EFFECT OF NITROGEN AND MOLYBDENUM ON THE GROWTH AND YIELD OF BARI BUSH BEAN-2

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DHAKA-1207

JUNE, 2015

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A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

IN

SOIL SCIENCE

SEMESTER: JANUARY-JUNE, 2015

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CERTIFICATE

This is to certify that the thesis entitled ***" "EFFECT OF NITROGEN AND MOLYBDENUM ON THE GROWTH AND YIELD OF BARI BUSH BEAN-2 (Phaseolus vulgaris) ""*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***SOIL SCIENCE,*** *embodies the results of a piece of bona fide research work carried out by* ***MD. ROCKYBUL HASAN,*** *Registration. No.* ***14-06316*** *under my supervision and guidance. No part of this 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.

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ACKNOWLEDGEMENT

ALLAH, to Him I express my supreme gratitude. All praises are due to the Almighty Allah, the great, the gracious, merciful and supreme ruler of the universe because he has given me the opportunity to conduct and complete the research work and thesis successfully for the degree of Master of Science in Soil Science.

The author feel much pleasure to express his gratitude, sincere appreciation and heartfelt indebtedness to his reverend research supervisor ***Professor Dr. Alok Kumar Paul****, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka for his systematic planning, initiative,innovative suggestion ,constant supervision and inspiration, invaluable, meticulous and scholastic guidance, encouragement, valuable suggestions, loving care and gratuitous labour in conducting and successfully completing the research work and in preparing the thesis.*

The author expresses highly indebtedness, gratefulness, boundless gratitude and best regards to his respectable co-supervisor ***Professor. A.T.M. Shamsuddoha*** *and respectable teachers Professor Dr. Md. Asaduzzaman Khan, Professor Mst. Afrose Jahan and Assistant Professor. Mohammad Issak, Fazle Bari, Saima Sultana, Syfullah Shahriar Department of soil science, Sher-e-Bangla Agricultural University (SAU), Dhaka for their co-operation ,direct and indirect advice, encouragement and cooperation during the whole study periodand also constructive suggestions in all phases of the research.*

The author expresses his grateful appreciation and heartful thanks to Professor Mosharraf Hossain, chairman, Department of soil science, Sher-e-Bangla Agricultural University (SAU), Dhaka, for his help, heartiest co-operation, valuable advice, constructive criticism ,valuable suggestions, loving care and inspiration and supports needed to undertake during the research work and preparing the thesis.

The author is highly kindful to Hider, Taposh, Mizan and the members of soil science Laboratoey,Sher-e-Bangla Agricultural University (SAU), Dhaka, for their help in conducting the experiment.

The author also expresses his heartiest indebtedness to his beloved parents, brother, sisters for their moral support, constant inspirations, blessings and spiritual support.

Place: Dhaka *The Author*

Dated:

ABSTRACT

A field experiment was carried out in Modhupur Tract (AEZ- 28) at research field of Sher-e-Bangla Agricultural University, Dhaka, during the Rabi season from November 2014 to March 2015 to study the effect of Nitrogen and Molybdenum on the growth and yield of bush bean (*Phaseolus vulgares* L.) cv. BARI Jhar Sheem-2. The treatments consisted of 4 (four) levels of N (0, 60, 80, 100 kg ha^{-1}) designated as N_0, N_{60}, N_{80}, N_{100} respectively and 3 (three) levels of Mo (0, 0.3 and 0.6 kg ha^{-1}) designated as Mo_0, $Mo_{0.3}$, and $Mo_{0.6}$ respectively. Urea and ammonium molybdate were used as the sources of nitrogen and molybdenum respectively. There was a positive impact on number of effective plant $height^{-1}$, number of branches $plant^{-1}$, number of green pod plant $^{-1}$, pod length, pod yield $plot^{-1}$, green pod weight, and stover yield with increasing the rate of nitrogen and molybdenum, all these parameters increased up to N_{100} and $Mo_{0.6}$. The highest green pod yield (13.40 t ha^{-1}) was obtained from N_{100}. The highest green pod yield (13.07 t ha^{-1})) was obtained from $Mo_{0.6}$. The maximum pod yield (14.50 t ha^{-1}) was attained in $N_{100}Mo_{0.6}$ treatment. The highest N, P, K and S contents in plant were recorded in $N_{80}Mo_{0.3}$ and $N_{100}Mo_{0.6}$ treatment and the lowest result was found in control treatment NoMo.

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CHAPTER 1

INTRODUCTION

Bush bean or French bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family Leguminosae and sub family Papiolionaceae, which was originated in the Central and South America (Swiader *et al.,* 1992). It is also known as Kidney bean, Snap bean, Pinto bean, Green bean, Raj bean, Navy bean, Pole bean, Wax bean, String bean and bonchi (Duke, 1983; Salunkhe *et al*., 1987; Tindall, 1988). In our country it is known as Farashi Seem (Rashid, 1993). In Bangladesh, bush bean is mainly used as green vegetable. It is the most widely cultivated food legume (FAO, 1985), being cultivated throughout the temperate, tropical, subtropical regions of the world (George, 1985).

According to FAO statistics, bush bean including other related species of the genus *Phaseolus* occupied 27.08 million hectares of the World's cropped area and the production of dry pods was about 18.94 million tons with an average yield of 699 kg ha -1 (FAO, 2000).

The bush bean is the dwarf type of French bean whose green pods are used for consumption. It holds second position in production among the bean family (Rashid, 1998) and consumed as the main food legume in America where it is a great agricultural importance especially in Brazil, Mexico and U.S.A. In Asia, French bean has been extensively cultivated in India (34% of the cultivated area, Lue *et al*., 1990). It has been newly introduce as a winter vegetable crop in Bangladesh. Only two varieties were released by Bangladesh Agricultural Research Institute (BARI) in the year of 1996 and 2002 namely (BARI Jhar Sheem-1 and BARI Jhar Sheem-2). It is cultivated in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country.

Both pods and seeds of French bean are nutritionally rich. Each 100 g of pod contain average 36 calories food energy, 89 % moisture, 2.7 g of protein, 0.2 g lipid, 7.9 g of Carbohydrate, 43 mg of Ca, 29 mg of Mg, 28 mg of P, 1.4 mg of

Fe, 0.8 mg of Thiamin and 8.5 mg of Niacin. On the other hand, dry bean contains 336 calories for energy with 12 % moisture, 21.7 g of protein, 1.5 g of lipid, 60 g CHO, 120 mg of Ca, 8.2 mg of Fe, 0.37mg of Thiamin and 2.4mg of Niacin. (Schoonhoren and Rovset, 1993). Keeping aside its nutritive value, the crop is reported to be quick growing and it can also be used as fodder crop and some extent it has the potentiality as green manure.

The immature pods are marketed fresh, frozen or canned. The dry seeds also provide hay, silage and green manures. 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 thiamin, niacin, folic acid (Rashid, 1993). Recently cultivation of bush bean is gaining popularity in Bangladesh mainly because of its demand as a commodity for export.

Bush bean shows high yield potential, but unlike other leguminous crops it does not nodulate with the native rhizobia (Ali and Kushwaha, 1987). Therefore, requirement of nitrogenous fertilizers for the crop is prime importance. Nutrient requirement for different cultivars usually similar except on poor soils (Adams, 1984). Nitrogen is necessary for its vegetative growth and development. Fertilizer placement at 10-15 cm depth has promoted growth and development of root and shoot of French bean (Chaib *et al.*, 1984). However, excessive or under dose of nitrogen can affect the growth and yield.

Nitrogen is the key element for crop production. Organic matter is the main source of nitrogen and Bangladesh soil are deficit in organic matter content. Nitrogen content of Bangladesh soil is very low. Nitrogen nutrition is a major consideration for increasing yield and quality of bush bean. Bush bean cultivation requires enough supply of nitrogen. However, excessive or under dose of nitrogen can affect the growth and yield. An optimum amount of nitrogen is necessary to produce maximum yield of good quality bush bean. Bush bean, like other legumes has ability to fix atmospheric nitrogen through partnership with symbiotic root nodule bacteria *(Bacillus japonica*) and thus enrich the soil fertility (Mahabal, 1986). It fixes about 270 kg N ha^{-1} annually compared to 58 to 157 kg N ha^{-1} by other pulses.

Molybdenum is an essential micronutrient, is known to participate in the nitrate reduction system of nitrogen metabolism in higher plants (Nicholas, 1961).The direct effect of molybdenum deficiency was on nitrogen metabolism through accumulation of non- protein soluble nitrogen in the tissues without its utilization in the growth of the plant.

Molybdenum (Mo) is responsible for formation of nodule tissue and increase nitrogen fixation (Lewis, 1980 and Sharma *et al.*, 1988).However, the requirement is so small that the seed of grain legumes can contain sufficient molybdenum for the growth of one generation of plant (Harris *et al.*, 1965). It is indispensable for many plant species especially in root nodule legumes. Because Mo plays an important role in increasing yield of legumes, oilseed and pulses through their effect on the plant itself and on the nitrogen fixing symbiotic process. Nitrogenase is a molybdenum (Mo) containing enzyme. It catalyzes the fixation of nitrogen gas to ammonia, which can be utilized by the host plant. Without adequate quantities of molybdenum (Mo), nitrogen fixation cannot occur and also microbial activities are depressed. Legume and pulses can produce active nodule only when soils are properly supplied with molybdenum (Ahmed, 1982).

Keeping in mind the above facts were undertaken with the following broad objective(s):

(i) To determine the optimum level of Nitrogen for maximizing the growth and yield of BARI Bush bean-2

(ii) To determine the optimum level of Molybdenum for maximizing the growth and yield of BARI Bush bean-2

(iii) To study the combined effect of Nitrogen with Molybdenum for maximizing the growth and yield of BARI Bush bean-2

CHAPTER 2

REVIEW OF LITERATURE

Bush bean (*Phaseolus vulgaris* 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. It has been recently introduced in Bangladesh. Some of the important findings related to the present study are reviewed in this chapter:

2.1 Effect of nitrogen on growth and yield of bush bean

Nitrogen is one of the most essential elements for crop production. It encourages vegetative growth and increases leaf area of plants, which helps in photosynthetic activity.

Bhatnagar *et al*. (1992) observed that when Nitrogen was applied at 20, 40 or 60 kg ha^{-1} in French bean. The seed yield and nitrogen uptake in seed increased and crude protein percentage decreased with increasing nitrogen application rate.

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}.

Singh *et al.* (1990) found that N fertilization and irrigation in French bean increased the number of pods per plant and 100 seed weight with increase in nitrogen level.

Srinivas and Naik (1988) stated that the response of vegetable French bean to nitrogen and phosphorus fertilization. When nitrogen was applied at 0, 40, 80, 120 or 160 kg N/ha. Pod yields were increased with increasing fertilizer rate from 3927 kg ha^{-1} at 0 kg ha^{-1} to 13167 kg ha^{-1} at 160 kg ha^{-1} N.

Katoch *et al*. (1983) revealed that nitrogen at 30 kg N ha^{-1} increased the maximum nodule number and nodule weight $plant^{-1}$ of French bean.

Gonzalez *et al*. (1983) observed that seed yields with different fertilizer treatments in French bean such as 2.07 t ha^{-1} with 80:90:90: NPK/ha and 1.64 t ha^{-1} with 120:60:90 NPK ha^{-1}.

Bhopal and Singh (1987) conducted that response of French bean to nitrogen and phosphorus fertilizers with *Phaseolus vulgaris* bean grown for green pods. Nitrogen was applied at 0-90 kg ha^{-1} and P_2O_5 at 0-120 kg $ha^{-1,}$ and a basal dose of K_2O at 50 kg ha^{-1}. The optimum nitrogen: phosphorus dose was 67.3:79.7 kg ha^{-1} and yields over 210 q ha^{-1}.

Chandra *et al*. (1987) showed that plant growth and yield (46.19-71.59 q ha^{-1}) of bush bean increased with increasing N (0-50 kg ha^{-1}) and seed inoculation with Rhizobium.

Kushwaha (1987) found that the response of French bean at different levels of Nitrogen and Phosphorus 0, 30, 60, 90 and 120 kg N ha^{-1} and seed yields are 1.32, 2.05, 2.33, 54 and 2.76 t ha^{-1}. The yield differences were related with differences in pod number $plant^{-1}$.

Hegde and Srinivas (1990) observed that water and nutrient relation in French bean nitrogen application increased green pod yield, nutrient uptake and water use efficiency but had no effect on water relation and canopy temperature.

Parthiban and Thamburaj (1991) reported that increased grain yield with nitrogen fertilization at 50 kg N ha^{-1} and number of pods, grain yield $plant^{-1}$ increased with nitrogen fertilization over the control.

Hegde and Srinivas (1989) found that the effect of nitrogen and irrigation on growth, yield and water use of French bean. The crop received 0, 40, 80 or 120 kg ha^{-1} of nitrogen. The green pod yield increased with (124.3-132.3 q ha^{-1}) at the highest N rate.

Ali and Tripathi (1988) observe that nitrogen levels (0-60 kg ha^{-1}) and plant population of French bean influence genotype, and number of pods $plant^{-1}$, 100 seed weight, seed yield and seed protein content increased with increasing nitrogen rate.

Singh *et al*. (1981) showed that seed yields of *Phaseolus vulgaries* were increased with increasing N rates (0-120 kg N ha^{-1}) and with up to 60 kg P_2O_5 ha^{-1}.

Abu-Shakra and Bassiri (1972) revealed that number of nodules $plant^{-1}$ decreases due to N_2 application in French bean.

Chandel *et al*. (2002) founded that 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. Crop yield components and protein yield increased with increasing nitrogen levels and the highest values were 120 kg N ha^{-1} during both years. Rhizobium inoculation increased crop yield over the control. Strain Raj-2 produced higher grain and protein yield compared to HURR-3.

Prajapati *et al*. (2004) stated that application of nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) nutrient uptake and yield of french bean as affect by weed control methods. Among the N rates (120 kg ha^{-1}) increases 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}).

Singh and Verma (2002) showed that the higher rates of nitrogen (120 kg ha^{-1}) and phosphorus (60 kg ha^{-1}) increases with increasing plant height, branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, 100-seed weight, grain yield (21.19 q ha^{-1} with 120 kg N ha^{-1}) and 18.68 q ha^{-1} with 60 kg P_2O_5 ha^{-1}) and straw yields (29.76 q ha^{-1} with 120 kg N ha^{-1}) and 24.76 q ha^{-1} with 60 kg P_2O_5 ha^{-1}).

Farkade *et al*. (2002) revealed that effect of N: P fertilizers at 60:45, 90:5 and 120:75 kg ha^{-1} in French bean. The yield and growth characters increased with increasing N: P fertilizer level and the higher (15.93 q ha^{-1}) were at 120: 75 kg ha^{-1}.

Rajesh *et al*. (2001) found that 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 (2091 kg ha^{-1}) straw yields (3331 kg ha^{-1}) total N uptake (90.70 kg ha^{-1}) and S uptake (6.58 kg ha^{-1}) at N level of 240 kg ha^{-1} and Sulphur (S) at 40 kg ha^{-1} at highest grain yield (1811 kg ha^{-1})and total N uptake (77.45 kg ha^{-1}) and S uptake (6.06 kg ha^{-1}).

Ghosal *et al*. (2000) stated that the effect of varying N rates (0, 40, 80, 120,160 kg N ha^{-1}) and times of application on the growth and yield of french bean. Number of pods plant $^{-1}$, weight of pods $plant^{-1}$, grain yield and straw yield increased with increasing application of nitrogen at 160 kg ha^{-1}

Durgen *et al.* (1997) found that the highest yield of French bean (957 kg ha^{-1}) was obtained with 150 kg N ha^{-1}.

Singh *et al*. (1996) reported that response of French bean to spacing and nitrogen levels. Seed yield increased at 120 kg N and spacing (30×10) cm.

Koli *et al*. (1996) revealed that influence of nitrogen level, row spacing and plant density on yield of French bean. Seed yield was increased at 60 kg N ha^{-1} (yield 1041 t) & density of 3,33,333 plants ha^{-1} (yield 1.41t), row spacing of 30cm (yield 1.13 t).

Sushant *et al*. (1999) stated that effect of N (0, 50 or 100 kg N ha^{-1}) and P (0, 30 or 60 kg P ha^{-1}) on the yield and water use efficiency of French bean. Yield increased with increasing irrigation, N and P rates. The highest yield at the rate of 100 kg N ha^{-1} and 60 P_20_5 kg ha^{-1}. Water use efficiency increased with increasing N and P rates. Interaction with Irrigation and N and N and P enhance for pods $plant^{-1}$ and seed yield.

Nandan and Prasad (1998) found that yield and water use efficiency of *Phaseolus. Vulgaris.* With 6 irrigation treatment and 3 N treatments (40, 80 or 120 kg N ha^{-1}.). First year, seed yield highest (1.31 t ha^{-1}) when given 3 irrigations at 25, 50 and 75 days after sowing, Second year highest yield of 1.35 t ha^{-1} when irrigating at a 0.8 IW : CPE [irrigation water: cumulative pan evaporation] ratio. Both years Yield and water use efficiency increased with increasing N rate.

Dhanjal *et al*. (2001) revealed that effects of N (0, 60, or 120 kg ha^{-1}) & crop density (500000, 333000, or 250000 plants ha^{-1}) applied at sowing on yield and yield components of *Phaseolus vulgaris*. When crop density lowest (250000 plants ha^{-1}) enhance highest values of growth and yield components, except plant height was higher under 500000 plants ha^{-1}. The seed and stover yields was higher in medium crop density (333000 plants ha^{-1}). The yield and yield components increases when N rate was applied.

Prajapati *et al*. (2001) reported that effects of weed control methods and N fertilizer application on the physiology of french bean. The fresh and dry weight $plant^{-1}$, net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), and grain yield was higher in weed free conditions. Physiological parameters, namely fresh and dry matter production plant $^{-1}$ LAI, NAR, RGR, and CGR was higher at 120 kg N ha^{-1}.

Chaudhari *et al*. (2001) stated that nutrient management of French bean applied with recommended dose of fertilizer at 90kg N ha^{-1} and 60kg P ha^{-1}. Plant height, pod number and grain yield $plant^{-1}$ increased.

Gajendra and Singh (1998) reported that application of 120 kg N ha^{-1}, 90 kg P_20_5 ha^{-1} and 45 kg K_20 ha^{-1} gave higher grain yield of french bean.

Furlani *et al*. (1996) stated that application of N in green house leaf chlorophyll content and leaf N concentration was highly significant. Chlorophyll content gave accurate assessment of N status in bean plant.

Calvache *et al*. (1997) revealed that application of Nitrogen seed yield, pod number $plant^{-1}$, number of seeds pod^{-1} and harvest index was increased in French bean.

Kikuti *et al*. (2005) reported that effect of several treatment N (0, 70,140 and 210 kg ha^{-1}) and P_2O_5 (0, 100, 200 and 300 kg ha^{-1}) on the bean. The initial and final stands of the plants, grain productivity and utilization efficiency of N and of P_2O_5 treatments were evaluated. N and K association resulted in small bean plant populations and P lessened that effect. According to the seasons, application of N and P_2O_5 treatments the productivity was increased. Maximum efficiency of N and P_2O_5 levels higher than those recommend dose for bean crop.

Ram Gopal *et al*. (2003) found that effect of nitrogen (50, 100 and 150 kg ha^{-1}) irrigation (0.5, 0.7 and 0.9 W/CPE) and with or without (5 t FYM ha^{-1}), on the yield and water use of french bean. 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 with the addition of FYM.

Farkadeet *et al. (*2002) revealed that effect of N: P fertilizers at 60:45, 90:75 and 120:75 kg ha^{-1} on *Phaseolus vulgaris* cultivars. Yield and growth characters increased with increasing N: P fertilizer level and high yield (15.93 q ha^{-1}) at 120:75 kg ha^{-1}.

Dhanjal *et al.* (2003) reported that 3 French bean (P. vulgaris) cultivars (HUR 87, PDR 14 and VL 63), 3 planting densities (250x103, 333x103 and 500x103 plants ha^{-1}) and 3 N levels (0, 60 and 120 kg ha^{-1}). Leaf area index and crop growth rate higher at 500x103 plants ha^{-1}, where dry weight plant $^{-1,}$ net assimilation rate and relative growth rate higher at 250x103 plants ha $^{-1}$. Levels of N up to 120 kg ha^{-1} increase with increasing dry weight, leaf area index, crop growth rate and relative growth rate, but net assimilation rate increase up to 60 kg N ha-^{1} only.

Lal (2004) stated that effects of N (0, 20, 40 and 60 kg ha^{-1}) and P 0, 30, 60 and 90 kg ha^{-1}) on the seed yield of pea& bean. N at 40 kg ha^{-1} was optimum for maximizing pea and bean seed yields. Seed yield of both crops increased with increasing P rates up to 60 kg ha^{-1}.

Verma and Saxena (1995) reported that growth and yield of *Phaseolus vulgaris* response of N (0, 60 or 120 kg ha^{-1}), P_2O_5 and K_2O. Higher Seed yields at 120 kg N or 120 kg P_2O_5, but not affected by K_2O.

Dwivedi *et al.* (1994) stated that Application of N (40, 60, 80 or 100 kg ha^{-1}) in *Phaseolus vulgaris* (PDR-14) was sown at inter-row spacing of 30, 45 or 60 cm with an intra-row spacing of 8 cm to give densities of 400000, 286000 and 200 000 plants ha^{-1}. Seed yield was highest at the density of 400000 plants ha^{-1} and increased with up to 80 kg N ha^{-1}.

Teixeira *et al. (*2000) found that effect of sowing density (6, 10, 14 and 18 seeds/$m2$) and N levels (0, 50, 100 and 150 kg ha^{-1}) on *Phasolus vulgaris*. Grain yield increased with increasing N rates, numbers of pods/plant, seeds/pod and 100-seed weight. The effect influenced by seasons and sowing densities. With increase in sowing density reduced the number of pods $plant^{-1}$, and absence of N fertilizers increased the grain yield. An increase in sowing density also reduced weed infestation during harvest.

Singh and Singh (2000) revealed that different levels nitrogen (0, 40, 80 or 120 kg ha^{-1}) on yield and yield components of French bean Seed yield and 100-seed weight increased with increasing N rate.

Arya *et al*. (1999) stated that the effect of N, P and K on French bean. They used different doses of NPK combinations. N promoted growth at 25kg N ha^{-1}, 75 P_20_5 kg ha^{-1} and 50 kg ha^{-1} K_20 ha^{-1} was the best combination in terms of economics and seed yield.

Bildirici *et al*. (2005) reported that effects of bacterial (*Rhizobium phaseoli*) inoculation, N fertilizers (0, 20, 40, 60 kg ha^{-1}) and P fertilizer (0, 40, 60, 80 kg ha^{-1}) on field bean. N fertilizer shows positive effect on pod number, grain yield and raw protein proportion. There is no effect on seed number pod^{-1} and 1000-seed weight. P fertilizer rates are not significant for all of the factors. On the contrary, bacterial inoculation shows positive effect on pod number plant $^{-1}$ and grain yield.

Tewari *et al*. (2000) reported that effect of of nitrogen (0, 40, 80, 120 or 160 kg ha^{-1}) and phosphorus (0, 20, 40 or 60 kg ha^{-1}) for better growth and seed yield of french bean. Plant height, number of branches and length of pod increased with increasing in the doses of nitrogen as well as phosphorus. Application of N at 120 kg ha^{-1} produced higher number of pods plant^{-1}, weight of seeds plant $^{-1}$, number of seeds pod $^{-1}$ and seed yield, where N at 160 kg ha^{-1} was reduced seed yield. The highest values on yield were observed at P (60 kg ha^{-1}). Application of N, P_2O_5 (120 kg + 60 kg ha^{-1}) along with K_2O, 60 kg ha^{-1} gave the highest seed yield, net profit and net return investment.

Negi and Shekhar (1993) revealed that response of French bean genotypes to nitrogen. These treatment are *Phaseolus vulgaries*, Katrain 1, Him 1, B4 and B6 and N at 0-90 kg ha^{-1}. Seed yield was highest at B6 (1.99 t ha^{-1}) and lowest in Katrain1 (1.45 t ha^{-1}) and it increased with up to N at 60 kg ha^{-1}.

Dahatonde *et al*. (1992) stated that response of French bean to irrigation regimes and nitrogen levels (0-120kg N ha^{-1}). Seed yield increased from 0.38 to .92 t ha^{-1} with increasing in number of irrigation and N_2 application with up to 90 kg ha^{-1}.

Sharma *et al*. (1996) revealed that doses of N fertilizer (0, 40, 80 and 120 kg ha^{-1}) and timing of application on growth and yield of French bean. The level of N increased with increasing seed yield, number and weight of pods plant^{-1} and number of seeds pod^{-1} up to 120 kg N ha^{-1}. There is no variation on seed yield, pod length and 100 seed weight at 80 and 120 kg N ha^{-1}. Application of N in three equal splits gave higher seed yield attributes in French bean.

Effect of molybdenum on growth and yield of bush bean

Molybdenum is an essential micronutrient for increasing crop production. It has pronounced effect on plant growth, pod formation that progressively increased the yield of bush bean.

Andrade *et al*. (1999) reported that application of molybdenum on the growth and yield of bean. Foliar applications of Mo (0, 30, 60, 90 or 120) kg ha^{-1} were used. There were no significant effects of Mo rates or rate x cultivar interaction on yield or yield components. There were significant differences between cultivars for height of first pod, seed number per pod, 100-seed weight and yield.

Hazra and Tripathi (1998) reported that application of molybdenum at 1.5 kg ha^{-1} French bean increase forage and seed yields in calcareous soil.

Berger *et al.* (1995) reported that application of Mo at 20 kg ha^{-1} in sowing and spray foliar application of 20 kg Mo ha^{-1}. 25 days after emergence had a greater effect when French bean plants were grown on poorer soil.

Anwar (1989) reported that application of Calcareous Dark Flood plain soil with mungbean (*Vigna rediata L.*). Application of molybdenum had significant effect on grain yield and molybdenum content in straw bulk and grain.

Sarkar and Banik (1991) found that application of molybdenum on green gram increased pods plant $^{-1}$ seed pod $^{-1}$, 1000 seed weight, seed yield and straw yield. They also reported that application of molybdenum at the rate of 0 and 0.25 kg ha^{-1} gave 11.45 q ha^{-1} straw yield, 19.25 and 20.18 pods plant $^{-1}$.

Manga *et al*. (1999) reported that effect of phosphorus and molybdenum on the growth and yield of French bean. Crop received 0, 13 or 26 kg P and 0, 5 or 1.0 kg ammonium molybdate ha^{-1}. Application of Phosphorus increases with increasing number of pods plant $^{-1}$, number of seeds pod and shelling percentage. Seed yield was increased by 43.2 and 73.32% (averaged over years) when 13 and 26 kg P ha^{-1} were applied. Application of Molybdenum increased the number of pods plant $^{-1}$, number of seeds pod $^{-1}$ and seed yield. Seed yield increase in 15.7 and 25.9% when 0.5 and 1.0 kg ammonium molybdate ha^{-1} were applied.

Pires *et al*. (2004) stated that effects of foliar application of Mo on the yield of common bean (*Phaseolus vulgaris*). The treatments consisted of a control (without Mo), 80 g Mo ha^{-1} applied at 15 days after emergence (DAE), 40 g Mo ha $^{-1}$ applied at 15 and 20 DAE, 40 g Mo ha $^{-1}$ applied at 15 and 25 DAE, 40 g Mo ha^{-1} applied at 15 and 30 DAE, 80 g Mo ha $^{-1}$ applied at 20 DAE, 40 g Mo ha $^{-1}$ applied at 20 and 25 DAE, 40 g Mo ha^{-1} applied at 20 and 30 DAE, 80 g Mo ha^{-1} applied at 25 DAE, and 40 g Mo ha^{-1} applied at 25 and 30 DAE. Mo foliar spray increased the yield and index in summer-autumn cultivation when started at 15 or 20 DAE, but not at 25 DAE. Rate partitioning reduce yields. In winter-spring cultivation, all treatments increased the yields.

Kushwaha (1999) found that effect of zinc, boron and molybdenum on the growth and yield of French bean (*Phaseolus vulgaris*) on sandy loam soil 25 kg ZnSO4, 10 kg borax and 1kg sodium molybdate ha^{-1} were applied singly or in all combinations. All trace element treatments increased seed and haulm yield. Mean seed yield was 1736 kg ha $^{-1}$ in controls and the highest 2459 kg with borax alone.

Padma *et al*. (1989) reported that application of of N (20 kg ha $^{-1}$), P (50 kg ha $^{-1}$) and K (50 kg ha $^{-1}$) on French bean. Mo (as sodium molybdate) at 75 or 150 ppm were applied, individually and in combination, as foliar sprays 20 days after sowing and again 40 days after sowing. Control plants were sprayed with distilled water. The greatest plant height (35.0 cm), number of leaves plant^{-1} (14.6), number of branches plant^{-1} (4.3), tap root length (20.4 cm), leaf area plant^{-1} (941.2 cm), leaf area index (0.60) and DM production (62.8 g plant $^{-1}$) are at 75 ppm. Mo + 2.5 ppm. B treatment.

Combined effect of nitrogen and molybdenum on the growth and yield of bush bean

Wang *et al*. (1995) reported that application of molybdenum increased the yield of wheat by 11.45 % and 45 %, at low level of N (0.05 N kg soil $^{-1}$) and high level of N (0.2 N kg soil $^{-1}$). Activity of nitrate reductase in wheat with molybdenum greater than that of control. Molybdenum also increased the efficiency of nitrogen fertilizer utilization.

Andrade *et al*. (1998) reported that yield of *Phaseolus vulgaris* as influenced by 0, 20 or 40 kg N ha^{-1} at sowing top dressing with 0 or 30 kg N, and foliar application of 0 or 40 g Mo ha^{-1}. Seed yield was 775, 1259 and 1464 kg ha^{-1} with 0, 20 and 40 kg basal N ha^{-1}, 973 and 1358 kg without and with top-dressed N, and 976 and 1355 kg without and with Mo fertilizer, respectively.

Vieira *et al*. (1998a) stated that Mo application at 25 days after plant emergence decreased nodule number $plant^{-1}$, and also increase nodule weight when unaffected. Application of N in planting decreased number and weight of nodules .When N applied side dressing did not affect nodule number or weight. Application of Mo increase size of nodules, and Mo on nodulation avoidance of nodule senescence and also maintaining a longer period of effective N fixation.

Carvalho *et al.* (1998) found that effects of nitrogen and molybdenum physiological quality of seeds and field performance of bean (*Phaseolus vulgaris*) cv. IAC Carioca crop, with and without inoculation with Rhizobium leguminosarum bv. *phaseoli*. The seed quality was evaluated through standard germination, accelerated aging, seed germination index. First count, germination, and field emergence, dry matter weight of seedling and crop production. The results showed that effects of nitrogen, molybdenum and seed inoculation on the seed quality. Inoculation resulted in better bean performance compared to others treatments. The nitrogen and molybdenum application were beneficial to development and yield of bean crop.

Coelho *et al*. (2001) reported that on common bean (*Phaseolus vulgaris*) treated with side dressings of 0 and 40 kg N ha^{-1}; foliar sprays of 0 and 75 g Mo ha^{-1} and weed management. The treatments were applied 20 days after seedling emergence. N concentration in the leaves of the plants increased by 8- 9 % due to Mo and N fertilizers. Without weed control, N promoted increases of 3 pods per plant and 64 % grain yield, while it decreased final stand and the number of seeds pod^{-1}. Under hoe weeding, N increased crop yield by 69 %. Herbicide-treated plants exhibited yields similar to those obtained with hoe treatment, with or without N application. Mo fertilizers increased 100-seed weight and grain yield by 5 and 17%.

Jesus *et al*. (2004) found that French bean with N (20 kg ha^{-1}), P (50 kg ha^{-1}) and K (50 kg ha^{-1} were applied. Mo (as sodium molybdate) at 75 or 150 ppm. and B (as borax) at 2.5 ppm were applied, individually and in combination, as foliar sprays 20 days after sowing and again 40 days after sowing. Control plants were sprayed with distilled water. The greatest plant height (35 cm), number of leaves/plant (14.6), number of branches/plant (4.3), tap root length (20.4 cm), leaf area/plant (941.2 cm), leaf area index (0.60) and DM production (62.8 g/plant) were obtained with the 75 ppm. Mo + 2.5 ppm. B treatment.

Bassan (2001) found that application of Mo through leaves or in the rows, and side dressing with 4 N levels on a winter bean (*Phaseolus vulgaris*) crop. Inoculation increased plant dry matter weight, but decreased number of pod plant $^{-1}$, grains plant $^{-1}$ and 100-seed weight. N applied at 90 kg ha^{-1} resulted in high seed production, with or without inoculation. No effect of Mo was observed in any treatments. Inoculation did not affect seed germination and field seedling emergence, where the treatment with Mo and without 90 kg N ha^{-1} provided seeds with high germination index.

Soratto (2000) stated that application of nitrogen (0, 25, and 50 kg ha-1) and foliar application of molybdenum (0, 25, 50, and 75 g ha-1), on bean *Phaseolus vulgaris* crops in winter season. Time from emergence to flowering, plant DM yield, leaf N content, yield and yield components, and seed quality (germination and vigour) were observed in N increased yield. Mo application did not affect yield or yield components, and seed quality was not affected by fertilizer treatment.

Oliveira *et al*. (2000) showed that Magnesium was applied together with lime, N, K, Cu, Zn, B, and Mo as calcium carbonate, ammonium nitrate, potassium phosphate, cupric and zinc sulphate, boric acid and sodium molybdate generally a month before planting and P as phosphoric acid at the planting of *Phaseolus vulgaris*. The pH reached the equilibrium after six weeks of incubation. Higher plant height, leaf area, and dry matter weight: leaf area ratio and nutrient concentrations were observed in plants cultivated in soils treated with Mg to reach 8 mm/cm3 and 16 mm/cm3 when the plant was present. The plant top P content was very low but N, Ca and Mg contents can be considered.

Amane *et al*. (1999) revealed that effects of N, Mo and rhizobium with different level of N (0, 30, 60, and 90 kg ha-1) and Mo (0, 40, 80, and 120 g ha-1) on french bean .Mo (as foliar spray) and N (as side dressing) were applied at 25 days after plant emergence. Inoculation with selected strains of Rhizobium had no effect on grain yield. Molybdenum fertilization increased bean yield, and maximum yields were attained with 80 to 120 kg Mo ha^{-1}, depending on N fertilization. Small rate of Mo was needed when a larger dose of N was used and vice versa. Application of Nitrogen applied at planting time is essential and side-dressing application could not compensate its absence. The N and Mo combination increased bean yield by 90 to 200%.

Gualberto *et al*. (1995) reported that common beans cultivar Carioca-IAC 80Sh, to verify the Rhizobium *phaseoli* inoculation effects with the commercial products: Nutrimins molibdenio (4 % Mo); Nutrimins Co Mo (5% Mo and 1% Co) applied to leaves, of nitrogen fertilization on yield, some characteristics of bean plants, including the nitrogen concentrations and leaves chlorophyll content and the treatments were: N at planting + inoculant; N at planting + Mo; N at planting + Co Mo; N at planting + Co Mo + inoculant; N at planting + Mo + inoculant; Mo alone; Co Mo + inoculant; and N at planting + N at side dressing (control). Significant effects were shown on leaves chlorophyll content; and it was verified that Mo being simpler and faster could be used in substitution for nitrogen fertilization.

Rana *et al.* (2012) resulted that *Phaseolus vulgaris* seed and straw yields increased significantly with each increment in N rate in both seasons. The mean increase in seed yields with 120 kg N ha^{-1} compared with 0, 40, 80 kg N ha^{-1} was 66.6, 21.7 and 7.0 %. Growth and yield parameters are the same trend.

CHAPTER 3

MATERIALS AND METHODS

The Research work was conducted in Rabi season at Sher-e- Bangla Agricultural University, Dhaka- 1207, during the period from November 20014 to March 2015 to find out the effect of N and M_0 on the growth and yield of BARI Bush bean-2 (*Phaseolus vulgaris* L.)

3.1 Description of the Experimental Site

The Research field was located at 23^0 77 N latitude and 90^0 3 E longitude with an elevation of 8.5 meter above sea level.

3.2 Soil

The soil of the experimental field belongs to the Tejgaon soil series of the Madhupur Tract (AEZ-28). The general soil type of the experimental field is Deep Red Brown Terrace Soil. Organic matter content is very low (1.34 %) and soil pH is 5.00-6.00. The land is above flood level and well drained. The initial morphological Physical and Chemical characteristics of soil are presented in appendix I.

3.3 Climate

The monthly Rainfall of the site was 26.22 mm and Relative humidity was 68.2 %. The average maximum & minimum temperature was 31.4^0c & 12.4^0c. The average mean temperature was $26^0{}_C$. The humidity varied from 78 % to 54 %. The weather data were collected from Bangladesh Meteorological Department (Climate & weather division), Agargoan, Dhaka.in appendix II.

3.4 Collection of Seed

The seeds were collected from Horticultural Research Center (HRC) of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.5 Experimental Treatment

The experiment consists of two factors viz. Nitrogen (4 level) and molybdenum (3 level).Total number of treatment combinations were 12.

A. Nitrogen level: 4

1) N_0: Control

2) N_{60}: 60 kg N ha^{-1}

3) N_{80}: 80 kg N ha^{-1}

4) $N_{100:}$ 100 kg N ha^{-1}

B. Molybdenum level: 3

1) Mo_0: Control

2) $Mo_{0.3:}$ 0.3 kg Mo ha^{-1}

3) $Mo_{0.6:}$ 0.6 kg Mo ha^{-1}

There were 12 treatment combinations of nitrogen and molybdenum levels used in the experiment as followings**:**

$T_1 = N_0\ Mo_0$ (Control)

$T_2 = N_{60}\ Mo_0$ kg ha^{-1}

$T_3 = N_{80}\ Mo_0$ kg ha^{-1}

$T_4 = N_{100}\ Mo_0$ kg ha^{-1}

$T_5 = N_0\ Mo_{0.3}$ kg ha^{-1}

$T_6 = N_{60}\ Mo_{0.3}$ kg ha^{-1}

$T_7 = N_{80}\ Mo_{0.3}$ kg ha^{-1}

$T_8 = N_{100}\ Mo_{0.3}$ kg ha^{-1}

$T_9 = N_0\ Mo_{0.6}$ kg ha^{-1}

$T_{10} = N_{60}\ Mo_{0.6}$ kg ha^{-1}

$T_{11} = N_{80}\ Mo_{0.6}$ kg ha^{-1}

$T_{12} = N_{100}\ Mo_{0.6}$ kg ha^{-1}

3.6 Design of the experiment

The experiment consist of 12 treatment combination and was laid out in Randomized Complete Block Design (RCBD) with 3 replications. The plot was divided into three equal blocks. The related parameters of land were as follows:

Total number of plot = 36

Individual plot size = 2 m × 2 m (4 m^2)

Plot to Plot distance = 0.5 m

Row to row distance = 25 cm

Plant to plant distance =10 cm

Block to block distance = 1 m

3.7 Land preparation

The land was first opened on 13 November, 2014, with the help of a power tiller, later the land was prepared by deep and cross ploughing with the tractor followed by harrowing and alternate laddering up to a good tilth. Weeds, stubbles and crop residues were removed from the field. Field layout was done on 17 November 2014. Finally, individual plots were prepared with spade on 18 November 2014. Drains were made around each plot and the excavated soil was used for raising the bed of plots to about 5 cm high from the soil surface.

3.8 Fertilizer application

Required amounts of nitrogen and molybdenum fertilizers were applied as per treatments and all other fertilizers were applied in the whole plots as basal dose according to the fertilizer recommendation guide. Half of nitrogen and whole of molybdenum and basal dose of phosphorus, potassium, zinc and sulphur were applied during final land preparation in the form of Urea, Ammonium molybdate, Triple super phosphate (TSP), Muriate of potash (MP), Zinc Sulphate ($ZnSO_4$) and Gypsum ($CaSO_4.2H_2O$). The fertilizers were mixed thoroughly with the soil and rest nitrogen was applied 30 days after sowing.

3.9 Rate of common doses of fertilizers and manures

According to the recommendation rate of BARI which was as follows:

Common doses:

Manures/fertilizer	**Dose (kg ha^{-1})**
Urea	100
TSP	200
MOP	150
Gypsum	10

3.10 Sowing of seeds

The seeds were sown in each hill at a depth of 3.0 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands .The sowing was done on 19 November, 2014 in rows and spacing of 25cm ×10cm.

3.11 Intercultural operations

3.11.1 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. Damage seedling were replaced by using healthy plants from the excess plants within two weeks.

3.11.2 Thinning of seedlings

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

3.11.3 Weeding and Mulching

The experimental plots were kept weed free by hand weeding. Weeding were done three times as and when necessary and the crust was broken. It also helped in soil moisture conservation**.**

3.11.4 Irrigation

Irrigation was applied whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation was given six times at an interval of 10 days depending on soil moisture content.

3.11.5 Urea top dressing and earthing up

Earthing up was done four times at 10, 30, 40 and 50 days after sowing. The rest of urea was applied in 30 days after seed sowing.

3.11.6 Plant protection activities

a) To Control Insect pests

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

b) To Control Diseases

Seedlings were attacked by damping off and root rot disease and Bavistin was sprayed at the rate of 2ml/L at an interval of 15 days.

3.12 Harvesting

Immature green pods were harvested at tender stage, suitable for use as vegetable through hand picking and weighed to estimate the yield of fresh pod. At harvest, pods were nearly full-size, with the seeds still small (about one quarter developed) with firm fresh (Swiader *et al*., 1992). Harvesting was done at 60, 68, 75 and 80 Days after sowing (DAS).

3.13 Collection of data

3.13.1 Number of Pod plant^{-1}

The number of pods plant^{-1} from five randomly selected sample plants of each plot as a treatment wises.

3.13.2 Number of branch plant^{-1}

The number of branches of five randomly selected samples plants of each plot as a treatment wises.

3.13.3 Fresh weight of pods plot^{-1}

The fresh weight of 10 pods were randomly selected of five samples plants of each plot as treatment wises. As harvesting was done at different interval and the total pod weights were recorded in each unit plot and expressed in kg.

3.13.4 Length of green pod (cm)

Length of five randomly selected pods were taken from each plants and were measured using centimeter scale and mean value was calculated and was expressed in centimeter (cm).

3.13.5 Pod yield plot^{-1}

Green pods were harvested from each unit plot at different days and their weight was recorded. Harvesting was done at different times and their total weight was recorded in each unit plot and expressed in kilogram (kg). The total yield then converted into t ha^{-1}.

3.13.6 Plant height plant^{-1}

The height of five randomly selected plants were measured from the base of the plant to the tip of the tallest leaf. The height of plants were recorded in cm and the mean values of five plants for each plot were determined.

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

After separating the pod from the plants and drying the harvested plants in the sun, total weight of stover of each plot was taken in kilograms and converted into tons per hectare.

3.14 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 soil texture, soil pH, organic matter, total nitrogen, available phosphorus, exchangeable potassium and available sulphur.

3.14.1 Particle size analysis of soil

Particle size analysis of the soil was done by hydrometer method (Bouyoucos, 1927). The textural class was determined using Marshell's Triangular co-ordinate as designated by USDA (1951).

3.14.2 Soil pH

The glass electrode pH meter was used to determine the pH of the soil samples. The ratio of soil and water in the solution was maintained 1: 2.5 (Jackson, 1973).

3.14.3 Organic Carbon (%)

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

% organic matter = % organic carbon × 1.724

3. 14.4 Total nitrogen (%)

Total nitrogen in the soil samples were determined by Micro Kjeldhal method (Page *et al.*,1982).The procedure was digestion of soil sample by conc. H_2SO4, 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. 14.5 Available Phosphorus (ppm)

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

3.14.6 Exchangeable potassium (meq/100g 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.

3.14.7 Available Sulphur (ppm)

Available S in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.,* 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.15 Statistical analysis

The data obtained from experiment on various parameters were statistically analyzed with MSTAT-C computer program by completely Randomized block design (RCBD) (Russel, 1986). The analyses of variance for various crop characters 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 were accomplished by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises of the presentation and discussion of the results obtained due to application of different rate of Nitrogen (N) and Molybdenum(Mo) and their interaction effects on growth and yield by BARI bush bean-2 (*Phaseolus vulgares*) at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2014 to March, 2015.The result of the studies such as plant height, Number of branches plant^{-1}, Length of green pods by bush bean plant as well as yield attributes, Total green pods, Fresh wt. of green pod and Stover yields and Post harvest soil are discussed in this chapter.

4.1 Plant height

4.1.1 Effect of nitrogen

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 stover yield incase of the tallest plant significantly influence the straw yield of bush bean. Plant height was found to be statistically significant for application of different levels of nitrogen treatments used in the experiment. The plant height ranged from 46.89 to 49.39 cm for nitrogen application. Plant height increased with increasing the application of N. The maximum plant height (49.39 cm) was attained in the treatment N_{100} and the minimum plant height of bush bean plants (46.89 cm) was obtained in control treatment (Table 1). Ghosal et al. (2000) have also obtained the similar results.

Analysis of variance data on the performance of variety significantly influence on plant height at harvest in this study (Fig.1). The results reported that, variation in plant height was observed due to the variation in genetic variability and adaptibility in studied area. Similar results were 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 make up.

4.1.2 Effect of Molybdenum

The plant height varied significantly influenced by the application of different levels of molybdenum (Table 2 and Fig. 2). The plant height ranged from 36.17 to 41.12 cm. The highest plant height (41.12 cm) was obtained in treatments 0.6 kg Mo ha^{-1}. The lowest plant height (36.17 cm) was obtained in the control treatment (0 kg Mo ha^{-1}).

4.1.3 Interaction effect of Nitrogen and Molybdenum

The treatment combinations of nitrogen and molybdenum has significant effect on plant height of Bush Bean (Table 3). The plant height ranged from 42.17 to 55.00 cm. The highest plant height 55.00 cm was obtained from the treatment combination of N_{100} $Mo_{0.6}$ which is statistically identical with $N_0Mo_{O.3}$, $N_{60}Mo_{O.3}$, $N_{80}Mo_{O.6}$, $N_{80}Mo_{0.6}$. The lowest plant height (42.17cm) was obtained from the control treatment No Mo.

4.2 Number of branches plant-1

4.2.1 Effect of Nitrogen

The effect of N on number of branches per plant was influenced significantly (Table 1). The number of branches per plant ranged from 11.22 to 12.78. The highest number of branches per plant (12.78) was recorded from the treatment of 100 kg N ha-1, which was statistically identical with treatment N_{80}. The lowest number of branches per plant (11.22) was found in the control treatment (0 kg N ha-1). Nitrogen enhanced vegetative growth and development of plant, which ultimately may have increased the number of branches per plant. Singh and Verma (2002), Tewari et al. (2000) and Ravi Nandan and Prasad (1998) also observed the similar results in bush bean.

Table 1. Effect of different levels of nitrogen on the growth and yield contributing characters of BARI bush bean-2.

Nitrogen (kg ha^{-1})	Plant height $plant^{-1}$ (cm)	No. of branches $plant^{-1}$	No. of green pod $plant^{-1}$	Av. Length of green pod (cm)	Fresh wt. of green pod $plot^{-1}$ (kg)	Total green pod Yield (t ha^{-1})	Stover yield (t ha^{-1})
N_0	46.89c	11.22c	9.53d	12.98b	6.30d	10.76d	3.85d
N_{60}	48.56b	11.78b	11.33c	13.08b	6.73c	12.30b	5.147c
N_{80}	48.28b	12.22a	12.44b	13.25ab	7.90b	11.62c	4.60b
N_{100}	49.39a	12.78a	13.11a	13.36a	9.11a	13.40a	6.07a
Level of significance	**	**	*	*	**	**	**
CV (%)	7.03%	8.10%	9.57%	4.05	6.40	4.85	7.46

In a column figures having similar letter(s) do not differ significantly.

N_0 = 0 kg N ha^{-1} * = Significant at 5% level

N_{60} = 60 kg N ha^{-1} ** = Significant at 1% level

N_{80} = 80 kg N ha^{-1}

N_{100} = 100 kg N ha^{-1}

4.2.2 Effect of Molybdenum

Number of branches per plant varied significantly with different levels of molybdenum treatment (Table 2). The number of branches per plant ranged from 9.33 to 13.08. The highest number of branches per plant (13.08) was found from the treatment of 0.6 kg Mo ha-1. The lowest number of branches per plant (9.33 cm) was obtained in the control treatment (Mo0 kg ha-1).

Table 2. Effect of different levels of molybdenum on the growth and yield contributing characters of BARI bush bean-2.

Molybdenum (kg ha^{-1})	Plant height (cm)	No. of branches $plant^{-1}$	No. of green pod $plant^{-1}$	Av. Length of green pod (cm)	Fresh wt. of green pod $plot^{-1}$ (kg)	Total green pod Yield (t ha^{-1})	Stover yield (t ha^{-1})
Mo_0	36.17c	9.333c	9.88 c	12.90 c	6.52c	10.85c	4.33 c
$Mo_{0.3}$	40.09b	11.58b	11.27b	13.21 b	8.57b	12.14b	4.89b
$Mo_{0.6}$	41.12a	13.08a	12.70 a	13.39 a	9.50a	13.07a	5.52 a
Level of significance	**	**	*	**	**	**	**
CV (%)	7.03%	8.10%	9.57%	4.05	6.40	4.85	7.46

M_{00} = 0 kg Mo ha^{-1} * = Significant at 5% level

Mo0.3= 0.3 kg Mo ha^{-1} ** = Significant at 1% level

Mo0.6= 0.6 kg Mo ha^{-1}

4.2.3 Interaction effect of Nitrogen and Molybdenum

Number of branches per plant was significantly influenced by the interaction effects of the nitrogen and molybdenum. The combined effect of nitrogen and molybdenum levels on the number of branches per plant was highly significant (Table 3). The number of branches per plant varied between 8.33 & 17.00. The maximum number of branches per plant (17.00) was obtained from the treatment combination of 100 kg N ha^{-1} and 0.6 kg Mo ha^{-1} which was statistically identical with $N_0Mo_{0.6}$, $N_{60}Mo_{0.6}$, $N_{80}Mo_{0.6}$. The lowest number of branches per plant (8.33) was obtained from the control treatment (NoMo).

4. 3 Number of green pods plant^{-1}

4.3.1 Effect of Nitrogen

Nitrogen had highly significant effect on the number of green pods per plant (Table1). The number of green pods per plant varied between 9.53 & 13.11. The highest number of green pods per plant (13.11) was recorded from the treatment of 100 kg N ha^{-1}, which was significantly different from others treatments. The lowest number of green pods per plant (9.53) was found in the control treatment (0 kg N ha^{-1}). But the application of 80 kg N ha^{-1} did not result in any further increase in number of pods per plant compared with 100kg N ha^{-1}. Singh and Verma (2002), Tewari *et al*. (2000) and Calvache *et al*. (1997) also observed the similar results in bush bean.

4.3.2 Effect of Molybdenum

The number of green pod per plant was significantly influenced by different Mo levels (Table 2). The number of green pods per plant varied between 12.70 & 9.88 .The highest number of green pods per plant (12.70) was recorded from the treatment of 0.6 Mo ha^{-1}. The lowest number of green pods per plant (9.88) was found in the control treatment (Mo_O).

4.3.3 Interaction effect of Nitrogen and Molybdenum

The interaction of Different nitrogen and molybdenum levels showed the significant influence on the number of pod per plant (Table 3). The number of green pods per plant varied between 14.73 & 8.73.The highest number of green pods per plant (14.73) was recorded from the treatment combination of 100 N/ha and 0.6 kg Mo ha^{-1}. The lowest number of green pods per plant (8.73) was obtained from the control treatment (NoMo).

4. 4 Length of green pod (cm)

4.4.1 Effect of Nitrogen

Length of green pod showed significant influence by the application of different nitrogen levels (Table 1 and Fig 1). The length of green pods ranged from 12.98 to 13.36 cm. The highest length of green pods (13.36 cm) was recorded from the treatment of 100 kg N ha^{-1} which was statistically identical with the treatment of 80 kg N. The lowest length of green pods (12.98 cm) was found in the control treatment (No) which was statistically similar with that of 60 kg N ha^{-1}. Similar results were also reported by Tewari *et al.* (2000) and Sharma (1999).

Table 3. Combined effect of different levels of Nitrogen and Molybdenum on the growth and yield contributing characters of BARI bush bean-2.

Nitrogen × Molybdenum (kg ha^{-1})	Plant height (cm)	No. of branches $plant^{-1}$	No. of green pod $plant^{-1}$	Av. Length green pod (cm)	Fresh wt. of green pod $plot^{-1}$ (kg)	Total green pod Yield (t ha^{-1})	Stover yield (t $ha^{-1)}$
N_0Mo_0	42.17e	8.33e	8.73h	12.71	4.20igh	10.00i	3.56g
$N_0Mo_{0.3}$	50.67abc	11.00cde	10.53f	13.13	5.40gh	10.89gh	3.90fg
$N_0Mo_{0.6}$	46.00cde	16.00ab	9.33h	13.09	4.75ghh	11.40fg	4.10ef
$N_{60}Mo_0$	48.33bcde	9.33de	9.40gh	12.73	6.60g	10.89gh	4.33de
$N_{60}Mo_{0.3}$	46.33cde	12.00cde	12.67bc	13.32	6.90d	12.50de	5.20c
$N_{60}Mo_{0.6}$	51.00abc	13.33abcd	11.60de	13.19	6.70fg	13.50bc	5.91b
$N_{80}Mo_0$	50.00abcd	10.33cde	11.33 e	13.16	6.70fg	11.89ef	5.35c
$N_{80}Mo_{0.3}$	45.17cde	12.33bcde	12.00cde	13.61	6.80de	13.81b	5.89b

$N_{80}Mo_{0.6}$	53.00ab	14.00abc	12.13cd	13.31	7.10c	12.89cd	5.10c
$N_{100}Mo_{0}$	44.00de	9.33de	10.07fg	13.00	6.60gh	10.60hi	4.10ef
$N_{100}Mo_{0.3}$	47.67bcde	11.00cde	12.87b	13.25	8.30b	11.37fg	4.60d
$N_{100}Mo_{0.6}$	55.00a	17.00a	14.73a	13.49	9.16a	14.50a	6.97a
Level of significance	**	*	**	NS	**	*	**
CV (%)	7.03	8.10	9.57	4.05	6.40	4.85	7.46

NS = Non significant

In a column figures having similar letter(s) do not differ significantly.

4.4.2 Effect of Molybdenum

Length of green pod was influenced statistically by the application of different molybdenum levels (Table 2 and Fig 2). The length of green pods ranged from 12.90 to 13.39 cm. The highest length of green pods (13.39 cm) was recorded from the treatment of 0.6 kg Mo ha^{-1}, which was significantly different from other treatment. The lowest length of green pods (12.90 cm) was found in the control treatment Mo.

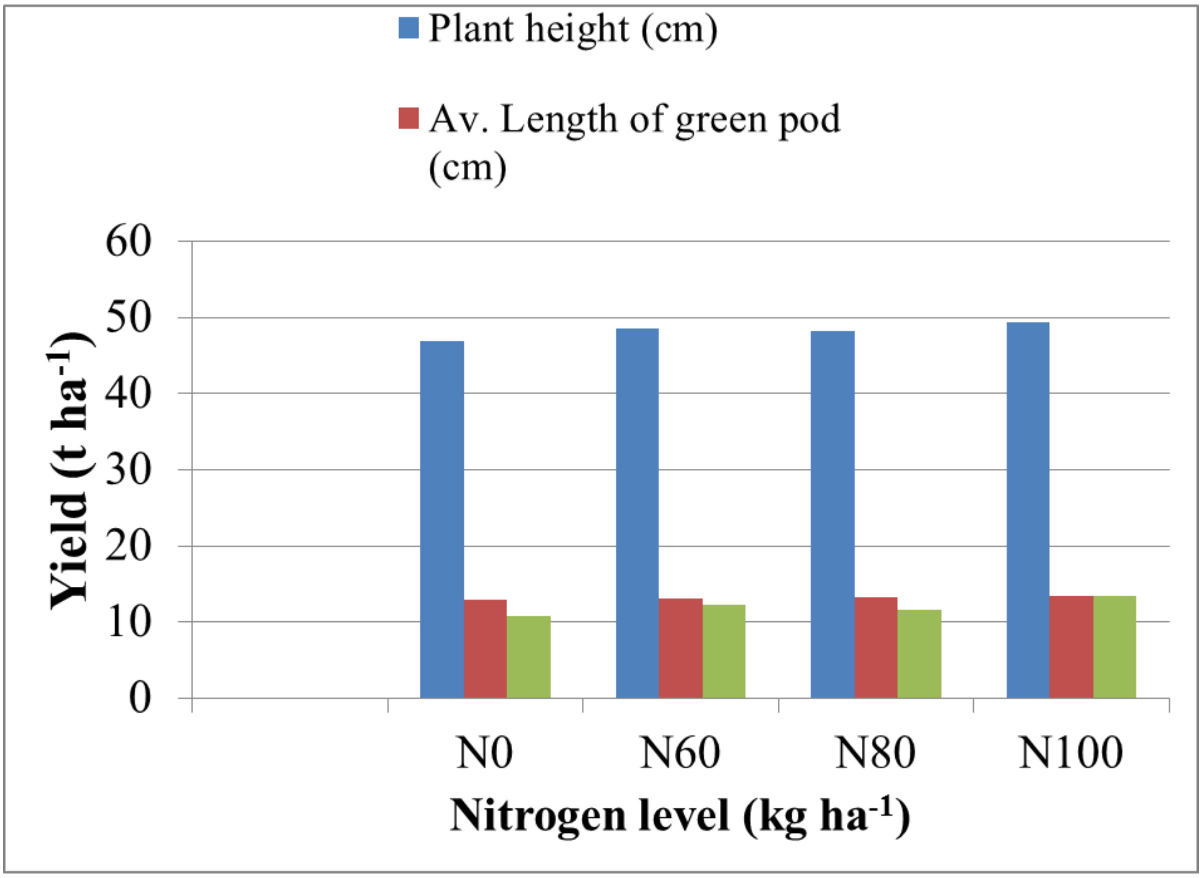

Fig. 1. Effect of Nitrogen level on the plant height, average length of green pod and pod yields of BARI bush bean-2.

4.4.3 Interaction effect of Nitrogen and Molybdenum

The interaction effect of different doses of nitrogen and molybdenum on green pod length was insignificant (Table 3). The length of green pods ranged from 12.71 to 13.61 cm. The highest length of green pod (13.61 cm) was obtained from the treatment combination of 80 N ha^{-1} and 0.3 kg Mo ha^{-1}. The lowest length of green pod (12.71 cm) was obtained from the control treatment combination (NoMo).

4.5 Fresh wt. of Green pod $plot^{-1}$ (kg)

4.5.1 Effect of Nitrogen

Fresh weight of pod $plot^{-1}$ showed significant influence by the application of different nitrogen levels (Table1). The fresh weight of green pods ranged from 6.30 to 9.11 kg ha^{-1} .The maximum weight of green pods (9.11 kg) per plot was recorded from the treatment of 100 kg N ha^{-1}. The minimum weight of green pods (6.30 kg) per plot was found in the control treatment (N_0 kg ha^{-1}).

4.5.2 Effect of Molybdenum

Fresh weight of pod $plot^{-1}$ was influenced statistically by the application of different molybdenum levels (Table 2). The weight of green pods ranged from 6.52 to 9.50 kg ha^{-1}. The highest weight of green pods (9.50 kg) $Plot^{-1}$ was recorded from the treatment of 0.6 kg Mo ha^{-1}, which was significantly different from other treatment. The lowest weight of green pods (6.52 kg) $Plot^{-1}$ was found in the control treatment (N_0 kg ha^{-1}).

4.5.3 Interaction effect of Nitrogen and Molybdenum

The interaction effect of different doses of nitrogen and molybdenum on Fresh weight of pod $plot^{-1}$ was significant (Table 3). The length of green pods ranged from 4.20 to 9.16 kg ha^{-1}. The highest weight of green pod (9.16kg) was obtained from the treatment combination of 100 N ha^{-1} and 0.6 kg Mo ha^{-1}, which was statistically similar with that of $N_{100}Mo_{0.3.}$ The lowest weight of green pod (4.20 kg ha-1) was obtained from the control combined treatment ($NoMo_O$).

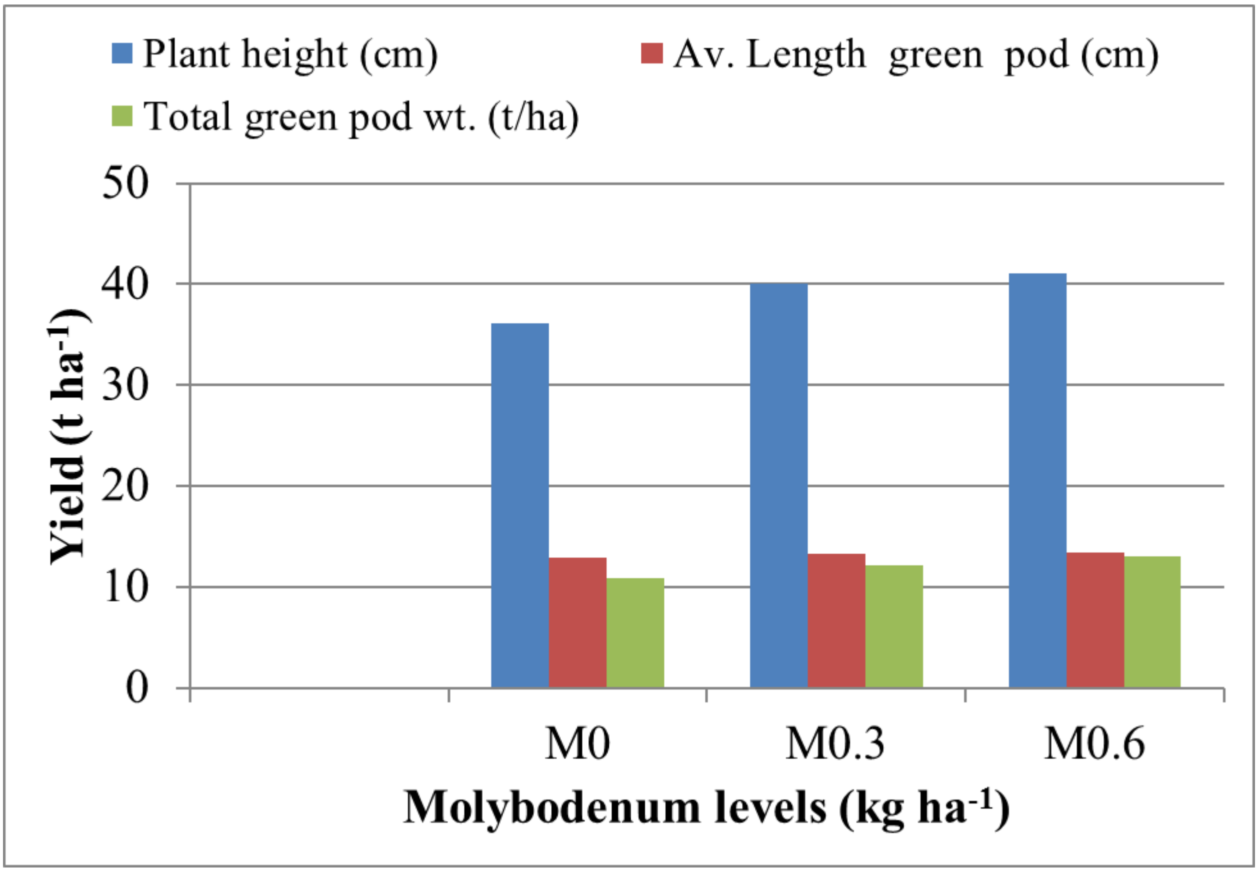

Fig. 2. Effect of molybdenum level on the plant height, average length of green pod and pod yields of BARI bush bean-2.

4.6 Green Pod yield (t ha^{-1})

4.6.1 Effect of Nitrogen

The pod yield of bush bean per hectare was significantly influenced by different levels of nitrogen (Table 1 and Fig. 1). The pod yield ranged from 10.76 to 13.40 t ha^{-1}. The maximum yield of green pod (13.40 t ha^{-1}) was recorded with the application of 100 kg N ha^{-1}, which was significantly different with other treatments and the minimum yield of green pod (10.76 t ha^{-1}) was found from the control treatment where no nitrogen was applied. From these result it was obtained that mainly nitrogenous fertilizer increased vegetative growth as well as green pod yield. The results are in agreement with that of Chandel *et al.* (2002), Singh and Verma (2002), Tewari and Singh (2000).

4.6.2 Effect of Molybdenum

Pod yield was significantly influenced by different levels of molybdenum (Table 2 and Fig. 2). The pod yield ranged from 10.85 to 13.07 t ha^{-1}. The highest pod yield of bush bean per hectare (13.07 t ha^{-1}) was obtained when the crop was fertilized with 0.6kg Mo ha^{-1} and the lowest pod yield of bush bean per hectare (10.85 t ha^{-1}) was obtained in the control treatment $Mo_{O.}$

4.6.3 Interaction effect of Nitrogen and Molybdenum

Different treatment combinations of nitrogen (N) and molybdenum (Mo) influenced significant effect on pod yield (Table 3 and Fig.2). The pod yield ranged from 10 to 14.50 t ha^{-1}. The highest pod yield (14.50 t ha^{-1}) was recorded from the treatment combination of 100 N ha^{-1} and 0.6 kg Mo ha^{-1}, which was significantly different with other treatments. The lowest pod yield (10 t ha^{-1}) was in the control treatment NoMo.

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

4.7.1 Effect of Nitrogen

Stover yield was significantly affected by different levels of N (Table 1).The stover yield ranged from 3.85 to 6.07 t ha^{-1}. The highest stover yield (6.07 t ha^{-1}) was obtained from the treatment of 100 N ha^{-1}. The lowest stover yield (3.85 t ha^{-1}) was obtained in the control treatment No. This result is in agreement with the finding of Prajapati *et al*. (2004), Singh and Verma (2002).

4.7.2 Effect of Molybdenum

The effect of molybdenum on straw yield was found statistically significant (Table 2). The straw yield ranged from 4.33 to 5.52 t ha^{-1}. The highest straw yield (5.52 t ha^{-1}) was obtained from the treatment of 0.6 kg Mo ha^{-1} and the lowest straw yield (4.33 t ha^{-1}) was obtained in the control treatment Mo.

4.7.3 Interaction effect of Nitrogen and Molybdenum

Different treatment combinations of nitrogen (N) and molybdenum (Mo) had significant effect on stover yield (Table 3). The stover yield ranged from 3.56 to 6.97 t ha^{-1}. The highest stover yield (6.97 t ha^{-1}) was obtained from the treatment combination of 100 kg N ha^{-1} and 0.6 kg Mo ha^{-1}. The lowest stover yield (3.56 t ha^{-1}) was obtained from the control treatment (NoMo).

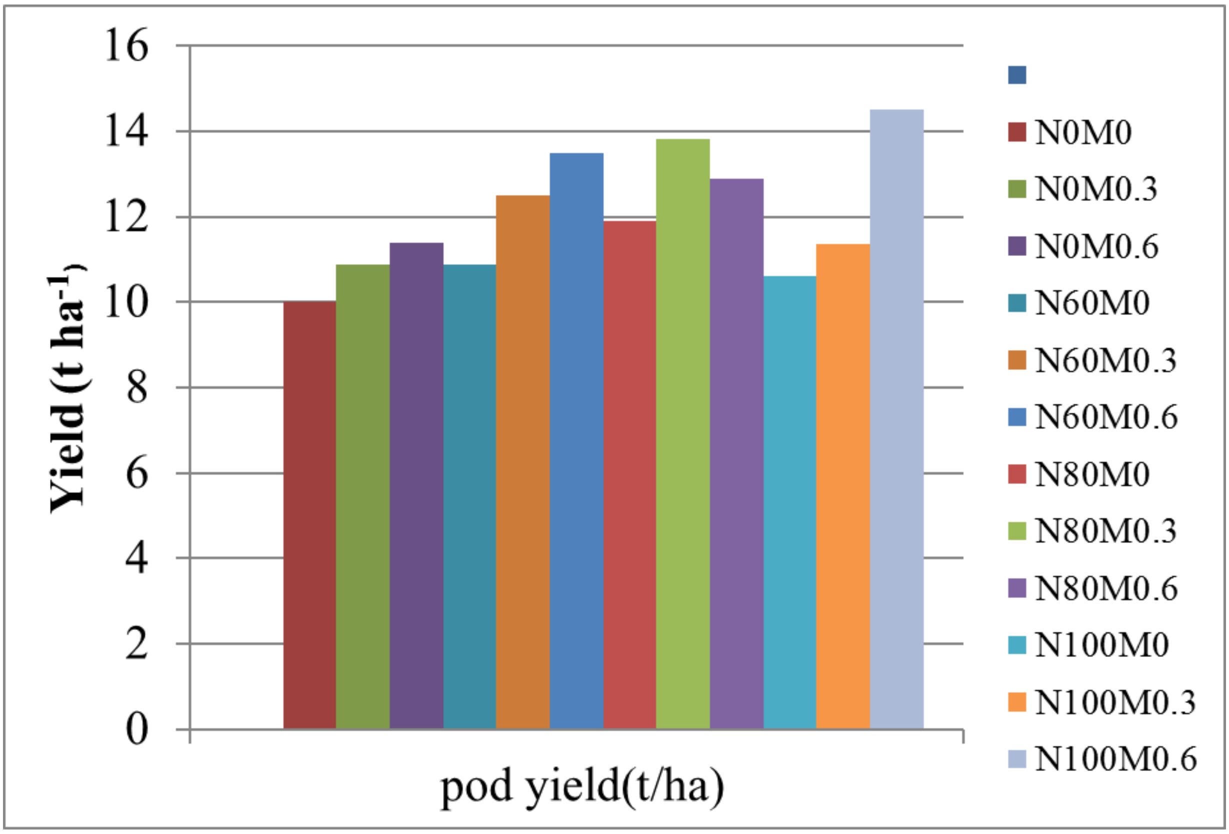

Fig.3. Combined effect of Nitrogen and Molybdenum on the pod yield of BARI bush bean-2.

4.8 Characteristics of the post-harvest soils

The characteristics of the post-harvest soils as influenced by different treatments. Showed a marked variation on the soil pH, organic carbon, N, P, K and S content in the post-harvest soil due to addition of nutrients in soil and their uptake by plants.

4.8.1 Soil pH

A significant variation was not observed on the content in soil pH after harvest where the nitrogen was incorporated in soil (Table 4). Soil pH values of the post-harvest soils ranged from 5.15 to 5.70. The highest pH value (5.70) was recorded in N_{60} treatment and lowest pH value (5.15) was recorded in control treatment (N_{o}).

A significant variation was not observed on the content in soil pH after harvest where the molybdenum was incorporated in soil (Table 5). Soil pH values of the post-harvest soils ranged from 5.42 to 5.78. The highest pH value (5.78) was recorded in $Mo_{0.3}$ treatment and lowest pH value (5.42) was recorded in control treatment N_o.

Combined application of different doses of nitrogen and molybdenum was not showed a significant effect on the content in soil pH after harvest (Table 6). The soil pH values in the post-harvest soil ranged from 5.10 to 5.90. The higher soil pH (5.90) were recorded in the treatment combination of $N_{60}Mo_{0.3}$ which was statistically similar with treatment $N_{100}M_0$ and the minimum soil pH (5.10) was obtained in the control treatment NoMo.

4.8.2 Organic carbon content (%)

A significant variation was not observed on the content in organic carbon after harvest where the nitrogen was incorporated in soil .The organic carbon content of the post-harvest soil ranged from 0.52% to 0.60% (Table 4). The maximum organic matter content (0.60%) was obtained in the treatment N_{100} which was statistically similar with treatment N_{80} and the minimum organic matter content (0.56%) was obtained in the control treatment.

A significant variation was not observed on the organic carbon content after harvest where the molybdenum was incorporated in soil. The organic carbon content in the post-harvest soil ranged from 0.56 % to 0.62% (Table 5). The maximum organic carbon content (0.60%) was obtained in the treatment $Mo_{0.3}$ and the minimum organic carbon content (0.56%) was obtained in the control treatment.

Combined application of different doses of nitrogen and molybdenumwas not showed a significant effect on the organic carbon content in soil after harvest (Table 6). The organic carbon content in the post-harvest soil ranged from 0.53 % to 0.63 %. The higher organic carbon contents (0.63%) were recorded in the treatment combination of $N_{80}Mo_{0.3}$ which was statistically similar with treatment combination of $N_{60}Mo_{0.3}$ and $N_0Mo_{0.6}$ and the minimum organic carbon content (0.53%) was obtained in the control treatment.

4.8.3 Total nitrogen (%)

A statistically significant variation was not observed in the total N content in the post-harvest soil. The total N content of the post-harvest soil varied from 0.059 % to 0.067 % (Table 4). The highest total N content (0.067 %) was observed in N_{100} treatment and the lowest value of 0.059 % in control.

Statistically significant variation was not observed in total N content of the post-harvest soil (Table 5). The total N content of the post-harvest soil ranged from 0.063 % to 0.066 %. The highest total N content (0.066 %) was observed in $Mo_{0.3}$ treatment and the minimum value (0.061 %) was found in the control treatment.

The effect of combined applications of different doses of nitrogen and molybdenum resulted was not significant variations in nitrogen content in the post-harvest soil (Table 6). The total N content in the post-harvest soil ranged from 0.055% to 0.073%. The higher total N content of the post-harvest contents (0.073 %) were recorded in the treatment combination of $N_{80}Mo_{0.3}$ and the lowest value of 0.055% in control(N_0Mo_0) which was statistically similar with treatment $N_0Mo_{0.3.}$

4.8.4 Available phosphorus (ppm)

The effect of application of N at different levels showed significant differences in respect of P content in soil after harvest (Table 4). The P content in post-harvest soils ranged from 14.5 ppm to 17.8 ppm. The highest P content was recorded in N100 treatment and the lowest P content was found in the control treatment.

Statistically significant variation was observed due to the application of Mo at different doses on the content of avail P of the post-harvest soil (Table 5). The P content in the post-harvest soil ranged from 13.52 to 17.23 ppm. The highest P content (17.23 ppm) was observed in Mo0.3 treatment and the minimum value (15.2 ppm) was found in the control treatment.

The effect of combined application of nitrogen and molybdenum showed significant differences in respect of P content in soil after harvest (Table 6). The P content in the post-harvest soil ranged from 12.14 to 18.89 ppm. The highest P content (18.89 ppm) was observed in N100Mo0.6 treatment and the minimum value (12.14 ppm) was found in the control treatment (NoMo.)

4.8.5 Exchangeable potassium

The effect of application of N showed significant differences in respect of K content in soil after harvest (Table 4). The K content in post-harvest soils ranged from 0.19 to 0.23. The highest K content was recorded in N80 treatment (0.23) and the lowest K content (0.19) was found in the control treatment No.

Statistically significant variation was observed in K content of the post-harvest soil with the application of various levels of Mo (Table 5). The K content in post-harvest soils ranged from 0.17 to 0.22. The highest K content was recorded in M0.6 treatment (0.22) and the lowest K content (0.17) was found in the control treatment Mo.

The effect of combined application of nitrogen and molybdenum showed significant differences in respect of K content in soil after harvest (Table 6). The K content in the post-harvest soil ranged from 0.17 to 0.25. The highest K content (0.25) was observed in N100Mo0.6 treatment and the minimum value (0.17) was found in the control treatment (NoMo).

4.8.6 Available Sulphur

The effect of application of N showed significant differences in respect of S content of soil after harvest (Table 4). The S content in post-harvest soils ranged from 16.3 to 23.9 ppm. The highest S content (23.9 ppm) was recorded in N100 treatment and the lowest S content (16.3 ppm) was found in the control treatment.

Statistically significant variation was observed in molybdenum content in respect of the post-harvest soil (Table 5). The S content in the post-harvest soil ranged from 15.14 to 21.21 ppm. The highest P content in (21.21 ppm) was observed in $Mo_{0.3}$ treatment and the minimum value (15.14 ppm) was found in the control treatment.

The effect of combined application of nitrogen and molybdenum showed significant differences in respect of S content of soil after harvest (Table 6). The S content of the post-harvest soil ranged from 13.23 to 25.67 ppm. The highest S content (25.67 ppm) was observed in N80Mo0.3 which was statistically similar with treatment $N_{100}Mo_{0.6}$ and the minimum value (13.23 ppm) was found in the control treatment (NoMo).

Table 4. Effect of N fertilizers on the soil pH, Organic Carbon, total N, available P, available K and available S content in the soil after BARI bush bean-2 harvest.

Nitrogen fertilizer	Soil pH	Organic Carbon (%)	Total Nitrogen (%)	Available P (ppm)	Available K(meq/100 g soil)	Available S (ppm)
N_0	5.15d	0.52c	0.059c	14.5	0.19	16.3
N_{60}	5.70a	0.55b	0.060c	16.7	0.21	17.7
N_{80}	5.53b	0.59a	0.062b	16.1	0.23	19.4
N_{100}	5.43c	0.60a	0.067a	17.8	0.18	23.9
Level of significance	**	**	**	NS	NS	NS
CV (%)	4.32	0.53	0.067	19.89	0.25	25.89

NS = Non significant

In a column figures having similar letter(s) do not differ significantly.

Table 5. Effect of Mo on the soil pH, Organic Carbon, total N, available P, available K and available S content in the soil after BARI bush bean-2 harvest.

Molybdenum (kg/ha^{-1})	Soil pH	Organic Carbon (%)	Total Nitrogen (%)	Available P (ppm)	Available K (meq/100 g soil)	Available S (ppm)
Mo_0	5.42 c	0.56 c	0.063	13.52	0.17	15.14
$Mo_{0.3}$	5.78 a	0.62 a	0.066	17.23	0.21	21.21
$Mo_{0.6}$	5.61 b	0.59 b	0.065	16.13	0.22	20.24
Level of significance	**	**	NS	NS	NS	NS
CV (%)	4.32	0.53	0.06	19.89	0.25	25.89

NS = Non significant

In a column figures having similar letter(s) do not differ significantly.

Table 6. Combined effect of N and Mo fertilizers on the soil pH, Organic Carbon, total N, available P, available K and available S content in the soil after BARI bush bean-2 harvest.

Nitrogen × Molybdenum (kg/ha^{-1})	Soil pH	Organic Carbon (%)	Total Nitrogen (%)	Available P (ppm)	Available K (meq/100g soil)	Available S (ppm)
N_0Mo_0	5.10 e	0.53 d	0.055 b	12.14	0.17	13.23
$N_0Mo_{0.3}$	5.80ab	0.59 b	0.056 b	13.45	0.21	16.06
$N_0Mo_{0.6}$	5.20d	0.62 a	0.060 b	15.65	0.22	18.34
$N_{60}Mo_0$	5.70b	0.53 d	0.065 ab	17.16	0.20	23.67
$N_{60}Mo_{0.3}$	5.90a	0.62 a	0.062 b	14.34	0.18	21.43
$N_{60}Mo_{0.6}$	5.7 b	0.59 b	0.064 ab	18.76	0.23	13.78
$N_{80}Mo_0$	5.90 a	0.59 b	0.066 ab	18.0	0.21	19.13
$N_{80}Mo_{0.3}$	5.65a	0.63 a	0.073 ab	18.79	0.18	25.67
$N_{80}Mo_{0.6}$	5.58 d	0.60 b	0.059 ab	17.45	0.24	18.12
$N_{100}Mo_0$	5.80ab	0.56 c	0.062 b	17.07	0.25	21.32
$N_{100}Mo_{0.3}$	5.60 b	0.59 b	0.065 ab	18.02	0.18	20.04
$N_{100}Mo_{0.6}$	5.80ab	0.57 c	0.070 ab	18.89	0.25	25.65
Level of significance	**	**	**	NS	NS	NS
CV (%)	4.32	0.53	0.06	19.89	0.25	25.89

NS = Non significant

In a column figures having similar letter(s) do not differ significantly.

CHAPTER 5

SUMMARY AND CONCLUSION

The present Experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 20014 to March 2015 to study the effects of Nitrogen and Molybdenum on growth and yield of BARI bush bean-2 (*Phaseolus vulgaris* L.).

The soil of the experimental field was Silty Clay Loam terrace soil in texture belonging to the Tejgoan soil series of the Madhupur Tract (AEZ -28). Soil pH is 5.00 (at 0-15 cm) depth. The soil contained 27.08% sand, 39.80% silt, 25.16% clay, 0.07% Total N, 0.81% organic-C, 1.23% OM, 9.65:1 C:N ratio, 19 ppm available P, 0.20% exchangeable K and 13 ppm S.

The treatments consisted of four levels of N (0, 60, 80 & 100 kg ha^{-1} designated as N_0, N_{60}, N_{80} & N_{100}, respectively) and three levels of Mo (0, 0.3 & 0.6 kg ha^{-1} designated as M_0, $M_{0.3}$ & $M_{0.6}$ respectively). There were 12 treatments combinations in the experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 4 m^2 (2 m x 2 m) and the space between block and between plots were 1m and 0.5m respectively. The land was fertilized with P_{20}, K_{30}, S_4 in the form of triple super phosphate, Muriate of potash, Gypsum. Total amount of chemical fertilizers without urea were applied as basal dose. Rest of the urea was applied top dressing 30 days after planting. Seeds were shown in 19November, 2014. Intercultural operations were done as when necessary.

From each unit plot 5 plants were randomly selected to record data on growth, yield attributes and yield after harvesting. Data on different parameters were recorded. Data were analyzed using the computer package MSTAT-C and the difference between means was compared by LSD test. At the time of final land preparation soil sample and after harvest soil sample was taken for chemical analysis. Results of the samples were also statistically analyzed. The individual and combined effects of Nitrogen (N) and Molybdenum (Mo) on the growth and yield of BARI Bush Bean-2.

Data on plant characters were recorded at different stages. Nitrogen and molybdenum fertilization at different levels individually influenced plant characters. The individual and interaction effects of N and Mo on growth and yield were found positive. Both the growth and yield increased with increasing Nitrogen and Molybdenum.

Plant height was significantly influenced by different level of N and Mo. The tallest plant (55.00 cm) was found in $N_{100}Mo_{0.6}$ treatment. This result indicate that higher dose of N and Mo produced the tallest plants. Plant height also increased with increasing level of N and Mo individually.

The individual application of N_{100} and $Mo_{0.6}$ had positive effect on the number of branches per plant, number of green pod plant^{-1}, pod length, pod yield plot^{-1}. $N_{100}Mo_{0.6}$ treatment combination appeared to have produced the maximum number of effective branches plant^{-1} (17.00), number of green pod plant^{-1} (14.73), pod length (13.61cm) and Number of pod yield plot^{-1} (14.50 kg) and the minimum values was found in control ($NoMo_0$).

The maximum pod yield (13.40 t ha^{-1}) was attained in N_{100} treatment and the maximum pod yield (13.07 t ha^{-1}) was attained in $Mo_{0.6}$ treatment. The maximum pod yield (14.50 t ha^{-1}) was attained in $N_{100}Mo_{0.6}$ treatment combination and minimum result found in control ($NoMo_0$).The maximum stover yield (6.97 t ha^{-1}) was obtained in $N_{100}Mo_{0.6}$ treatment combination and the lowest value (3.56 t ha^{1}) was obtained in control.

Application of N and Mo showed considerable influence on the properties of the post-harvest soils such as pH, organic carbon, total N, available S, available P and exchangeable K. The pH value of post-harvest soils range varied from 5.10 to 5.90. All the treatments recorded higher pH value as compared to the initial soil. The organic carbon content of the post-harvest soils ranged from 0.53 to 0.63. The N, P, K and S content of the post-harvest soils ranged from 0.055 to 0.073%, 0.00120 to 0.00187%, 0.00440 to 0.00590% and 0.00130 to 0.00250%.The highest N, P , K and S content was recorded in N_{80} $Mo_{0.3}$ treatment and lowest values were obtained control ($NoMo_{0)}$.

The following conclusions could be drawn from the results of the present experiment:

i) Individual effect of N and Mo on growth and yield of bush bean was found positive and significant. The highest yield was found in application of N @ 100 kg ha^{-1} and Mo @ 0.3 kg ha^{-1}.

ii) The combined effect of N and Mo enhanced growth and yield of bush bean with treatment of $N_{100}Mo_{0.6}$.

iii) Application of N @ 100 kg ha^{-1} and Mo @ 0.6 kg ha^{-1} was the most suitable combination to give the highest yield of bush bean in Deep Red Brown Terrace Soils under Tejgaon series of Bangladesh.

For successful production of bush bean the effect of confirmation of the present findings different levels of nitrogen and molybdenum may be investigated further at different locations of Bangladesh.

CHAPTER 6

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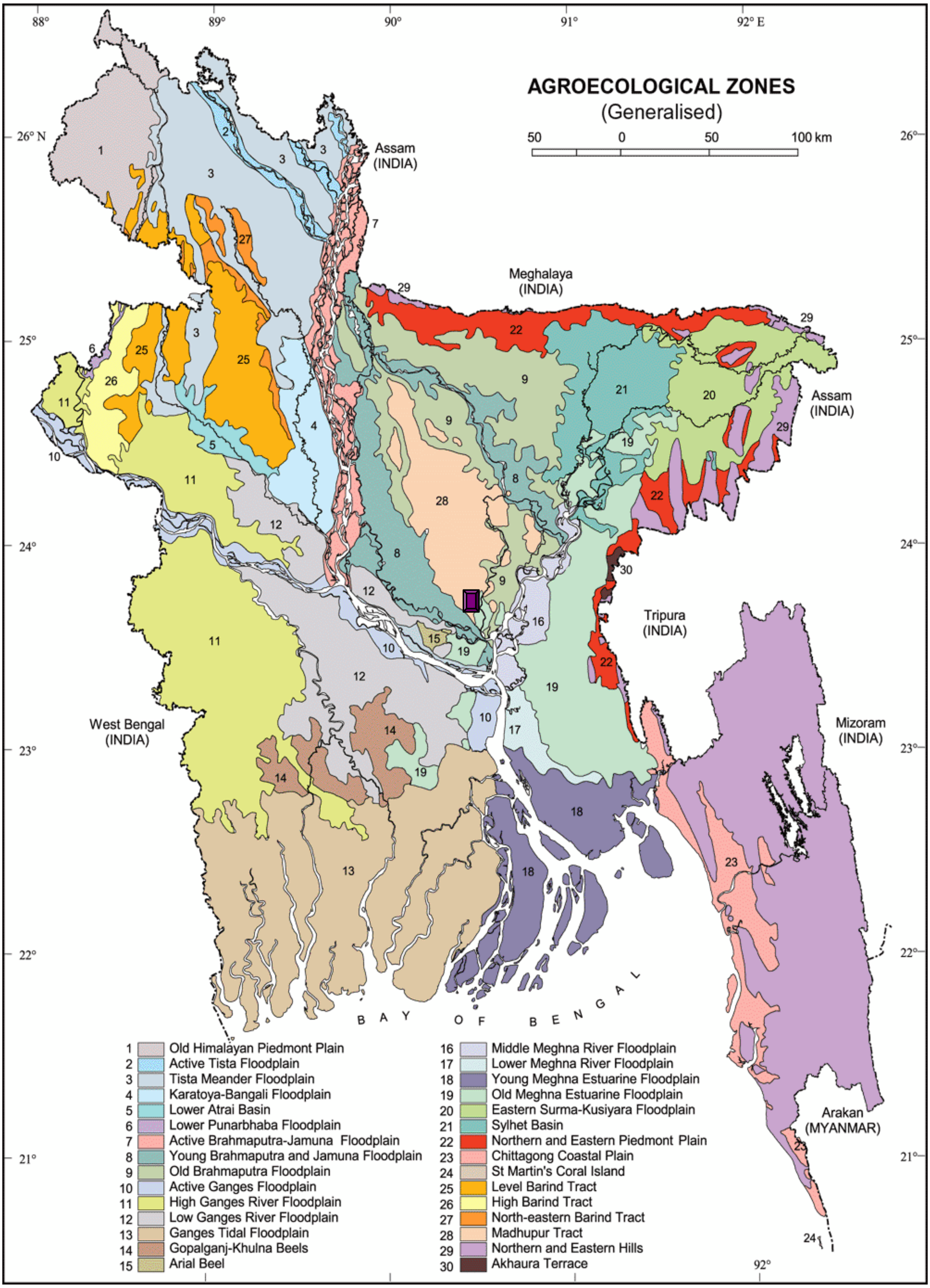
APPENDICES

Apendix I. The experimental site is shown in the AEZ Map of Bangladesh.



Appendix II: .Physical and Chemical properties of the Experimental soil

Soil Properties	Value
A. Physical Properties	
1.Particle size analysis of soil	
% Sand	27.08
% Silt	39.80
% clay	25.16
2. Soil Texture	Silty Clay loam
B. Chemical Properties	
1.Soil pH	5.00
2. Organic Carbon (%)	0.81
3. Organic matter (%)	1.23
4. Total N (%)	0.07
5. C : N ratio	9.65 : 1
6. Available P (ppm)	19
7. Exchangeable K (meq/100g soil)	0.20
8. Available S (ppm)	13

LIST OF PLATES

Plate.1 View Of The Experimental Field

Plate.2 View Of The Experimental Field

Plate. 3 View Of The Experimental Field

Appendix III. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November 2014 to March 2015

Month	*Air temperature (^{0}C)		*Relative humidity (%)	Rainfall (mm) (total)
	Maximum	Minimum		
November, 2014	25.82	16.04	78	00
December, 2014	22.4	13.5	74	00
January, 2015	24.5	12.4	68	00
February, 2015	27.1	16.7	67	3
March, 2015	31.4	19.6	54	11

* Monthly average

* Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan, Dhaka