EFFECT OF NITROGEN AND MOLYBDENUM APPLICATION ON THE GROWTH AND YIELD OF BUSH BEAN (*Phaseolus vulgaris* L.)

A Thesis

By

MD. KAMAL HOSSAIN

DEPARTMENT OF SOIL SCIENCE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-e-BANGLA NAGAR, DHAKA-1207

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Approved as to style and content by:

Co-supervisor	**Supervisor**
(Dr. Md. Nurul Islam)	**(Dr. Gopi Nath Chandra Sutradhar)**
Professor	Professor
Department of Soil Science	Department of Soil Science
Sher-e-Bangla Agricultural University	Sher-e-Bangla Agricultural University
Dhaka-1207	Dhaka-1207

Chairman
Dr. Alok Kumar Paul
Professor
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207

CERTIFICATE

This is to certify that thesis entitled, "*EFFECT OF NITROGEN AND MOLYBDENUM APPLICATION ON THE GROWTH AND YIELD OF BUSH BEAN (Phaseolus vulgaris)*" submitted to the *DEPARTMENT OF SOIL SCIENCE*, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degre of *MASTER OF SCIENCE (M.S.)* in *SOIL SCIENCE* embodies the result of a piece of *bona fide* research work carried out by *MD. KAMAL HOSSAIN*, Registration No. *0602159* 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 him.

Dated.........................

....

Place: Dhaka, Bangladesh

Supervisor

(Dr. Gopi Nath Chandra Sutradhar)
Professor
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207

Dedicated To My

Beloved Parents

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ABSTRACT

A field experiment was carried out at research field of Sher-e-Bangla Agricultural University, Dhaka in Modhupur Tract (AEZ 28), during the *rabi* season from December 2006 to February 2007 to study 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, $Mo_{0.5}$, and $Mo_{1.0,}$ respectively. Urea and ammonium molybdate were used as the sources of nitrogen and molybdenum, respectively. There was a positive impact of each nutrient and their interaction on number of effective branches $plant^{-1}$, population m^{-2}, 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 upto 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 $Mo_{0.5.}$ The maximum pod yield (18.50 t ha^{-1}) and seed yield (3.50 t ha^{-1}) was attained in $N_{120}Mo_{0.5}$ treatment. The highest N, P, K and S contents in plant were recorded in $N_{120,}$ $Mo_{0.5}$ and $N_{120}Mo_{0.5}$ treatment and similarly the highest N, P, K and S uptake by plant were recorded in $N_{120,}$ $Mo_{0.5}$ and $N_{120}Mo_{0.5}$ treatment. The highest N, P, K and S contents in seed were recorded in $N_{120,}$ $Mo_{0.5}$ and $N_{120}Mo_{0.5}$ treatment, and similarly the highest N, P, K and S uptake by seed were recorded in $N_{120,}$ $Mo_{0.5}$ and $N_{120}Mo_{0.5}$ treatment. The results of economic analysis showed that the highest net benefit of Tk.1,68,722.00 ha^{-1} was obtained in $N_{120}Mo_{0.5}$ treatment and the lowest net benefit of Tk.16,559.00 ha^{-1} was found in control.

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LIST OF ABBREVIATIONS AND SYMBOLS

1.	%	Per cent
2.		
3.	^0C	Degree Celsius
4.	AEZ	Agro- Ecological Zone
5.	ANOVA	Analysis of Variance
6.	BBS	Bangladesh Bureau of Statistics
7.	BCR	Benefit Cost Ratio
8.	BARI	Bangladesh Agriculture Research Institute
9.	BARC	Bangladesh Agriculture Research Council
10.	BCMV	Bean Common Mosaic Virus
11.	cm	Centimeter
12.	cv.	Cultivar
13.	CV	Coefficient of Variation
14.	CGR	Crop Growth Rate
15.	Dr.	Doctor
16.	DAS	Days After Sowing
17.	DMRT	Duncun's Multiple Range Test
18.	EC	Emulsifiable Concentrate
19.	FAO	Food and Agriculture Organization
20.	Fig	Figure
21.	g	Gram

22.	HRC	Horticulture Research Center
23.	ha	Hectare
24.	kg	Kilogram
25.	LSD	Least Significant Difference
26.	ppm	Parts per million
27.	M P	Murate of potash
28.	m	Meter
29.	ml	Milliliter
30.	t	ton
31.	$t\ ha^{-1}$	Ton per Hectare
32.	TSP	Triple Super phosphate
33.	RCBD	Randomized Completely Block Design
34.	USDA	United Sates Department of Agriculture

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Chapter 1
Introduction

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; Salukhe *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. Its young pods and mature seeds are used as cooked vegetable. It is very rich in protein. Geographical and agro climatic conditions of Bangladesh are favourable for bush bean cultivation.

It is widely cultivated in the temperate and subtropical regions, and also in many parts of the tropics (Purseglove, 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. It is more suitable as a winter (*rabi*) crop in the northeastern parts of India (AICPIP, 1987). According to the recent 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). Brazil is the largest bush bean producing country in the world. In Bangladesh there is no statistics about the area and production of this crop. It is not new crop in our country. It is cultivated in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country in a rather limited scale.

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, fibre, thiamin, riboflavin, Ca and Fe (Shanmugavelu, 1989) and the seed contains significant amount of 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. Hortex foundation exported 23.86 tons of vegetable bush bean during July- December 2001 (Anonymous, 2001).

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 of prime importance. Nutrient requirement for different cultivars usually is similar except on poor soils (Adams, 1984). Bush bean cultivation requires ample supply of nitrogen. 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. An optimum amount of nitrogen is necessary to produce maximum yield of good quality french bean.

The productivity of french bean at the farmers' field is very low (7-8 q ha^{-1}) due to lack of information about optimum sowing time, poor fertility management and exclusively growing local cultivars (Saini and Negi, 1996). Temperature ranging from 19-27 °C is suitable for the growth and development of French bean. Abdullah and Fischbeck (1978) have stated that the pod set of french bean was poor at day/ night temperature of 30/25 °C. On average, duration of the flowering in french bean was doubled when the day or night temperature was increased from 15/12°C to 18/15°C (Apel, 1988). In Bangladesh, french bean grows successfully in winter season due to optimum temperature for their growth, development and fruit setting.

Bush bean or french bean is a short duration crop and thus, yield per day is comparatively high, it can fit well in intercropping with other crops such as wheat, maize, sunflower and sugarcane (Frances *et al.*, 1986). Various problems, however, hamper bush bean production in Bangladesh. Fertilizers especially nitrogenous and phosphate are the most critical imput for increasing crop production and has been recognized as the central element or agricultural development (Mukhopadhyay *et al.*, 1986).

In case of application of the various fertilizer doses, there were significant differences in pod number $plant^{-1}$ in bush bean (Sa *et al.*, 1982). The plant height, number of branches, length of pod $plant^{-1}$ and seed yield pod^{-1} increase with successive increase in the doses of nitrogen as well as phosphorus (Tewari and Singh, 2000). Chandra *et al.*, (1987) stated that plant growth and yield increased with increasing nitrogen and phosphorus fertilizer. Optimum combination of nitrogen and molybdenum may bring about considerable increase in the yield of bush bean due to their complementary effects.

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. Nitrogen should be applied in such a way that minimum is leached or washed out and maximum its utilization for grain production. Bush bean cultivation requires ample supply of nitrogen. Nitrogen is necessary for its vegetative growth and development. 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 by other pulses.

Macro and micronutrients deficiency, especially N and Mo deficiencies are observed in most of the soils of Bangladesh causing the low yield of crops. This is why the application of nutrients (N and Mo) in the soil is increasing gradually. A detailed and systemic study is needed to find out the requirement and effect of nitrogen and molybdenum for maximizing the yield of bush bean in Bangladesh. The aim of nitrogen and molybdenum application in bush bean are, therefore, to increase the crop growth and development, and at the same time, to increase the yield of the crops.

Molybdenum (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. But deficiency of these nutrients is very much pronounced under multiple cropping systems due to excess removal there by necessity their exogenous supply.

Molybdenum is an essential micronutrient, is known to participate in the nitrate reduction system of nitrogen metabolism in higher plants (Nicholas, 1961). The reduction of oxidized form of nitrogen, nitrate to ammonia, is biological redox potential system. The direct effect of molybdenum deficiency was on nitrogen metabolism through accumulation of nonprotein soluble nitrogen in the tissues without its utilization in the growth of the plant. The essentiality of molybdenum for the growth and development of plants were thus confirmed.

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 it is directly involved in the nitrogen fixating enzyme nitrogenase and nitrogen reduced enzyme nitrate reductase. 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).

Evidences reveal that nitrogen and molybdenum fertilizers play an important role for french bean production. As a part of nitrogenase enzyme, Mo is essential for atmospheric nitrogen fixation. In addition, Mo availability is reduced in acidic soil. The yield of french bean may be increased through judicious combination of nitrogen and molybdenum application. Considering the above facts the present piece of work was undertaken to study the effect of N and Mo on growth and yield of bush bean in acidic soil of Sher-e- Bangla Agricultural University Farm. The major objectives of the experiment are:

i) to study the optimum level of nitrogen for maximizing the growth and yield of bush bean.

ii) to study the optimum level of molybdenum for maximizing the growth and yield of bush bean.

iii) to study the effect of nitrogen in combination with molybdenum for maximizing the growth and yield of bush bean.

Chapter 2
Review of Literature

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. Many research works have been done in different parts of the world to study the effect of the nitrogen and molybdenum on the growth and yield of bush bean. It has been recently introduced in Bangladesh. However, a very few research works have been carried out on bush bean production under Bangladesh conditions. 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. 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.

Kikuti *et al.* (2005) studied the effects of different levels of N (0, 70, 140 and 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 populations, and the P lessened that effect. The productivity was increased in response to N and P_2O_5 treatments, which varied according to the seasons. The maximum efficiency was obtained with 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}) and P fertilizer (0, 40, 60, 80 kg P_2O_5 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 seed number pod^{-1} and 1000-seed weight. The rates of P fertilizer were not significant for all of the factors. On the other hand, bacterial inoculation exerted a significant and positive effect on pod number $plant^{-1}$ and grain yield.

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 and120 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 cost benefit ratio (1: 2.44).

Ram-Gopal *et al.*, (2003) investigated the effects of irrigation (0.5, 0.7 and 0.9 W/CPE) and nitrogen rates (50, 100 and 150 kg ha^{-1}), with or without 5 t farmyard manure (FYM)/ha, 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. The treatments consisted of 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 were 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 up to 120 kg 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.

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 two-year experiment was conducted during 1995-97 with 5 nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and 3 phosphorus levels (0, 30 and 60 kg P_2O_5 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}) and phosphorus (60 kg ha^{-1}) resulted in the highest plant height, branches per plant, pods per plant, seeds per pod, 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}).

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 field experiment was conducted by Farkadeet and Pawar (2002) in Maharashtra, India to determine the effect of N: P fertilizers at 60: 45, 90: 75 and 120: 75 kg/ha on *Phaseolus vulgaris* cultivars. The yield and growth characters increased with increasing N: P fertilizer level and the highest (15.93 q ha $^{-1}$) were observed at 120: 75 kg/ha.

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 $^{-1}$ in french bean. They recommended fertilizer dose of 90kg N ha $^{-1}$ and 60 kg P_2O_5 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) straw yields (3331kg ha $^{-1}$), total N uptake (90.70 kg ha $^{-1}$) and S uptake (6.58 kg ha $^{-1}$) was 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 plant height which was the 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 a corresponding improvement in yield and yield components.

Prajapati *et al.* (2001) conducted an experiment in Gujarat, India, to determine the effects of weed control methods and N fertilizer application on the physiology of french bean cv. The highest values of fresh and dry weight per plant, net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), and grain yield were recorded under weed free conditions. Similarly, most of the physiological parameters, namely fresh and dry matter production per plant, LAI, NAR, RGR, and CGR were significantly high with 120 kg N/ha.

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 $^{-1}$) and phosphorus (0, 20, 40 or 60 kg P_2O_5 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 as well as phosphorus. 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. The highest values on the above yield attributes were recorded with 60 kg P_2O_5 ha $^{-1}$. The combination of 120 kg N + 60 kg P_2O_5 ha $^{-1}$ along with 60 kg K_2O ha $^{-1}$ gave the highest seed yield, net profit and net return per rupee investment.

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.

Ghosal *et al.* (2000) conducted a field trial in Bihar, India to study 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. They observed that nitrogen at the rate of 160 kg N ha $^{-1}$ resulted in significantly highest values for number of pods plant $^{-1}$, weight of pods plant $^{-1}$, grain yield and straw yield.

Daba and Haile (2000) reported that *Rhizobium* inoculation and N significantly increased grain yield, nodule number and dry matter yield of french bean.

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 100-seed weight increased with increasing N rate.

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

Sushant *et al*. (1999) conducted an experiment in India to investigate the 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 used efficiency of french bean. Yield increased with increasing irrigation and N and P rates. The highest yield was obtained at 100 kg N ha^{-1} and 60 P_20_5 kg ha^{-1}. Water use efficiency increased with increasing N and P rates. Interaction of irrigation and N, and N and P was significant for pods $plant^{-1}$ and seed yield.

In a field experiment during the rainy seasons of 1993/94 and 1994/95 at Rahuri, Maharashtra, India, and *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 values increased with increasing N rate and were highest with irrigation at 75 mm CPE.

Nandan and Prasad (1998) conducted a field trial at Pusa, Bihar to study yield and water use efficiency of *P. vulgaris* cv. Uday and was given 6 irrigation treatment and 3 N treatments (40, 80 or 120 kg N ha^{-1}). Seed yield in the first year was the highest (1.31 t ha^{-1}) when given 3 irrigations at 25, 50 and 75 days after sowing, while in the second year the highest yield of 1.35 t ha^{-1} was obtained when irrigating at a 0.8 IW: CPE [irrigation water: cumulative pan evaporation] ratio. Yield and water use efficiency increased with increasing N rate in both 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 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. Applied P also increased seed yield, and 100 kg P_2O_5 ha^{-1} gave 39.8 and 7.4% more yield than 0 and 50 kg P_2O_5 ha^{-1}, respectively.

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}.

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.

Calvache *et al.* (1997) found significant increase in seed yield, pod number $plant^{-1}$, number of seeds pod^{-1} and harvest index in french bean through increased nitrogen application.

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

Furlani *et al.* (1996) conducted an experiment in green house and observed a highly significant correlation between leaf chlorophyll content and leaf N concentration with N application rate. It was concluded that the chlorophyll content gave accurate assessment of N status in bean plant.

Sharma *et al.* (1996) studied the effect of N fertilizer (0, 40, 80 and 120 kg N ha^{-1}) and timing of application on 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} upto 120 kg N ha^{-1}. However, in the case of seed yield, pod length and 100 seed weight, variation in 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 seed yield was the 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).

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.

An experiment was conducted by Dahatonde and Nalamwar (1996) at Maharashtra, India to study the effect of nitrogen and irrigation levels on yield and water use of french bean. Seed yields were increased significantly up to 90 kg N ha^{-1}.

A field experiment was conducted by Bagal and Jadhav (1995) to find out the effects of nitrogen and *Rhizobium* on yield and nutrient uptake by french bean. Seeds were inoculated with *Rhizobium phaseoli* or not inoculated 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}.

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, P_2O_5 as super phosphate and K_2O as muriate of potash. Seed yields were the highest with 120 kg N or 120 kg P_2O_5, but were not significantly affected by K_2O.

Dwivedi *et al.* (1994) conducted a field experiment during the winter seasons of 1990-92 at Agwanpur, Bihar, *Phaseolus vulgaris* cv. 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 400 000, 286 000 and 200 000 plants ha^{-1}, respectively, and was given 40, 60, 80 or 100 kg N ha^{-1}. Seed yield was the highest at the density of 400 000 plants ha^{-1} and increased with up to 80 kg 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 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 high significance, except for N content in tops and pod alcohol-insoluble solids content.

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,B_4 and B_6 and 0 –90 kg N/ha 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 it increased with up to 60kg N ha^{-1}.

Dahatonde *et al.* (1992) carried out an experiment in Akola, India to observe the response of french bean to irrigation regimes and nitrogen levels (0-

120 kg N ha^{-1}). They stated that seed yield increased from 0.38 to .92 t ha^{-1} with the increase in number of irrigation and N application with up to 90 kg ha^{-1}.

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 and crude protein percentage decreased with increasing nitrogen application rate.

Bengtsson (1991) conducted an experiment on *P. vulgaris* cv. with 0, 30 or 60 kg N ha^{-1}. N fertilizer generally increased seed yield, 1000-seed weight and seed protein content. The number of root nodules were significantly increased by inoculation.

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}.

Parthiban and Thamburaj (1991) recorded increased grain yield with nitrogen fertilization upto 50 kg N ha^{-1}. Number of pods and grain yield $plant^{-1}$ increased significantly with nitrogen fertilization over the control.

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} and P_2O_5 at 0, 40 and 80 kg ha^{-1}. They observed that application of nitrogen and phosphorus increased plant growth, nutrient uptake and yield of green pods.

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.

Singh et al. (1990) reported that N fertilization and irrigation french bean increased the number of pods $plant^{-1}$ and 100 seed weight with increase in nitrogen level.

In a field at Bangalore, India Hegde and Srinivas (1989) worked on the effect of irrigation and nitrogen on growth, yield and water use of french bean. In their trial, the crop received 0, 40, 80 or 120 kg ha^{-1} of nitrogen. The green pod yield was the greatest (124.3 – 132.3 q ha^{-1}) at the highest N rate. Kuccy

(1989) noted that addition of nitrogen at 30 mg kg^{-1} soil had stimulatory effect on plant growth.

Srinivas and Naik (1988) carried out an experiment at Bangaloe, India to study the response of vegetable French bean to nitrogen and phosphorus fertilization. Nitrogen was applied at 0, 40, 80, 120 or 160 kg N ha^{-1}. They reported that 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 N ha^{-1}.

Ali and Tripathi (1988) worked with an experiment in Uttar Pradesh, India to observe the influence of genotype, nitrogen levels (0 –60 kg ha^{-1}) and plant population of french bean and noticed that number of pods $plant^{-1}$, 100- seed weight, seed yield and seed protein content increased with increasing nitrogen rate.

Bhopal and Singh (1987) conducted a field trail in Himachal Pradesh, India to find out the 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}; it gave yields over 210 q ha^{-1}.

In a field trail at Varanasi India, Chandra *et al.*(1987) showed that plant growth and yield (46.19 – 71.59 q ha^{-1}) increased with increasing N (0- 50 kg ha^{-1}) and with seed inoculation with *Rhizobium.*

Kushwaha (1987) conducted an experiment in Uttar Pradash, India to study the response of french bean to different levels of nitrogen and phosphorus. He used 0, 30, 60, 90 and 120 kg N ha^{-1} and obtained seed yields of 1.32, 2.05, 2.33, 2.54 and 2.76 t ha^{-1}, respectively. It was reported that yield differences were associated with differences in pod number per plant.

Katoch *et al.* (1983) while working with nitrogen reported that 30 kg N ha^{-1} increased the maximum nodule number and nodule weight $plant^{-1}$ of french bean.

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

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

Abu-Shakra and Bassiri (1972) reported the decreased number of nodules/plant due to N application in French bean.

Cardoso *et al.* (1978) stated that seed yield of French bean showed a positive linear response to nitrogen.

2.2 Effect of molybdenum on growth and yield of bush bean

The importance of trace elements including molybdenum has been well suggested for various crops. 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.

Pires *et al.* (2004) conducted an experiment to study the effects of the foliar application of Mo on the yield of common bean (*P. 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 did not significantly increase the yields. In winter-spring cultivation, all treatments increased the yields.

Pessoa *et al.* (2000) investigated the effects of molybdenum (Mo) leaf application in beans. Levels of Mo (0, 40, 80 and 120 g ha^{-1}), using ammonium molybdate applied to the leaves 25 days after emergence. There was a quadratic response due to increasing doses of Mo applied, on the leaf and grain concentrations of Mo, total N and organic N. Leaf Mo increased from 0.49 mg kg^{-1} (control) up to 0.95 mg kg^{-1}, what improved N utilization resulting in higher leaf and grain concentrations of total N and organic N, better plant growth and darker green leaves.

Kushwaha (1999) conducted a field study during the winter seasons of 1991-93 at Kanpur, Uttar Pradesh on sandy loam soil to study the effect of zinc, boron and molybdenum on the growth and yield of french bean (*Phaseolus vulgaris* cv. PDR 14). 25 kg ZnSO4, 10 kg borax and 1 kg sodium molybdate ha^{-1} were applied singly or in all combinations. All trace element treatments generally increased seed and haulm yield. Mean seed yield was 1736 kg ha^{-1} in controls and the highest 2459 kg ha^{-1} with borax alone.

Manga *et al.* (1999) reported that the growth and yield of french bean were influenced by phosphorus and molybdenum fertilization. In their trial, the crop received 0, 13 or 26 kg P and 0, 0.5 or 1.0 kg ammonium molybdate/ha. Phosphorus application significantly increased the number of pods plant^{-1}, number of seeds pod^{-1} and shelling percentage. The seed yield was increased by 43.2 and 73.32% (averaged over years) when 13 and 26 kg P ha^{-1} respectively were applied. Molybdenum application increased the number of pods plant^{-1}, number of seeds pod^{-1} and seed yield. The seed yield increase was 15.7 and 25.9% when 0.5 and 1.0 kg ammonium molybdate ha^{-1} respectively were applied.

Andrade *et al.* (1999) reported that the growth and yield of bean cv. were influenced by molybdenum fertilization. In their trial foliar applications of 0, 30, 60, 90 or 120 g Mo 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 pod^{-1}, 100-seed weight and yield.

Hazra and Tripathi (1998) observed that molybdenum application at the rate of 1.5 kg ha^{-1} M_oO_4 ha^{-1} to be seam increase forage and seed yields in calcareous soil.

Rodrigues (1996) conducted an experiment with *P. vulgaris* cultivars and 0, 40, 80 or 120 g Mo ha^{-1} applied to the leaves 25 days after emergence. They gave the highest seed yields (1.62-1.93 t ha^{-1}) in all seasons. Only in the dry summer/autumn season there was no response to Mo; in the rainy summer season and autumn/winter the response of seed yield to Mo was quadratic with highest yields corresponding 76-81 g Mo ha^{-1}. Applied Mo all significantly increased pod number/plant, harvest index and 100-seed weight in all season. It is suggested that increasing rates of applied foliar Mo beyond 20-40 g ha^{-1}, as commonly practiced and should result in economically viable yield increases.

Lopez martinez *et al.* (1996). Grew *Phaseolus vulgaris* in Buenos Aires in nutrient solution containing 1, 5 or 10 mg Mo litre^{-1} Mo content in roots, stems and leaves increased over time. Root Absorption Index (Mo in roots/Mo in nutrient solution) was the highest at 1 mg Mo $litre^{-1}$. This concentration provided the plant with Mo requirement, but there was no visible damage caused by higher Mo concentrations.

Zaman *et al.* (1996) conducted an experiment on mungbean and found that 1 kg Mo ha^{-1} produced 40.49% plant higher, 44.6% higher root length, 97% higher nodule number and 180% higher nodule weight over control. They also reported 89% higher branches $plant^{-1}$ with 2 kg Mo ha^{-1} over control.

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

Li and Gupta (1995) conducted an experiment in USA and observed that application of molybdenum (2mg soil) increased leaf nitrogen and shoot, root and nodule dry weight but did not significantly increase mean photosynthesis, nodule nitrogenase activity and chlorophyll content in soybean.

Singh *et al.* (1992) reported that application of molybdenum at the rate of 1 kg ha^{-1} increased the grain yield of chickpea significantly. Further increase in molybdenum level had no effect on the yield.

Sarkar and Banik (1991) conducted an experiment in the Calcatta on green gram and observed that molybdenum application significantly 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 straw yield, 19.25 and 20.18 pods $plant^{-1}$, respectively.

Padma *et al.* (1989) conducted an experiment on french bean. With the application of 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 p.p.m. 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 (941.2 cm), leaf area index (0.60) and DM production (62.8 g $plant^{-1}$) were obtained with the 75 p.p.m. Mo + 2.5 p.p.m. B treatment.

Anwar (1989) conducted a field experiment at BARI farm, Faridpur in Calcareous Dark Grey Flood plain soil with mungbean (*Vigna radiata* L.). He observed that application of molybdenum had significant effect on grain yield and molybdenum content in straw bulk and grain.

According to FAO (1983) application of molybdenum at the rate of 0.4 kg ha^{-1} is sufficient for the maximum nodulation in legumes on acid soils. Total molybdenum content of most agricultural soils lies between 0.6 and 3.5 ppm with an average available content of 0.2 ppm molybdenum occurs in soil mainly as molybdenum. This particular minor element is an essential component of two major enzymes nitrogenous and nitrate as pointed out by Mengel and Kirkby (1982)

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

Jesus tumor *et al* (2004) conducted a field trial on french bean 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 p.p.m. and B (as borax) at 2.5 ppm were also 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 (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 $plant^{-1}$) were obtained with the 75 p.p.m. Mo + 2.5 p.p.m. B treatment.

Bassan (2001) studied that the application Mo application 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 the number of pods $plant^{-1}$, 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 of the treatments. Inoculation did not affect seed germination and field seedling emergence, whereas the treatment without Mo and with 90 kg N ha^{-1} provided seeds with high germination index.

Andrade *et al.* (2001) studied that the application of molybdenum on the bean crop (*Phaseolus vulgaris* L.) and its possible interaction with different forms of application of nitrogen, in the plots with four forms of nitrogen and two doses of molybdenum (0 and 40 g of Mo ha^{-1}). Grain yield and its components (number of pods $plant^{-1}$, number of grain pod^{-1} and weight of 100 grains) in addition to the final stand and harvest index. Addition of N dressing or at sowing dressing provided increases of 48 and 93%, respectively over the yield of the check. With foliar application of 40 g of Mo ha^{-1} it was possible to obtain taller plants and greater number of pods, resulting the increased yield of the order of 91% relative to the control.

Coelho *et al.* (2001) conducted a field experiment 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 and 9% due to Mo and N fertilizers, respectively. Mo fertilizers increased 100-seed weight and grain yield by 5 and 17%, respectively.

Soratto *et al.* (2000) studied 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 the winter season. Time from emergence to flowering, plant DM yield, leaf N content, yield and yield components, and seed quality (germination and vigour) were determined in N increased yield. Mo application did not affect yield or yield components, and seed quality was not significantly affected by fertilizer treatment.

Vieira *et al.* (2000) showed that the effects of 40 kg N ha^{-1}, 16.5 g Mo ha^{-1} and an inoculants on the yield and yield components of common bean (*Phaseolus vulgaris*) cultivars. The interaction of N, Mo and the inoculants recorded positive significant effects on the yield. Nitrogen recorded the greatest effect and had effects on the number of pods $plant^{-1}$ while Mo and the inoculants recorded no isolated influence on the yield or the yield components examined.

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, respectively 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, 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 normal.

Amane *et al.* (1999) conducted at experiment to study the effects of N, Mo, and *rhizobium* at four rates of N (0, 30, 60, and 90 kg ha^{-1}) and four rates of Mo (0, 40, 80, and 120 g ha^{-1}). In all experiments, 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 g Mo ha^{-1}, depending on N fertilization; a smaller rate of Mo was needed when a larger dose of N was used and vice versa. Nitrogen applied at planting time was also essential and side-dressing application could not generally compensate its absence. The N and Mo combination increased bean yield by 90 to 200%.

Carvalho *et al.* (1998) investigated the effects of nitrogen and molybdenum rates on the physiological quality of seeds and field performance of bean (*P. 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 the effects of nitrogen, molybdenum and seed inoculation on the seed quality. Inoculation resulted in better bean performance compared to the others treatments. The nitrogen and molybdenum application were beneficial for development and yield of bean crop.

Vieira *et al.* (1998 b) carried out an experiment to study the response of *Phaseolus vulgaris* to foliar application of molybdenum (40 g ha^{-1}) 25 days after plant emergence and application of 20 kg N ha^{-1} as ammonium sulfate at sowing .Nitrogen fertilizer application, either at planting (20 kg N ha^{-1}) or as a side dressing (30 kg N ha^{-1}) 25 days after plant emergence, did not affect foliar nitrate reeducates activity. Mo foliar spray as ammonium molybdate and N applied as a side dressing increased equally the total N content in the pods. A 10% increase in 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 applied as a side dressing. In a similar experiment

Vieira et al. (1998 a) showed that Mo application at 25 days after plant emergence decreased nodule number plant^{-1}, while nodule weight was unaffected at and was increased. N fertilizer application at planting decreased the number and the weight of nodules at both sites, while N applied, as a side dressing did not affect nodule number or weight. The main effect of Mo fertilizer application was an increase in the size of nodules, and it is suggested that the effect of Mo on nodulation was the avoidance of nodule senescence, therefore maintaining a longer period of effective N fixation.

Andrade *et al*. (1998) reported the 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 with 0, 20 and 40 kg basal N/ha, 973 and 1358 kg without and with top-dressed N, and 976 and 1355 kg without and with Mo fertilizer, respectively.

Gualberto *et al.* (1995) conducted an experiment on common beans cultivar Carioca-IAC 80Sh, to verify the *Rhizobium phaseoli* inoculation effects with the commercial products: Nutrimins molibdenio (4% Mo); Nutrimins CoMo (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 + CoMo; N at planting + CoMo + inoculant; N at planting + Mo + inoculant; Mo alone; CoMo + inoculant; and N at planting + N at side dressing (control). Significant effects were only observed on leaves chlorophyll content; and it was verified that Mo being simpler and faster could be used in substitution for nitrogen fertilization.

Wang *et al*. (1995) showed that the application of molybdenum increased the yield of wheat by 11.45% and 45%, respectively at low level of N (.05 N kg soil^{-1}) and high level of N (0.2 N kg soil^{-1}). The activity of nitrate reductase in wheat with molybdenum treatment was greater than that of control. They also pointed out that molybdenum also increased the efficiency of nitrogen fertilizer utilization.

Chapter 3
Materials and Methods

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at the research field in Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from December 2006 to February 2007 to find out the effect of N and Mo application on the growth and yield of bush bean (*Phaseolus vulgaris* L.)

3.1 Experimental site

The experimental field was located at $23^0 77'$ N latitude and $90^0 3'$ E longitude with an elevation of 1.0 meter above sea level (Fig. 1).

3. 2 Soil

The soil of the experimental field belongs to the Tejgoan soil series of the Madhupur Tract (Agro ecological Zone AEZ-28). The General Soil Type of the experimental field is Deep Red Brown Terrace Soil. Topsoil is silty clay loam in texture. Organic matter content is very low (1.34 %) and soil pH varies from 5.8 – 6. The land is above flood level and well drained. The initial morphological, physical and chemical characteristics of soil are presented in Tables 1 and 2.

3.3 Climate

The annual precipitation of the site was 2152 mm and potential evapotranspiration was 1297 mm. The average maximum temperature was 30.34^0C and average minimum temperature was 21.210C. The average mean temperature was 25.17^0C. Temperature during the cropping period was ranged between 12.20^0C to 29.2^0C. The humidity varied from 73.52 % to 81.2 5%.

Fig.1. Map showing the experimental site under study.

Table 1. Morphological characteristics of experimental field

Morphological Features	Characteristics
Location	Sher-e- Bangla Agril. University Farm, Dhaka
AEZ No. and name	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Table 2. Physical and chemical properties of the experimental soil

Soil properties	Value
A. Physical properties	
1. Particle size analysis of soil.	
% Sand	29.04
% Silt	41.80
% Clay	29.16
2. Soil texture	Clay loam
B. Chemical properties	
1. Soil pH	5.8
2. Organic carbon (%)	0.78
3. Organic matter (%)	1.34
4. Total N (%)	0.08
5. C : N ratio	9.75 : 1
6. Available P (ppm)	15.0
7. Exchangeable K (me/100 g soil)	0.18
8. Available S (ppm)	16.0

The day length was reduced to 10.5 – 11.0 hours only and there was a very little rainfall from the beginning of the experiment to harvesting. The monthly average temperature, humidity, bright sunshine, solar radiation, precipitation and potential evapotranspiration pattern of the site during the experimental work are presented in Appendix -1.

3.4 Collection of seed

The variety of bush bean used in the experiment was BARI Jhar Sheem-1. The seeds were collected from Horticultural Research Center (HRC), Joydebpur, Gazipur.

3.5 Experimental treatment

The experiment was undertaken to study the effect of 5 levels of Nitrogen and 3 levels of Molybdenum on the growth and yield of bush bean.

The study comprised the following treatments:

A. Nitrogen level: 5

1). N_0 : Control

2). N_{40} : 40 kg N ha^{-1}

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

4). N_{120} : 120 kg N ha^{-1}

5). N_{160}: 160 kg N ha^{-1}

B. Molybdenum level : 3

1). Mo_0 : Control

2). $Mo_{0.5}$: 0.5 kg Mo ha^{-1}

3). $Mo_{1.0}$: 1.0 kg Mo ha^{-1}

There were 15 treatment combinations of nitrogen and molybdenum levels used in the experiment as followings:

T_1 : $N_0 Mo_0$ (Control)

T_2 : $N_{40} Mo_0$ kg ha^{-1}

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

T_4 : $N_{120} Mo_0$ kg ha^{-1}

T_5 : $N_{160} Mo_0$ kg ha^{-1}

T_6 : N_0 $Mo_{0.5}$ kg ha^{-1}

T_7 : N_{40} $Mo_{0.5}$ kg ha^{-1}

T_8 : N_{80} $Mo_{0.5}$ kg ha^{-1}

T_9 : N_{120} $Mo_{0.5}$ kg ha^{-1}

T_{10} : N_{160} $Mo_{0.5}$ kg ha^{-1}

T_{11} : N_0 $Mo_{1.0}$ kg ha^{-1}

T_{12} : N_{40} $Mo_{1.0}$ kg ha^{-1}

T_{13} : N_{80} $Mo_{1.0}$ kg ha^{-1}

T_{14} : N_{120} $Mo_{1.0}$ kg ha^{-1}

T_{15} : N_{160} $Mo_{1.0}$ kg ha^{-1}

3.6 Design and layout of the experiment

The experiment was laid out with randomized completely block design (RCBD) with three replications. The experimental plot was first divided into three blocks. Each block consisted of 15 units of plots. Different combination of N and Mo were assigned randomly to each block as per design of the experiment.

Total number of plot = 45

Individual plot size = 2 m × 2.5 m (5 m^2)

Plot to plot distance = 0.5 m

Row to row distance = 30 cm

Block to block distance = 1 m

3.7 Land preparation

The land was first opened on 30 November 2006, with the help of a power tiller, later the land was prepared very well 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 2 December 2006 according to the design adopted. Finally, individual plots were prepared with spade on 3 December 2006. Drains were made around each plot and the excavated soil was used for raising the plots to about 5 cm high from the soil surface.

3. 8 Collection of initial soil sample

Initial soil sample was collected before land preparation from 0 –15 cm soil depth. The samples were drawn by means of an auger from different locations covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of the soil samples the plant roots, leaves etc, were picked up and removed.

Then the sample was air dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis

3.9 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 (BARC, 1997). 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 superphosphate (TSP), muriate of potash (MP), zinc sulphate ($ZnSO_4$) and gypsum ($CaSO_4$. 2. H_2O), respectively. The fertilizers were mixed thoroughly with the soil and rest nitrogen applied 30 days after planting

	2.5m ↔									
2m ↕	$N_{160}Mo_{1}$	0.5m ↔	$N_{40}Mo_{.5}$		$N_{0}Mo_{0}$	0.5m ↔	$N_{120}Mo_{.5}$		$N_{0}Mo_{1}$	
			↔ 0.5m				↔ 0.5m			
	$N_{160}Mo_{.5}$		$N_{80}Mo_{0}$		$N_{160}Mo_{0}$		$N_{120}Mo_{1}$		$N_{40}Mo_{0}$	
			↔ 0.5m				↔ 0.5m			
	$N_{80}Mo_{.5}$		$N_{0}Mo_{.5}$		$N_{120}Mo_{0}$		$N_{40}Mo_{1}$		$N_{80}Mo_{1}$	
	↕ 1m				↕ 1m				↕ 1m	
	2.5m ↔									
2m ↕	$N_{120}Mo_{0}$	0.5m ↔	$N_{160}Mo_{1}$		$N_{80}Mo_{0}$	0.5m ↔	$N_{120}Mo_{1}$		$N_{0}Mo_{.5}$	
					↔ 0.5m				↔ 0.5m	
	$N_{80}Mo_{1}$		$N_{0}Mo_{0}$		$N_{80}Mo_{.5}$		$N_{120}Mo_{.5}$		$N_{160}Mo_{0}$	
	$N_{40}Mo_{.5}$		$N_{40}Mo_{0}$		$N_{80}Mo_{1}$		$N_{160}Mo_{.5}$		$N_{0}Mo_{1}$	
	↕ 1m				↕ 1m				↕ 1m	
	2.5m ↔									
2m ↕	$N_{0}Mo_{0}$	0.5m ↔	$N_{120}Mo_{1}$		$N_{160}Mo_{0}$	0.5m ↔	$N_{80}Mo_{.5}$		$N_{80}Mo_{.5}$	
	$N_{80}Mo_{1}$		$N_{80}Mo_{0}$		$N_{160}Mo_{1}$		$N_{160}Mo_{.5}$		$N_{40}Mo_{1}$	
			↔ 0.5m						↔ 0.5m	
	$N_{40}Mo_{0}$		$N_{120}Mo_{0}$		$N_{40}Mo_{.5}$		$N_{0}Mo_{1}$		$N_{120}Mo_{.5}$	

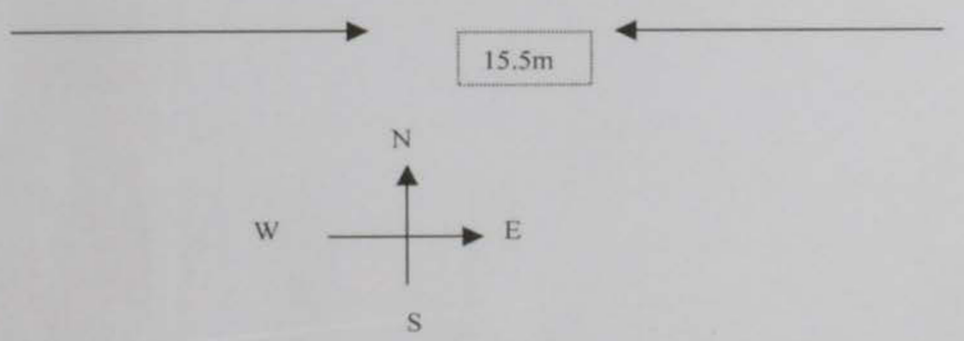

Fig. 2 Layout of the experimental plot

3.10 Sources of nutrients and their levels used in the experiment

Nutrient	Doseha^{-1}	Dose plot^{-1}	Source
Nitrogen (N)	0, 40, 80, 120 and 160 kg N	40 g 80 g 130 g 150 g	Urea $CO(NH_2)_2$
Molybdenum (Mo)	0, .5 and 1 kg Mo	0.46 g 0.92 g	Ammonium molybdate $(NH4)_6MoO_7$. 2 H_2O
Phosphorus (P)	60 kg P_2O_5	150 g	TSP $Ca(H_2PO_4)_2$
Potassium (K)	60 kg K_2O	60 g	MP KCl
Sulphur (S)	10 kg S	2.77 g	Gypsum ($CaSO_4.2\ H_2O$
Zinc (Zn)	2 kg Zn	27.8 mg	Zinc sulphate ($Zn\ SO_4.\ H_2O$)

3.11 Sowing of seeds

Two 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 3 December, 2006. The seeds were covered with loose soil. French bean was sown as border crops to reduced border effects.

3.12 Intercultural operations

3.12.1 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 when watering was done to protect the seedling from wilting. All gaps were filled up within two weeks after germination of seeds.

3.21.2 Thinning of seedlings

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

3.12.3 Weeding

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

3.12.4 Irrigation

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

3.12.5 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 planting of the plants.

3.12.6 Plant protection

a) Insect pests

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

b) Diseases

Seedlings were attacked by damping off and root rot, and Dithane M-45 was sprayed at the rate of 2ml L^{-1} at an interval of 15 days. Some plants were attacked by bean common mosaic virus (BCMV), which is an important disease of bush bean bean. These plants were removed from the plots and destroyed.

3.13 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). First harvest was done at 60 days after sowing. Again the pods were harvested at mature stage when the plants and pods become yellow and fully dry.

3 .14 Post-harvest operation

The sample plants were harvested separately for according yield and yield components. The harvested crop was cleaned, dried, shelled and finally dried plot by plot separately to collect necessary data on various aspects.

3.15 Collection of data

Five plants were selected at random in such a way that the border effect could be avoided. For this reason, the outer two lines and the outer plants of the middle lines in each unit plot were avoided. Data were recorded periodically from the sample plants at 15 days interval. The details of data recording are given below:

A) Plant characters and growth parameters

i) Number of branch plant^{-1}

ii) Plant population m^{-2}

iii) Total dry weight of plants (g plant^{-1})

iv). Crop growth rate (CGR, g plant^{-1} day^{-1})

v). Plant height (cm)

B). Yield and yield components

i) Number of pod plant^{-1}

ii) Length of green pods (cm)

iii) Number of seeds pod^{-1}

iv) Diameter of pod (cm)

v) Pod weight plot^{-1} (kg)

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

vii) Weight of 1000 seeds

viii) Seed weight plot^{-1} (kg)

ix) Seed weight (t ha^{-1})

x) Yield (t ha^{-1})

C) Chemical analysis of soil sample

i) Nitrogen

ii) Phosphorus

iii) Potassium

iv) Sulphur

v) %Organic carbon

vi) Soil pH

D) Chemical analysis of plant and seed sample

i) % Total Nitrogen

ii) Available Phosphorus

iii) Exchangeable Potassium

iv) Available Sulphur

A brief on data recording is given below:

3. 15.1 Plant height

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 5 plants for each plot were determined. The plant height was recorded at 30, 45, 60 and 90 days after sowing (DAS).

3.15.2 Plant Population

One square meter was randomly selected and counted total number of plant of this area.

3.15.3 Branches plant^{-1}

The number of branches of five randomly selected plants was counted and mean was calculated.

3.15.4 Total dry weight of plants

Total dry weight of the plant was recorded at 30, 45, 60 and 90 days after sowing (DAS). Five randomly selected sampled plants from each plots and were dried in the sun. Then the plants were kept in the paper bags and oven dried at a temperature of 70 °C and weighted in gm by an electric balance and the weights were converted into gm/plant.

3.15.5 Crop growth rate (CGR)

Crop growth rate is the increase in plants dries material per unit area of land per unit time. The crop growth rate (CGR) values were calculated following the formulae at 15 days intervals:

$$\text{Crop growth rate (CGR)} = \frac{W_2 - W_1 \text{ (g plant}^{-1}\text{ day}^{-1})}{T_2 - T_1}$$

Meaning the symbols used in the above formulae are given below :

W_1 = total dry weight at time T_1

W_2 = total dry weight at time T_2

T = t time

3.15.6 Number of pod plant^{-1}

The number of pods plant^{-1} from five randomly selected sample plants of each plot were counted, averaged and recorded at the time of final harvest.

3.15.7 Length of green pod

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).

3.15.8 Diameter of green pod

Diameter of green pods of five randomly selected pods from each plots were measured in cm and the mean value was calculated.

3.15.9 Number of seeds pod^{-1}

Number of seeds pod^{-1} was recorded from five randomly selected plants and mean value was calculated, averaged and recorded.

3.15.10 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).

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

Green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval and the total pod weights were recorded in each unit plot and expressed in kilogram (kg). The green pod yield plot^{-1} was finally converted to yield hectare^{-1} and was expressed in ton (t).

3.15.12 1000-seed weight (g)

One thousand dried seed of five randomly selected plants plot^{-1} were taken and then weighed and recorded.

3.15.13 Seed yield plot^{-1} (kg)

It was measured by following formula weight of seeds per plot = Seed weight in individual plant × Total number of plant in a unit plot.

3.15.14 Seed yield (t ha^{-1})

Seed yield of plot was converted into yield in ton $hectare^{-1}$.

3.15.15 Straw yield (t ha^{-1})

After separating the seeds from the plants and drying the harvested plants in the sun, total weight of straw of each plot was taken in kilograms and converted into tons $hectare^{-1}$.

3.16 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 togethers made a composite sample and analyzed for soil texture, soil pH, organic matter, total nitrogen, available phosphorus, exchangeable potassium and available sulphur.

3.16.1 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).

3.16.2 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).

3.16.3 Organic carbon (%)

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

3.16.4 C/N ratio

The C/N ratio was calculated from the percentage of organic carbon and total N.

3.16.5 Organic matter (%)

Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942).

$$\% \text{ organic matter} = \% \text{ organic carbon} \times 1.724$$

3.16.6 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_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).

3.16.7 Available phosphorus (ppm)

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

3.16.8 Exchangeable potassium (meq/100 g 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.

3.16.9 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.

3.17 Plant and seed sample analysis

For chemical analysis plant and seed samples, randomly from collected samples each plot at harvest were oven dried at 72°C for 72 hours. Then dried plant sample were ground by grinding machine. The plant and seed samples of different treatments were analyzed for N,P,K and S. For determination of N, P, K and S content in seed, the samples were first digested with acid and determination of elements in the digest were performed .For N, digestion was done with conc. H_2SO_4 and digest was distilled over following the procedure outlined under Soil Analysis section (3.16). The amount of these elements in the digest was estimated following the procedure described under Soil Analysis section (3.16).

3.18 Statistical analysis

.The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Least

Significant Difference value was determined with appropriate levels of significance and the means were tabulated.

3.19 Economical analysis

Economical analysis was done in order to find out the most profitable treatment combinations. Calculation was done in details according to the procedure of Alam *et al.*, (1989).

3.19.1 Analysis of total cost of production of french bean

Total input cost, miscellaneous cost, all the non- material input cost, interest on fixed capital of land were considered for calculation of the total cost of production. Interest was calculated at rate of 13% of six months and miscellaneous cost was considered as 5% of the total input cost. The value of one hectare of land was considered as Tk. 35,500.

3.19.2 Gross income and return

Gross income was calculated on the sale price of marketable green pod of French bean. The price of green pod in the market was considered as Tk.15000 /t.

3.19. 3 Net income

Net income was calculated by deducting total production cost from the gross income for each treatment combination.

3.19.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated using following formula for each treatment combination.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income}}{\text{Total cost of production}}$$

Chapter 4
Results and Discussion

Chapter 4
RESULTS AND DISCUSSIONS

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, yield , nutrient content and nutrient uptake by bush bean (*Phaseolus vulgaris*) at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from December 2006 to February 2007. The result of the studies such as plant height, total dry weight of plant, crop growth rate, nutrient content and uptake by bush bean plant as well as yield attributes, pod yield, seed yield and straw yields and chemical characteristics of post harvest soil are discussed in this chapter.

4.1 Plant height

4.1.1 Effect of nitrogen

Plant height, one of the agronomic characteristics, was found to be statistically significant for nitrogen treatments used in the experiment. The results on the main effects of nitrogen on the plant height of bush bean at 30, 45, 60, 75 and 90 days after sowings have been presented in (Fig. 3 and app.2).The plant height ranged from 35.17 to 48.65 cm at 90 days after sowings . Plant height increased with increasing the application of N. The maximum plant height (48.65 cm) was attained in the treatment N_{160} which was statistically similar with that of treatment of N_{120} and the minimum plant height of bush bean plants (35.17 cm) was obtained in control treatment. Gosal *et al*. (2000) have also obtained the similar results.

4.1.2 Effect of Molybdenum

Plant height varied significantly due to application of different levels of molybdenum (Fig. 4 and App. 3). The plant height ranged from 37.63 to 35.17 cm at 90 days after sowings. The highest plant height (37.63 cm) was obtained in treatments 0.5 kg Mo ha^{-1} which was statistically similar with that of 1.0 kg Mo ha^{-1}. The lowest plant height (35.17cm) 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 had significant effect on plant height in (Table 3.). The plant height ranged from 35.17 to 49.90 cm at 90 days after sowings. The maximum plant height (49.90 cm) at 90 days after sowings was obtained from the treatment combination of N_{160} $Mo_{1.0,}$ which was statistically similar with N_{120} $Mo_{0.5}$. The lowest plant height (35.17 cm) was obtained from the control treatment.

4.2 Total dry weight of plant (g $plant^{-1}$)

4.2.1 Effect of Nitrogen

Total dry weight of plant varied significantly in different days after planting. Total dry weight of plant was gradually increased day by day and was the highest at 90 DAS (Fig. 5 and App. 4). The highest total dry weight of plant (40.50 g $plant^{-1}$) was recorded at 90 DAS in 160 kg N ha^{-1}, which was statistically different with other treatment. The lowest total dry weight of plant (18.46 g $plant^{-1}$) was recorded in control. Similar result was obtained by the Gosal *et al*. (2000).

4.2.2 Effect of Molybdenum

Total dry weight of plant was gradually increased day by day and was the highest at 90 DAS (Fig. 6 and App. 5). The highest total dry weight of plant (27.04 g/$plant^{-1}$) was recorded in 0.5 kg Mo ha^{-1}, which was statistically similar with $Mo_{1.0}$ and the lowest total dry weight of plant (18.46 g $plant^{-1}$) was recorded in control.

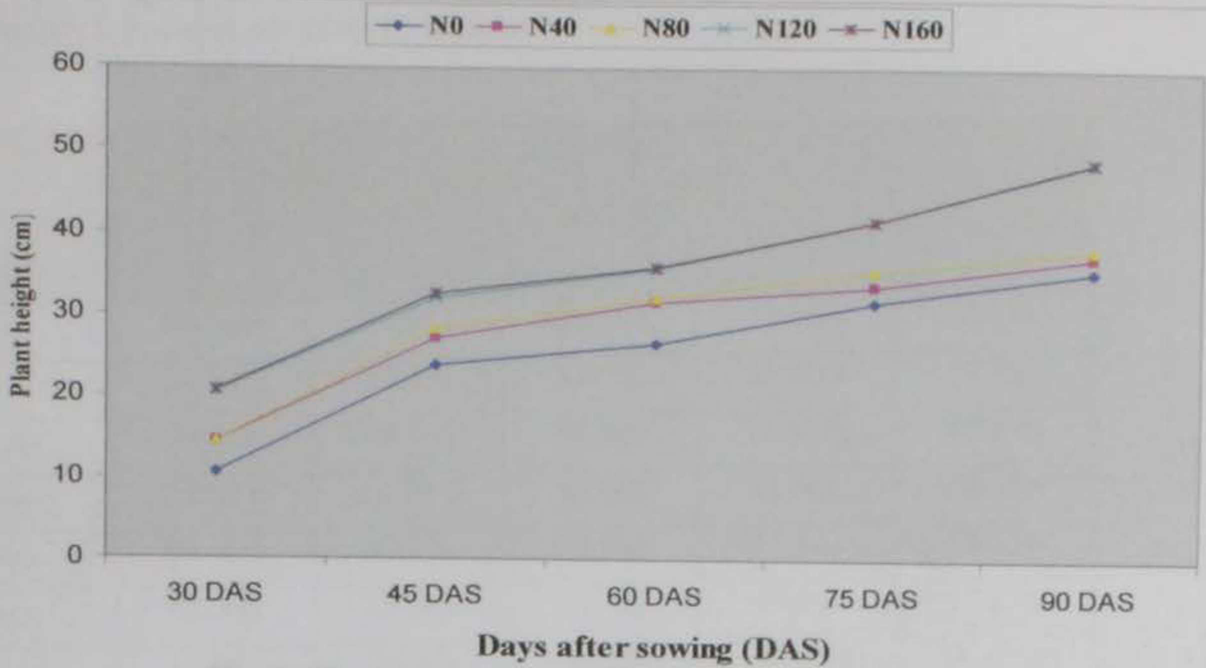

Fig. 3 Effect of nitrogen on plant height of bush bean

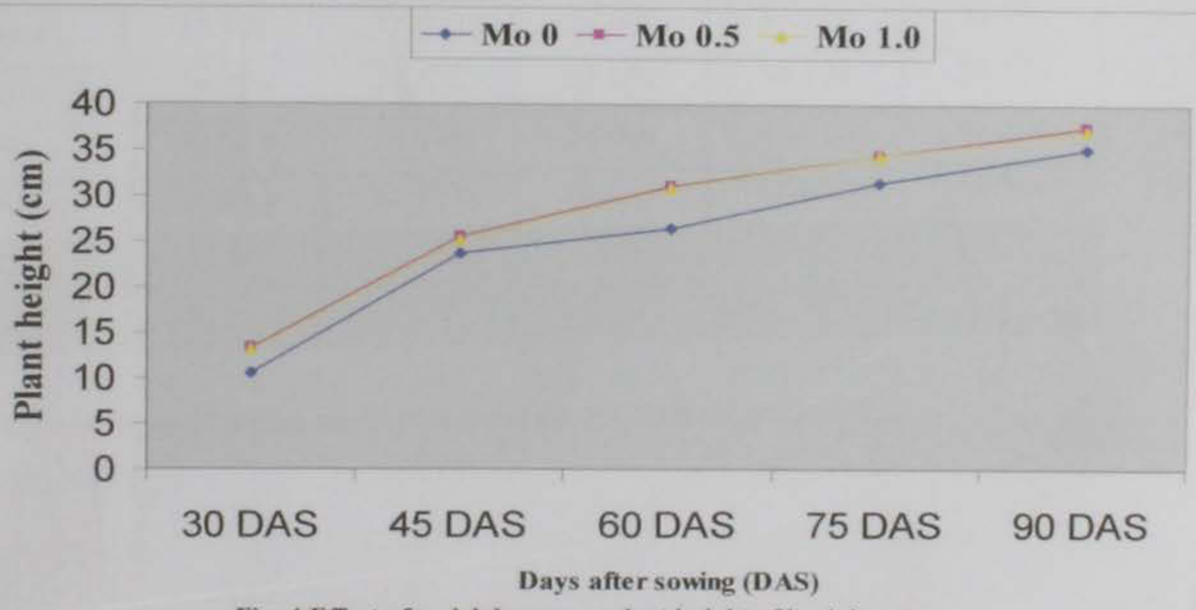

Fig. 4 Effect of molybdenum on plant height of bush bean

Table. 3 Combined effects of different levels of nitrogen and molybdenum on plant height

Nitrogen× Molybdenum (kg ha^{-1})	Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
N_0Mo_0	10.50m	23.67 l	26.50 l	31.50 j	35.17k
$N_{40}Mo_0$	14.33 j	27.10i	31.50i	33.50 i	37.00j
$N_{80}Mo_0$	14.50i	28.20g	32.00h	35.40fg	37.93hi
$N_{120}Mo_0$	20.50 d	31.90 d	35.60d	41.50c	48.50b
$N_{160}Mo_0$	20.60 c	32.60c	35.80c	41.55c	48.55b
$N_0Mo_{0.5}$	13.33k	25.50k	31.10j	34.50h	37.63ij
$N_{40}Mo_{0.5}$	14.61h	26.00j	31.50i	35.50fg	38.10fgh
$N_{80}Mo_{0.5}$	14.67g	27.07i	30.20k	35.60f	38.20fgh
$N_{120}Mo_{0.5}$	21.30 b	33.00b	36.30b	42.50b	49.70a
$N_{160}Mo_{0.5}$	21.50 a	33.50a	36.50a	43.50a	49.90a
$N_0Mo_{1.0}$	13.15 l	25.20 k	31.00j	34.50h	37.20jk
$N_{40}Mo_{1.0}$	15.87f	27.80h	32.60f	35.10g	38.50e
$N_{80}Mo_{1.0}$	16.73e	28.87f	32.10g	36.50e	39.40d
$N_{120}Mo_{1.0}$	20.55 c	31.90e	34.50e	38.61d	45.50c
$N_{160}Mo_{1.0}$	21.26 b	32.95 b	36.23 b	42.45 b	48.50b
LSD (1%)	0.050	0.074	0.074	0.46	0.46
CV%	6.04	7.14	6.13	8.67	5.67

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

4.2.3 Interaction effect of Nitrogen and Molybdenum

Total dry weight of bush bean was significantly influenced by the interaction of nitrogen and molybdenum levels at all DAS (Table 8.). The maximum total dry weight of bush bean (50.86 g $plant^{-1}$) was obtained from the treatment combination of 160 N ha^{-1} and 0.5 kg Mo ha^{-1} at 90 DAS. The lowest total dry weight of bush bean (18.46 g $plant^{-1}$) was obtained from the control treatment at 90 DAS.

4.3 Crop growth rate (CGR, g $plant^{-1}$ day^{-1})

4.3.1 Effect of Nitrogen

A significant variation was recorded in consideration of crop growth rate (CGR) in different nitrogen fertilizer application and the result was presented in (Fig.7 and App. 6) . Crop growth rate was significantly influenced by nitrogen fertilization at all DAS. Crop growth rate was gradually increased up to the period 60 DAS and then declined. The maximum crop growth rate (0.80 g $plant^{-1}$ day^{-1}) at 46-60 DAS was obtained when the crop was fertilized with 160 N ha^{-1}, which was statistically similar with N_{120} treatment. The lowest plant growth rate (0.17 g $plant^{-1}$ day^{-1}) at 90 DAS was obtained in the control condition. Dhanjal *et al.* (2003) also observed the similar results in bush bean.

4.3.2 Effect of Molybdenum

A significant variation was recorded in consideration of crop growth rate (CGR) with different levels of molybdenum fertilizer application and the result was presented in (Fig.8 and App.7). Crop growth rate was significantly influenced by molybdenum fertilization at all DAS. It was observed that CGR increased with the age of plant and attained peak within the period of 46-60 DAS and thereby declined at maturity of crop. The maximum crop growth rate (0.43 g $plant^{-1}day^{-1}$) at 46-60 DAS was obtained when the crop was fertilized with 0.5 Mo ha^{-1}, which was statistically similar with $Mo_{1.0}$. The lowest plant growth rate (0.17 g $plant^{-1}$ day^{-1}) at 90 DAS was obtained in the control condition.

4.3.3 Interaction effect of Nitrogen and Molybdenum

Interaction effects between different levels of nitrogen and molybdenum fertilizers showed statistically significant differences in respect of crop (CGR) (Table 5). The maximum crop growth rate (1.15 g $plant^{-1}$ day^{-1}) at 46-60 DAS was obtained from the treatment combination of 160 N ha^{-1} and 0.5 kg Mo ha^{-1}. The lowest number of crop growth rate (0.17 g $plant^{-1}$ day^{-1}) at 90 DAS was obtained from the control condition.

4.4 Plant population m^{-2}

4.4.1 Effect of Nitrogen

The number of plants per square meter of the experimental crop varied significantly influenced by the application of different nitrogen levels (Table 6). The number of plant per square meter ranged from 20.54 to 26.55. The highest number of plant per square meter (26.55) was recorded from the treatment of 120 kg N ha^{-1}, which was statistically similar with that of 160 kg N ha^{-1}. The lowest number of plant per square meter (20.54) was obtained in the control treatment.

4.4.2 Effect of Molybdenum

The number of plant population per square meter also influenced significantly with different molybdenum levels (Table7). The number of plant per square meter ranged from 20.54 to 24.55. The highest number of plant per square meter (24.55) was recorded from the treatment of 0.5kg Mo ha^{-1}, which was statistically similar with that of 1 kg Mo ha^{-1} .The lowest number of plant population per square meter (20.54) was obtained in the control treatment.

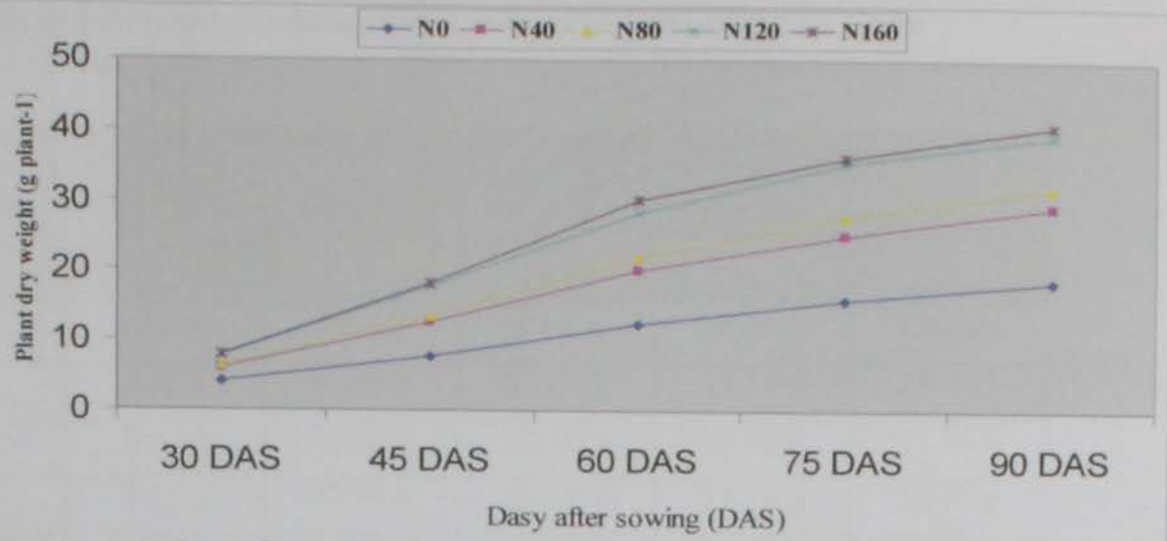

Fig. 5 Effect of nitrogen on plant dry matter weight of bush bean

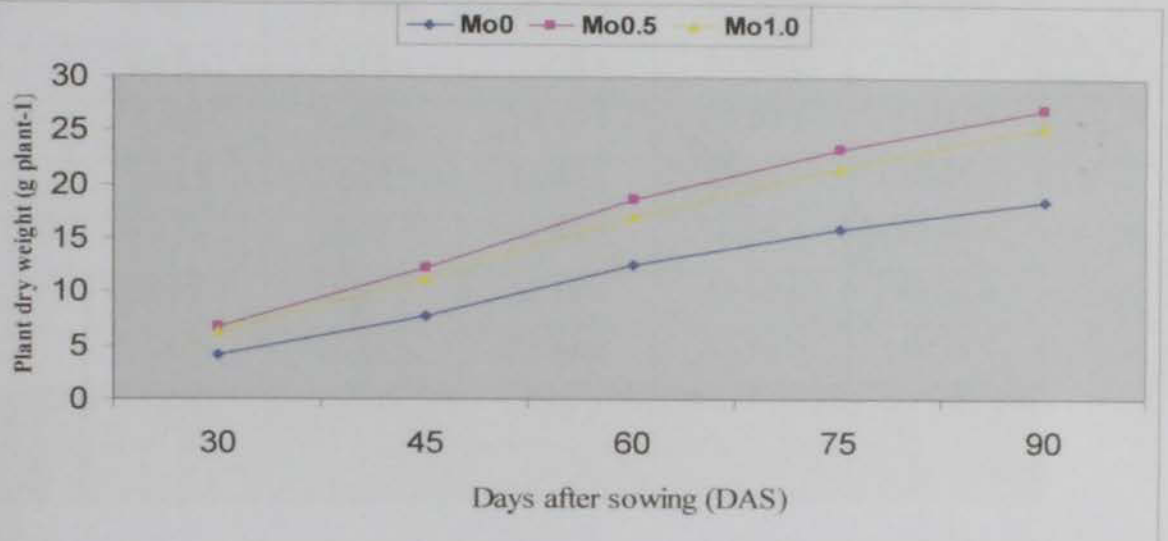

Fig. 6 Effect of molybdenum on plant dry weight of bush bean

Table. 4 Combined effects of different levels of nitrogen and molybdenum on total dry matter weight of bush bean

Nitrogen× Molybdenum (kg ha^{-1})	Total dry matter weight of plant (g plant^{-1})				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
NoMo$_0$	4.06 m	7.66 n	12.46 m	15.86 m	18.46 n
N_{40} Mo$_0$	5.05 j	12.69 h	20.08 h	25.10 h	29.10 i
$N_{80}Mo_0$	6.31 i	13.48 g	22.10 g	27.76 g	31.90 h
$N_{120}Mo_0$	7.62 d	17.70 e	28.10 e	35.18 e	30.10 g
$N_{160}Mo_0$	8.00 c	18.10 d	30.10 c	36.08 d	40.50 f
NoMo$_{0.5}$	4.67 k	9.34 l	15.10 k	20.04 k	23.40 l
$N_{40}Mo_{0.5}$	6.68 h	12.19 i	18.59 i	23.28 j	27.04 k
$N_{80}Mo_{0.5}$	6.73 g	11.22 k	24.18 f	30.48 f	35.86 g
$N_{120}Mo_{0.5}$	9.70 b	19.90 b	33.18 b	43.72 b	47.10 b
$N_{160}Mo_{0.5}$	9.87 a	20.18 a	34.08 a	44.90 a	50.86 a
$N_0Mo_{1.0}$	4.45 l	8.47 m	14.07 l	18.07 l	21.00 m
$N_{40}Mo_{1.0}$	7.26 f	11.42 j	18.42 j	23.66 i	27.70 j
$N_{80}Mo_{1.0}$	7.41 e	15.75 f	28.95 d	36.26 d	42.04 e
$N_{120}Mo_{1.0}$	8.09 c	18.42 c	30.18 c	37.10 c	45.94 b
$N_{160}Mo_{1.0}$	9.69 b	19.88 b	33.12 b	43.70 b	43.78 d
LSD (1%)	0.224	0.549	0.396	0.555	0.396
CV%	9.38	10.20	11.22	10.22	10.49

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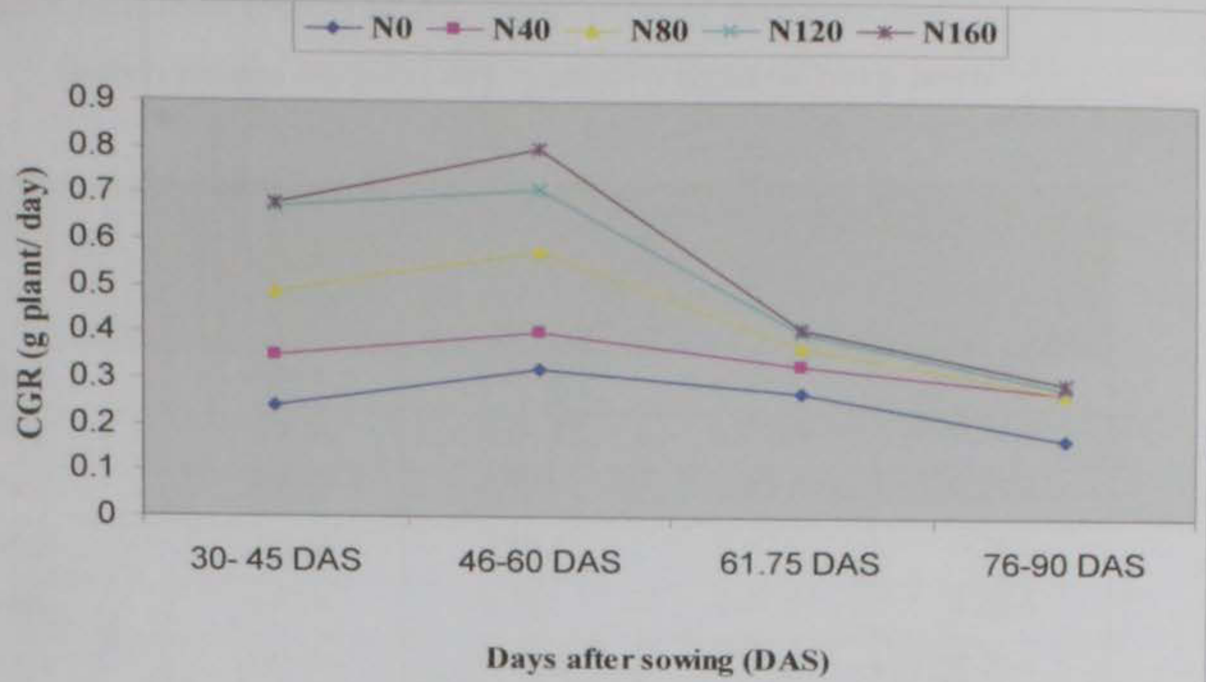

Fig. 7. Effect of nitrogen level (kg/ha) on crop growth rate (CGR) of bush bean.

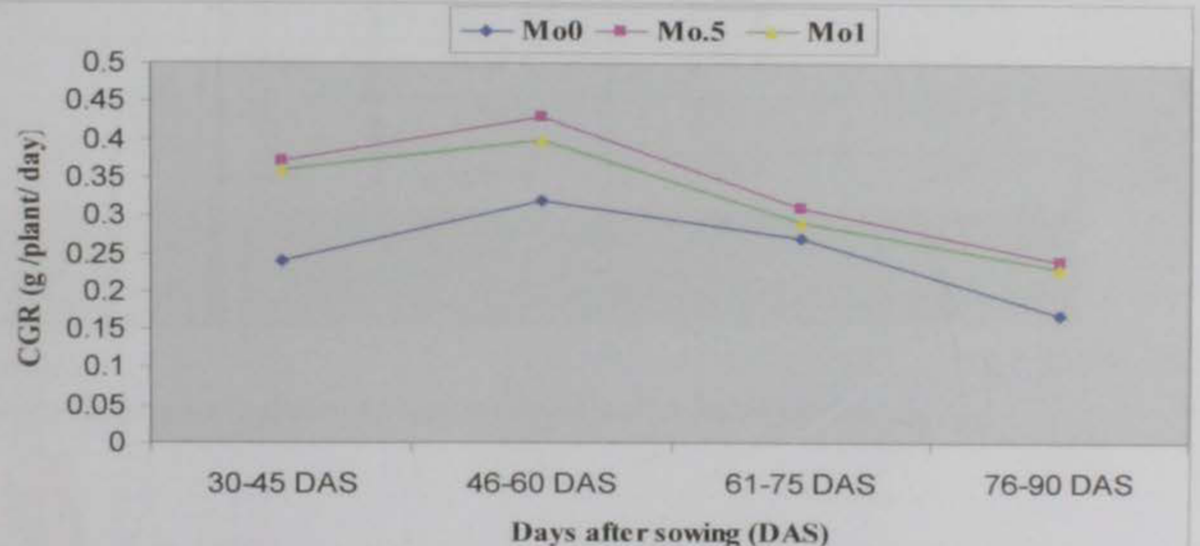

Fig. 8. Effects of molybdenum level (kg/ha) on crop growth rate (CGR) of bush bean.

Table. 5 Combined effects of different levels of nitrogen and molybdenum on total dry matter weight of bush bean

Nitrogen× Molybdenum (kg ha^{-1})	Crop growth rate (g plant^{-1} day^{-1})			
	30-45 DAS	46-60 DAS	61-75 DAS	76-90 DAS
N_0Mo_0	0.24 e	0.32 g	0.27 i	0.17 f
N_{40} Mo_0	0.35 de	0.40 f	0.33 gh	0.27 d
$N_{80}Mo_0$	0.49 c	0.57 e	0.37 f	0.27 d
$N_{120}Mo_0$	0.57 bc	0.69 d	0.40 e	0.28 d
$N_{160}Mo_0$	0.67 a	0.80 c	0.41 d	0.29 d
$N_0Mo_{0.5}$	0.31 de	0.38 g	0.33 gh	0.24 e
$N_{40}Mo_{0.5}$	0.37 d	0.43 f	0.31 h	0.24 e
$N_{80}Mo_{0.5}$	0.30 de	0.86 c	0.42 d	0.36 c
$N_{120}Mo_{0.5}$	0.53 bc	0.93 bc	0.45 c	0.39 b
$N_{160}Mo_{0.5}$	0.67 a	1.15 a	0.59 a	0.41 a
$N_0Mo_{1.0}$	0.27 e	0.37 g	0.27 i	0.23 e
$N_{40}Mo_{1.0}$	0.30 de	0.47 f	0.35 g	0.27 d
$N_{80}Mo_{1.0}$	0.57 bc	0.88 c	0.49 b	0.38 bc
$N_{120}Mo_{1.0}$	0.58 b	0.98 b	0.59 a	0.42 a
$N_{160}Mo_{1.0}$	0.58 b	0.98 b	0.49 b	0.37 c
LSD (1%)	0.082	0.087	0.015	0.15
CV%	10.78	7.71	7.14	6.15

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

4.4.3 Interaction effect of Nitrogen and Molybdenum

The combined effects of nitrogen and molybdenum levels on the Plant per square meter were highly significant (Table 8). The number of plant per square meter ranged from 20.54 to 27.33. The highest number of plant per square meter (27.33) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1} which was statistically similar with that of treatment combination of $N_{120}Mo_0$ and $N_{160}Mo_{1\text{-}0}$. The lowest number of plant per square meter (20.54) was obtained from the control treatment which was statistically similar with that of treatment combination of $N_{40}Mo_0$.

4.5 Number of branches $plant^{-1}$

4.5.1 Effect of Nitrogen

The effect of N on number of branches per plant was influenced significantly (Table 6). The number of branches $plant^{-1}$ ranged from 10.83 to 17.50 at 90 DAS .The highest number of branches $plant^{-1}$ (17.50) was recorded from the treatment of 120 kg N ha^{-1}, which was significantly different from other treatments. The lowest number of branches $plant^{-1}$ (10.83) 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 $plant^{-1}$. Singh and Verma (2002), Tewari and Singh (2000) and Nandan and Prasad (1998) also observed similar results in bush bean.

4.5.2 Effect of Molybdenum

Number of branches $plant^{-1}$ varied significantly with different levels of molybdenum treatment (Table7). The number of branches $plant^{-1}$ ranged from 10.83 to 13.50. The highest number of branches $plant^{-1}$ (13.50) was found from the treatment of 0.5 kg Mo ha^{-1}. The lowest number of branches $plant^{-1}$ (10.83 cm) was obtained in the control treatment (0 kg Mo ha^{-1}).

4.5.3 Interaction effect of Nitrogen and Molybdenum

Number of branches plant^{-1} 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 plant^{-1} was highly significant (Table 8). The number of branches plant^{-1} ranged from 10.83 to 18.50. The maximum number of branches plant^{-1} (18.50) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1}. The lowest number of branches plant^{-1} (10.83) was obtained from the control treatment.

4. 6 Number of green pods plant^{-1}

4.6.1 Effect of Nitrogen

Nitrogen had highly significant effect on the number of green pods plant^{-1} (Table 6). The number of green pods plant^{-1} ranged from 13.53 to 23.40. The highest number of green pods plant^{-1} (23.40) was recorded from the treatment of 120 kg N ha^{-1}, which was significantly different from others, treatments. The lowest number of green pods plant^{-1} (13.53) was found in the control treatment (0 g N ha). Application of 160 kg N ha^{-1} did not result in any further increase in number of pods per plant^{-1} compared with 120 kg N ha^{-1}. Singh and Verma (2002), Tewari and Singh. (2000) and Calvache *et al.* (1997) also observed the similar results in bush bean.

4.6.2 Effect of Molybdenum

The number of green pod plant^{-1} was significantly influenced by Mo levels (Table 8). The number of green pods plant^{-1} ranged from 13.53 to 16.50. The highest number of green pods plant^{-1} (16.50) was recorded from the treatment of 0.5 Mo ha^{-1}, which was statistically similar with $Mo_{1.0}$. The lowest number of green pods plant^{-1} (13.53) was found in the control treatment.

4.6.3 Interaction effect of Nitrogen and Molybdenum

The interaction of nitrogen and molybdenum levels showed the significant influence on the number of pod per plant^{-1} (table11). The number of green pods per plant^{-1} ranged from 13.53 to 24.50 .The highest numbers of green pods per plant^{-1} (24.50) was recorded from the treatment combination of 120 N/ha^{-1} and 0.5 kg Mo/ha^{-1}. The lowest number of green pods per plant^{-1} (13.53) was obtained from the control treatment.

4. 7 Length of green pod (cm)

4.7.1 Effect of Nitrogen

Length of green pod showed significant influence by the application of different nitrogen levels (Table 6). The length of green pods ranged from 10.17 to 15.50 cm. The highest length of green pods (15.50 cm) was recorded from the treatment of 120 kg N ha^{-1}, which was statistically similar with that of 160 kg N ha^{-1} and 80 kg N ha^{-1}. The lowest length of green pods (10.17 cm) was found in the control treatment (0 kg N ha^{-1}). Similar results were also reported by Tewari and Singh (2000) and Sharma *et al.* (1996).

4.7.2 Effect of Molybdenum

Length of green pod was influenced statistically by the application of different molybdenum (Table 7). The length of green pods ranged from 10.17 to 12.88 cm. The highest length of green pods (12.88 cm) was recorded from the treatment of 0.5 kg Mo ha^{-1}, which was significantly different from other treatment. The lowest length of green pods (10.17 cm) was found in the control treatment (0 kg Mo ha^{-1}).

4.7.3 Interaction effect of Nitrogen and Molybdenum

The interaction effect of different doses of nitrogen and molybdenum on green pod length was significant (Table 8). The length of green pods ranged from 10.17 to 16.00 cm. The highest length of green pod (16.00 cm) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1}, which was statistically similar with $N_{120}Mo_0$ and $N_{160}Mo_0$. The lowest length of green pod (10.17 cm) was obtained from the control treatment.

Plate 1. A photograph showing of the bush bean having fertilized with N_0Mo_0

Plate 2. A photograph showing of the bush bean having fertilized with $N_{120}Mo_{0.5}$

Table 6. Effect of different levels of nitrogen on the growth and yield contributing characters of bush bean at 90 DAS

Nitrogen Fertilizer (kg ha^{-1})	Plant populationm^{-2}	Branch plant^{-1}	Number of green pods plant^{-1}	Pod length (cm)	Diameter of pod (cm)	No. of Seed pod^{-1}
N_0	20.54d	10.83d	13.53e	10.17c	1.14d	5.07c
N_{40}	21.44cd	12.10c	16.07d	12.93b	1.22cd	5.33bc
N_{80}	23.07bc	12.50c	16.97c	13.63ab	1.32cd	5.50bc
N_{120}	26.55a	17.50a	23.40a	15.50a	1.90a	6.20a
N_{160}	24.55ab	16.60b	22.20b	14.79ab	1.55b	5.87ab
LSD (1%)	2.16	0.46	-	-	0.1191	-
LSD (5%)	-	-	1.04	2.29	-	.0176

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

Table 6. (Contd.)

Nitrogen Fertilizer (kg ha^{-1})	Pod yield ploat^{-1} (kg)	Pod yield (t ha^{-1})	1000-seed weight (kg)	Seed yield Ploat^{-1} (kg)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
N_0	4.47 e	8.73 e	193 c	0.73 e	1.46 e	3.18 d
N_{40}	6.87 d	13.94 d	220 bc	1.14 d	2.28 d	3.52 c
N_{80}	7.31 c	14.62 c	237 ab	1.24 c	2.48 c	3.58 b
N_{120}	9.00 a	18.00 a	267 a	1.55 a	3.10 a	3.97 a
N_{160}	8.83 b	1.77 b	263 a	1.49 b	2.98 b	4.02 a
LSD (1%)	0.103	0.15	-	0.08	0.016	0.053
LSD (5%)	-	-	33.86	-	-	-

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

Table 7. Effect of different levels of molybdenum on the growth and yield contributing characters of bush bean at 90 DAS

Molybdenum Fertilizer ($kg\ ha^{-1}$)	Plant Population/m^2	Branch/ Plant	Number of green pods/plant	Pod length (cm)	Diameter of pod (cm)	No. of Seed/ pod
Mo_0	20.54b	10.83c	13.53b	10.17c	1.14b	5.07b
$Mo_{.5}$	24.55a	13.50a	16.50a	12.88a	1.41a	5.83a
Mo_1	23.44a	12.50b	16.40a	11.80b	1.38a	5.70a
LSD (1%)	1.492	.30	-	.998	-	-
LSD (5%)	-	-	1.04	-	.14	.33

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

Table 7. (Contd.)

Molybdenum Fertilizer ($kg\ ha^{-1}$)	Pod yield $ploat^{-1}$ (kg)	Pod yield ($t\ ha^{-1}$)	1000-seed weight (kg)	Seed yield $Ploat^{-1}$ (kg)	Seed yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
Mo_0	4.47 b	8.73 b	193 b	0.73 b	1.46 a	3.48 b
$Mo_{0.5}$	6.07 a	12.14 a	247 a	1.25 a	2.50 a	3.77 a
$Mo_{1.0}$	5.95 a	11.90 a	230 a	1.15 a	2.30 a	3.74 a
LSD (1%)	0.22	0.34	-	0.124	0.24	0.041
LSD (5%)	-	-	20.50	-	-	-

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

Table 8. Combined effect of different levels of nitrogen and molybdenum on the growth and yield contributing characters of bush bean at 90 DAS

Nitrogen × Molybdenum (kg ha^{-1})	Plant Population m^{-2}	Branch plant^{-1}	Number of green pods plan^{-1}t	Pod length (cm)	Diameter of pod (cm)	No. of seed pod^{-1}
N_0Mo_0	20.54f	10.83j	13.53h	10.17g	1.14f	5.07f
N_{40} Mo_0	21.44f	12.10i	16.06fg	12.93def	1.22f	5.33ef
N_{80} Mo_0	23.07e	12.50h	16.97ef	13.63cde	1.32e	5.50def
N_{120} Mo_0	26.55ab	17.50b	23.40b	15.50ab	1.90ab	6.20ab
N_{160} Mo_0	24.55cde	16.60c	22.20c	14.79abc	1.55c	5.87bcd
N_0 $Mo_{0.5}$	24.55cde	13.50g	16.50f	12.78ef	1.41de	5.83bcde
N_{40} $Mo_{0.5}$	24.50cde	14.50f	17.60e	14.13bcde	1.51cd	5.50def
N_{80} $Mo_{0.5}$	24.47cde	14.80e	18.77de	14.50bc	1.51cd	6.00bcd
N_{120} $Mo_{0.5}$	27.33a	18.50a	24.50a	16.00a	1.96a	6.50a
N_{160} $Mo_{0.5}$	25.33bcd	16.50c	22.40bc	14.23bcd	1.58c	5.67cde
N_0 $Mo_{1.0}$	23.44e	12.50h	16.40f	12.00f	1.38e	5.70cde
N_{40} $Mo_{1.0}$	23.88de	13.60g	17.90e	14.41bc	1.39e	5.70cde
N_{80} $Mo_{1.0}$	25.50bc	14.40f	19.20d	13.80cde	1.51cd	5.7obcde
N_{120} $Mo_{1.0}$	25.44bcd	16.50c	22.27c	14.55bc	1.83b	6.00bcd
N_{160} $Mo_{1.0}$	26.33ab	15.90d	22.00c	13.54cde	1.51cd	6.00bcd
LSD (1%)	1.370	.248	1.04	1.223	0.0916	0.4519

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

Table 8. (Contd.)

Nitrogen × Molybdenum (kg ha^{-1})	Pod yield plot^{-1} (kg)	Pod yield (t ha^{-1})	1000 seed wt .(g)	Seed yield Plot $^{-1}$ (kg)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
N_0Mo_0	4.47j	8.73m	193 f	0.73d	1.46e	2.90i
N_{40} Mo_0	6.87g	13.94j	220 ef	1.14 c	2.28 d	3.40fg
N_{80} Mo_0	7.31f	14.62i	236 cde	1.24c	2.48cd	3.45f
N_{120} Mo_0	9.00c	18.00c	267 abc	1.55ab	3.10 b	3.80c
N_{160} Mo_0	8.83d	17.66e	263 abcd	1.35bc	2.70 c	3.85c
N_0 $Mo_{0.5}$	6.07h	12.14k	230 de	1.18 c	2.35cd	3.77d
N_{40} $Mo_{0.5}$	7.68ef	15.36h	237 cde	1.25 c	2.50cd	3.55e
N_{80} $Mo_{0.5}$	7.75e	15.47g	237 cde	1.30bc	2.60cd	3.60e
N_{120} $Mo_{0.5}$	9.25a	18.50a	286 a	1.75 a	3.50a	4.15a
N_{160} $Mo_{0.5}$	8.85d	17.70e	253 bcde	1.45bc	2.90bc	4.20a
N_0 $Mo_{1.0}$	5.95i	11.90l	230 de	1.15c	2.30 d	3.74h
N_{40} $Mo_{1.0}$	8.76d	17.52f	243 bcde	1.26 c	2.52cd	3.60e
N_{80} $Mo_{1.0}$	7.67ef	15.34h	233 cde	1.28bc	2.55cd	3.70d
N_{120} $Mo_{1.0}$	9.12b	18.24b	278 a	1.46bc	2.92bc	3.95b
N_{160} $Mo_{1.0}$	8.92d	17.84d	276 ab	1.48	2.95bc	4.00b
LSD (1%)	0.37	0.074	31.15	0.269	0.350	0.092

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

4. 8 Diameter of green pod

4.8.1 Effect of Nitrogen

Diameter of green pod was found statistically significant due to the application of different nitrogen levels (Table 6). The diameter of green pods ranged from 1.14 to 1.90 cm. The highest diameter of green pods (1.90 cm) was recorded from the treatment of 120 kg N ha^{-1}. The lowest diameter of green pods (1.14 cm) was found in the control treatment (0 kg N ha^{-1}).

4.8.2 Effect of Molybdenum

Molybdenum had significant effect on diameter of green pod (Table7). The diameter of green pods ranged from 1.14 to 1.41 cm .The highest diameter of green pods (1.41 cm) was recorded from the treatment of 0.5kg Mo ha^{-1} which was statistically similar with that of 1.0 kg Mo ha^{-1}. The lowest diameter of green pod (1.14cm) was obtained in the control treatment.

4.8.3 Interaction effect of Nitrogen and Molybdenum

The interaction effect of different doses of nitrogen and molybdenum on diameter green pod was found to be significant (Table 8). The diameter of green pods ranged from 1.14 to 1.96 cm .The highest diameter of green pod (1.96 cm) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1}, which was statistically similar with $N_{120}Mo_0$. The lowest diameter of green pod (1.14 cm) was obtained from the control. Which was statistically similar with that of $N_{40}Mo_0$.

4.9 Number of seeds pod^{-1}

4.9.1 Effect of Nitrogen

There were significant differences among the different levels of N on green seeds pod^{-1} (Table 6). It was observed that the number of seeds was increased with the increase of nitrogen level. The number of green seed $pods^{-1}$ ranged from 5.07 to 6.20. The maximum number of green seeds pod^{-1} (6.20) was found at 120 N ha^{-1} which was closely followed 160 kg N ha^{-1} (5.87) and the lowest number of green seed pod^{-1} (5.07) was obtained in the control treatment (0 kg N ha^{-1}). The application of nitrogen produced significantly the higher number of green seeds pod^{-1} of bush bean, as reported by Singh and Verma (2002) and Tewari and Singh (2000).

4.9.2 Effect of Molybdenum

Molybdenum had significant effect on the number of green seeds pod^{-1} (Table 7). The number of green seed pod^{-1} ranged from 5.07 to 5.83. The highest number of green seeds pod^{-1} (5.83) was obtained when the crop was fertilized with 0.5kg Mo ha^{-1}, which was statistically similar with that of 1 kg Mo ha^{-1} and the lowest number of green seeds pod^{-1} (5.07) was obtained in the control treatment.

4.9.3 Interaction effect of Nitrogen and Molybdenum

The interaction effects of different doses of nitrogen and molybdenum on green seed pod^{-1} was found to be significant (Table11). The number of green seed pods ranged from 5.07 to 6.50. The highest number of green seed pod^{-1} (6.50) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1} which was statistically similar to $N_{120}Mo_0$. The lowest number of green seed pod^{-1} (5.07) was obtained from the control treatment.

4.10 Pod weight plot^{-1} (kg)

4.10.1 Effect of Nitrogen

The pod weight plot^{-1} was significantly influenced by different levels of nitrogen (Table 6). The pod weight plot^{-1} ranged from 4.47 to 9.00 kg. The highest pod weight plot^{-1} (9.00 kg) was obtained when the crop was fertilized with 120 kg N ha^{-1}, which was significantly different from other treatment. The lowest pod weight plot^{-1} (4.47 kg) was found from control treatment where no nitrogen was applied. From these result it was found that mainly nitrogenous fertilizer increased vegetative growth as well as green pod yield.

4.10.2 Effect of Molybdenum

The pod weight plant^{-1} was significantly influenced by molybdenum application (Table 7). The pod weight plot ranged from 4.47 to 6.07 kg. The highest pod weight plot^{-1} (6.07 kg) was obtained when the crop was fertilized with 0.5kg Mo ha^{-1}, which was statistically similar $Mo_{1.0}$treatment and the lowest pod weight plot^{-1} (4.47 kg) was obtained in the control.

4.10.3 Interaction effect of Nitrogen and Molybdenum

The interaction effect of different doses of nitrogen and molybdenum on pod weight plot^{-1} was found to be significant (Table 8). The pod weight plot^{-1} ranged from 4.47 to 9.25 kg. The highest pod weight plot^{-1} (9.25 kg) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1} which was significantly different from other treatment combinations. The lowest pod weight per plot^{-1} (4.47 kg) was obtained from the control.

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

4.11.1 Effect of Nitrogen

The pod yield of bush bean hectare^{-1} was significantly influenced by different levels of nitrogen (Table 6 and Fig. 9). The pod yield ranged from 8.73 to 18.00 t ha^{-1}. The maximum yield of green pod (18.00 t ha^{-1}) was recorded with the application of 120 kg N ha^{-1}, which was significantly different with other treatments and the minimum yield of green pod (8.73 t ha^{-1}) was found from the control treatment where no nitrogen was applied. From these result it was found 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).

4.11.2 Effect of Molybdenum

Pod yield was significantly influenced by different levels of molybdenum (Table7 and Fig. 10). The pod yield ranged from 8.73 to 12.14 t ha^{-1}. The highest pod yield of bush bean per hectare (12.14 t ha^{-1}) was obtained when the crop was fertilized with 0.5kg Mo ha^{-1}, which was statistically similar $Mo_{1.0}$treatments and the lowest pod yield of bush bean per hectare (8.73 t ha^{-1}) was obtained in the control treatment.

4.11.3 Interaction effect of Nitrogen and Molybdenum

Different treatment combinations of nitrogen and molybdenum influenced significant effect on pod yield (Table 8 and Fig.11). The pod yield ranged from 8.73 to 18.50 t ha^{-1}. The highest pod yield (18.50 t ha^{-1}) was recorded from the treatment combination of 120 N/ha and 0.5 kg Mo ha^{-1}, which was significantly different from other treatments. The lowest pod yield (8.73 t ha^{-1}) was in the control treatment.

4. 12 Thousand seed weight (g)

4.12.1 Effect of Nitrogen

The results indicated that the effects of different treatments of nitrogen on 1000-seed weight were statistically significant (Table 6). The highest 1000-seeds weight (267 g) was obtained when the crop was fertilized with 120 N ha^{-1} which was statistically similar with N_{160} and N_{80} and the lowest number of 1000- seed weight (193 g) was obtained in the control. This result is in agreement with the finding Singh and Verma (2002).

4.12.2 Effect of Molybdenum

The results indicated that the effects of different treatments of molybdenum on 1000-seed weight were statistically significant (Table 7). The highest weight of 1000- seeds (246 g) was obtained when the crop was fertilized with 0.5kg Mo ha^{-1}, which was statistically similar $Mo_{1.0}$treatment and the lowest weight of 1000-seeds (193 g) was obtained in the control.

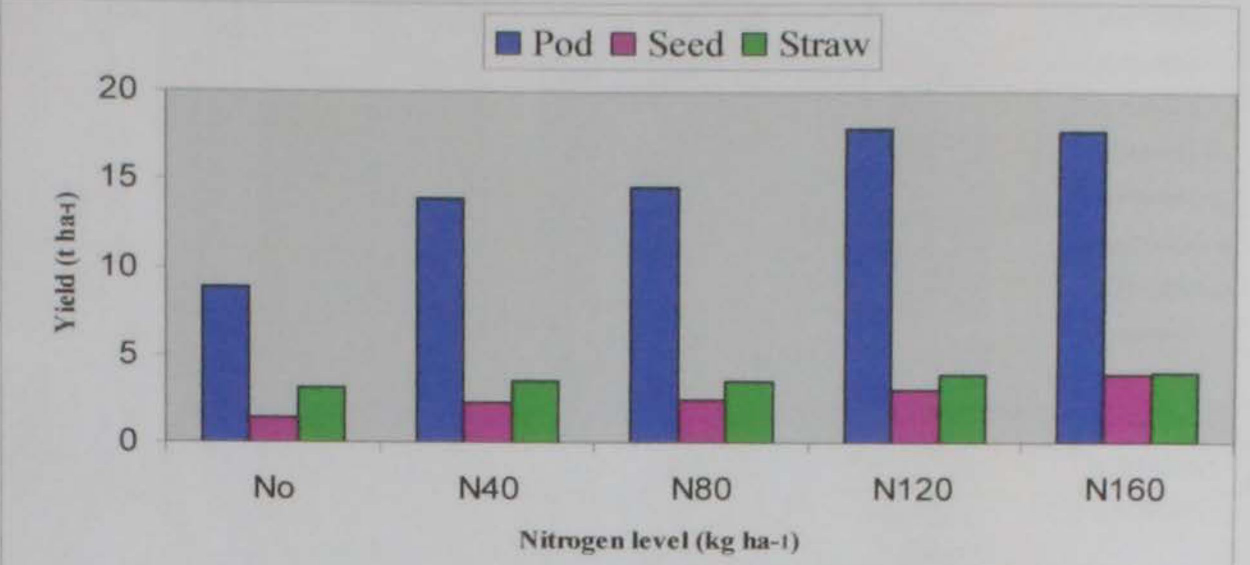

Fig. 9 Effect of nitrogen level on pod, seed and straw yields of bush bean.

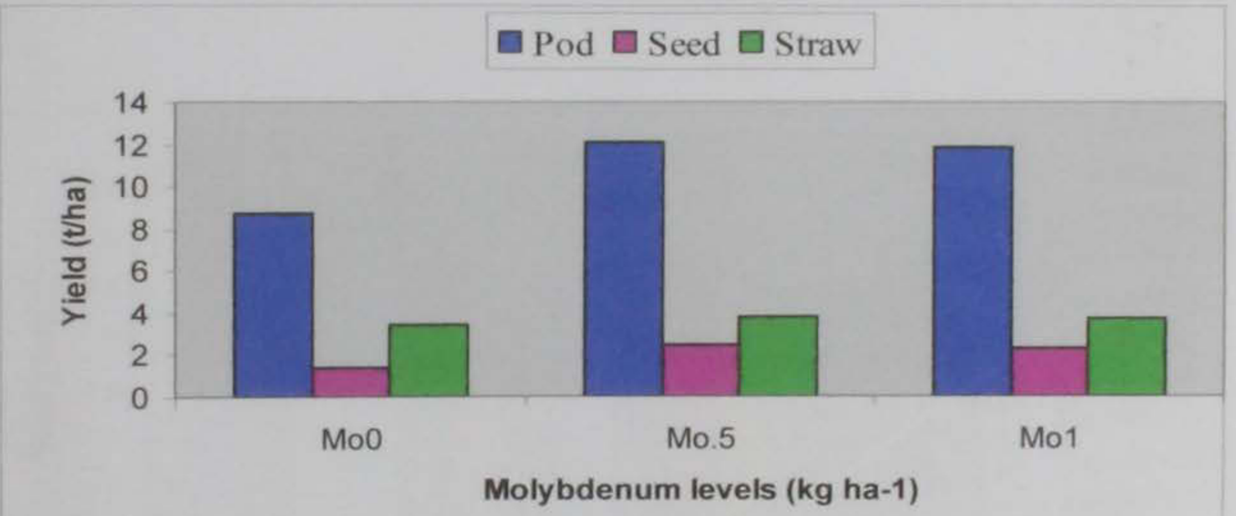

Fig. 10 Effect of molybdenum levels on pod, seed and straw yields of bush bean.

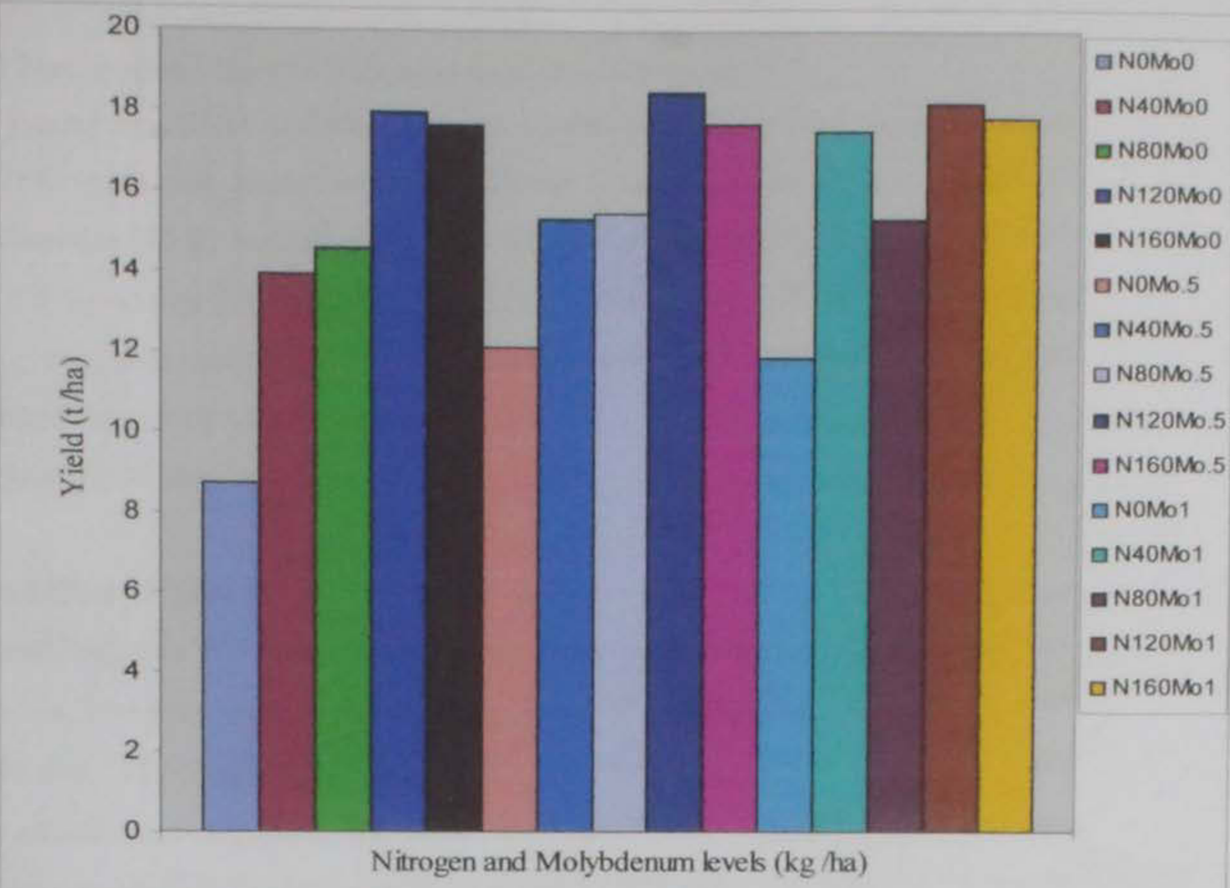

Fig.11 Combined effect of nitrogen and molybdenum on pod yield of bush bean.

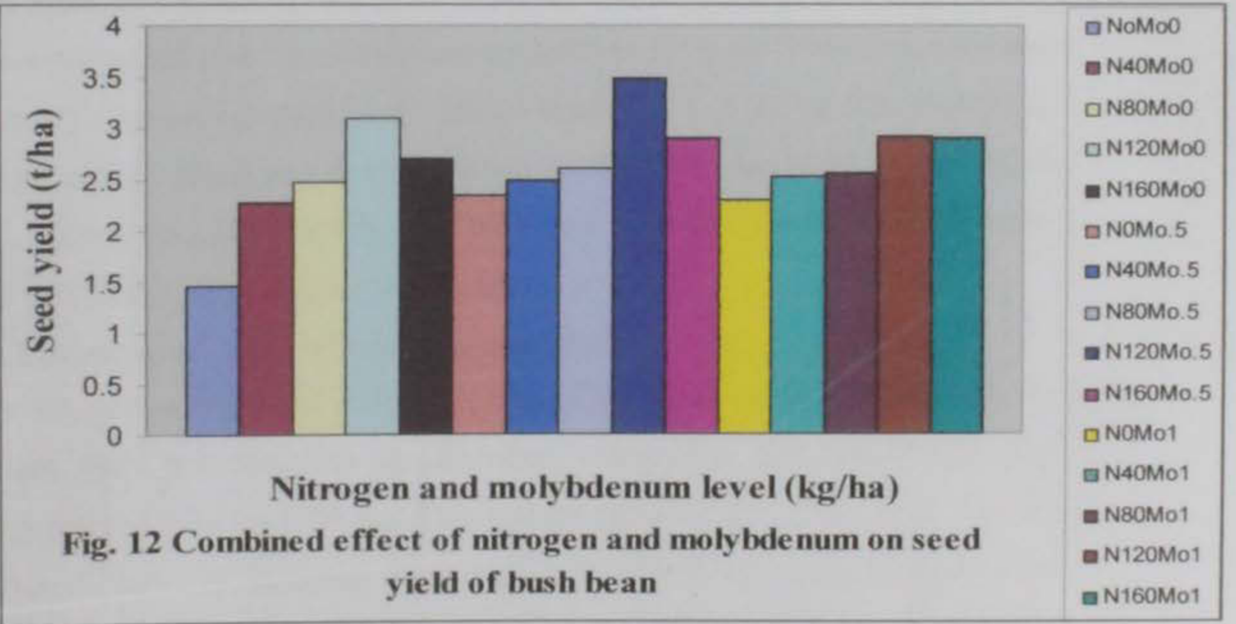

Fig. 12 Combined effect of nitrogen and molybdenum on seed yield of bush bean

4.12.3 Interaction effect of Nitrogen and Molybdenum

The interaction effect of different doses of nitrogen and molybdenum on weight of 1000-seeds was found to be significant (Table 8). The highest weight of 1000-seeds (287 g) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1}, which was statistically similar to N_{120} $Mo_{0,}$ N_{160} $Mo_{0,}$ N_{160} $Mo_{0.5,}$ N_{120} $Mo_{1.0}$ and N_{160} $Mo_{1.0}$. The lowest weight of 1000-seeds (193 g) was obtained from the control treatment.

4.13 Seed yield $plot^{-1}$ (kg)

4.13.1 Effect of Nitrogen

The seed weight $plot^{-1}$ was significantly influenced by different levels of nitrogen (Table 6). The seed weight $plot^{-1}$ ranged from 0.73 to 1.55 kg. The highest seed weight $plot^{-1}$ (1.55 kg) was obtained when the crop was fertilized with 120 kg N ha^{-1}, which was significantly different from other treatments. The lowest seed weight $plot^{-1}$ (0.73 kg) was found from control treatment where no nitrogen was applied.

4.13.2 Effect of Molybdenum

The seed weight $plot^{-1}$ was significantly influenced by molybdenum application (Table7). The seed weight $plot^{-1}$ ranged from 0.73 to 1.25 kg. The highest pod weight plot (1.25kg) was obtained when the crop was fertilized with 0.5kg Mo ha^{-1}, which was statistically similar $Mo_{1.0}$ with and the lowest seed weight $plot^{-1}$ (0.73 kg) was obtained in the control.

4.13.3 Interaction effect of Nitrogen and Molybdenum

The interaction effects of different doses of nitrogen and molybdenum on seed weight $plot^{-1}$ was found to be significant (Table 8). The seed weight $plot^{-1}$ ranged from 0.73 to 1.75 kg. The highest seed weight $plot^{-1}$ (1.75 kg) was obtained from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1}, which was statistically similar with $N_{120}Mo_0$. The lowest seed weight $plot^{-1}$ (0.73 kg) was found from control treatment where no nitrogen was applied.

4.14 Seed yield (t/ha)

4.14.1 Effect of Nitrogen

Seed yield was significantly affected by different levels of N (Table 6 and Fig.9). The seed yield ranged from 1.46 to 3.10 t ha^{-1}. The maximum seed yield (3.10 t ha^{-1}) was recorded with the application of 120 kg N ha^{-1}, which was significantly different with other treatments. The minimum seed yield (1.46 t ha^{-1}) was found from the control treatment where no nitrogen was applied. The results are in agreement with that of Dhanjal *et al.* (2004, Singh and Verma (2002), Dhanjal *et al.* (2001), Tewari and Singh (2000), Bamboo *et al.* (1998), Nandan and Prasad (1998), and Dahatonde *et al.* (1992).

4.14.2 Effect of Molybdenum

Seed yield was significantly affected by different levels of molybdenum (Table 7 and Fig. 11). The seed yield ranged from 1.46 to 2.50 t ha^{-1}. The highest seed yield of bush bean per hectare (2.50 t ha^{-1}) was obtained when the crop was fertilized with 0.5kg Mo ha^{-1}, which was statistically similar $Mo_{1.0}$ treatments and the lowest pod yield of bush bean per hectare (1.46 t ha^{-1}) was obtained in the control treatment.

4.14.3 Interaction effect of Nitrogen and Molybdenum

Different treatment combinations of nitrogen (N) and molybdenum (Mo) had significant effect on seed yield (Table 8 and Fig.12). The seed yield ranged from 1.46 to 3.50 t ha^{-1}. The highest seed yield (3.50 t ha^{-1}) was recorded from the treatment combination of 120 N ha^{-1} and 0.5 kg Mo ha^{-1}, which was statistically different with the other treatments. The lowest seed yield (1.46 t ha^{-1}) was found by the control treatment.

4.15 Straw yield (t/ha)

4.15.1 Effect of Nitrogen

Straw yield was significantly affected by different levels of N (Table 6 and Fig.9). The straw yield ranged from 3.18 to 4.02 t ha^{-1}. The highest straw yield (4.02 t ha^{-1}) was obtained when the crop was fertilized with 160 N ha^{-1}, which was statistically similar to N_{120}. The lowest straw yield (3.18 t ha^{-1}) was obtained in the control treatment (0 kg N ha^{-1}). This result is in agreement with the finding of Prajapati *et al.* (2004), Singh and Verma (2002).

4.15.2 Effect of Molybdenum

The effect of molybdenum on straw yield was found statistically significant (Table7 and Fig.10). The straw yield ranged from 3.48 to 3.77 t ha^{-1}. The highest straw yield (3.77 t ha^{-1}) was obtained when the crop was fertilized with 0.5 kg Mo ha^{-1} which was statistically similar with the 1.0 kg Mo ha^{-1} and the lowest straw yield (3.48 t ha^{-1}) was obtained in the control .

4.15.3 Interaction effect of Nitrogen and Molybdenum

Different treatment combinations of nitrogen and molybdenum had significant effect on straw yield (Table 8). The straw yield ranged from 2.90 to 4.20 t ha^{-1}. The highest straw yield (4.20 t ha^{-1}) was obtained from the treatment combination of 160 kg N ha^{-1} and 0.5 kg Mo ha^{-1}, which was statistically similar with N_{120} $Mo_{0.5}$ .The lowest straw yield (2.90 t ha^{-1}) was obtained from the control.

Plate 3. A photograph showing pod of the bush bean having fertilized with $N_{120}M_{o0.5}$

Plate 4. A photograph showing pod of the bush bean having fertilized with N_0Mo_0

Plate. 5 A photograph showing seed of the bush bean having fertilized with $N_{120}Mo_{0\cdot5}$

Plate. 6 A photograph showing seed of the bush bean having fertilized with N_0Mo_0

4.16 Characteristics of the post harvest soils

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

4.16.1 Soil pH

A significant variation was observed on the content in soil pH after harvest where the nitrogen was incorporated in soil (Table 9). pH values of the post harvest soils ranged from 6.30 to 6.80. The highest pH value (6.80) was recorded in N_{40} treatment which was statistically similar with N_{120} and the lowest pH value (6.30) was recorded in control treatment.

A significant variation was observed on the content in soil pH after harvest where the molybdenum was incorporated in soil (Table10). pH values of the post harvest soils ranged from 6.46 to 6.71. The highest pH value (6.71) was recorded in $Mo_{0.5}$ treatment and the lowest pH value (6.46) was recorded in control treatment.

Combined application of different doses of nitrogen and molybdenum showed a significant effect on the content in soil pH after harvest (Table 11). The soil pH values in the post harvest soil ranged from 5.80 to 6.90. The higher soil pH (6.90) were recorded in the treatment combination of $N_{120}Mo_{0.5}$, $N_{80}Mo_{0.5}$, $N_{160}Mo_{0.5}$ which was statistically similar with $N_{120}Mo_{1.0}$, $N_{40}Mo_{1.0}$, $N_{160}Mo_0$ and the minimum soil pH (5.80) was obtained in the control.

4.16.2 Organic carbon content (%)

A significant variation was 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 0.56 % to 0.60% (Table 9). The maximum organic matter content (0.60%) was obtained in the treatment N_{120} and N_{160} which was statistically similar with treatment N_{80} and the minimum organic matter content (0.56%) was obtained in control.

A significant variation was 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 0.58% to 0.60% (Table 10). The maximum organic carbon content (0.60%) was obtained in the treatment $Mo_{0.5}$ and the minimum organic carbon content (0.56%) was obtained in control.

Combined application of different doses of nitrogen and molybdenum showed a significant effect on the organic carbon content in soil after harvest (Table 11). 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 $N_{120}Mo_{0.5}$ which was statistically similar with $N_{80}Mo_0$, $N_{160}Mo_0$, $N_0Mo_{0.5}$ and $N_{160}Mo_{1.0}$,and the minimum organic carbon content (0.53%) was obtained in control.

4.16.3 Total nitrogen

A statistically significant variation was 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 0.072% (Table 9). The highest total N content (0.072%) was observed in N_{160} 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 10). The total N content of the post harvest soil ranged from 0.061% to 0.068%. The highest total N content (0.068%) was observed in $Mo_{0.5}$ treatment and the minimum value (0.061%) was found in control.

The effect of combined applications of different doses of nitrogen and molybdenum resulted significant variations in nitrogen content in the post harvest soil (Table 11). The total N content in the post harvest soil ranged from 0.055% to 0.075%. The higher total N content of the post harvest contents (0.075%) were recorded in the treatment combination of $N_{160}Mo_{0.5}$ which was statistically similar with treatment combination of $N_{120}Mo_0$, $N_{40}Mo_{0.5}$, $N_{80}Mo_{0.5}$, $N_{120}Mo_{0.5}$, $N_{80}Mo_{1.0}$, $N_{120}Mo_{1.0}$ and $N_{160}Mo_1$ and the lowest value of 0.055% in control (N_0Mo_0).

Table 9. Effect of N fertilizers on the soil pH, %Organic Carbon, total N, available P, exchangeable K and available S content in the soil after bush bean harvest

Nitrogen Fertilizer (kg ha^{-1})	Soil pH	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K(meq100 g^{-1})	Available S (ppm)
N_0	6.30 d	0.56 c	0.059 c	14.3	0.12	17.3
N_{40}	6.80 a	0.58 b	0.061 bc	16.9	0.13	16.7
N_{80}	6.66 b	0.59 a	0.064bc	16.3	0.13	19.0
N_{120}	6.70 ab	0.60 a	0.069 b	18.0	0.14	24.3
N_{160}	6.58 c	0.60 a	0.072 a	18.9	0.14	25.3
LSD (1%)	0.081	0.018	0.0097	NS	NS	NS
CV%	4.28	5.31	6.49	5.54	4.34	6.18

NS = Non significant

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

Table 10. Effect of Mo on the soil pH, Organic Carbon, total N, available P, exchangeable K and available S content in the soil after bush bean harvest

Molybdenum Fertilizer (kg ha^{-1})	Soil pH	Organic Carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K(meq100 g^{-1})	Available S (ppm)
Mo_0	6.46 c	0.58 c	0.061	15	0.13	19
$Mo_{.5}$	6.71 a	0.60 a	0.068	18	0.14	22
Mo_1	6.64 b	0.59 b	0.066	18	0.14	21
LSD (1%)	0.0626	0.0074	NS	NS	NS	NS
CV%	3.45	4.55	6.49	5.54	4.34	6.18

NS = Non significant

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

Table 11. Combined effect of N and Mo fertilizers on the soil pH, Organic Carbon, total N, available P, exchangeable K and available S content in the soil after bush bean harvest

Nitrogen × Molybdenum (kg ha^{-1})	Soil pH	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K(meq100 g^{-1})	Available S (ppm)
N_0Mo_0	5.80 e	0.53 d	0.0 55 b	12.0	0.11	13.0
N_{40} Mo_0	6.80ab	0.59 b	0.056 b	13.0	0.12	16.0
N_{80} Mo_0	6.20d	0.62 a	0.060 b	15.0	0.12	18.0
N_{120} Mo_0	6.70b	0.53 d	0.065 ab	17.0	0.13	23.0
N_{160} Mo_0	6.80ab	0.62 a	0.062 b	17.7	0.13	23.3
N_0 $Mo_{0.5}$	6.90a	0.62 a	0.062 b	14.0	0.12	21.0
N_{40} $Mo_{0.5}$	6.7 b	0.59 b	0.064 ab	18.0	0.13	13.0
N_{80} $Mo_{0.5}$	6.90 a	0.59 b	0.066 ab	18.0	0.13	19.0
N_{120} $Mo_{0.5}$	6.90a	0.63 a	0.073 ab	18.7	0.14	25.0
N_{160} $Mo_{0.5}$	6.90a	0.57c	0.075 a	19.7	0.15	26.7
N_0 $Mo_{1.0}$	6.10 d	0.60 b	0.059 b	17.0	0.12	18.0
N_{40} $Mo_{1.0}$	6.80ab	0.56 c	0.062 b	17.7	0.14	21.0
N_{80} $Mo_{1.0}$	6.60 b	0.59 b	0.065 ab	18.0	0.14	20.0
N_{120} $Mo_{1.0}$	6.80ab	0.57 c	0.070 ab	18.3	0.14	25.0
N_{160} $Mo_{1.0}$	6.50c	0.62 a	0.072 ab	19.3	0.14	26.0
LSD (1%)	0.015	0.017	0.013	NS	NS	NS

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

4.16.4 Available phosphorus

The effect of application of N at different levels showed no significant differences in respect of P content in soil after harvest (Table 9). The P content in post harvest soils ranged from 14.3 ppm to 18.9 ppm. The highest P content was recorded in N_{160} treatment (18.9 ppm) and the lowest P content (14.3 ppm) was found in the control.

Statistically significant variation was not observed due to the application of Mo at different doses on the content of avail P of the post harvest soil (Table 10).The P content in the post harvest soil ranged from 15.0 ppm to18.0 ppm. The highest P content (18.0ppm) was observed in $Mo_{0.5}$ and $Mo_{1.0}$ treatment and the minimum value (15.0 ppm) was found in the control.

The effect of combined application of nitrogen and molybdenum showed no significant differences in respect of P content in soil after harvest (Table 11). The P content in the post harvest soil ranged from 12.0 ppm to 19.7 ppm. The highest P content (19.7 ppm) was observed in $N_{160}Mo_{0.5}$ treatment and the minimum value (12.0 ppm) was found in the control.

4.16.5 Exchangeable potassium

The effect of application of N showed no significant differences in respect of K content in soil after harvest (Table 9). The K content in post harvest soils ranged from 0.12 mgq 100 g^{-1} to 0.14 mgq 100 g^{-1}. The highest K content was recorded in N_{160} treatment (0.14 mgq 100 g^{-1}) and the lowest K content (0.12 mgq 100 g^{-1}) was found in the control.

Statistically significant variation was not observed in K content of the post harvest soil with the application of various levels of Mo (Table 10). The K content of the post harvest soil ranged from 0.13 mgq 100 g^{-1} to 0.14 mgq 100 g^{-1}. The highest K content (0.14 mgq 100 g^{-1}) was observed in $Mo_{0.5}$ treatment and the minimum value (0.12 mgq 100 g^{-1}) was found in the control.

The effect of combined application of nitrogen and molybdenum showed no significant differences in respect of K content in soil after harvest (Table 11). The K content in the post harvest soil ranged from 0.11 mgq 100 g^{-1} to 0.15 mgq 100 g^{-1}. The highest K content (0.15 mgq 100 g^{-1}) was observed in $N_{160}Mo_{0.5}$ treatment and the minimum value (0.11 mgq 100 g^{-1}) was found in the control.

4.16.6 Available sulphur

The effect of application of N showed no significant differences in respect of S content of soil after harvest (Table 9). The S content in post harvest soils ranged from 17.3 ppm to 25.3 ppm. The highest S content (25.3 ppm) was recorded in N_{160} treatment and the lowest S content (17.3 ppm) was found in control.

Statistically significant variation was not observed in molybdenum content in respect of the post harvest soil (Table 10). The S content in the post harvest soil ranged from 19.0 ppm to 22.0 ppm. The highest S content in (22.0 ppm) was observed in $Mo_{0.5}$ treatment and the minimum value (19.0 ppm) was found in control.

The effect of combined application of nitrogen and molybdenum showed no significant differences in respect of S content of soil after harvest (Table 11). The S content of the post harvest soil ranged from 13.0 ppm to 26.7 ppm. The highest S content (26.7 ppm) was observed in $N_{160}Mo_{0.5}$ treatment and the minimum value (13.0 ppm) was found in control.

4.17. Nutrient content in plant.

4.17.1 N content

The N content in plant was found statistically significant due to different treatments of nitrogen (Table 12). The N content in plant in different treatments ranged from 0.93 to 1.29%. The highest N content in plant (1.29%) was observed in N_{120} treatment and the lowest N content in plant (0.93%) was noted in control.

Nitrogen content in plant was significantly influenced by different molybdenum level (Table 13). The N content in plant in different treatments ranged from 1.03 to

1.32%. The highest N content in plant (1.32%) was observed in Mo $_{0.5}$ treatment and the lowest N content (1.03 %) was noted in control.

The combined effect of N and Mo on N content in plant was significant (Table 14). The N content in plant ranged from 0.89% to 1.33%. The highest N content in (1.43 %) was obtained with $N_{120}Mo_{0.5}$ treatments, which was statistically identical with $N_{160}Mo_{0.5}$ and $N_{120}Mo_0$ .The minimum N content in Stover (0.89%) was found in control.

4.17.2 P content

A significant increase in P content in straw was recorded due to different treatments of nitrogen (Table 12). The P content ranged from 0.399 to 0.481%. The highest value (0.481%) was obtained in N_{120} treatment which was statistically different from other treatments. The minimum value (0.399 %) was obtained in control.

Phosphorus content in straw was also influenced by different levels of Mo (Table 13). Phosphorus content in straw ranged from 0.403% to 0.434%. The highest phosphorus content in straw (0.434%) was found in $Mo_{0.5}$ kg ha^{-1}, which was statistically similar to $Mo_{1.0}$. The lowest phosphorus content in straw (0.403 %) was found in control.

The treatment combinations of nitrogen and molybdenum significantly influenced the phosphorus content in straw (Table 14). Phosphorus content in straw was ranged from 0.361% to 0.530%. The maximum P content (0.530%) in straw was found in $N_{120}Mo_{0.5}$ treatment and the minimum phosphorus content (0.361%) was observed in N_0Mo_0.

4.17.3 K content

A significant increase in K content in straw was recorded due to different treatments of nitrogen (Table 12). The K content ranged from 0.849% to 0.937%. The highest value (0.937%) was obtained in N_{120} treatment which was statistically significant from other treatments. The minimum value (0.849%) was obtained in control.

Table 12. Effect of different doses of N fertilizer on the NPKS concentration in bush bean plant

Nitrogen fertilizer (kg ha^{-1})	Concentration (%)			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0	0.93 e	0.396 c	0.849 d	0.310 e
N_{40}	1.02 d	0.399 c	0.856 d	0.325 d
N_{80}	1.06 c	0.404 c	0.890 c	0.350 c
N_{120}	1.29 a	0.481 a	0.937 a	0.448 a
N_{160}	1.14 b	0.427 b	0.908 b	0.368 b
LSD (1%)	0.03	0.010	0.010	0.010

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

Table13. Effect of different doses of Mo fertilizer on the N,P,K,S concentration in bush bean plant

Molybdenum fertilizer (kg ha^{-1})	Concentration (%)			
	Nitrogen	Phosphorous	Potassium	Sulphur
Mo_0	1.03 c	0.403 b	0.861 c	0.288 c
$Mo_{0.5}$	1.32 a	0.434 a	0.910 a	0.411 a
$Mo_{1.0}$	1.10 b	0.428 a	0.894 b	0.382 b
LSD (1%)	0.024	0.0075	0.0075	0.0075

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

Table 14. Combined effect of different doses of N and Mo fertilizer on the NPKS concentration in bush bean plant

Nitrogen × Molybdenum Fertilizer (kg ha^{-1})	Concentration (%)			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0Mo_0	0.89 e	0.361 h	0.807 i	0.234 j
N_{40} Mo_0	1.06 c	0.485 c	0.906 d	0.287 h
N_{80} Mo_0	1.06 c	0.426 d	0.936 c	0.256 i
N_{120} Mo_0	1.31 a	0.509 b	0.969 b	0.385 cd
N_{160} Mo_0	1.25 b	0.387 fg	0.950 b	0.278 h
N_0 $Mo_{0.5}$	0.99 d	0.426 d	0.893 de	0.375 cde
N_{40} $Mo_{0.5}$	0.97 d	0.402 ef	0.893 de	0.375 cde
N_{80} $Mo_{0.5}$	1.06 c	0.382 g	0.883 ef	0.380 cde
N_{120} $Mo_{0.5}$	1.33 a	0.530 a	0.990 a	0.589 a
N_{160} $Mo_{0.5}$	1.30 a	0.410 de	0.890 de	0.335 f
N_0 $Mo_{1.0}$	0.91e	0.399 efg	0.847 g	0.365 e
N_{40} $Mo_{1.0}$	1.02 cd	0.394 efg	0.872 f	0.389 e
N_{80} $Mo_{1.0}$	1.06 c	0.405 ef	0.904 d	0.467 b
N_{120} $Mo_{1.0}$	1.23 b	0.405 ef	0.851 g	0.369 de
N_{160} $Mo_{1.0}$	1.24 b	0.402 ef	0.829 h	0.318 g
LSD (1%)	0.0529	0.0167	0.0167	.0167
CV%	6.83	7.14	6.35	8.14

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

Potassium content in straw was significantly influenced by different levels of Mo (Table 13). Potassium content in straw ranged from 0.861% to 0.910%. The highest Potassium content in straw (0.910%) was found with the application of $Mo_{0.5}$ kg ha^{-1}. The lowest potassium content in straw (0.861%) was found in control.

Potassium (K) content in straw was significantly influenced by the combined effect of nitrogen and molybdenum (Table 14). Potassium content in straw was ranged from 0.807% to 0.990%. The maximum potassium content in straw (0.990%) was found in $N_{120}Mo_{0.5}$ treatment and the minimum potassium content in straw (0.807%) was observed in N_0 Mo_0.

4.17.4 S content

A significant increase in S content in straw was recorded due to different treatments of nitrogen (Table 12). The S content ranged from 0.310% to 0.448%. The highest value (0.448%) was obtained in N_{120} treatment which was different with other treatments. The minimum value (0.310%) was obtained in control.

Sulphur content in straw was also influenced significantly by different levels of Mo (Table 13). Sulphur content in straw ranged from 0.288% to 0.41%. The highest S content in straw (0.410%) was obtained in $Mo_{0.5}$ kg/ha. The lowest S content in straw (0.288%) was found in control.

The Interaction effect of Nitrogen and molybdenum on S content in straw was significant (Table 114). Sulphur content in straw ranged from 0.234% to 0.589%. The maximum sulphur content (0.589%) in straw was found in $N_{120}Mo_{0.5}$ treatment and the minimum sulphur content (0.234%) was observed in N_0Mo_0.

4.18 Nutrient uptake by bush bean plant

4.18.1 Nitrogen uptake

The N uptake by the straw of bush bean was found statistically significant due to different treatments of nitrogen (Table15). The N uptake by straw due to different treatments ranged from 28.19 kg ha^{-1} to 53.84 kg/ha .The highest N uptake (53.84

kg ha^{-1}) was observed in N_{120} treatment and the lowest N uptake (28.19 kg ha^{-1}) was noted in control.

Nitrogen uptake by straw was significantly affected by different molybdenum level (Table 16). The N uptake by straw due to different Mo treatments ranged from 40.03 kg ha^{-1} to 44.78 kg ha^{-1}. The highest N uptake (44.78 kg ha^{-1}) was observed in $Mo_{0.5}$ treatment and the lowest N uptake (40.03 kg ha^{-1}) was noted in control.

The combined effect of N and Mo on N uptake by straw was significant (Table 17). The N uptake by straw ranged from 25.81 kg ha^{-1} 59.35 kg ha^{-1}. The highest N uptake (59.35 kg ha^{-1}) obtained with $N_{120}Mo_{0.5}$ treatments, which was statistically similar with $N_{160}Mo_{0.5}$. The minimum N uptake by straw (25.81 kg ha^{-1}) was found in N_0Mo_0

4.18.2 Phosphorus uptake

Phosphorus uptake by the straw of bush bean was found statistically significant due to different treatments of nitrogen (Table15). The P uptake by straw due to different treatments ranged from 12.57 kg ha^{-1} to 19.11 kg ha^{-1}. The highest P uptake (19.11 kg ha^{-1}) was observed in N_{120} treatment and the lowest P uptake (12.17 kg ha^{-1}) was noted in control.

Phosphorus uptake by straw was significantly affected by different molybdenum level (Table 16). Phosphorus uptake by straw was ranged from 14.84 kg ha^{-1} to 16.47 kg ha^{-1}. The highest P uptake by straw (16.47 kg ha^{-1}) was found in $Mo_{0.5}$ treatment and the lowest P uptake by straw (14.84 kg ha^{-1}) was found with control.

The treatment combinations of nitrogen and molybdenum significantly influenced the phosphorus uptake by straw (Table 17). Phosphorus uptake by straw was ranged from 10.47 kg ha^{-1} to 22.00 kg ha^{-1}. The highest P uptake by straw (22.00 kg ha^{-1}) was obtained from the treatment $N_{120}Mo_{0.5}$ which was significantly different from all other treatment combinations and the lowest values (10.47 kg ha^{-1}) was obtained from control.

Table15. Effect of different levels of N on nutrient uptake by bush bean plant

Nitrogen fertilizer (kg ha^{-1})	Nutrient uptake by straw (kg ha^{-1})			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0	28.19 e	12.57 d	26.95 e	10.40 e
N_{40}	35.73 d	15.26 c	31.21 d	12.36 d
N_{80}	37.98 c	14.48 d	32.15 c	13.26 b
N_{120}	53.84 a	19.11 a	37.17 a	17.88 a
N_{160}	52.18 b	16.07 b	35.71 b	12.50 c
LSD (1%)	0.46	0.22	0.28	0.05

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

Table 16. Effect of different levels of N on nutrient uptake by bush bean plant

Molybdenum fertilizer (kg ha^{-1})	Nutrient uptake by straw (kg ha^{-1})			
	Nitrogen	Phosphorous	Potassium	Sulphur
Mo_0	40.03 b	14.84 c	31.83 c	10.14 c
$Mo_{0.5}$	44.78 a	16.47 a	34.38 a	15.61 a
$Mo_{1.0}$	39.94 b	15.18 b	32.92 b	14.09 b
LSD (1%)	0.35	0.17	0.23	0.04

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

Table 17. Combined effect of different levels of N and Mo on nutrient uptake by of bush bean plant

Nitrogen × Molybdenum Fertilizer (kg ha^{-1})	Nutrient uptake by straw (kg ha^{-1})			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0Mo_0	25.81 k	10.47 j	23.40 h	6.79 k
N_{40} Mo_0	36.04 h	16.49 d	30.53 g	9.76 i
N_{80} Mo_0	36.57 g	14.70 g	32.29 e	8.83 j
N_{120} Mo_0	53.58 b	19.34 b	36.82 c	14.63 c
N_{160} Mo_0	48.13 d	14.90 fg	36.8 0 c	10.70 h
N_0 $Mo_{0.5}$	37.32 g	16.06 e	33.67 d	14.14 d
N_{40} $Mo_{0.5}$	34.44 i	15.12 f	31.70 f	13.31 f
N_{80} $Mo_{0.5}$	38.16 f	13.75 i	31.79 ef	13.67 e
N_{120} $Mo_{0.5}$	59.35 a	22.00 a	41.09 a	24.44 a
N_{160} $Mo_{0.5}$	58.80 a	17.22 c	37.38 b	14.07 d
N_0 $Mo_{1.0}$	33.29 j	14.92 fg	31.68 f	13.65 e
N_{40} $Mo_{1.0}$	36.72 g	14.17 h	31.39 f	14.00d
N_{80} $Mo_{1.0}$	39.22 e	14.99 fg	33.45 d	17.28b
N_{120} $Mo_{1.0}$	48.59 d	16.00 e	33.61 d	14.58c
N_{160} $Mo_{1.0}$	49.60 c	16.08 e	33.16 d	12.72 g
LSD (1%)	0.79	0.38	0.51	0.09
CV%	6.20	7.41	6.31	8.86

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

4.18.3 Potassium uptake

Effect of N levels on K uptake by straw responded significantly due to different treatments (Table 15) and ranged from 26.95 kg ha^{-1} to 37.17 kg ha^{-1}. The highest K uptake (37.17 kg ha^{-1}) was noted in N_{120} treatment and the lowest value (26.95 kg ha^{-1}) was found in control.

Potassium uptake by straw was also significantly influenced by different Mo levels (Table 16) and ranged from 31.83 to 34.38 kg ha^{-1}. The highest K uptake straw (34.38 kg ha^{-1}) was found with $Mo_{0.5}$ treatment and the lowest value (31.83 kg ha^{-1}) was found in control.

Potassium (K) uptake by straw was significantly affected by the combined effect of nitrogen and molybdenum (Table 17). The K uptake ranged from 23.40 to 41.09 kg ha^{-1}. The treatment combination $N_{120}Mo_{0.5}$ gave the highest K uptake by straw (41.09 kg ha^{-1}), which was significantly different from other treatments. The lowest K uptake by (23.40 kg ha^{-1}) was found in control (N_0Mo_0).

4.18.4 Sulphur uptake

Effect of N levels on S uptake by straw responded significantly due to different treatment. The S uptake ranged from 10.14 to 17.88 kg ha^{-1} (Table 15). The highest S uptake (17.88 kg ha^{-1}) was obtained in N_{120} treatment and the lowest (10.40 kg ha^{-1}) was found in control.

Sulphur uptake by straw was also significantly influenced by different levels of Mo (Table 16). Sulphur uptake by straw ranged from 10.14 kg ha^{-1} to 15.61 kg ha^{-1}. The highest S uptake by straw (15.61 kg ha^{-1}) was found in $Mo_{0.5}$ kg ha^{-1}, which was significant from other treatments. The lowest S uptake by straw (10.14 kg ha^{-1}) was found in control.

Interaction effect of different levels of nitrogen and molybdenum on S uptake by straw was significantly influenced (Table17). Sulphur uptake by straw ranged from 6.79 kg ha^{-1} to 24.44 kg ha^{-1}. The maximum sulphur uptake by straw (24.44 kg ha^{-}

$^{-1}$) was found in $N_{120}Mo_{0.5}$ treatment and the minimum sulphur uptake straw (6.79 kg ha^{-1}) was observed in control.

4.19 Nutrient content in seed of bush bean plant

4.19.1 N content

A significant increase in N content in seed was recorded due to different treatments of nitrogen (Table 18). The N content ranged from 2.36% to 2.93%. The highest value (2.93%) was obtained in N_{120} treatment which was statistically significant with other treatments. The minimum value (2.36%) was obtained in control.

Nitrogen content in seeds was also influenced by different levels of Mo (Table 19). Nitrogen content in seeds ranged from 2.60% to 2.80%. The highest N content in seeds was found with the application of $Mo_{0.5}$ kg ha^{-1}. The lowest N content in seeds (2.60%) was found in control.

The combined effect of N and Mo on N content in seed was significant (Table 20). Nitrogen content in seed was ranged from 1.95% to 3.06%. The maximum nitrogen content (3.06%) in seed was found in $N_{120}Mo_{0.5}$ treatment and the minimum nitrogen content (1.95%) was observed in N_0Mo_0.

4.19.2 P content

A significant increase in P content in seed was recorded due to different treatments of nitrogen (Table 18). The P content ranged from 0.123 to 0.163%. The highest value (0.163%) was obtained in N_{120} treatment which was statistically identical with other treatments. The minimum value (0.123%) was obtained in control.

Phosphorus content in seeds was also influenced by different levels of Mo (Table 19). Phosphorus content in seeds ranged from 0.126% to 0.145%. The highest Phosphorus content in seeds (0.145%) was found with the application of $Mo_{0.5}$ kg ha^{-1}, which was statistically similar to $Mo_{1.0}$. The lowest phosphorus content in seeds (0.126%) was found in control.

Table 18. Effect of different levels of N fertilizers on the NPKS concentration in bush bean seed

Nitrogen fertilizer ($kg\ ha^{-1}$)	Concentration (%)			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0	2.36e	0.123 c	0.832 e	0.276 d
N_{40}	2.67 d	0.131 bc	0.843 d	0.299 c
N_{80}	2.79 c	0.140b	0.871 c	0.293 c
N_{120}	2.93 a	0.163 a	0.963 a	0.354 a
N_{160}	2.86 b	0.140 b	0.883 b	0.334 b
LSD (1%)	0.03	0.010	0.010	0.010

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

Table 19. Effect of different levels of Mo fertilizers on the NPKS concentration in bush bean seed

Molybdenum fertilizer ($kg\ ha^{-1}$)	Concentration (%)			
	Nitrogen	Phosphorous	Potassium	Sulphur
Mo_0	2.60 c	0.126 b	0.852c	0.300 b
$Mo_{0.5}$	2.80 a	0.145 a	0.901a	0.318 a
$Mo_{1.0}$	2.76 b	0.139 a	0.882 b	0.315 a
LSD (1%)	0.02	0.007	0.007	0.007

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

Table 20. Combined effect of different levels of N and Mo fertilizers on the NPKS concentration in bush bean seed

Nitrogen × Molybdenum Fertilizer (kg ha^{-1})	Concentration (%)			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0Mo_0	1.95 i	0.095 i	0.786 l	0.234 i
N_{40} Mo_0	2.62 g	0.138 de	0.839 h	0.331 cd
N_{80} Mo_0	2.77 f	0.158 bc	0.807 jk	0.335 cd
N_{120} Mo_0	2.87 d	0.173 ab	1.00 b	0.370 b
N_{160} Mo_0	2.81 ef	0.164 bc	0.829 hi	0.318 de
N_0 $Mo_{0.5}$	2.60 g	0.164 bc	0.947 d	0.304 ef
N_{40} $Mo_{0.5}$	2.50 h	0.132 def	0.796 k	0.278 gh
N_{80} $Mo_{0.5}$	2.65 g	0.114 fgh	0.818 ij	0.326 cd
N_{120} $Mo_{0.5}$	3.06 a	0.185 a	1.050 a	0.396 a
N_{160} $Mo_{0.5}$	2.99 b	0.160 bc	0.893 f	0.273 h
N_0 $Mo_{1.0}$	2.52 h	0.150cd	0.915 e	0.291 fgh
N_{40} $Mo_{1.0}$	2.91 cd	0.123 efg	0.979 c	0.288 fgh
N_{80} $Mo_{1.0}$	2.94 bc	0.149 cd	0.872 g	0.340 c
N_{120} $Mo_{1.0}$	2.86 de	0.151 cd	0.839 h	0.295 fg
N_{160} $Mo_{1.0}$	2.79 f	0.153 cd	0.807 jk	0.287 fgh
LSD (1%)	0.05	0.017	0.017	0.017
CV%	9.12	10.14	11.35	12.14

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

The treatment combinations of nitrogen and molybdenum significantly influenced the phosphorus content in seed (Table 20). Phosphorus content in seed was ranged from 0.095% to 0.185%. The maximum P content (0.185%) in seed found in $N_{120}Mo_{0.5}$ treatment, which was statistically similar to $N_{120}Mo_0$ and the minimum phosphorus content (0.095%) was observed in N_0Mo_0 treatment.

4.19.3 K content

A significant increase in K content in seed was recorded due to different treatments of nitrogen (Table 18). The K content ranged from 0.832% to 0.963%. The highest value (0.963%) was obtained in N_{120} treatment which was statistically different from other treatments. The minimum value (0.832%) was obtained in control.

Potassium content in seeds was also influenced by different levels of Mo (Table 19). Potassium content in seeds ranged from 0.852% to 0.901%. The highest potassium content by seeds (0.901%) was found with the application of $Mo_{0.5}$ kg ha^{-1}. The lowest potassium content in seeds (0.852%) was found in control.

Potassium content in seed was significantly influenced by the combined effect of nitrogen and molybdenum (Table 20). Potassium content in seed was ranged from 0.786% to 1.05%. The maximum potassium content (1.05%) in seed was found in $N_{120}Mo_{0.5}$ treatment and the minimum potassium content (0.786%) was observed in N_0Mo_0 treatment.

4.19.4 S content

A significant increase in S content in seed was recorded due to different treatments of nitrogen (Table 18). The S content ranged from 0.276% to 0.354%. The highest value (0.354%) was obtained in N_{120} treatment which was statistically different from other treatments. The minimum value (0.276%) was obtained in control.

Sulphur content in seed was also influenced by different levels of Mo (Table 19). Sulphur content in seed ranged from 0.300% to 0.318%. The highest S content in seed (0.318%) was found with the application of $Mo_{0.5}$ kg ha^{-1}, which was statistically similar with $Mo_{1.0}$. The lowest S content in seed (0.300%) was found in control.

The interaction effect of nitrogen and molybdenum in S content in seed was significantly influenced (Table 20). Sulphur content in seed ranged from 0.234% to 0.396%. The maximum sulphur content (0.396%) in seed was found in $N_{120}Mo_{0.5}$ treatment and the minimum sulphur content (0.234%) was observed in $N_0 Mo_0$.

4.20 Nutrient uptake by seeds of bush bean

4.20.1 Nitrogen uptake

The N uptake by the seed of bush bean was found to be significant due to different treatments (Table 21). The N uptake by seed due to different N treatments ranged from 48.50 kg ha^{-1} to 93.05 kg ha^{-1}. The highest N uptake (93.05kg ha^{-1}) was observed in N_{120} treatment and the lowest N uptake (48.50 kg ha^{-1}) was noted in control.

Nitrogen uptake by seeds was significantly influenced by different molybdenum level (Table 22). The N uptake by seed due to different treatments ranged from 64.33 kg ha^{-1} to 77.20 kg ha^{-1}. The highest N uptake (77.20 kg ha^{-1}) was observed in $Mo_{0.5}$ treatment and the lowest N uptake (64.33 kg ha^{-1}) was noted in control.

The combined effect of N and Mo on N uptake by seeds was significant (Table 23). The N uptake by seeds ranged from 28.47 kg ha^{-1} to106.80 kg ha^{-1}. The highest N uptake (106.80 kg ha^{-1}) was obtained with $N_{120}Mo_{0.5}$ treatments, which was significantly different from other treatment combinations. The minimum N uptake by seeds (28.47 kg ha^{-1}) was found in control.

Table 21. Effect of different levels of N on nutrient uptake by seeds of bush bean

Nitrogen fertilizer (kg ha^{-1})	Nutrient uptake by seeds (kg ha^{-1})			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0	48.50 e	2.86 e	18.01 d	5.67 e
N_{40}	65.19d	3.18 d	21.23 c	7.25 d
N_{80}	70.86c	3.56 c	21.17 c	8.49 b
N_{120}	93.05a	5.42 a	30.75 a	11.31 a
N_{160}	81.63b	4.53 b	24.03 b	8.32 c
LSD (1%)	0.493	0.061	0.147	0.062

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

Table 22. Effect of different levels of Mo on nutrient uptake by seeds of bush bean

Molybdenum fertilizer (kg ha^{-1})	Nutrient uptake by seeds (kg ha^{-1})			
	Nitrogen	Phosphorous	Potassium	Sulphur
Mo_0	64.33 c	3.65 c	20.80 c	7.87 c
$Mo_{0.5}$	77.20 a	4.25 a	25.21 a	8.87 a
$Mo_{1.0}$	76.68 b	4.00 b	23.95 b	8.20 b
LSD (1%)	0.382	0.047	0.323	0.047

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

Table 23 . Combined effect of different levels of N and Mo on nutrient uptake by seeds of bush bean

Nitrogen × Molybdenum Fertilizer (kg ha^{-1})	Nutrient uptake by seed (kg ha^{-1})			
	Nitrogen	Phosphorous	Potassium	Sulphur
N_0Mo_0	28.47 n	1.39 j	11.48 j	3.42 l
N_{40} Mo_0	59.74 l	3.15h	19.13 i	7.55 g
N_{80} Mo_0	68.70 i	3.92 e	20.00 h	8.31 e
N_{120} Mo_0	88.88 b	5.36 b	31.00 b	11.47 b
N_{160} Mo_0	75.87 f	4.43 d	22.38 f	8.59 c
N_0 $Mo_{.5}$	61.10 k	3.85 ef	22.25 f	7.14 i
N_{40} $Mo_{.5}$	62.50 j	3.30 g	19.90 h	6.95 j
N_{80} $Mo_{.5}$	68.90 i	2.96 i	21.27 g	8.48 d
N_{120} $Mo_{.5}$	106.80a	6.48 a	36.75 a	13.86 a
N_{160} $Mo_{.5}$	86.71 c	4.64 e	25.90 c	7.92 f
N_0 Mo_1	57.96 m	3.30 g	21.05 g	6.70 k
N_{40} Mo_1	73.33 h	3.45g	24.67 d	7.26 h
N_{80} Mo_1	74.97 g	3.80 f	22.24 f	8.67 c
N_{120} Mo_1	83.51 d	4.41 d	24.50 de	8.61 c
N_{160} Mo_1	82.31 e	4.51 d	23.81 e	8.47 d
LSD (1%)	0.86	0.11	0.72	0.11
CV%	5.20	9.41	6.31	8.86

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

4.20.2 Phosphorus uptake

A significant increase in P uptake by seed was recorded due to different treatments of N (Table 21). Phosphorus uptake by seeds ranged from 2.86 kg ha^{-1} to 5.42 kg ha^{-1}. The treatment N_{120} showed the maximum P uptake (5.42 kg ha^{-1}) and control treatment showed the lowest P uptake (2.86 kg ha^{-1}).

Phosphorus uptake by seed was significantly influenced by different molybdenum level (Table 22). Phosphorus uptake by seeds was ranged from 3.65 kg ha^{-1} to 4.25 kg ha^{-1}. The highest P uptake by seed (4.25 kg ha^{-1}) was found in $Mo_{0.5}$ treatment and lowest P uptake by seed (3.65 kg ha^{-1}) was found in control.

The treatment combinations of nitrogen and molybdenum significantly influenced the phosphorus uptake by seed (Table 23). Phosphorus uptake by seeds ranged from 1.39 kg ha^{-1} to 6.48 kg ha^{-1}. The highest P uptake by seed (6.48 kg ha^{-1}) was obtained from the treatment $N_{120}Mo_{0.5}$ which was significantly different from all other treatment combinations and the lowest one (1.39 kg ha^{-1}) was obtained from control.

4.20.3 Potassium uptake

Effect of N levels on K uptake by seed responded significantly due to different treatments (Table 21) and ranged from 18.01 to 30.75 kg ha^{-1}. The highest K uptake (30.75 kg ha^{-1}) was noted in N_{120} treatment and the lowest value (18.01 kg ha^{-1}) was found in control.

Potassium uptake by seeds was also significantly influenced by different Mo levels (Table 22) and ranged from 20.80 to 25.21 kg ha^{-1}. The highest K uptake by seeds (25.21kg ha^{-1}) was found with $Mo_{0.5}$ treatment and the lowest value (20.80 kg ha^{-1}) was found in control.

Potassium (K) uptake by seeds was significantly influenced by the combined effect of nitrogen and molybdenum (Table 23) and ranged from 11.48 to 36.75 kg ha^{-1}. The treatment combination $N_{120}Mo_{0.5}$ gave the highest K uptake by seeds (36.75 kg ha^{-1}), which was significantly different from other treatments. The lowest K uptake by seeds (11.48 kg ha^{-1}) was found in control (N_0Mo_0).

4.20.4 Sulphur uptake

Effect of N levels on S uptake by seed responded significantly due to different treatment. The S uptake ranged from 5.67 to 11.31 kg ha^{-1} (Table 21) .The highest S uptake (11.31 kg ha^{-1}) was obtained in N_{120} treatment and the lowest value (5.67 kg ha^{-1}) was found in control.

Sulphur uptake by seeds was influenced by different levels of Mo (Table 22). Sulphur uptake by seeds ranged from 7.87 kg ha^{-1} to 8.87 kg ha^{-1}. The highest S uptake by seeds was found with the application of $Mo_{0.5}$ kg ha^{-1}, which was significant with other treatments. The lowest S uptake by seeds (7.87 kg ha^{-1}) was found in control treatment.

Interaction effect of nitrogen and molybdenum on S uptake by seeds was significantly influenced (Table 23). Sulphur uptake by seeds ranged from 3.42 kg ha^{-1} to 13.86 kg ha^{-1}. The maximum sulphur uptake by seeds (13.86 kg ha^{-1}) was found in $N_{120}Mo_{0.5}$ treatment and the minimum sulphur uptake by seeds (3.42 kg ha^{-1}) was observed in control.

4.21 Economical analysis

4.21.1 Cost of production

The details of economic analysis have been shown in Appendix 8. The total cost of production varied from Tk. 89881/- to Tk. 91500/- among the treatment combinations (Table24) .It was due to variable cost of urea.

4.21.2 Gross income

The gross income was recorded from Tk.106440/- to Tk. 259680/- for the various treatment combinations (table 24). Gross income was calculated on the basis of pod yield (21.64 t ha^{-1}) of bush bean at Tk.15000/- per ton.

Table. 24. Cost and benefit analysis of bush bean due to different level of nitrogen and molybdenum.

Treatment	Pod yield (t ha^{-1})	Gross return (Tk ha^{-1})	Total cost of production (T kha^{-1})	Net return (Tk $kgha^{-1}$)	Benefit cost ratio (BCR)
N_0Mo_0	8.73	106440	89881	16559	1.18
$N_{40} Mo_0$	13.94	167280	90147	77133	1.86
$N_{80}Mo_0$	14.62	175440	90413	85027	1.94
$N_{120} Mo_0$	18.00	246240	90680	155560	2.72
$N_{160} Mo_0$	17.66	211920	90946	120974	2.33
$N_0 Mo_{0.5}$	12.14	145680	89482	56198	1.63
$N_{40} Mo_{0.5}$	15.36	184320	89746	94574	2.05
$N_{80} Mo_{0.5}$	15.47	186000	90691	95309	2.05
$N_{120} Mo_{0.5}$	18.50	259680	90958	168722	2.85
$N_{160} Mo_{0.5}$	17.70	212400	91224	121176	2.33
$N_0 Mo_{1.0}$	11.90	127200	90437	36763	1.41
$N_{40} Mo_{1.0}$	17.52	210240	90702	119538	2.32
$N_{80} Mo_{1.0}$	15.34	184080	90968	93112	2.02
$N_{120} Mo_{1.0}$	18.24	230880	91235	139645	2.53
$N_{160} Mo_{1.0}$	17.84	214080	91500	122580	2.34

Price of Urea = Tk. 6.00 kg^{-1}

TSP = Tk. 15.00 kg^{-1}

MP = Tk. 15.00 kg^{-1}

Gypsum = Tk. 6.00kg^{-1}

Zinc = TK. 50.00 kg^{-1}

Mo = 500 kg^{-1}

Per labor wage = TK. 75.00 day^{-1}.

Price of harvested green pod @ TK. 15,000/t

BCR = Gross return: Total cost of production

4.21.3 Net income

Net return or net profit was calculated through excluding the production cost from gross income (Table 24). It was varied from Tk.16559/- to 168722/-. The highest net income was obtained from the treatment combination of 120 kg N ha^{-1} and 0.5 kg Mo ha^{-1}. The result also revealed that the highest net return (Tk. 168722/-) was obtained from the highest pod yield (18.50 t ha^{-1}). But the lowest net return (Tk.16559/-) was obtained from the lowest yield of bush bean (8.73 t ha^{-1}) received from the control treatment. So it is clearly indicated that 120 kg N ha^{-1} and 0.5 kg Mo ha^{-1} contributed to higher net return.

4.21.4 Benefit cost ratio (BCR)

The benefit cost ratio was found to be the highest (2.85) in the treatment combination of 120 kg N ha^{-1} and 0.5 kg Mo ha^{-1} (Table 24) . Here the highest net return (Tk.168722) showed the highest BCR (2.85). The lowest benefit cost ratio (BCR) was observed (1.18) from the control. From economic point of view, the treatment combination of 120 kg N ha^{-1} and 0.5 kg Mo ha^{-1} was found to be the most suitable treatment combination for bush bean production.

It was observed that the application of 120 kg N ha^{-1} and 0.5 kg Mo ha^{-1} was more profitable than all other treatment combinations. However, the economic analysis is based on crop yield as well as factors such as cost of inputs and marketable price of the harvested materials which may vary from year to year. Therefore, the economic analysis for a crop grown in particular year may not represent exactly.

Chapter 5
Summary and Conclusion

Chapter 5

SUMMARY AND CONCLUSION

The present piece of work was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from December 2006 to February 2007 to study the effects of nitrogen and molybdenum on growth and yield of bush bean (*Phaseolus vulgaris* L.) cv. BARI Jhar Sheem-1.

The soil of the experimental field was silty clay loam in texture belonging to the Tejgoan soil series of the Madhupur Tract (Agro ecological zone AEZ-28). The selected plot was a medium high land that remained fallow during the previous summer. Top soil is silty clay loam texture with pH 5.8 (at 0-15 cm) depth. The soil contained, 29.04% sand, 41.80% silt , 29.17% clay, 0.08% Total N, 0.78% organic carbon, 1.34% OM, 9.75:1 C:N ratio, 15 ppm available P, 0.18% exchangeable K and 16.0 ppm S.

The treatments consisted of five levels of N (0, 40, 80, 120 & 160 kg ha^{-1} designated as N_0, N_{40}, N_{80}, N_{120} & N_{160}, respectively) and three levels of Mo (0, .5 &1 kg ha^{-1} designated as Mo_0, $Mo_{0.5}$ & $Mo_{1.0}$, respectively). There were 15 treatment combinations in the experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 5 m^2 (2.5 m x 2 m) and the space between block and between plots were 1m and 0.5 m, respectively. The land was fertilized with P_{60}, K_{60}, S_{10} and $Zn_{1.0}$ kg ha^{-1} in the form of triple super phosphate, muriate of potash, gypsum, zinc sulphate. 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 the plot on 3 December, 2006. 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 at regular interval 15 days after sowing. Data on different parameters were recorded. Data were analyzed using the computer package M-STAT and the difference between means was compared by LSD test. Initial and post harvest soil sample, plant samples and seed samples were taken for chemical analysis and to assess the nutrient status. Results of the samples were also statistically analyzed. The individual and combined effects of nitrogen

(N) and molybdenum (Mo) on growth, yield and nutrient stratus of soil, plants and seeds of bush bean were studied.

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, yield and nutrient content 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 (49.90 cm) was found in $N_{160}Mo_{.5}$ treatment, which was similar with $N_{120}Mo_{.5}$ treatment (49.80 cm). 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.

There were significant differences in different treatments on total dry weight of plant and crop growth rate (CGR) of bush bean. The individual application of N 160 kg ha^{-1} produced maximum total dry weight of plant (40.50 g $plant^{-1}$), whereas application of Mo 0.5 kg ha^{-1} produced maximum total dry weight of plant (27.07g $plant^{-1}$) which was statistically similar with 1.0 Mo kg ha^{-1}. The maximum total dry weight of bush bean (50.86 g $plant^{-1}$) was obtained from the treatment of $N_{160}Mo_{0.5}$ at 90 DAS. The maximum crop growth rate (1.15 g $plant^{-1}$ day^{-1}) at 46-60 DAS was obtained from the treatment $N_{160}Mo_{0.5}$. The individual application of N 160 kg ha^{-1} produced maximum crop growth rate (0.80 g $plant^{-1}$ day^{-1}), whereas application of Mo 0.5 kg/ha produced maximum crop growth rate (0.43 g $plant^{-1}$ day^{-1}) at 46-60 DAS which was statistically identical with 1.0 Mo kg ha^{-1}.

The individual application of N_{120} and $Mo_{0.5}$ had positive effect on the number of branches $plant^{-1}$, plant population m^{-2} ,number of green pod plant $^{-1}$,pod length, diameter of pod , no. of seed pod $^{-1}$, pod yield $plot^{-1}$, seed yield $plot^{-1}$ and 1000-seed weight. $N_{120}Mo_{0.5}$ treatment combination appeared to have produced the maximum number of effective branches plant $^{-1}$ (18.50), plant population m^{-2} (27.33), number of green pod plant $^{-1}$ (24.50), pod length (16.00 cm), diameter of pod (1.96 cm), no. of seed pod $^{-1}$ (6.50), pod yield plot^{-1} (9.25 kg), seed yield plot^{-1} (1.75 kg) and 1000- seed weight (287 g) and the minimum values was found in control.

The maximum pod yield (18.00 t ha^{-1}) and seed yield (3.20 t ha^{-1}) was attained in N_{120} treatment and the maximum pod yield (12.14 t ha^{-1}) and seed yield (2.50 t ha^{-1}) was attained in $Mo_{0.5}$ treatment. The maximum pod yield (18.50 t ha^{-1}) and seed yield (3.50 t ha^{-1}) was attained in $N_{120}Mo_{0.5}$ treatment combination and minimum result found in control. The maximum straw yield (4.20 t ha^{-1}) was obtained in $N_{160}Mo_{0.5}$ treatment combination which was statistically similar with $N_{120}Mo_{0.5}$ and the lowest value (2.90 t ha^{-1}) was obtained in control.

Nitrogen, P, K and S content as well as uptake by plant of bush bean had significant variation. The maximum N, P, K and S content as well as uptake were attained in $N_{120}Mo_{0.5}$ treatment combination and the lowest value was observed in control. The highest N, P, K and S contents in plant (1.33%, 0.530%, 0.990% and 0.589% ,respectively) were recorded in $N_{120}Mo_{0.5}$ treatment and similarly the highest N, P, K and S uptake by plant (59.35 kg ha^{1}, 22.00 kg ha^{-1}, 41.09 kg ha^{-1}, 24.44 kg ha^{-1}, respectively) were recorded in $N_{120}Mo_{0.5}$ treatment.

Nitrogen, P, K and S content as well as uptake by seed of bush bean had significant variation. The maximum N, P, K and S content as well as uptake by plant were attained in $N_{120}Mo_{0.5}$ treatment and the lowest value was observed in control. The nutrient content as well as uptake by seed of bush bean was found significant. The highest N, P, K and S contents in seed (3.06%, 0.186%, 1.050% and 0.396%, respectively) were recorded in $N_{120}Mo_{0.5}$ treatment and similarly the highest N, P, K and S uptake by seed (106.80 kg ha^{1}, 6.48 kg ha^{-1}, 36.75 kg ha^{-1}, 13.86 kg ha^{-1}, respectively) were recorded in $N_{120}Mo_{0.5}$ treatment.

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 5.80 to 6.90. 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 0.075%, 12.0 to 19.7

ppm, 0.11to 0.15 meq 100 g^{-1} and 13.0 to 26.7 ppm , respectively. The highest N, P , K and S content was recorded in N_{160} $Mo_{0.5}$ treatment and the lowest values were obtained control respectively.

The results of economic analysis showed that the highest net benefit of Tk. 168722.00 ha^{-1} was obtained in $N_{120}Mo_{0.5}$ treatment and the lowest net benefit of Tk.16559.00 ha^{-1} was found in control.

The total cost of production, estimated for different combinations of nitrogen and molybdenum level, indicate that treatment combination $N_{160}Mo_{1.0}$ was more expensive (Tk. 91500).

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

i). Individual effect of N and Mo on growth, yield components and yield of bush bean was found positive and significant. The yield increased with increasing N rate upto 120 kg N ha^{-1} and Mo rate upto 0.5 kg Mo ha^{-1}.

ii). The combined effect of N and Mo enhanced growth, yield and yield attributes of bush bean.

iii). Application of N @ 120 kg ha^{-1} and Mo @ 0.5 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
References

Chapter 6
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Appendix

Appendix 1. Monthly average maximum and minimum air temperature during November 2006 to February 2007)

Month	Temperature (Maximum)	Temperature (Minimum)	Humidity (%)	Precipitation (mm)	Potential Evapotranspiration (mm day $^{-1}$)	Average sunshine (Hours)
October	31.51	24.13	85.00	168	3.612	172.0
November	30.20	20.13	83.30	31	2.966	193.6
December	26.60	13.5	81.00	9	2.43	208.6
January	25.40	12.93	78.00	7	2.387	213.2
February	25.30	14.2	73.68	7	2.37	247.6

Source : Weather Yard, Bangladesh Metrological Department, Dhaka

Appendix. 2 Effect of nitrogen on plant height of bush bean

Nitrogen (kg ha^{-1})	Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
N_0	10.50 c	23.67 e	26.50 d	31.50 d	35.17d
N_{40}	14.33 b	27.10 d	31.50 c	33.50 c	37.00 c
N_{80}	14.50 b	28.20 c	32.20b	35.40 b	37.93 b
N_{120}	20.50 a	31.90 b	35.60 a	41.50a	48.50a
N_{160}	20.60 a	32.60a	35.80 a	41.55a	48.65a
LSD (1%)	0.502	0.590	0.601	0.19	0.78

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

Appendix. 3 Effect of molybdenum on plant height of bush bean

Molybdenum (kg ha^{-1})	Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Mo_0	10.40 c	23.67 c	26.50 b	31.50b	35.17b
$Mo_{0.5}$	13.33 a	25.50 a	31.10a	34.50a	37.63a
$Mo_{1.0}$	1315 a	25.20 a	31.00 a	34.40a	37.20a
LSD (1%)	0.59	0.42	0.34	0.72	0.76

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

Appendix 4. Effect of nitrogen on plant dry matter weight of bush bean

Nitrogen (kg/ha)	Total dry weight of plant (g/plant)				
	30 DAS	45DAS	60 DAS	75 DAS	90 DAS
N_0	4.06e	7.66e	12.46e	15.86e	18.46e
N_{40}	6.05d	12.69d	20.08d	25.10d	29.10d
N_{80}	6.31c	13.48c	22.10c	27.70c	31.90c
N_{120}	7.62b	17.70b	28.10b	35.18b	39.10b
N_{160}	8.00a	18.10a	30.10a	36.08a	40.50a
LSD(1%)	0.042	0.092	0.092	0.0112	0.102

Appendix. 5 Effects of molybdenum on the total dry matter weight of bush bean

Molybdenum Level(kg/ha)	Total dry matter weight of plant (g/plant)				
	30 DAS	45DAS	60 DAS	75 DAS	90 DAS
Mo_0	4.06b	7.66b	12.46b	15.86b	18.46b
$Mo_{.5}$	6.67a	12.19a	18.59a	23.30a	27.04a
Mo_1	6.30a	11.20a	17.10a	21.50a	25.50a
LSD (1%)	0.406	1.06	1.56	2.10	2.05
LSD (5%)	-	-	-	-	-

Appendix. 6 Effects of nitrogen on crop growth rate of bush bean

Nitrogen ($kg\ ha^{-1}$)	Crop growth rate ($g\ plant^{-1}\ day^{-1}$)			
	30-45 DAS	46-60 DAS	61-75 DAS	76-90 DAS
No	0.24d	0.32c	0.27d	0.17c
N_{40}	0.35c	0.40c	0.33c	0.27b
N_{80}	0.49b	0.58b	0.37b	0.27b
N_{120}	0.67a	0.71ab	0.40ab	0.28b
N_{160}	0.68a	0.80a	0.41a	0.29a
LSD (1%)	0.031	0.023	0.029	0.025

Appendix. 7 Effects of molybdenum on crop growth rate of bush bean

Nitrogen (kg ha^{-1})	Crop growth rate (g $plant^{-1}$ day^{-1})			
	30-45 DAS	46-60 DAS	61-75 DAS	76-90 DAS
Mo_0	0.24b	0.32b	0.27b	0.17b
$Mo_{.5}$	0.37a	0.43a	0.31a	0.24a
Mo_1	0.36a	0.40a	0.29a	0.23a
LSD (1%)	0.014	-	-	0.023
LSD (5%)		0.039	0.029	

Appendix 8. Production cost of green pod of bush bean per hectare

A. Input cost (Material and Non material)

Treatment Combinations	Labour cost (Tk.)	Plugging cost (Tk.)	Seed cost (Tk.)	Pesticide cost (Tk.)	Irrigation cost (Tk.)	Urea cost (Tk.)
N_0Mo_0	4550	3000	25000	1000	1000	0
N_{40} Mo_0	4550	3000	25000	1000	1000	240
$N_{80}Mo_0$	4550	3000	25000	1000	1000	480
$N_{120}Mo_0$	4550	3000	25000	1000	1000	720
N_{160} Mo_0	4550	3000	25000	1000	1000	960
$N_0Mo_{0.5}$	4550	3000	25000	1000	1000	0
$N_{40}Mo_{0.5}$	4550	3000	25000	1000	1000	240
$N_{80}Mo_{0.5}$	4550	3000	25000	1000	1000	480
$N_{120}Mo_{0.5}$	4550	3000	25000	1000	1000	720
$N_{160}Mo_{0.5}$	4550	3000	25000	1000	1000	960
$N_0Mo_{1.0}$	4550	3000	25000	1000	1000	0
$N_{40}Mo_{1.0}$	4550	3000	25000	1000	1000	240
$N_{80}Mo_{1.0}$	4550	3000	25000	1000	1000	480
$N_{120}Mo_{1.0}$	4550	3000	25000	1000	1000	720
$N_{160}Mo_{1.0}$	4550	3000	25000	1000	1000	960

Appendix 8.(Contd.)

Treatment Combinations	Mo cost (Tk.)	TSP cost (Tk.)	MP Cost (Tk.)	Gyps-um cost (Tk.)	Zinc cost (Tk.)	Total input cost (Tk.)
N_0Mo_0	0	900	900	60	100	67460
N_{40} Mo_0	0	900	900	60	100	67700
$N_{80}Mo_0$	0	900	900	60	100	67940
$N_{120}Mo_0$	0	900	900	60	100	68180
N_{160} Mo_0	0	900	900	60	100	68420
$N_0Mo_{0.5}$	250	900	900	60	100	67710
$N_{40}Mo_{0.5}$	250	900	900	60	100	67950
$N_{80}Mo_{0.5}$	250	900	900	60	100	68190
$N_{120}Mo_{0.5}$	250	900	900	60	100	68430
$N_{160}Mo_{0.5}$	250	900	900	60	100	68670
$N_0Mo_{1.0}$	500	900	900	60	100	67960
$N_{40}Mo_{1.0}$	500	900	900	60	100	68200
$N_{80}Mo_{1.0}$	500	900	900	60	100	68440
$N_{120}Mo_{1.0}$	500	900	900	60	100	68680
$N_{160}Mo_{1.0}$	500	900	900	60	100	68920

Labor wage Tk. 75.00/day
Urea Tk. 6.00/kg
TSP Tk. 15.00/kg
MP Tk. 15.00/kg
Molybdenum TK. 500/kg
Gypsum Tk. 6.00/kg
Zinc Tk. 50/kg

Appendix 8.(Contd.)

B. Overhead cost (Tk./ha)

Treatment Combinations	Cost for the land (for 6 month)	Miscellaneous cost (5% of the input cost)	Interest on the running capital for 6 month (12%)	Sub total (Tk.)	Total cost (Tk.)
N_0Mo_0	15000	3373	4048	22421	89881
$N_{40}\,Mo_0$	15000	3385	4062	22447	90147
$N_{80}Mo_0$	15000	3397	4076	22473	90143
$N_{120}Mo_0$	15000	3409	4091	22500	90680
$N_{160}\,Mo_0$	15000	3421	4105	22526	90946
$N_0Mo_{0.5}$	15000	3386	3386	21772	89482
$N_{40}Mo_{0.5}$	15000	3398	3398	21796	89746
$N_{80}Mo_{0.5}$	15000	3410	4091	22501	90691
$N_{120}Mo_{0.5}$	15000	3422	4106	22528	90958
$N_{160}Mo_{0.5}$	15000	3434	4120	22554	91224
$N_0Mo_{1.0}$	15000	3398	4078	22477	90437
$N_{40}Mo_{1.0}$	15000	3410	4092	22502	90702
$N_{80}Mo_{1.0}$	15000	3422	4106	22528	90968
$N_{120}Mo_{1.0}$	15000	3434	4121	22555	91235
$N_{160}Mo_{1.0}$	15000	3446	4135	22581	91500