49.550 **		17.383**	121.616**	2.967*
AB	4	5.117*		1.783**	12.260**	1.092ns
Error	18	1.216		0.363	0.111	0.813

NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

Appendix IV. Analysis of variance (mean square) for yield contributing traits of bush bean

Source of variation	Degrees of freedom	Mean square for			
		Number of pods plot^{-1}	Pod length (cm)	Weight of pods (g plant^{-1})	Weight of pods (g plot^{-1})
Replication	2	50.033	0.107	11.725	16520.833
Factor A	1	338778.133**	23.532 **	4864.133**	32813020.833**
Factor B	4	12570.967 **	5.948**	1143.904**	5124812.500**
AB	4	2260.300**	0.798*	272.654**	2641145.833**
Error	18	69.589	0.275	7.077	66567.130

*= Significant at 1% and **= Significant at 5% level of probability

Appendix V. Analysis of variance (mean square) for yield characters of bush bean

Source of variation	Degrees of freedom	Mean square for	
		Pod yield (t ha^{-1})	Stover yield (t h^{-1})
Replication	2	0.991	0.000
Factor A	1	107.352 **	0.011ns
Factor B	4	18.294 **	0.891**
AB	4	9.090**	0.017**
Error	18	0.852	0.003

NS = Non significance and **= Significant at 5% level of probability

Appendix VI. Analysis of variance (mean square) for nutrient content of the studied soil

Source of variation	Degrees of freedom	Mean square for				
		C %	N	P	K(Meq/100G)	S(ppm)
Replication	2	0.001	00	0.005	0.020	0.979
Factor A	1	0.006 **	00ns	1.550**	0.073ns	76.416**
Factor B	4	0.026**	00**	6.316**	0.027 ns	491.814**
AB	4	0.001**	00**	0.681**	0.030ns	28.378**
Error	18	0.000	00	0.001	0.025	0.011

NS = Non significance, *= Significant at 1% and **= Significant at 5% level of probability

Parthiban, S and Thamburaj, S. 1991. Influence of *Rhizobium* culture and nitrogen fertilization in french bean. South Indian Hort., 39 (3): 137-138.

Pawar, S.U., Kharwade, M.L. and Awari, H.W. 2007. Effect of Plant Density on vegetative growth and yield performance of different varieties of French bean under Irrigated Condition. Karnataka J. Agric. Sci., 20 (3): 684-685.

Perseglove, J.W. 1987. Tropical Crops: Dicotyledons. Longram. New York.
Piper, c.s. 1942. Soil and plant analysis. Adelaide Univ. Press. Australia.

Prajapati, M.P., Patel, H.A., Prajapati, B.H. and Patel, L.R. 2004. Studies on nutrient uptake and yield of French bean (*Phaseolus vulgaris* L.) as affected by weed control methods and nitrogen levels. Legume Res., 27(2): 99-102

Rahman, F., Sakhawat Hossain, A.T.M., Saha, P.K., Saha, P.K. and Mazid Miah, M.A. 2009. Effect of integrated use of organic manures and chemical fertilizers on yield, nutrient uptake and nutrient balance in the Bush bean -T. aus - T. aman cropping pattern Bangladesh J. Agril. Res., 34(1): 157-164.

Ram-Gopal, Ghanshyam-Singh and Singh, G.R. 2003. Effect of irrigation and nitrogen levels with and without FYM on the yield and water use of French bean (*Phaseolus vulgaris* L.). Farm Sci. J., 12(2): 182-183.

Rana D.K. and Arvind, K. 2012. Performance of various French bean (*Phaseolus vulgaris* L.) genotypes under mid-hill condition of Garhwal Himalaya. Prog. Hort., 40(2): 184-186.

Rana, N.S., Singh, R. and Ahlawat, I.P.S. 1998. Dry matter production and nutrient uptake in French bean (*Phaseolus vulgaris* L.). as affected by nitrogen and phosphorus application. Indian J. Agron., 43(1): 114-117.

Rashid, M.M. 1993. Sabji Biggan (in Bengali), 1st ed. Bangla Academy, Bangladesh. pp. 387-390.

Rejesh-Singh, O.N. Singh and Singh, R.S. 2001. Effect of nitrogen and sulphur application on its uptake and grain yield in French bean. Indian J. Pulses Res., 14(2): 154-155.

Roy, K.R. and Parthasarathy, V.A. 1999. Note on phosphorus requirement of French bean (*Phaseolus vulgaris*) varieties Planted at different dates. Indian J. Hort., 56(4): 317-320.

Roy, S.K. 2004. Characterization and yield variation in Bush bean (*Phaseolus vulgaris* L.) genotypes. MS Thesis, Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh. pp.1-69.

Russell, D.F. 1986. MSTAT-C package programme. Dept. Crop Soil Sci. Michigian State Univ. USA. p. 59-60.

Safapour, M., Ardakani, M., Khaghani, S., Rejali, F., Zargari, K., Changizi, M. and Teimuri, M. 2011. Response of yield and yield components of three red bean (*Phaseolus vulgaris* L.) genotypes to co-inoculation with *Glomus intraradices* and *Rhizobium phaseoli*. American-Eurasian J. Agric. & Environ. Sci., 11 (3): 398-405.

Salunkhe, D.K., Desai, B.B. and Bhat, N.R. 1987. Leguminous vegetables (peas and beans). In vegetables and flower seed production, Agricole Publishing Academy, New Delhi. pp. 265-302.

Sarangi, S.K. and De, L.C. 2010. Varietal Evaluation of French Bean (*Phaseolus vulgaris* l.) at Mid-hills of Arunachal Pradesh. Indian J. Hill Farming, 23(2): 53-54.

Sardana, V., Dhingrae, K.K., Gille, M.S. and Singh, I.J. 2000. Production technology of French bean *(Phaseolus vulgaris* L.*)* cultivation: a review. Agrlc. Rev., 21(3): 141-154.

Saxena, K.K. Arun-Srivastava and R.B. Singh, 2003. Response of French bean to nutrient application (NPK) in relation to physiological traits and their consequent effect on yield. Farm Sci. J., 12(2):150-152.

Schoonhoven and Voyset. 1991. Common beans : Research for crop improvement. *Centro Int. de Agric Tropical*. pp. 18-27.

Sen, R., Rhaman, M.A., Hoque, A.K.M.S., Zaman, S. and Noor, S. 2010. Response of Different Levels of Nitrogen and Phosphorus on the Growth and Yield of French Bean. Bangladesh J. Sci. Ind. Res., 45(2): 169-172.

Shanmugavelu, K.G. 1989. Production technology of vegetable crops. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. pp. 446-461.

Sharma, H.M, Singh, R.N.P., Singh, H. and Sharma, R.P.R. 1996. Effect of rate and timing of N application on the growth and yield of winter Rajmash. Indian J. Agron., 9(1): 25-30.

Singer, S.M., Ali, A.H., EL-Desuki, M., Gomaa, A.M. and Khalafallah, M.A. 2000. Synergistic effect of bio and chemical fertilizers to improve quality and yield of snap bean grown in sandy soil. Acta Horticulturae, 513: 213-220.

Singh, A.K. and Singh, S.S. 2000. Effect of planting dates, nitrogen and phosphorus levels on yield contributing factors in French bean. Legume Res., 23(1): 33-36.

Singh, A.K., Singh, S.B. and Singh, V. 2009. Influence of nitrogen doses on growth and green pod yield parameters of French bean varieties during *kharif* season under subtropical area of Jammu region. Legume Res., 32(2): 142-144.

Singh, D.N., Mehar, R.C. and Singhans, M. 1990. Response of French bean to irrigation and nitrogen application. Haryana J. Agron., 6(1): 94-95.

Singh, D.P., Rajput, A.L. and Singh, S.K. 1996. Response of French bean (*Phaseolus vulgaris* L.) to spacing and nitrogen levels. Indian J. Agron., 41(4): 608-608.

Singh, N.B. and Verma, K.K. 2002. Nitrogen and phosphorus nutrition of French bean (*Phaseolus vulgaris* L.) grown in eastern Uttar Pradesh under late-sown condition. Indian J. Agron., 47(1): 89-93.

Slaton, N.A., Golden, B.R., DeLong, R.E. and Massey, C.G. 2007. Green bean yield as affected by nitrogen fertilization strategy (Wayne E. Sabbe Arkansas Soil Fertility Studies 2007). AAES Research Series 558: 77-79. Online available at: http://arkansasagnews.uark.edu/558-18.pdf

Souza, A.B.D. and De, M.J.B. Andrade, N.M.B. Vieira and A. De. Albuquerque, 2008. Sowing densities and NPK and liming levels on common bean yield, in conventional cropping system, in Ponta Grossa, Parana State, Brazil. Pesquisa Agropecuaria Tropical, 38(1): 39-43.

SRDI. 1991. Land and Soil Resource Utilization Guide: Mymensingh Sadar Thana, Mymensingh. (In Bangali,). SRDI, Ministry of Agricultural, Dhaka, Bangladesh. P. 3.

Srinivas, K. and Naik, L.B. 1988. Response of French bean (*Phaseolus vulgaris* L.) to nitrogen and phosphorus fertilization. Indian Agril. Sci., 58(9): 707-708.

Swiader, J.M., Ware, G.W. and Mccollum, J.P. 1992. Producing vegetable crops. 4th ed. Interstate publisher Inc. Danville. Illions. USA. pp. 223-249.

Teixeira, I.R., Andrade, M.J.B., Carvalho, J.G., Morais, A.R. and Correa, J.B.D. 2000. Response of French bean (*Phaseolus vulgaris* L.) crop to different sowing densities and nitrogen levels. Ciencia-e-Agrotecnologia., 24(2): 399-408.

Tewari, J.K. and Singh, S.S. 2000. Effect of nitrogen and phosphorus on growth and seed yield of French bean (*Phaseolus vulgaris* L.). Vegetable Sci., 27(2): 172-175.

Tindall, H.D. 1988. Vegetable in the tropics. Mcmillan Education Ltd. p. 527.

UNDP and FAO. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. Agro-ecological Regions of Bangladesh. United Nations Development Program and Food and Agriculture Organization. pp. 212-221.

Vargas, M.A.T., Ieda C. Mendes, Hungria Mariangela. 2000. Response of field-grown bean (Phaseolus vulgaris L.) to Rhizobium inoculation and nitrogen fertilization in two Cerrados soils. Biol. Fertil Soils, 32(2): 228-233.

Verma, V.S. and Szxena, K.K. 1995. Response of French bean (*Phaseolus vulgaris* L.) to graded doses of nitorgen, phosphorus and potassium in silty-loam soil of central Uttar Pradesh. Indian J. Agron., 40(1): 67-71.

Vieira, R.F., Cardoso, E.J.B.N., Vieira, C. and Cassini, S.T.A. 1998. Foliar application of molybdenum in common bean. III. Effect on nodulation. J. Plant Nutr., 21(10): 2153-2161.

Vishwakarma, B., Singh, C.S., Rajesh and Singh. 2002. Response of French bean (*Phaseolus vulgaris* L.) varieties to nitrogen application. India Res. Crops. 3(3): 529-532.

Wani, A.G., Tumbare, A.D. and Dhonde, M.B. 1998. Response of rainy-season French bean (*Phaseolus vulgaris*) to irrigation regimes and nitrogen. Indian J. Agron., 43(4): 694-699.