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

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CERTIFICATE

This is to certify that the thesis titled, "*EFFECT OF NITROGEN AND PHOSPHORUS APPLICATION ON THE GROWTH AND YIELD OF BARI BUSH BEAN-2* submitted to the *DEPARTMENT OF SOIL SCIENCE,* Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE (M.S.)* in ***SOIL SCIENCE*** embodies the result of a piece of *bona fide* research work carried out by *MUHAMMAD SHARIFUL HASAN,* Registration No. ***00720*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

(Prof. Dr. Gopi Nath Chandra Sutradhar)
Supervisor

Dedicated to

My

Beloved Parents

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Date: *The Author*

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LIST OF SYMBOLS AND ABBRIVIATIONS

ABBREVIATION	FULL NAME
@	At the rate
Cm	Centimeter
i.e	That is
%	Per cent
AEZ	Agro-Ecological Zone
CEC	Cation Exchange Capacity
$CuSO_4.5H_2O$	Green vitriol
cv.	Cultivar(s)
CV%	Percentage of Coefficient of Variance
DMRT	Duncan's Multiple Range Test
e.g.	example
et al	and others
FYM	Farm Yard Manure
g	Gram
H_3BO_3	Boric acid
$HClO_4$	Perchloric acid
HNO_3	Nitric acid
H_2O_2	Hydrogen per oxide
H_2SO_4	Sulfuric acid
K	Potassium
kg	Kilogram
kg ha^{-1}	Kg per hectare
K_2SO_4	Potassium Sulfate
LSD	Least Significant Difference
TSP	Triple Super Phosphate
m	Meter
ml	Milliliter
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
NaOH	Sodium Hydroxide
NPK	Nitrogen, Phosphorus and Potassium
NS	Not Significant
OM	Organic matter
pH	Hydrogen ion concentration
^0C	Degree Celsius
No.	Number
SAU	Sher-E-Bangla Agricultural University
RCBD	Randomized Complete Block Design

EFFECT OF NITROGEN AND PHOSPHORUS APPLICATION ON THE GROWTH AND YIELD OF BARI BUSH BEAN-II

MUHAMMAD SHARIFUL HASAN

ABSTRACT

A field experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka (Modhupur Tract, AEZ 28), during the *rabi* season from November 2007 to February 2008 to study the effect of nitrogen and phosphorus application on the growth and yield of bush bean (*Phaseolus vulgares* L.) cv. BARI bush bean-II. The treatments consisted of three levels of N i.e 0 kg ha^{-1} (N_0), 60 kg ha^{-1}(N_1), 120 kg ha^{-1} (N_2) and four levels of P i.e 0 kg/ha (P_0) 30 kg ha^{-1}(P_1) 60 kg ha^{-1} (P_2) 90 kg ha^{-1} (P_3) with 12 treatment combinations. Urea and triple super phosphate (TSP) were used as the sources of nitrogen and phosphorus, respectively the maximum pod yield (16.63), seed yield (2.85) and stover yield (3.72 t ha^{-1}) was obtained from the application of 120 kg N ha^{-1}. The results further demonstrated that parameters were significantly increased by different levels of phosphorus except plant height and plant population m^{-2}. The maximum pod yield (14.89), seed yield (2.79) and stover yield (3.92 t ha^{-1}) were obtained from 60 kg P_2O_5 ha^{-1}. The combined effects of nitrogen and phosphorus was insignificantly influenced all the growth and yield contributing characteristic of bush bean except seed yield ha^{-1}. The highest pod yield (18.90), seed yield (3.09) and Stover yield (4.10 t ha^{-1}) were obtained form the treatment combination N_2P_2 (120 kg N with 60 kg P_2O_5 ha^{-1}).

CHAPTER I

INTRODUCTION

CHAPTER - I

INTRODUCTION

Bush bean (*Phaseolus vulgaris* L.) belonging to the family Leguminosae and sub family papiolionaceae is reported to be a native of Central and South America (Swaider *et al*, 1992). It is also known as bush bean, kidney bean, snap bean, pinto bean, green bean, raj bean, navy bean, pole bean, wax bean, string bean and bonchi (Duke, 1983; Salunkhe *et al* 1987; Tindall, 1988).

It is widely cultivated in the temperate and subtropical regions and also in many parts of the tropics (Perseglove, 1987). French beans are grown intensively in five major continental areas: Eastern Africa, North and Central America, South America, Eastern Asia and Wesatern and South Eastern Europe. However Brazil is the largest bush bean producing country in the world.

It is more suitable as a winter (Rabi) crop in the North Eastern 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).

It is not a new crop in our country and is cultivated in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country rather in a limited scale. Recently cultivation of bush bean is gaining popularity in Bangladesh mainly because of its demand as a commodity for export. Hortex Foundation exported 23.86 tons of vegetable bush bean during July-December, 2001 (Anonymous, 2001).

Immature green pods are marketed fresh, frozen or canned. The dry seeds also may be used as pulses for human consumption or animal feed. After harvest, plants can be fed to cattle, sheep and horses. Its edible pods supply protein, carbohydrate, fat, fiber, thianin, riboflavin, Ca and Fe (Shanmugavelu, 1989) and the seed contains significant amount of thiamin, niacin, folic acid as well as fiber (Rashid, 1993).

In Bangladesh, bush bean is mainly used as green vegetable. Recently the feasibility of cultivating this crop in different parts of Bangladesh has been started in a small scale (Rashid, 1993). Because of high nutritive value, good taste and wide range of use, the popularity of French bean is increasing day by day in Bangladesh.

As a legume, roots of French bean root system has nodules with nitrogen fixing bacteria. It can also be used as a green manuring crop and included in the crop rotation system in the field to improve soil fertility status.

French bean or bush bean is a short durated crop and thus, yield per ha. is comparatively high. It can fit well in intercropping with other crops such as wheat, maize, sunflower and sugarcane. Various problems, however, hamper bush bean production in Bangladesh. Fertilizer specially nitrogenous and phosphatic are the most critical input for increasing crop production and had been recognized as the key element for agricultural development (Mukhopadhyay *et al*, 1986).

Bush bean shows high yield potential, but unlike other leguminous crops it does not nodulate with the native rhizobia (Ali and Kushwaha, 1987). For this reason, high dose of nitrogenous fertilizer or inoculation with effective stain of Rhizobium is required to exploit the yield potential of this crop.

Deficiency of phosphorus is now considered as one of the major constraints for successful production of legumes and upland crops in Bangladesh (Islam and Noor, 1982). The most obvious effect of phosphorus on the root development particularly of the lateral and fibrous rootlets those are essential to fix the atmospheric nitrogen in legume crops (Arya and Kalra, 1988). Phosphorus also make its contribution through seed formation (Buckman and Brady, 1980). Application of phosphorus in legume plants also increases the nodulation (Poi and Ghos, 1986) and crop nutrition (Fox, 1986).

In case of application of various fertilizer doses, there were significant differences in pod number per plant in bush bean (Sa *et al*, 1982). The plant height, number of branches, length of pod and seed yield 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 phosphorous may bring about considerable increase in the yield of Bush bean due to their complementary effects.

A detailed and systemic study is needed to find out the requirements of nitrogen and phosphorous for maximizing the yield of bush bean in Bangladesh. Considering the above situation, the present investigation was undertaken with the following specific objectives-

i) To study the growth and yield of bush bean under different levels of nitrogen and phosphorous application

ii) To find out the best combination of nitrogen and phosphorous for maximizing the production of BARI bush bean-II.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER – II

REVIEW OF LITREATURE

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

2.1. Effect of nitrogen on growth and yield of bush bean

Nitrogen is one of the most essential elements for crop any production. It encourages vegetative growth and increases leaf areas of plants, which helps 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.

Kamal (2007) conducted a field experiment at research field of Sher-e-Bangla Agricultural University, Dhaka in the 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. He found that 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}

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

Shamima (2005) carried a field experiment out at research field of Sher-e-Bangla Agricultural University, Dhaka in Modhupur Tract (AEZ 28), during the *rabi* season from December 2004 to February 2006 to study the effect of nitrogen and phosphorus on the growth and yield of bush bean (*Phaseolus vulgares* L.) cv. BARI bushbean-1. She found the highest green pod yield (16.56 t ha^{-1}) and seed yield (2.71 t ha^{-1}) from N_{40} kg ha^{-1}

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 benefit cost ratio (1: 2.44).

Ram-Gopal *et al.*, (2003) investigated the effects of irrigation (0.5, 0.7 and 0.9 W/CPE) 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. With 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 was highest at 500x103 plants ha^{-1}, whereas dry weight $plant^{-1}$, net assimilation rate and relative growth rate in general were the highest at 250x103 plants ha^{-1}. Increasing levels of N with 120 kg N ha^{-1} increased dry weight, leaf area index, crop growth rate and relative growth rate, but net assimilation rate increased up to 60 kg N ha^{-1} only.

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

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}.

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

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

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

Rahman (2001) conducted an experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh to investigate the influence of nitrogen and plant spacing on French bean. He used four levels of nitrogen viz. 0, 30, 60 and 90 kg N ha^{-1} and found that plant height, number of branches plant^{-1}, green pod length, individual pod weight, pods plant^{-1} and green pod yield ha^{-1} were significantly influenced by the higher dose of nitrogen.

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

Daba and Haile (2000) carried out a field experiment in Ethiopia on French bean cv. Red Wolaita, Ex Rico-2, A-176 and A-250. Seeds were inoculated with mixture CIAT *Rhizobium* isolates 384, 274, 632 and 23 kg N/ha was applied to the soil. They reported that *Rhizobium* inoculation and N significantly increased grain yield, nodule number and dry matter yield. On the other hand Bagal and

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

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

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

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

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

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

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

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

Ravi Naddan and Prasad (1998) reported that response of irrigation and nitrogen fertilization on French bean (*Phaseolus vulgaris*). They observed that plant height, branches $plant^{-1}$, leaves $plot^{-1}$ and seed yield increased due to increase in nitrogen level from 40 to 120 kg N ha^{-1}.

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

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}.

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

Gajendra and Singh (1998) stated that application of 120kg N ha^{-1}, 90 kg P_2O_5 ha^{-1} and 45 kg K_2O ha^{-1} gave higher grain yield of French bean.

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

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

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

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.

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

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

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

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

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

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 that increased up to 60kg N 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 but crude protein percentage decreased with increasing nitrogen rate.

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

Leelavathi *et al.* (1991) reported that the seed yield and dry matter production in French bean were increased up to 60 kg N ha^{-1}.

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

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.

Moraghan *et al.*, (1991) found that there was a response to N application up to 150 lb at one of the irrigated sites, but the seed yields of the rainfed crops tended to be depressed by N application. Rhizobium inoculation increased seed yields at one of the rainfed sites at all N fertilizer rates. Application of N had little effect on grain-N concentration.

Singh et al. (1990) reported that N fertilization and irrigation French bean increased the number of pods plant^{-1} and 1000 seed weight with increase in nitrogen level.

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

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

Hedge and Srinivas (1989) conducted a field trail to find out the effect of nitrogen and irrigation on the yield of French bean. Nitrogen was applied at 0, 40, 80 or 120 kg N ha^{-1} and the crop was irrigated at 4 soil metric potentials. The green pod yield was the highest (124.3-132.3 q ha^{-1}) at the highest N rate (120 kg ha^{-1}). Similarly, Singh *et al* (1990) reported that N-fertilization and irrigation in

French bean increased the number of pods $plant^{-1}$ and 1000 seed weight with increase in nitrogen level.

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

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.

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}.

Bhopal and Singh (1987) conducted a field trail in Himachal Pradesh, India to find out the response of French bean to nitrogen fertilizers with *Phaseolus vulgaris* bean grown for green pods. Nitrogen was applied at 0-90 kg ha^{-1} and a basal dose of K_2O at 50 kg ha^{-1}. The optimum nitrogen dose was 67.3 kg ha^{-1}; it gave yield over 210 q ha^{-1}.

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

Chandra *et al.* (1987) reported from an experiment that plant growth increased with increasing rate of nitrogen in French bean. Sa *et al.* (1982) observed that with the application of various fertilizer doses, pod number plant^{-1} was significantly influenced. Srinivas and Naik (1988) reported that increasing nitrogen fertilizer increased the pod yield in French bean.

Katock *et al.* (1983) obtained the maximum nodule number and nodule weight plant^{-1} with 30 kg N ha^{-1} in French bean.

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

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

2.2. Effect of phosphorus on the growth and yield of Bush bean

Shamima (2005) carried a field experiment at the research field of Sher-e-Bangla Agricultural University, Dhaka in Modhupur Tract (AEZ 28), during the *rabi* season from December 2004 to February 2005 to study the effect of nitrogen and phosphorus on the growth and yield of bush bean (*Phaseolus vulgares* L.) cv. BARI bush bean-1. The highest green pod yield (15.35 t ha^{-1}) and seed yield (2.58 t ha^{-1}) were obtained from $P_{75.}$

Younis *et al.* (2001) conducted an experiment to studies on the effect of phosphorus stress on growth and some metabolic processes in *Phaseolus vulgaris* plant, treatment of French bean seedlings and plants with decreasing concentrations of phosphorus supplied to Hoagland solution showed phosphorus deficiency in the culture solution induced decreases in all growth parameters in both seedlings and plants, compared with the control.

A field experiment was conducted by Singh and Singh (2000) in Uttar Pradesh, India. French bean (*Phaseolus vulgaris*) were given 0, 60 of 120 kg P/ha. They observed that yield and yield component were generally highest with 60 kg P.

A field experiment was conducted by Roy and Parthasarathy (1999) to investigate the phosphorus requirement of French bean varieties. They used 0-120 kg P ha^{-1} and observed that pod yield was highest (07.69 t ha^{-1}) with 120 kg P ha^{-1}.

Sexena *et al.* (1996) applied P_2O_5 at the rates of 0, 30 and 60 kg ha^{-1} and K_2O at the rates of 0, 20 and 40 kg ha^{-1}. They observed that seed yield was highest with 60 kg P_2O_5. They also reported that seed yield was positively correlated with leaf area, dry matter $plant^{-1}$, relative moisture content in leaves, number of branches, number of pods, seed yield $plant^{-1}$, 1000 seed weight and harvest index. Application of 60 kg P_2O_5 gave the highest seed yield (0.95 t ha^{-1}). On the other hand Tomar *et al.* (1991) obtained the highest seed yield with the application of 30 kg P_2O_5 ha^{-1} and rates beyond that did not give further significant increase in yield. However, applied P increased the nodule number $plant^{-1}$ from 26 to 51, seed and pod number $plant^{-1}$ and 1000 seed weight.

Ahlawat (1996) conducted a field experiment in New Delhi, India to study the comparative performance of French bean varieties and their response to phosphorus fertilizer. He reported that application of phosphorus greatly improved the yield attributes (pods $plant^{-1}$ and seeds pod^{-1}), seed yield and the N and P uptake. The response of applied P was linear up to 40 kg P ha^{-1}.

Noor *et al.* (1990) obtained the highest yield from fertilization with 60 kg P_2O_5 ha^{-1} in lablab bean. They also suggested that the available phosphorus of the experimental soils was below the critical level (1.25 micro gram ml^{-1}) before plantation and added phosphorus was effectively utilized by the plants and gave higher yield. Phosphorus resulted in an increased growth, yield and maximum accumulation of mineral nutrients in common bean (*Phaseolus vulgaris*) (Fageria, 1989).

Singh and Malik (1990) carried out an experiment in green house using bushbean as the test crop with different levels of P, S and Se. They reported that phosphorus and S concentration and uptake by plant increased with their addition. The dry matter yield of bushbean increased with S and P application.

Sairam *et al.* (1989) reported that phosphorus application at the rate of 920 kg ha^{-1} and inoculation with *Rhizobium* culture resulted in improved nodulation and physiological activity of nodules in cowpea as indicated by increase in leghaemoglobin content, nitrogen fixation and total dry matter production.

Arya and Kalra (1988) stated that application of phosphorus had no effect on vegetative growth of the plants, but phosphorus had pronounced effect of reproductive growth and number of pods $plant^{-1}$, weight of pods $plant^{-1}$, weight of grain $plant^{-1}$, number of grain $plant^{-1}$, grain yield $plant^{-1}$ and harvest index. They also reported that phosphorus induced early in flowering and maturity.

Prabhakar *et al.* (1987) reported that green pod yield of French bean increased with phosphorus fertilization up to 75 kg ha^{-1}.

Working with soybean [Glycine max (Linn)] Nimje and Seth (1987) stated that grain and straw yield increased significantly with phosphorus application up to 35.2 kg ha^{-1}. Dry matter plant^{-1}, primary branches plant^{-1}, pods and grain weight plant^{-1} increased with the increase of phosphorus.

Ahmed *et al.* (1984) found significant increase in grain and straw yield of mungbean with increasing application of phosphorus up to 60 kg ha^{-1}. They also reported a significant decrease in straw and grain yield with further addition of phosphorus. Other growth parameters, such as plant height, number of pods plant^{-1}, and 100 grain weight were also favourably influenced by the addition of phosphorus up to 60 kg P_2O_5 ha^{-1}.

Addition of phosphorus and zinc up to certain level increased the yield of green gram (Patial and Somawanshi, 1982). Robinson and Jones (1972) reported that phosphorus and sulfur interacted on growth of a variety of legume when they were grown in soils deficient in both nutrients.

Jones (1976) showed that P without K increased the number of soybean nodules by 91% and the number of nodules was increased to 220% with P and K. De Mooy and Pesek (1970) also reported that number, weight and size of nodule increased with increasing amount of phosphorus.

2.3. Interaction effects of nitrogen and phosphorus on the growth and yield of Bush bean

Shamima (2005) carried a field experiment at the research Field of Sher-e-Bangla Agricultural University, Dhaka in Modhupur Tract (AEZ 28), during the *rabi* season from December 2004 to February 2005 to study the effects of nitrogen and phosphorus on the growth and yield of bush bean (*Phaseolus vulgares* L.) cv. BARI bushbean-1 and observed that 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 phosphorus, all these parameters increased upto N_{40} and $P_{75.}$

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.

A field experiment was conducted by Chavan *et al.* (2000) to study the uptake of NPK and quality of French bean cultivars (Arka-Kormal and Waghya). Nitrogen were applied with 3 rates of N (0, 25 and 50 kg ha^{-1}) and 3 rates of P (0, 25 and 75 kg ha^{-1}). Seeds were evaluated for N, P and K contents, total dry matter and protein production. The highest P uptake (6.3 kg ha^{-1}) by seeds and straw were reported in both Waghya and Arka Kormal. Waghya recorded the highest total dry matter (17.2 q ha^{-1}), seed protein production (128.0 kg ha^{-1}) and N and K uptake (31.7 and 12.0 kg ha^{-1}, respectively). The highest total P uptake (8.5 kg ha^{-1}) was recorded from the highest N rate (50 kg ha^{-1}). Total P uptake increased linearly with the increases in P rates.

Tewari and Singh (2000) conducted a field experiment in India to determine the optimum and economical dose of nitrogen (0, 40, 80, 120 or 160 kg ha^{-1}) and phosphorus (0, 20, 40 or 60 kg ha^{-1}) for better growth and seed yield of

French bean. They reported that plant height, number of branches and length of pod increased with successive increase in the doses of nitrogen and phosphorus. Application of 120 kg N ha^{-1} produced significantly higher number of pod length, pods $plant^{-1}$, weight of seed $plant^{-1}$, number of seeds of pod and seed yield. However, 160 kg N ha^{-1} significantly reduced seed yield. The highest value on the above yield attributes were reduced with 60 kg P_2O_5 ha^{-1}. The combination of 120 kg P_2O_5 along with 60 kg K_2O ha^{-1} gave the highest 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 kg P_20_5 ha^{-1}. Water use efficiency increased with increasing N and P rates. Interaction of irrigation and N, and N and P were significant for pods $plant^{-1}$ and seed yield.

Arya *et al.* (1999) conducted an experiment to investigate the effects 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 25 kg N, 75 kg P_2O_5 and K_2O ha^{-1} was the best combination in terms of economics and seed yield.

Gajendra and Singh (1998) conducted a field experiment at Lalchaoti in India. He reported that 120 Kg N+ 90 kg P_2O_5 and 45 kg K_2O ha^{-1} gave higher grain yield of French bean.

Koli *et al.* (1996) worked on uptake pattern of N, P and K of French bean and observed that seed yield increased with increasing N. They also observed that yield was positively correlated with the uptake of N and P.

Sexena and Varme (1995) studied the effects of nitrogen, phosphorus and potassium on the growth and yield of French bean (*Phaseolus vulgaris*). They observed that nitrogen affected all the growth attributes, viz. plant height, leaf number, leaf area, fresh weight, dry weight, branches at harvest and yield significantly up to 120 kg N ha^{-1}. Interaction effect of nitrogen and phosphorus was noticed in leaves per plant. Nitrogen @120 kg and 120 kg P_2O_5 ha^{-1} produced the maximum leaves $plant^{-1}$. All the growth attributes were positive and significantly correlated with the grain yield.

Srinivas and Naik (1990) conducted field trials to study the nitrogen uptake of French bean as influenced by nitrogen and phosphorus fertilization. They applied N at 0, 40, 80 and 120 kg/ha and P_2O_5 at 0, 40 and 80 kg ha^{-1}. Half of N, all the P and basal K_2O at 40 kg ha^{-1} were applied at planting and the remaining N was applied, 25 days later. They found that both N and P application increased plant growth, plant height, nutrient uptake and yield green pods. In another experiment Srinivas and Naik (1988) reported that pod yield increased with increasing fertilizer rate from 3927 kg ha^{-1} at zero N to 13167 kg ha^{-1} at 160 kg N ha^{-1}.

Baboo *et al.* (1988) carried out an experiment to study the response of French bean to applied nitrogen and phosphorus. They used 0-120 kg N and 0-100 kg P_2O_5 ha^{-1}. Seed yield increased with the increase of fertilizers and that was higher with 120 kg N and 100 kg P_2O_5/ha.

Devender *et al.* (1988) conducted an experiment to study the effect of nitrogen and phosphorus on the yield of French bean. Seeds pod^{-1} and seed yield increased significantly with the application of 150 kg N and 60 kg P_2O_5 ha^{-1}.

Rana and Singh (1988) stated that seed and straw yield were increased significantly with N rate in French bean. They used 0, 40, 80 or 120 kg N ha^{-1} and 0, 50 or 100 kg P_2O_5 ha^{-1}. The mean increases in seed yield with 120 kg N ha^{-1} compared with 0, 40 and 80 kg N ha^{-1} were 66.66, 21.7 and 7.0%, respectively.

Bhopal and Singh (1987) studied the response of French bean to nitrogen and phosphorus fertilization. They applied N at 0-90 kg ha^{-1} and P_2O_5 at 0-120 kg ha^{-1}, plus a basal dose of 50 kg K_2O ha^{-1}. They found that the optimum dose of N:P was 67.3: 79.7 kg ha^{-1}.

Srinivas and Rao (1984) conducted an experiment in Bangalore, India during *kharif* season and observed that the yield of French bean was significantly increased by the different levels of nitrogen and phosphorus. Pod yield was the highest with 90 kg N and 150 kg P_2O/ha. However, the optimum combination was found to be 80 kg N and 123 kg P_2O_5 ha^{-1}. Singh *et al.* (1981) reported that seed yields of *Phaseolue vulgaris* increased significantly with increasing N and P_2O_5. From the above finding it may be concluded that both nitrogen and phosphorus play an important roles on vegetative growth and yield of French bean.

CHAPTER III

MATERIALS AND METHODS

CHAPTER – III

MATERIALS AND METHODS

An experiment was conducted at the research field in Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2007 to February 2008 to find out the effect of N and P application on the growth and yield of bush bean-2 (*Phaseolus vulgaris* L.)

3.1. Experimental site

The experimental field is located at 90.335^0 E longitude and 23.774^0 N latitude at a height of 1 (one) meter above the seas level.

3.2. Climate

The annual precipitation of the site is around 2200 mm and potential evapotranspiration is 1300 mm. The average maximum temperature is 30.34^0C and average minimum temperature is 21.21^0C. The average mean temperature is 25.17^0C. The experiment was done during the *rabi* season. Temperature during the cropping period ranged between 12.20^0C to 29.2^0C. The humidity varies from 73.52% to 81.2%. The day length was 10.5-11.0 hours only and there was no rainfall from the beginning of the experiment to harvesting. The monthly average temperature, humidity, bright sunshine, solar radiation, precipitation and potential evapotranspiration pattern of the site during the experimental work are enclosed in Appendix-1.

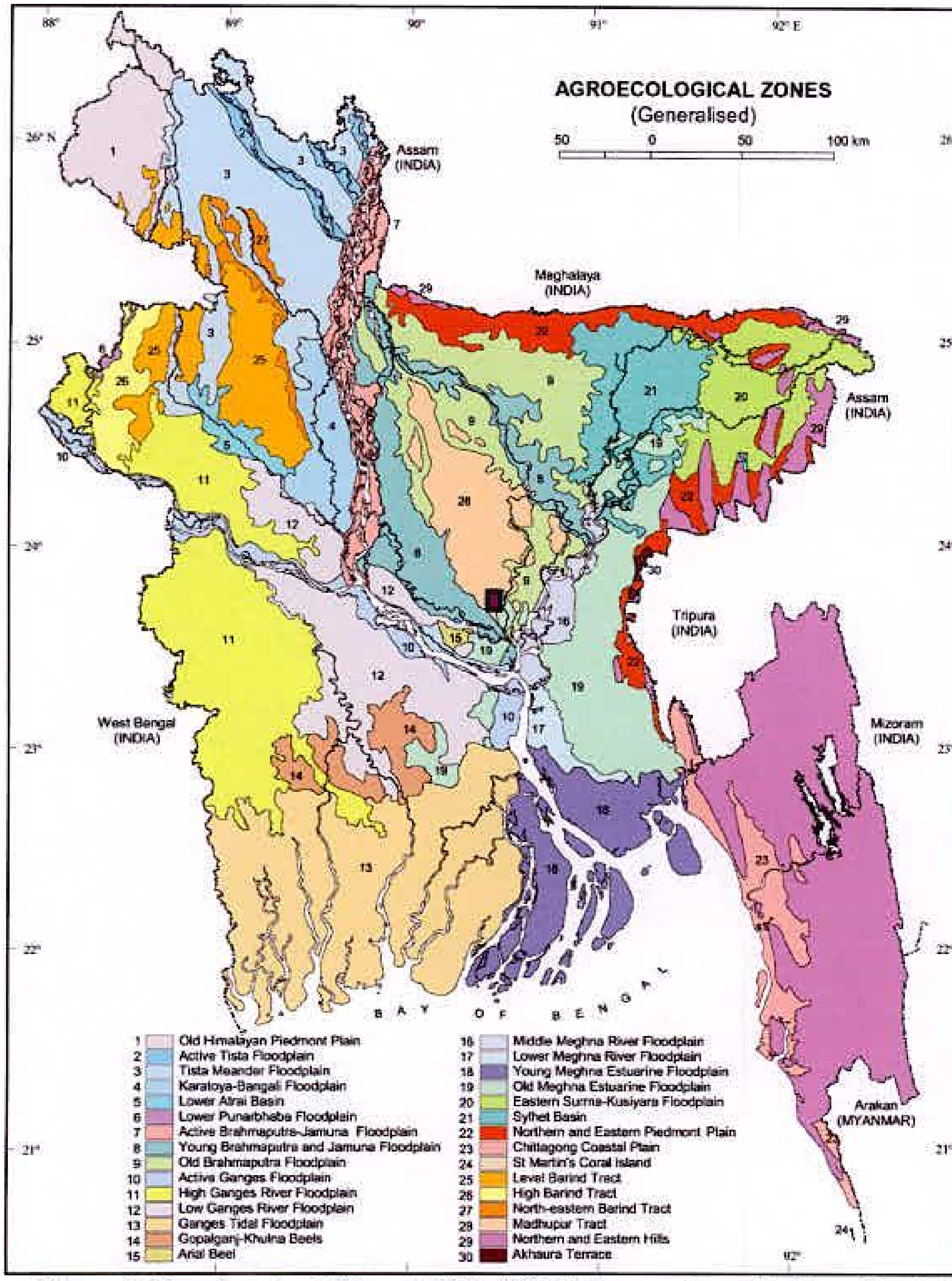


Figure 1. Map showing different AEZ of BD & the experimental site under study

3.3. Soil

The soil of the experimental field belongs to the Tejgaon 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 was very low (1.34 %) and soil pH varies from 5.8 – 6. The land was above flood level and well drained. The initial morphological, physical and chemical characteristics of soil are presented in the Tables 1 and 2.

Table 1. Morphological characteristics of the 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 level
Depth of inundation	Above the flood level
Drainage condition	Well drained
Land type	High

Table 2. Physical and chemical properties of the experimental land

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

3.4. Planting materials

The variety of bush bean used in the experiment was "BARI Jhar Sheem-2". The seeds were collected from the Horticultural Research Center (HRC), of BARI Joydebpur, Gazipur.

3.5. Treatments of the experiment:

The experiment was undertaken to study the effects of three different levels of nitrogen and four different levels of phosphorus on the growth and yield of bush bean. Thus the experiment included two Factors as follows:

Factor A: Levels of nitrogen

i)	0 kg/ha	(N_0)
ii)	60 kg/ha	(N_1)
iii)	120 kg/ha	(N_2)

Factor B: Levels of phosphorus (P)

i)	0 kg/ha	(P_0)
ii)	30 kg/ha	(P_1)
iii)	60 kg/ha	(P_2)
iv)	90 kg/ha	(P_3)

Treatment combinations:

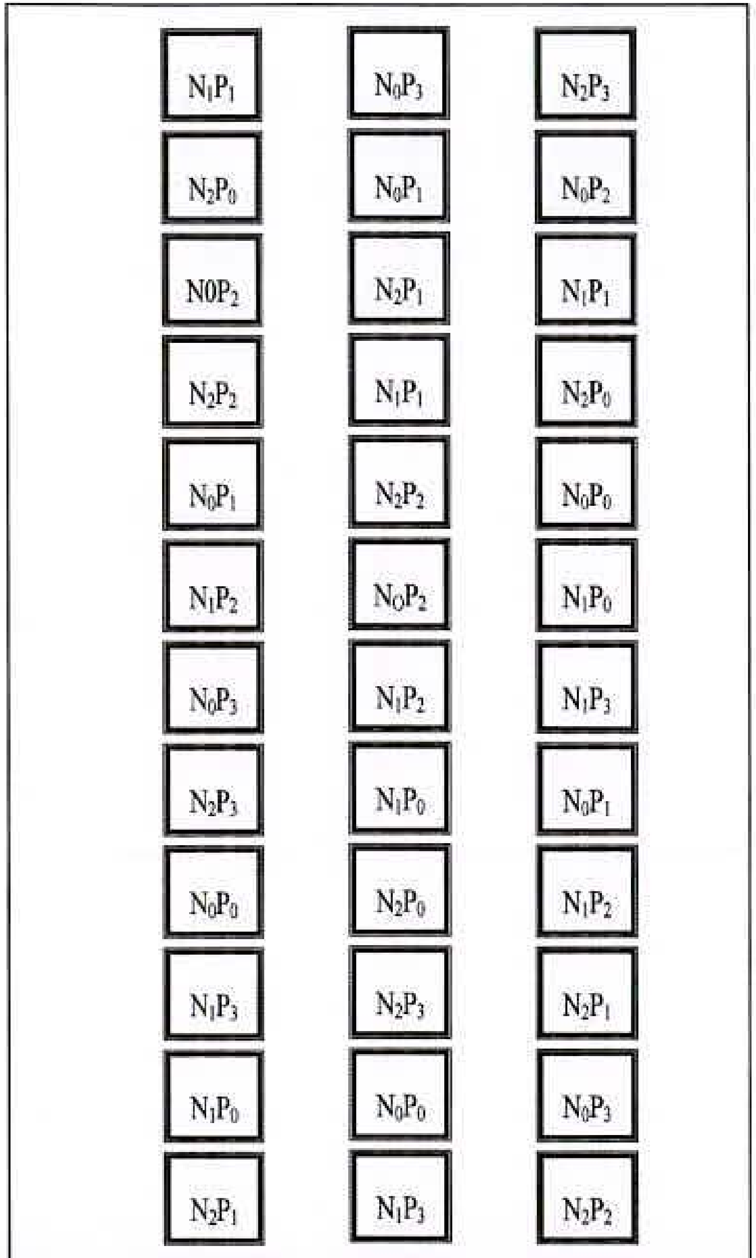
$T_1 = N_0P_0$	$T_2 = N_0P_1$
$T_3 = N_0P_2$	$T_4 = N_0P_3$
$T_5 = N_1P_0$	$T_6 = N_1P_1$
$T_7 = N_1P_2$	$T_8 = N_1P_3$
$T_9 = N_2P_0$	$T_{10} = N_2P_1$
$T_{11} = N_2P_2$	$T_{12} = N_2P_3$

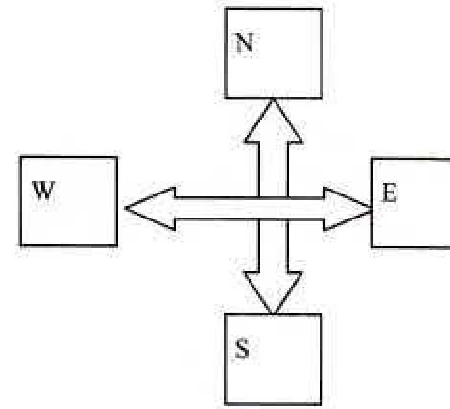
3.6. Layout and design of the experiment

The two factor experiment was laid out in the randomized completely block design (RCBD) with three replications. The experimental plot was first divided into three blocks. Each block was consisted of 12 unit plots. Thus the total number of plots was 36. Different combinations of nitrogen and phosphorus were assigned randomly to each block as per design of the experiment. The size of the unit plot was 2.5m x 2m. The distance of between the plot to plot and the block to block were 50cm and100cm respectively. The layout of the experiment is presented in the figure-2.

3.7. Land preparation

The land was opened with a tractor on 09 November 2007. Thereafter, it was ploughed and cross-ploughed several times with a power tiller. Each ploughing was followed by laddering to break the clods and to level the land. During land preparation, weeds and other stubbles of the previous crop were collected and removed from the land. These operations were done to bring the land for a good tilth condition. Irrigation channels were also made before sowing . All weeds and stubbles were removed and the land was finally prepared through addition of the basal doses of manure (cowdung) and potassium chloride or potash fertilizer.





Plot size : 2.5 m x 2 m (**5** m^2)
Plot to plot distance : **50** cm
Block to block distance : **100** cm

Figure 2: Layout of the experimental field

3.8. Manuring and fertilization

Full amount of MP (80 kg ha^{-1}) and cowdung (5 t ha^{-1}) were applied as broadcasted as basal dose and incorporated during the final land preparation. The required amount of P fertilizer as per treatment (as TSP) was applied as basal in the plots. Nitrogen fertilizer (as urea) was applied in the specified plots in 2 splits. Half as the basal doze and another half at the flowering initiation stage 25 days after sowing.

3.9. Sowing of seeds

Seeds of BARI bush bean-2 were sown on 22 November, 2007 following the spacing 30 cm x 10 cm in line sowing . Two seeds were sown in each hill at a depth of 5.0 cm and the seeds were covered with fine soil by hand. Immediate after sowing irrigation was done. Surrounding of the experimental plots three rows of beans were sown as the boarder crop to protect the experimental crops from grazing by animals.

3.10 Intercultural operations

3.10.1 Gap filling

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

3.10.2 Thinning of seedlings

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

3.10.3 Weeding

The experimental plots were kept weed free by hand weeding.

3.10.4. Irrigation

Four irrigations were given throughout the growing period by a water can. The first irrigation was given at 15 days after sowing (DAT) and the next three at 15 days interval after the 1st irrigation. Mulching was also done after each irrigation at appropriate time for breaking the soil crust and cleaning the weeds.

3.10.5 Pest management

a) Insect pests

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

b) Diseases

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

3.11. Harvesting

Immature green pods were harvested at tender stage, suitable for use as vegetable. At harvest, pods were nearly full size, with the seeds still small (about one quarter developed) with firm flesh (Swaider *et al.*, 1992). First harvesting was done at 45 days after sowing (DAS) and these pods were weighed to estimate fresh pod yield. Again the pods were harvested at mature stage when the plants and pods become yellow and fully dry. The seeds were collected from the pods and sun dried seeds were weighed to know the seed yield.

3.12. Collection of data

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

3.12.1. Plant height

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

3.12.2. Plant population

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

3.12.3. Number of pods per plant

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

3.12.4. Length of green pod

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

3.12.5 Diameter of green pod

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

3.12.6. Number of seeds per pod

Numbers of seed per green pod was recorded from five randomly selected pods and the mean value was calculated.

3.12.7. Weight of pods per plant (g)

Pods of ten sample plants were weighed and their average weight was taken in gram (g).

3.12.8. Pod yield

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

3.12.9 1000-seed weight (g)

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

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

It was measured by the following formula

Weight of seeds per plot = Seed weight in individual plant × Total number of plants in a unit plot.

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

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

3.13 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.

3.13.1. Particle size analysis

This analysis was done by the hydrometer method (Black, 1965) and textural classes were identified by plotting the values for % sand, % silt and % clay to the "Marshall's Triangular Coordinate" following the USDA system.

3.13.2. 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).

3.13.3. Organic carbon (%)

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

3.13.4. C/N ratio

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

3.13.5. 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).

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

3.13.6. Total nitrogen (%)

Total nitrogen in the soil sample was determined by the Micro Kjeldhal method (Page *et al.,* 1982) .The procedure was – digestion of soil sample by 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).

3.13.7. 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).

3.13.8. 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.

3.13.9. 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 a spectrophotometer the at 420 nm wavelength.

3.14. Plant sample analyses

Plant samples were collected from every individual plot for laboratory analysis at maturity stage of the crop. Plants were collected from each plot by cutting above ground level. For chemical analyses of plant samples, five plants were collected randomly from each plot at harvest period and oven dried at 72^0C for 72 hours. Then dried plant samples were ground by a grinding machine. The plant samples were collected by avoiding the border area of the plots.

3.15. Statistical analyses

The data obtained from the experiment were analyzed statistically to find out the significance of the difference among the treatments. The mean values of all the characteristic were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among pairs of treatment means was estimated by the Least Significant Difference (LSD) test at 5% and 1% level of probability as needed.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER - IV

RESULTS AND DISCUSSIONS

The experiment was conducted to observe the effects of different levels of nitrogen and phosphorus and their interaction on the growth and yield of BARI bush bean-2 and the results have been shown in various Tables, Figures and Appendices and discussed under following headings.

4.1 Effect of Nitrogen on the yield contributing characters of bush bean

4.1.1 Plant height

Different levels of nitrogen exhibited significant variation in respect of plant height of BARI bushbean-2. At final harvest the maximum plant height (45.39 cm) was obtained from the treatment N_2 (plant grown with 120kg N ha^{-1}) and the minimum (35.81cm) was recorded form the control treatment (N_0) (Table 3). Nandan and Prasad (1998) observed that plant height increased with increasing N doses up to 120 kg ha^{-1}. This result is in full agreement with Singh and Verma (2002) and they showed that the highest rates of nitrogen (120 kg ha $^{-1}$) resulted in the highest plant heigh.

4.1.2. Plant population m^{-2}

The number of plant population m^{-2} varied insignificantly due to response of different levels of nitrogen. The maximum plant population m^{-2} (25.83) was recorded from the treatment N_2 (at 120 kg Nha^{-1}) and the minimum (23.53) was found from the control treatment (Table 3). Ali and Tripathi (1988) observed that plant population m^{-2} increased with increasing nitrogen rate.

Table 3. Effect of Nitrogen on the growth and yield contributing characteristic of BARI Bush bean-2

Treatments	Plant height (cm)	Plant population m^{-2}	Pods $plant^{-1}$ (no.)	Pod length (cm)	Pod weight $plant^{-1}$ (g)
N_0	35.81 c	23.53	15.11 b	11.53 b	37.11 c
N_1	39.60 b	24.79	15.75 b	13.58 a	38.14 b
N_2	45.39 a	25.83	19.68 a	15.10 a	42.45 a
CV(%)	7.62	17.53	20.91	14.90	9.70
Sig. Level	**	NS	**	**	**

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

N_0= 0 kg ha^{-1}, N_1= 60 kg ha^{-1}, N_2= 120 kg ha^{-1}

NS = Non significance, *= 1% level of significance, **= 5% level of significance

4.1.3. No. of pods $plant^{-1}$

The number of pods $plant^{-1}$ at different levels of nitrogen was found to be significant. The maximum number of pods $plant^{-1}$ (19.68) was produced from the treatment N_2 (120 kg N ha^{-1}). On the contrary, the control treatment (N_0) produced the minimum number of pod $plant^{-1}$(15.11) (Table 3). It may be due to adequate supply of nitrogen to develop pod bearing branches. This result is in full agreement with Calvanche *et al.* (1997) and Sa *et al.* (1982). They reported that pods $plant^{-1}$ increased with increasing dose of nitrogen upto120 kg N ha^{-1}. Similar opinion was put forward by Rana and Singh (1988).

4.1.4. Pod length (cm)

Nitrogen influenced significantly in respect of pod length. Pod length increased gradually due to increasing dose of nitrogen fertilizer. The highest length of green pod of bush bean (15.10 cm) was found in the crop grown with the highest dose of nitrogen (120 kg Nha^{-1}) and the lowest (11.53 cm) was observed from the control (0 kg Nha^{-1}) treatment (Table-3). This result is in full agreement with Rahman (2001). He reported that pod length were significantly influenced by higher dose of nitrogen.

4.1.5. Pod weight plant^{-1} (g)

A significant influence was observed in respect of pod weight plant^{-1} at different levels of nitrogen. The highest pod weight plant^{-1} (42.45 g) was obtained from 120 kg N ha^{-1} and the lowest pods weight plant^{-1} (37.11 g) from the control (Table 3). It was clearly observed that there was a positive effect of nitrogen on the pod weight plant^{-1}. The result is similar to that of Wange *et al*. (1996)

4.1.6. Pod yield (t ha^{-1})

The results indicated that nitrogen had profound effect on pod yield ha^{-1}. The maximum pod yield (16.63 t ha^{-1}) was obtained from 120 kg N ha^{-1} and the minimum pod yield (10.04 t ha^{-1}) in control (N_0) (Table-3 and Figure-3). This result is in full agreement with Kamal (2007). He reported that pod yield increased with increasing dose of nitrogen upto120 kg N ha^{-1}. Similar opinion was also put forward by Chandel *et al*. (2002). On the other hand Rahman (2001) had the experience that there was a significantly influenced by higher dose of nitrogen on green pod yield ha^{-1}.

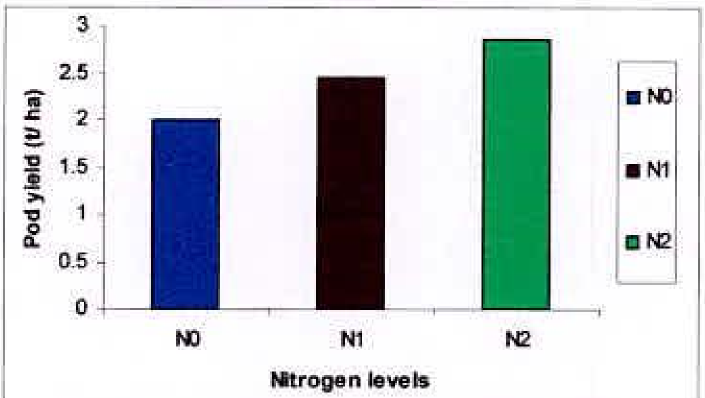


Fig.-3 Effect of different nitrogen treatment on pod yield t/ ha

Table 3. (Contd.)

Treatments	Pod yield (t ha^{-1})	No. of seeds pod^{-1}	1000 seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
N_0	10.04 c	5.15 b	225.5 b	2.00 b	3.38 b
N_1	13.85 b	5.39 ab	229.5 ab	2.44 a	3.54 ab
N_2	16.63 a	5.93 a	244.3 a	2.85 a	3.72 a
CV(%)	18.49	5.99	7.75	6.35	5.91
Sig. Level	**	**	*	*	*

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

N_0= 0 kg ha^{-1}, N_1= 60 kg ha^{-1}, N_2= 120 kg ha^{-1}
NS = Non significance, *= 1% level of significance, **= 5% level of significance

4.1.7. No. of seeds pod^{-1}

The number of mature seeds pod^{-1} was significantly influenced by the application of nitrogen. The highest number seeds pod^{-1} (5.93) was obtained from the plant receiving 120 kg N ha^{-1}, i.e. from the treatment N_2. The lowest number of mature seeds pod^{-1} (5.15) was noted from the control treatment (Table 3). This might be due to better growth and development and larger pod formation with higher rate of N application. This result matches with that of Calvache *et al.* (1997).

4.1.8. Thousand Seed weight (g)

A significant variation was experienced in respect of 1000 seed weight due to different nitrogen levels. Maximum weight of 1000 seeds (244.3 gm) was recorded from N_2 treatment with the application of 120 Nha^{-1}. The minimum weight of 1000 seed (225.5 gm) was obtained from the control treatment (Table 3). Singh and Singh (2000) opined that 1000-seed weight increased with elevated N rate. The result confirms the finding of Singh et al. (1990).

4.1.9. Seed yield (t ha^{-1})

Different nitrogen levels had significant effect on seed yield ha^{-1}. The maximum seed yield (2.85 ha^{-1}) was obtained from N_2 treatment (120 kg N ha^{-1}) and the minimum seed yield (2.00 ha^{-1}) was obtained from control treatment (Table-3 and Appendix-I). Baboo *et al.* (1998) found that seed yield was increased with the increase of nitrogen and it was higher with 120 kg N. 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 and found that seed yields was the highest with 120 kg N.

4.1.10. Stover yield (t ha^{-1})

The stover yield was significantly elevated by the application of nitrogen. The highest stover yield (3.72 t ha^{-1}) was obtained from the plant receiving 120 kg N ha^{-1}, i.e. from treatment N_2. The lowest stover yield (3.38 t ha^{-1}) was recorded from control treatment (Table 3 and Appendix-II). Singh and Verma (2002) showed that the highest rates of nitrogen (120 kg ha $^{-1}$) resulted in the highest stover yield with 120 kg N ha^{-1}. Similar opinion was also forward by Vishwakarma *et al.* (2002).

4.2 Effects of phosphorus on the growth and yield of Bush bean

4.2.1. Plant height

The results showed that there was an insignificant effect of phosphorus on plant height. The tallest plant was recognized from P_3 treatment (41.54 cm) with 90 kg P_2O_5 ha^{-1}. The shortest plant was identified from P_0 treatment (39.66 cm) with 0 kg P_2O_5 ha^{-1} (Table 4). Ahmed *et al.* (1984) reported plant height was favourably influenced by the addition of phosphorus up to 60 kg P_2O_5 ha^{-1}.

4.2.2. Plant population m^{-2}

Phosphorus treatments exhibited insignificant variation in respect of plant population m^{-2} of BARI French bean-2 (Table 4). The maximum (24.83) and the minimum (24.57) plant populations m^{-2} were recorded at P_2 (90 kg P_2O_5 ha^{-1}) and P_0 (0 kg P_2O_5 ha^{-1}) treatments, respectively.

Table 4. Effects of phosphorus on the growth and yield contributing characteristic of BARI frenchbean-2

Treatments	Plant height (cm)	Plant population m^{-2}	Pods $plant^{-1}$ (no.)	Pod length (cm)	Pod weight $plant^{-1}$ (g)
P_0	39.66	24.57	11.65b	11.24 b	23.77 c
P_1	39.86	24.71	16.92a	13.28 ab	29.85 b
P_2	40.02	24.83	19.40a	14.73 a	48.54 a
P_3	41.54	24.75	19.42a	14.35 a	44.69 ab
CV(%)	7.62	17.53	20.91	14.90	9.70
Sig. Level	NS	NS	**	**	*

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

P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}
NS = Non significan, *= 1% level of significance, **= 5% level of significance

4.2.3. No. of pods $plant^{-1}$

There was significant effect of phosphorus on the number of pods $plant^{-1}$. The number of pods per plant ranged from 11.65 to19.42 (Table 4 and Appendix-III). The maximum number of pods $plant^{-1}$ (19.42) was obtained from P_3 (90 kg P_2O_5 ha^{-1}) treatment. The number of pods $plant^{-1}$ decreased at 60 kg P_2O_5 ha^{-1}. The minimum number of pods $plant^{-1}$ (16.92) was counted from P_0 (0 kg P_2O_5 ha^{-1}). This result conforms the findings of Rana and Singh (1998).

4.2.4 Pod length (cm)

Length of fresh pod was also influenced significantly by the different doses of phosphorus. The longest green pod (14.73 cm) was visible from P_2 (60 kg P_2O_5 ha^{-1}) treatments, which was statistically analogous with P_3 (90 kg P_2O_5 ha^{-1}) treatments. The minimum length of pod (11.24 cm) was found from P_2 (0 kg P_2O_5 ha^{-1}) treatments (Table 4).

4.2.5 Pod weight plant^{-1} (g)

The level of phosphorus was also highly significantly accelerated the pod weight plant^{-1} of French bean. The highest pod weight (48.54 g) was recorded from the plant treated with P_2 (60 kg P_2O_5 ha^{-1}) followed by P_3 and P_1 and the lowest (23.77 g) from the control treatment (Table 4). Arya and Kalra (1988) stated that application of phosphorus had no effect on vegetative growth of the plants, but phosphorus had pronounced effect of reproductive growth and number of pods plant^{-1}, weight of pods plant^{-1}.

Table 4. (Contd.)

Treatments	Pod yield (t ha^{-1})	Seeds pod^{-1}	1000 seed wt (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0	10.46 b	5.13 b	211.2 b	1.86 b	3.13 b
P_1	13.92 a	5.44 ab	237.5 a	2.20 ab	3.44 ab
P_2	14.89 a	5.56 ab	243.2 a	2.79 a	3.92 a
P_3	14.57 a	5.63 a	240.6 a	2.52 a	3.70 a
CV(%)	18.49	5.99	7.75	20.72	5.91
Sig. Level	**	*	**	**	*

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

P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}
NS = Non significance, *= 1% level of significance, **= 5% level of significance

4.2.6. Pod yield (t ha^{-1})

Phosphorus influenced significantly the pod yield ha^{-1}. The maximum pod yield ha^{-1} (14.89 t ha^{-1}) was achieved from P_2 treatment with the 60 kg P_2O_5 ha^{-1}, while the minimum pod yield per hectare (10.46 t ha^{-1}) was achieved from control treatment (Figure-4). Singh and Singh (2000) in Uttar Pradesh, India. French bean (*Phaseolus vulgaris*) were given 0, 60 of 120 kg P/ha and it was observed that yield and yield component were generally highest with 60 kg P. Prabhakar *et al.* (1987) also reported that green pod yield of French bean increased with phosphorus fertilization up to 75 kg ha^{-1} and Roy and Parthasarathy (1999) to investigated the phosphorus requirement of French bean varieties. They used 0-120 kg P ha^{-1} and observed that pod yield was highest (07.69 t ha^{-1}) with 120 kg P ha^{-1}

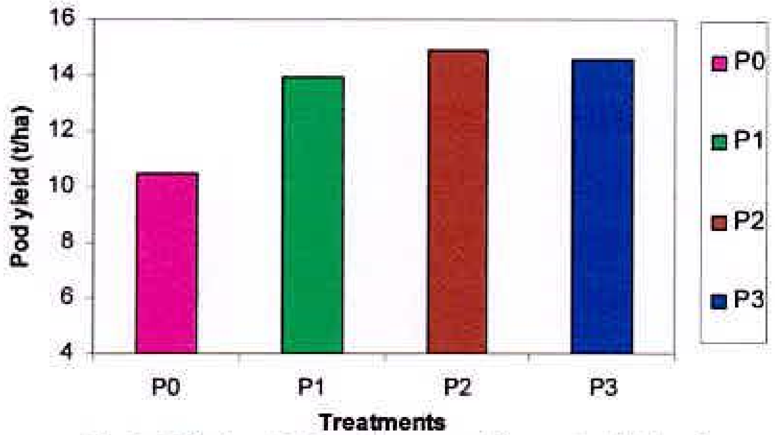


Fig-4. Effects of phosphorus on the pod yield of BARI frenchbean-2

4.2.7. No. of seeds pod^{-1}

Different doses of phosphorus also influenced significantly the number of seeds (Table 4). Number of seeds pod^{-1} increased with the increasing rates of phosphorus fertilizers. It was maximum (5.63) at P_3 treatment (90 kg P_2O_5 ha^{-1}), but statistically similar (5.56) with treatment (60 kg P_2O_5 ha^{-1}). Ahlawat (1996) reported that application of 40 kg P ha^{-1} greatly improved the number of seeds pod^{-1}.

4.2.8. Thousand Seed weight (gm)

The effect of phosphorus was found to be significant. The highest weight of 1000 seed (243.20 gm) was obtained from P_2 treatment with 60 kg of P_2O_5 ha^{-1}. The lowest 1000 seed weight (211.2 gm) was recorded from the control treatment (Table-4).

4.2.9. Seed yield (t ha^{-1})

Phosphorus influenced significantly the seed yield ha^{-1}. The maximum seed yield ha^{-1} (2.79 t ha^{-1}) was obtained with the 60 kg P_2O_5 ha^{-1} and the minimum seed yield (1.86 t ha^{-1}) was achieved from the control treatment (Table-4 and Appendix-IV). It was also clearly observed that seed yield increased with increasing levels of phosphorus up to P_2 treatment (60 kg P_2O_5 ha^{-1}). Sexena *et al.* (1996) applied P_2O_5 at the rates of 0, 30 and 60 kg ha^{-1} and observed that seed yield was highest with 60 kg P_2O_5.

4.2.10. Stover yield (t ha^{-1})

Phosphorus also influenced significantly the stover yield (t ha^{-1}). Maximum stover yield (3.92 t ha^{-1}) was achieved with the treatment P_2 (60 kg P_2O_5 ha^{-1}) while the minimum stover yield (3.13 t ha^{-1}) was noted from the control treatment (Table 4 and Appendix-V).

4.3. Interaction effects of nitrogen and phosphorus on the growth and yield contributing characteristic of Bush bean

4.3.1. Plant height

Plant height was insignificantly influnced by the interaction between nitrogen and phosphorus. At harvest the maximum plant height (48.20 cm) was observed from the treatment combination N_2P_3 (120 kg N with 90 kg P_2O_5 ha^{-1}). The minimum plant height (35.27 cm) was obtained from control treatment (Table 5). The present results correlate with the findings of Sexena and Varme (1995)

Table 5. Interaction effect of nitrogen and phosphorus on the growth and yield of BARI bush bean-2

Treat ment	Plant height (cm)	Plant population m^{-2}	Pod $plant^{-1}$ (no.)	Pod length (cm)	Pod wt. $plant^{-1}$ (g)
N_0P_0	35.27	23.60	10.50	10.23	29.02
N_0P_1	35.61	23.78	15.31	11.46	32.41
N_0P_2	36.02	23.67	17.28	12.49	48.29
N_0P_3	36.13	23.06	17.36	12.23	42.94
N_1P_0	39.12	24.50	11.33	11.53	31.69
N_1P_1	39.36	24.65	15.78	13.25	38.25
N_1P_2	39.63	24.92	17.89	14.71	49.39
N_1P_3	40.29	25.09	17.99	14.82	47.34
N_2P_0	44.37	25.61	13.12	11.95	29.84
N_2P_1	46.06	25.71	19.68	15.53	30.65
N_2P_2	44.40	25.89	23.04	17.29	48.30
N_2P_3	48.20	26.10	22.90	16.10	43.39
CV(%)	7.62	17.53	20.91	14.90	9.70
Sig. Level	NS	NS	NS	NS	NS

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

NS = Non significant

4.3.2. Plant population m^{-2}

There was no significant interaction due to different levels of nitrogen and phosphorus on the plant population m^{-2}(Table 5). The highest number of plant population m^{-2} (26.10) was recorded from the treatment combination of N_2P_3 (120 kg N ha^{-1} with 90 kg P_2O_5 ha^{-1}). The lowest number of plant population m^{-2} (23.60) was obtained from the treatment combination, N_0P_0.

4.3.3. No. of pods $plant^{-1}$

Statistically insignificant interaction effect of different levels of nitrogen and phosphorus on the number of pods per plant was found. The maximum number of pods $plant^{-1}$ (23.04) was obtained from the treatment combination N_2P_2 (120 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}). The minimum pod number (10.50) was found from the control treatment, N_0P_0 (Table 5).

4.3.4. Pod length (cm)

An insignificant interaction effect of different dose of nitrogen and phosphorus on green pod length was observed (Table 5). However, the longest pod length (17.29 cm) was recorded from the treatment combination N_2P_2 (120 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}). The minimum pod length (10.23 cm) was found from the control treatment (N_0P_0).

4.3.5. Pod weight $plant^{-1}$ (g)

The interaction effect of different levels of nitrogen and phosphorus on pod weight per plant was found statistically insignificant. The maximum (49.39 g) and the lowest pod weights (29.02 g) were obtained from the N_1P_2 and the control ((N_0P_0) treatment combination, respectively (Table 5).

Table 5. (Contd.)

Treat ment	Pod yield (t ha^{-1})	No. of seeds pod^{-1}	1000 seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
N_0P_0	9.04	3.39	205.00	1.60 c	2.95
N_0P_1	9.60	4.90	230.70	1.99 bc	3.38
N_0P_2	10.35	5.29	232.90	2.36 abc	3.41
N_0P_3	11.17	5.51	233.10	2.56 abc	3.77
N_1P_0	10.25	5.19	212.10	1.99 bc	3.15
N_1P_1	10.66	5.17	233.30	2.31 abc	3.45
N_1P_2	15.43	5.32	236.5	2.45 abc	3.58
N_1P_3	15.06	5.52	236.10	2.75 bc	3.98
N_2P_0	12.46	5.42	216.60	2.00 abc	3.29
N_2P_1	17.50	6.01	260.01	2.36 ab	3.48
N_2P_2	18.90	6.15	260.12	3.09 a	4.10
N_2P_3	17.48	5.71	252.50	2.66 ab	4.00
CV(%)	18.49	5.99	7.75	20.72	5.91
Sig. Level	NS	NS	NS	*	NS

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

N_0= 0 kg ha^{-1}, N_1= 60 kg ha^{-1}, N_2= 120 kg ha^{-1}
P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}
NS = Non significance, *= 1% level of significance, **= 5% level of significance

4.3.6. Pod yield (t ha^{-1})

The interaction effect of different levels of nitrogen and phosphorus on pod yield ha^{-1} was found to be statistically insignificant (Appendix- VI).The highest pod yield ha^{-1} (18.90 t ha^{-1}) was achieved from the treatment combination of N_2P_2 (120 kg nitrogen ha^{-1} with 60 kg P_2O_5 ha^{-1}), whereas lowest value ha^{-1} (9.04 t ha^{-1}) was found from the control treatment combination (N_0P_0). Gajendra and Singh (1998) conducted a field experiment at Lalchaoti in India. He reported that 120 Kg N and 90 kg P_2O_5 gave the highest pod yield of French bean.

4.3.7. No. of seeds pod^{-1}

There was also an insignificant interaction between nitrogen and phosphorus in respect of number of seed pod^{-1}. The maximum number of seeds pod^{-1} (6.15) was recorded from the treatment combination of N_2P_2 (120 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}) and the minimum seeds pod^{-1} (3.39) was found from the control treatment (Table 5).

4.3.8. Thousand Seed weight (g)

The combined effect of nitrogen and phosphorus on the thousand seed weight was insignificant. The highest weight of 1000 seed (260.12 gm) was obtained from the treatment combination of N_2P_2 (120 kg N ha^{-1} with 60 kg of P_2O_5 ha^{-1}). The lowest 1000 seed weight (205.00 gm) was recorded from the control treatment (Table 5).

4.3.9. Seed yield (t ha^{-1})

The interaction effect of different levels of nitrogen and phosphorus on seed yield ha^{-1} was found to be statistically significant. The highest yield (3.09 t ha^{-1}) was achieved from the treatment combination of N_2P_2 (120 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}) whereas the lowest value (1.60 t ha^{-1}) was found in the control treatment (Table 5). This result is in close agreement with the findings of Tewari and Singh (2000). Devender *et al.* (1988) also noted that the seed yield increased significantly with the application of 150 kg N and 60 kg P_2O_5 ha.

4.3.10. Stover yield (t ha^{-1})

The interaction between nitrogen and phosphorus in respect of stover yield (t ha^{-1}) was insignificant. The maximum stover yield (4.10 t ha^{-1}) was recorded from the treatment combination of N_2P_2 (120 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}) and the minimum stover yield (2.95 t ha^{-1}) was found from the control treatment (Table 5 and Appendix-VII). Shamima (2005) observed that stover yield increased significantly with the application of 40 kg N and 75 kg P_2O_5 ha^{-1}.

4.4. Characteristics of different treatments on the post harvest soil properties

4.4.1. Soil pH

The pH value of initial soil was 5.8. The result (Table-2) showed that due to the treatment, the pH value of the post harvest soils ranged from 5.8 to 6.9.

4.4.2. Organic matter content

Organic matter content varied due to application of different levels of fertilizers. The lowest organic matter content (0.61%) was obtained from both the treatments N_2P_2 and N_2P_3 whereas, the highest organic matter content (1.63%) was obtained from both the treatments N_0P_2 and N_0P_3 and the organic matter content of initial soil was 1.34.

4.4.3. Total nitrogen (%)

The highest total nitrogen (0.101%) was recorded from N_0P_2 treatments and the lowest (0.073%) in post harvest soils were observed in N_2P_3 treatment (Table-6).The total nitrogen value of the initial soil was 0.08%.

Table 6. Soil pH, organic matter, total N, available P, exchangeable K and available S contents of post harvest soils

Treatments	pH	O.M (%)	Total N (%)	P ($\mu g\ g^{-1}$)	K	S
					(m.eq /100 g)	
N_0P_0	5.80	1.60	0.090	17.17	0.32	7
N_0P_1	6.80	1.60	0.089	16.38	0.31	13
N_0P_2	6.20	1.63	0.101	22.19	0.29	14
N_0P_3	6.70	1.63	0.100	18.28	0.27	14
N_1P_0	6.80	1.58	0.097	19.96	0.30	15
N_1P_1	6.90	1.58	0.096	18.99	0.28	15
N_1P_2	6.70	0.76	0.085	23.29	0.28	16
N_1P_3	6.90	0.76	0.082	23.64	0.25	16
N_2P_0	6.90	1.58	0.088	22.31	0.31	17
N_2P_1	6.90	1.59	0.087	20.92	0.30	13
N_2P_2	6.10	0.61	0.074	22.85	0.26	13
N_2P_3	6.80	0.61	0.073	25.29	0.33	14

N_0= 0 kg ha^{-1}, N_1= 60 kg ha^{-1}, N_2= 120 kg ha^{-1}

P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}

4.4.4. Phosphorus content of soil

Available phosphorus of post harvest soil was presented in the table-6. The highest value of available phosphorus obtained (23.64 μg g^{-1}) in N_1P_3 treatment and the lowest available phosphorus (16.38 μg g^{-1}) in post harvest soils was observed in N_0P_1 treatment, whereas the available phosphorus of initial soil was (15 ppm).

4.4.5. Potassium content of soil

Potassium content of post harvest soil varied due to application of different levels of fertilizer treatments. The highest potassium content (0.33 m.eq/100 g)was obtained from the treatments N_2P_3 whereas, the lowest potassium content (0.25 meq $100ml^{-1}$) were obtained from the treatments N_1P_3 and the potassium content of initial soil was (0.18 meq $100ml^{-1}$).

4.4.6. Sulphur content of soil

Sulphur content of post harvest soil also varied due to application of different levels of fertilizer treatments. The lowest sulphur content (7 meq $100ml^{-1}$) was obtained from the treatments N_0P_0 whereas, the highest sulphur content (17 meq $100ml^{-1}$) were obtained from the treatments N_2P_0 and the sulphur content of initial soil was (16.0 ppm).

4.5. Effect of nitrogen on N and P content of BARI bush bean-2

4.5.1. Nitrogen content

Statistically significant variation in nitrogen content in the stover of bush bean plant was recorded when different doses of nitrogen were applied (Table-7). The highest nitrogen content (1.27 %) was recorded in N_2. The lowest nitrogen content (1.20 %) was recorded in the N_0 treatment where no nitrogen was applied.

Probably, higher dose of nitrogen helped to increase the nitrogen content in plant. These are in agreement with that Sexena and Varme (1995) who reported that different levels of nitrogen significantly increased nitrogen content.

Table7. Effect of nitrogen on N and P contents by BARI bush bean-2

Treatments	Content (%)	
	Nitrogen	Phosphorous
N_0	1.20 b	0.298 b
N_1	1.23 ab	0.323 a
N_2	1.27 a	0.318 ab
CV%	3.08	5.48
Significant Level	*	*

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

N_0= 0 kg/ha, N_1= 60 kg/ha, N_2= 120 kg/ha

NS = Non significant, *= 1% level of significant, **= 5% level of significant

4.5.2. Phosphorous content

Statistically significant variation was observed in phosphorous content in the stover of bush bean when different doses of nitrogen were applied (Table-7). The P content ranged from 0.298 to 0.323%. Among the different doses of nitrogen the highest phosphorous content (0.323 %) was recorded in N_1, which was significantly higher than N_2. On the other hand, the lowest phosphorous content (0.298%) was recorded in the N_0 treatment where no nitrogen was applied.

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4.6. Effect of nitrogen on N and P uptake by BARI bushbean-2

4.6.1. Nitrogen uptake

A significant variation in nitrogen uptake by stover of bushbean plant was recorded when different doses of nitrogen were applied (Table 8 and Figure-5). The N uptake by stover due to different treatments ranged from 40.56 kg ha^{-1} to 47.24 kg/ha . The highest nitrogen uptake (47.24 kg ha^{-1}) was recorded in N_2. The lowest nitrogen uptake (40.56 kg ha^{-1}) was recorded in the N_0 treatment where no nitrogen was applied. Probably, higher dose of nitrogen helped to increase the nitrogen content in plant. Prajapati *et al.* (2004) concluded that among the N rates, 120 kg ha^{-1} recorded the greatest N uptake (56.70 kg ha^{-1}). Srinivas and Naik (1990) observed that higher dose of nitrogen increased plant nutrient uptake.

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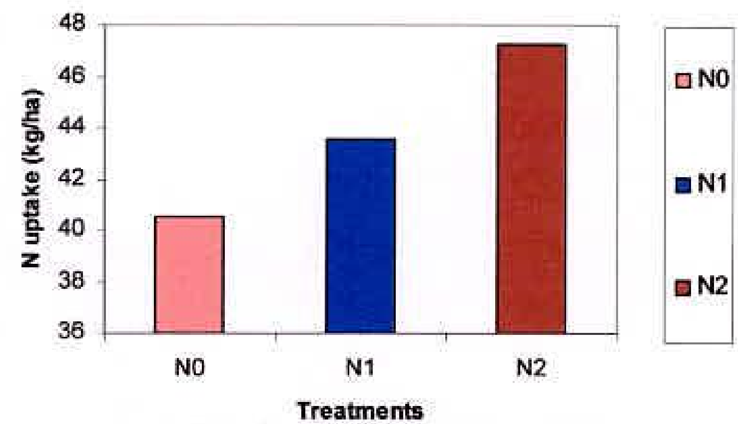

Fig.5 Effect of Nitrogen on N uptake by BARI bushbean-2

4.6.2. Phosphorous uptake

There was a significant variation observed in phosphorous uptake in the stover of bushbean when different doses of nitrogen were applied (Table 8). The P uptake by stover due to different treatments ranged from 10.07 kg ha^{-1} to 11.83 kg ha^{-1}. Among the different doses of nitrogen the highest phosphorous uptake (11.83 kg ha^{-1}) was recorded in N_2, which was significantly higher than N_1. On the other hand, the lowest phosphorous content (10.07 kg ha^{-1}) was recorded in the N_0 treatment where no nitrogen was applied. Prajapati *et al.* (2004) also reported that among the N rates,120 kg ha^{-1} recorded the greatest P uptake (18.47 kg ha^{-1}).

Table 8. Effect of Nitrogen on N and P uptake by BARI bushbean-2

Treatments	Nutrient uptake by stover (kg ha^{-1})	
	Nitrogen	Phosphorous
N_0	40.56 c	10.07 b
N_1	43.54 b	11.43 ab
N_2	47.24 a	11.83 a
CV%	5.78	6.83
Sig. Level	*	*

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

N_0= 0 kg ha^{-1}, N_1= 60 kg ha^{-1}, N_2= 120 kg ha^{-1}

NS = Non significance, *= 1% level of significance, **= 5% level of significance.

4.7. Effect of phosphorous on N and P content of BARI bush bean-2

4.7.1. Nitrogen content

Statistically significant variation in nitrogen content in the stover of bush bean plant was recorded when different doses of phosphorous were applied (Table-9 and Appendix-IX). The highest nitrogen content (1.28 %) was recorded in P_3. The lowest nitrogen content (1.19 %) was recorded in the P_0 treatment where no nitrogen was added. Probably, higher dose of phosphorous helped to increase the nitrogen content in plant. These are in agreement with that Srinivas and Naik (1990) who reported that different levels of nitrogen significantly increased nitrogen content.

Table 9. Effect of Phosphorus on N and P contents of BARI bush bean-2

Treatments	Content (%)	
	Nitrogen	Phosphorous
P_0	1.19 b	0.29 b
P_1	1.23 ab	0.31 a
P_2	1.23 ab	0.32 a
P_3	1.28 a	0.33 a
CV%	3.08	5.48
Significant Level	*	*

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

P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}
NS = Non significance, *= 1% level of significance, **= 5% level of significance.

4.7.2. Phosphorous content

A statistical significantly variation was observed in phosphorous content in the stover of bushbean when different doses of phosphorous were applied (Table 9). Among the different doses of nitrogen the highest phosphorous content (0.33 %) was recorded in P_3, which was identical to the P_1 and P_2 treatments. On the other hand, the lowest phosphorous content (0.29%) was recorded in the P_0 treatment where no nitrogen was applied.

4.8. Effect of phosphorous on N and P uptake of BARI bush bean-2

4.8.1 Nitrogen uptake

Application of different doses of phosphorous fertilizers showed a significant variation in respect of nitrogen uptake in the stover of bush bean (Table-10 and Figures-6). Among the different P doses, P_2 showed the highest nitrogen uptake (47.36 kg ha^{-1}), which was identical to P_3. Oppositely, the lowest nitrogen uptake (37.25 kg ha^{-1}) was recorded in the P_0 treatment where no fertilizer was applied.

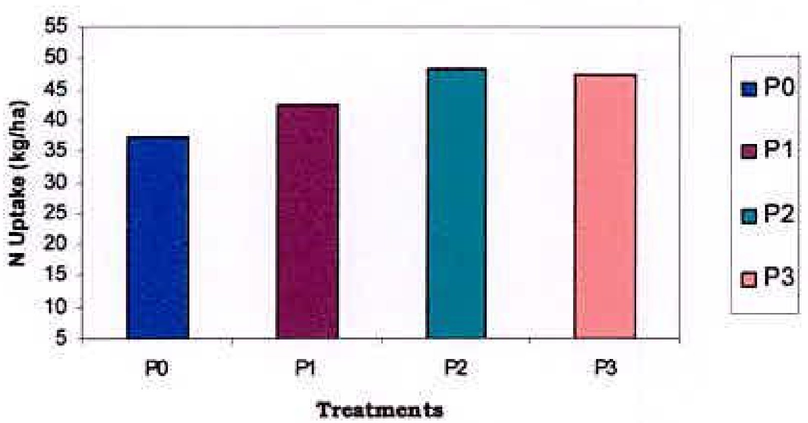

Fig.6 Effect of phosphorus on N uptake by BARI bushbean-2

4.8.2 Phosphorous uptake

There was a significant variation was observed in phosphorous uptake in the stover of BARI bushbean when different doses of phosphorous were applied (Table 10). Among the different doses of phosphorous the highest phosphorous uptake (12.54 kg ha^{-1}) was recorded in P_2, which was statistically comparable to P_3 and significantly higher than P_1. On the other hand, the lowest phosphorous content (9.10 kg ha^{-1}) was recorded in the P_0 treatment where no phosphorous was given. Singh and Malik (1990) carried out an experiment in green house using bushbean as the test crop with different levels of P and S. They opined that phosphorus and S uptakes by plant increased with their addition

Table10. Effect of phosphorus on N and P uptake by BARI bushbean-2

Treatments	Nutrient uptake by stover (kg ha^{-1})	
	Nitrogen	Phosphorous
P_0	37.25 c	9.10 c
P_1	42.31 b	10.67 b
P_2	48.22 a	12.54 a
P_3	47.36 ab	12.21 a
CV%	5.78	6.83
Significan Level	*	*

In a column figures having similar letter(s) do not differ significantly.
P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}
NS = Non significant, *= 1% level of significant, **= 5% level of significant

4.9. Interaction effect of Nitrogen and Phosphorus on N and P contents and their uptake by BARI bush bean-2

4.9.1. Nitrogen content

Combined application of different doses of nitrogen and phosphorous showed an insignificant effect on the N content in the stover of bush bean (Table-11). The highest N content in the stover of bushbean crop (1.33 %) was recorded in the treatment combination of N_2P_3 (120 kg N ha^{-1} with 90 kg P_2O_5 ha^{-1}). On the other hand, the lowest N content (1.17 %) was recorded in N_0P_0 (0 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1}).

4.9.2. Phosphorous content

Combined effect of different doses of nitrogen and phosphorous showed an significant effect in respect of P content in the stover of bush bean (Table 11). The highest P content in the stover of bushbean crop (0.35%) was recorded in the treatment combination of N_2P_3 (120 kg N ha^{-1} with 90 kg P_2O_5 ha^{-1}). On the other hand, the lowest P content (0.26 %) was recorded in N_0P_0 (0 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1}).

Table11. Combined effects of Nitrogen and Phosphorus on N and P contents and their uptake by BARI bush bean-2

Treatments	Nitrogen		Phosphorus	
	Content (%)	Nutrient uptake by stover (kg ha^{-1})	Content (%)	Nutrient uptake by stover (kg ha^{-1})
N_0P_0	1.17	34.51 f	0.26 e	7.67 d
N_0P_1	1.20	40.56 cd	0.29 d	9.80 fd
N_0P_2	1.18	40.24 cd	0.31 ed	10.57 f
N_0P_3	1.23	46.36 abc	0.32 bc	12.06 cd
N_1P_0	1.20	37.80 e	0.33 abc	11.39 de
N_1P_1	1.22	42.09 bc	0.33 abc	11.38 de
N_1P_2	1.24	44.39 abc	0.31 cd	11.09 de
N_1P_3	1.27	50.55 ab	0.32 bc	12.73 bc
N_2P_0	1.21	39.81 cd	0.27 e	8.88 fg
N_2P_1	1.26	43.85 abc	0.32 bc	11.13 de
N_2P_2	1.28	52.48 ab	0.34 ab	13.94 ab
N_2P_3	1.33	53.20 a	0.35 a	14.00 a
CV%	3.08	5.78	5.48	6.83
Significant Level	NS	*	**	*

In a column figures having similar letter(s) do not differ significantly.
N_0= 0 kg ha^{-1}, N_1= 60 kg ha^{-1}, N_2= 120 kg ha^{-1}
P_0= 0 kg ha^{-1}, P_1= 30 kg ha^{-1}, P_2= 60 kg ha^{-1}, P_3= 90 kg ha^{-1}
NS = Non significance, *= 1% level of significance, **= 5% level of significance.

4.9.3 Nitrogen uptake

The effect of combined application of nitrogen and phosphorous showed marked differences in respect of N uptake in the stover of bush bean (Table-11and Appendix X). The N uptake by stover ranged from 34.51 kg ha^{-1} to 53.20 kg ha^{-1} The highest N uptake in the stover of bushbean crop (53.20 kg ha^{-1}) was recorded in the treatment combination of N_2P_3 (120 kg N ha^{-1} with 90 kg P_2O_5 ha^{-1}) and the lowest N uptake (34.51 kg ha^{-1}) was recorded with N_0P_0 (0 kg N ha^{-1} with 0 kg P_2O_5 ha^{-1}) treatment combination. Srinivas and Naik (1990) conducted field trials to study the nitrogen uptake of French bean as influenced by nitrogen and phosphorus fertilization. They applied N at 0, 40, 80 and 120 kg/ha and P_2O_5 at 0, 40 and 80 kg ha^{-1} and found that both N and P application increased plant growth and nutrient uptake.

4.9.4 Phosphorous uptake

Combined treatments of various doses of nitrogen and phosphorous showed significant effect on the P uptake in the stover of bushbean (Table-11 and Appendix XI). Phosphorus uptake by stover was ranged from 7.67 kg ha^{-1} to 14.00 kg ha^{-1} .The lowest P uptake of the crop (7.67 kg ha^{-1}) was recorded in the control treatment i.e., N_0P_0 (0 kg N and 0 kg P_2O_5 ha^{-1}) treatment. On the other hand, the highest P uptake (14.00 kg ha^{-1}) was recorded in N_2P_3 (120 kg N ha^{-1} with 90 kg P_2O_5 ha^{-1}) treatment. This result agreement with Srinivas and Naik (1990). and that of the present one are identical.

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER – V

SUMMARY AND CONCLUSIONS

A field experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2007-2008 to find out the effect of nitrogen and phosphorus on the growth and yield of BARI bush bean-2. The experiment consisted of two factors namely, (i) three different levels of nitrogen (N) viz., 0, 60 and 120 kg N ha^{-1} and (ii) four levels of phosphorus (P_2O_5) viz., 0, 30, 60 and 90 kg P_2O_5 ha^{-1}. The experiment consisted of 12 treatment combinations and laid in the Randomized Complete Block Design (RCBD) with three replications.

The size of each unit plot was 5 m^2 (2.5m x 2m) and the seeds of bush bean were sown on 22 November, 2007. The sample plants were randomly selected from each plot to recorded data on green pod and seed yield and yield contributing characteristic. The collected data were statistically analyzed and the difference between means was evaluated by LSD.

The results of the study revealed that most of the growth and yield contributing parameters were significantly governed by nitrogen. There was an increasing significant response on most of the parameters to the increasing levels of nitrogen up to 120 kg N ha^{-1}. The maximum plant height (45.39 cm), number of pods $plant^{-1}$ (19.68), the highest pod length (15.10 cm), number of seeds pod^{-1} (5.93), pod weight $plant^{-1}$ (42.45 g), pod yield t ha^{-1} (16.63 kg), seed yield (2.85 t ha^{-1}) and stover yield (3.72 t ha^{-1}) were obtained from the application of 120 kg N ha^{-1}. Plant population m^{-2} was insignificantly influenced by N treatment. The highest weights of 1000 seed (244.3 g) was achieved from 120 kg N ha^{-1}.

Phosphorus also played important role on the growth, yield and yield contributing characters of bush bean. The results of the experiment demonstrated that of parameters were significantly increased by different levels of phosphorus except plant height and plant population m^{-2}. The maximum plant height (41.54 cm) at harvest and number of seeds pod^{-1} (5.63) were obtained from 90 kg P_2O_5. The highest pod length (14.73 cm) and plant population m^{-2} (24.83) were recorded from the treatment of 60 kg P_2O_5 ha^{-1}. The maximum pod weight $plant^{-1}$ (48.54 g), pod yield ha^{-1} (14.89 t), 1000 seed weight (243.2 g), seed yield ha^{-1} (2.79 t) and stover yield ha^{-1} (3.92 t) were also obtained from 60 kg P_2O_5 ha^{-1}. Plant height and plant population m^{-2} were insignificantly influenced by P_2O_5 treatment.

The combined effects of nitrogen and phosphorus insignificantly influenced all the growth and yield contributing attribute of bush bean except seed yield, However, the highest pod length (17.29 cm), number of pod $plant^{-1}$ (23.04), pod weight $plant^{-1}$ (48.30 g), number of seeds pod^{-1} (6.15), 1000 seed weight (260.12 g), seed yield (3.09 t ha^{-1}) at harvest, respectively were obtained form the treatment combination N_2P_2 (120 kg N with 60 kg P_2O_5 t ha^{-1}). The highest plant height (48.20 cm) and plant population m^{-2} (26.10) were recorded from N_2P_3 treatment (120 kg N ha^{-1}, 90 kg $P_0O_5ha^{-1}$). It was noted for most of the observations that lowest results observed in control (N_0P_0) treatment combination (N_0P_0).

The highest green pod yield of 18.90 t ha^{-1} and Stover yield 4.10 t ha^{-1} were obtained from the treatment combination of N_2P_2 (120 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}).

In case of nutrient contents and uptakes, statistically significant variation was observed N and P when different doses of nitrogen and phosphorous fertilizers were applied. Among the different doses of nitrogen the highest N & P content (1.27 % and 0.323 %) were recorded in N_2 and N_1, treatments respectively.

On the other hand, the lowest N and P content (1.20 % & 0.298%) were noted in the N_0 treatment. Among the different doses of nitrogen the highest N and P uptake (47.24 and 11.83 kg ha^{-1} respectively) were recorded in N_2 treatments.

Among the different doses of phosphorous the highest N and P content (1.28 % & 0.33 %) and the highest N and P uptake (48.22 and 12.54 kg ha^{-1}) were recorded in the P_3 and P_2 treatments, respectively. Among the combined treatments of nitrogen and phosphorous the highest N and P content (1.33 % and 0.35 %) were recorded both in N_2P_3 treatment whereas the highest N and P uptake (53.20 and 14.00 kg ha^{-1}) were recorded in the treatment combination of N_2P_3 treatments, respectively.

From the above results it may be concluded that both nitrogen and phosphorus mascularly governed on the pod yield of BARI bushbean-2 when applied at the rate of 120 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}. However, the maximum yield was obtained with the highest dose of N such as 120 kg N/ha. The potential for further increase yield with an enhanced N rate may be investigated. In addition, effective stain of rhizobium could be developed for nodulation N fixation and bumper yield of bush bean under Bangladesh conditions.

CHAPTER VI

REFERENCES

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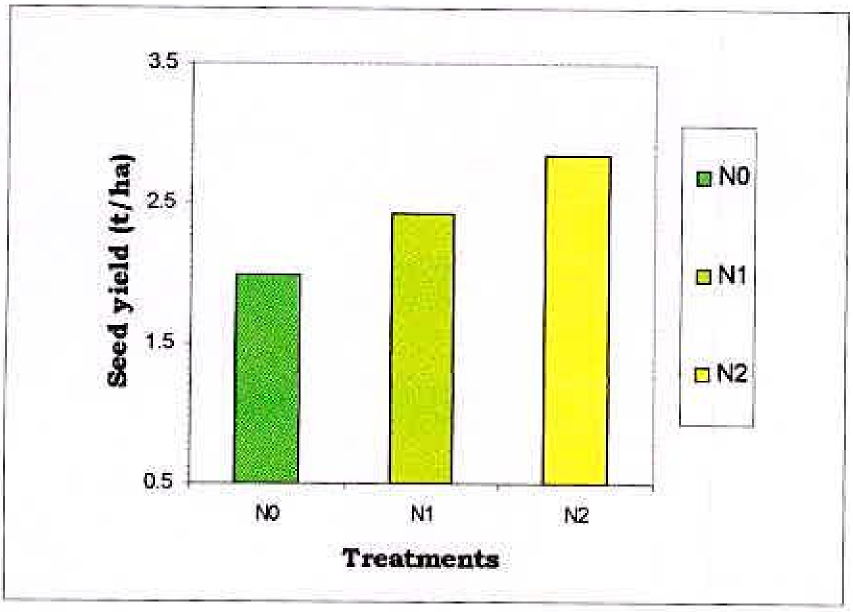
APPENDICES

Appendix

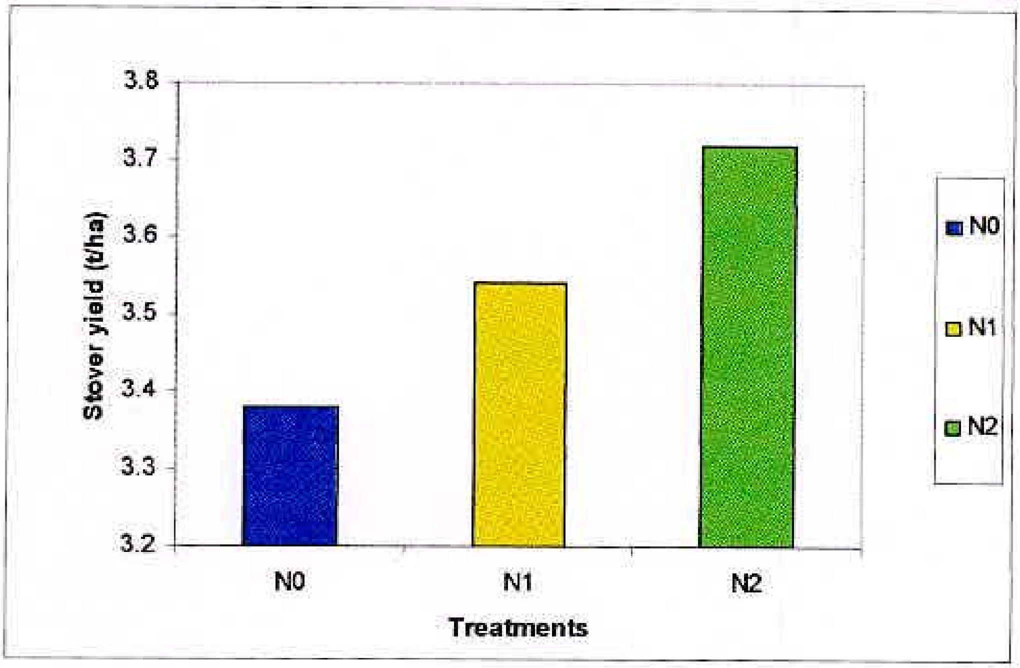
Appendix Table-I: Monthly average of temperature, relative humidity and sunshine hour of the experimental site during the period from 17 November 2007 to February 2008.

Month	Temperature (Maximum)	Temperature (Minimum)	Humidity (%)	Precipitation (mm)	Potential Evapotranspiration (mm day^{-1})	Solar radiation	Average sunshine (Hours)
October	31.51	24.13	85.00	168	3.612	16.61	172.0
November	30.20	20.13	83.30	31	2.966	15.364	193.6
December	26.60	13.5	81.00	9	2.43	14.089	208.6
January	25.40	12.93	78.00	7	2.387	14.766	213.2
February	25.30	14.2	73.68	7	2.37	14.866	247.6

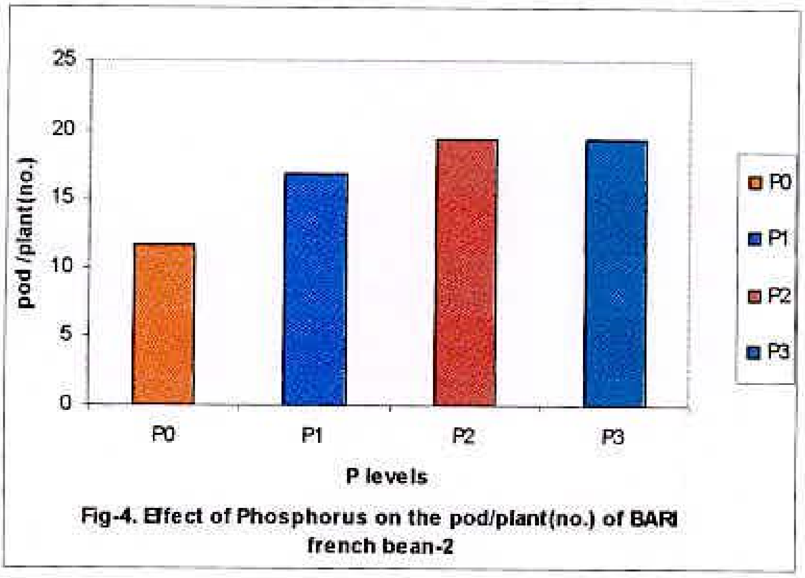
Source: Bangladesh Meteorological Department (Climate division), Dhaka.



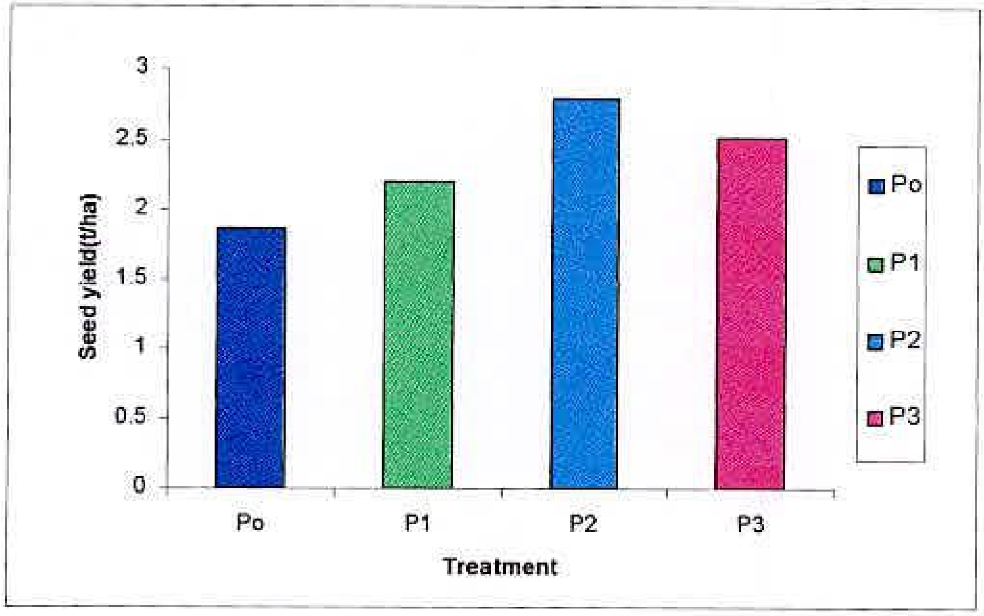
Appendix Fig.-I. Effect of Nitrogen on seed yield (t/ha) of BARI frenchbean-2



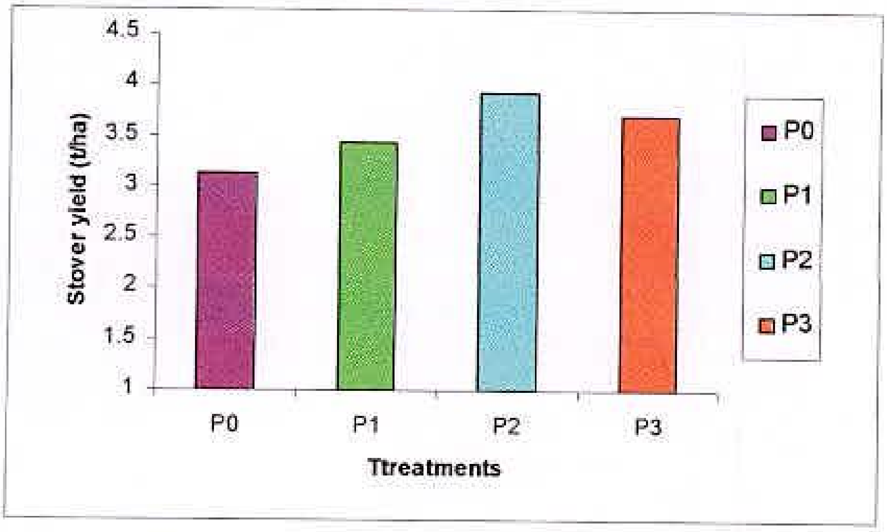
Appendix Fig.-II Effect of Nitrogen on stover yield of BARI frenchbean-2



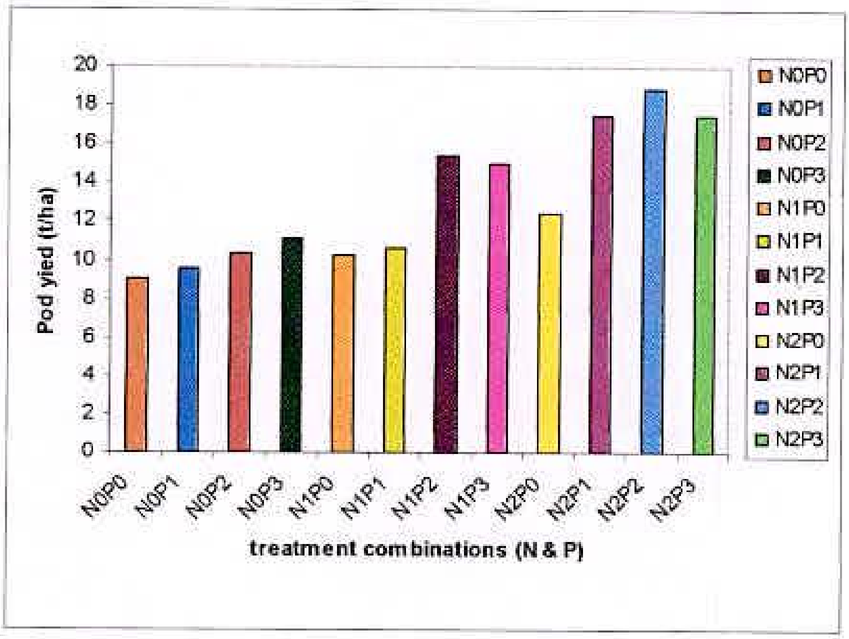
Appendix Fig.-III. Effect of Phosphorus on the pod/plant of BARI french bean-2



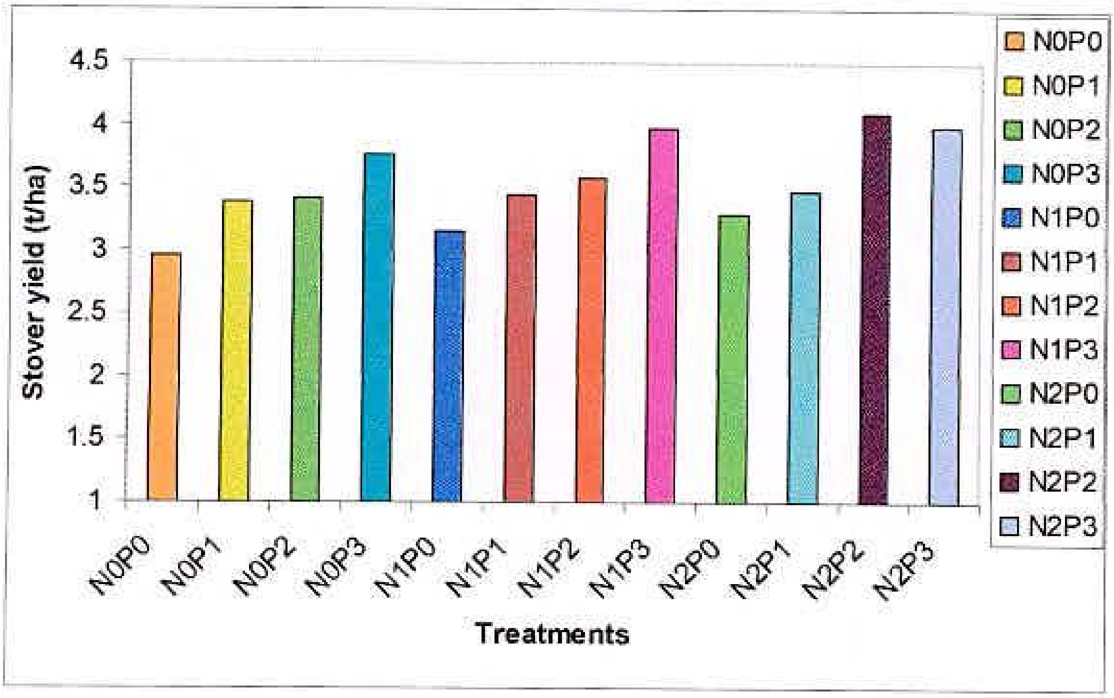
AppendixFig.IV Effects of phosphorus on the seed yield (t/ha) of BARI frenchbean2



Appendix Fig.-V Effects of phosphorus on the stover yield of BARI frenchbean-2



Appendix Fig.-VI Effect of N & P treatment combinations on the pod yield (t/ha) of BARI frenchbean-2



Appendix Fig.-VII Interaction effect of nitrogen and phosphorus on the stover yield of BARI frenchbean-2

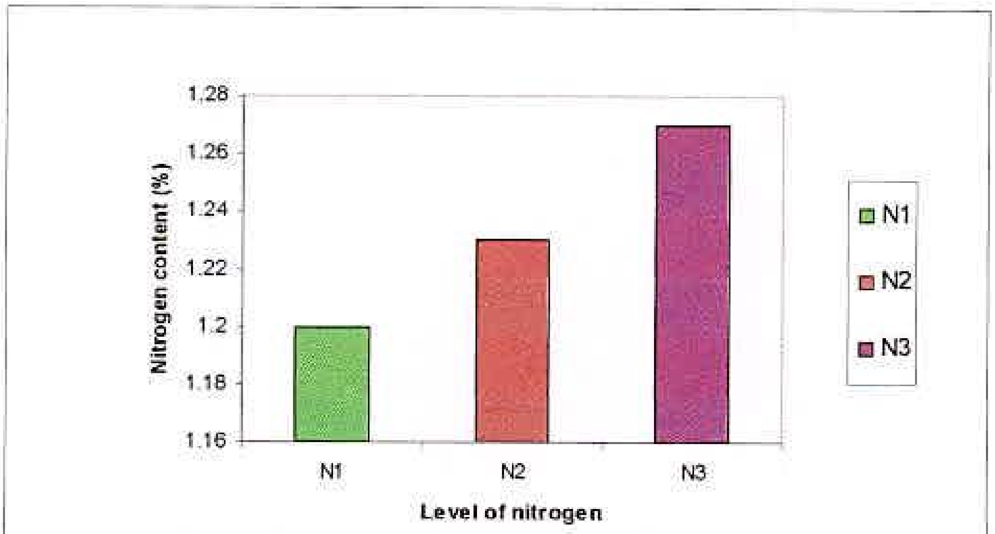


Fig.8 Effect of nitrogen on N contents by BARI bushbean-2

Appendix Fig.-VIII. Effect of Nitrogen on N content by BARI bushbean-2

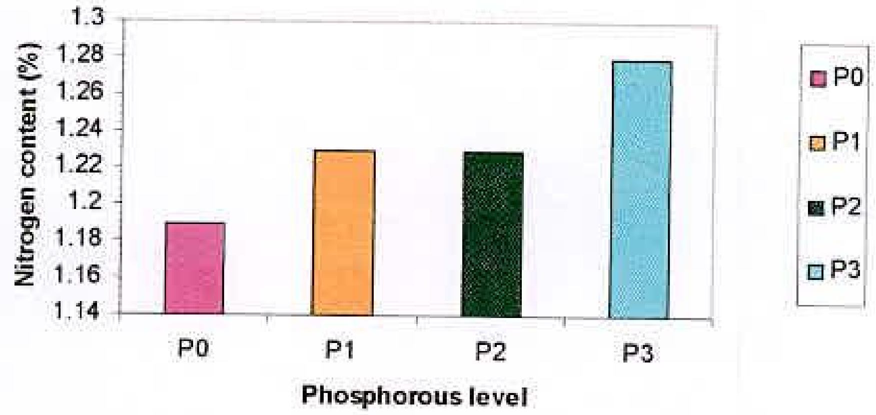
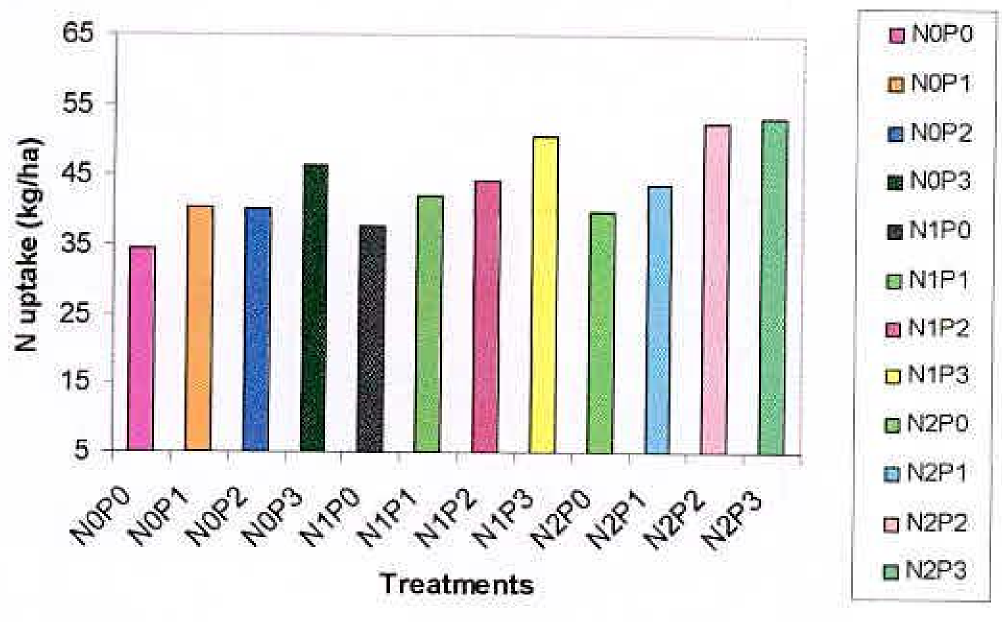
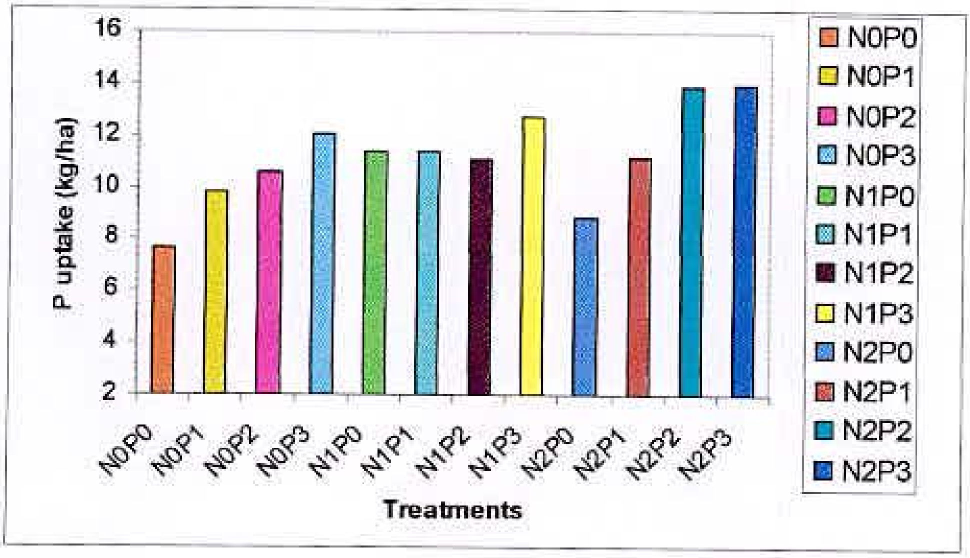


Fig.10 Effect of phosphorous on nitrogen content of BARI bushbean-2

Appendix Fig.-IX Effect of Phosphorus on nitrogen content of BARI bushbean-2



Appendix Fig.-X Combined effect of Nitrogen and Phosphorus on N uptake by BARI bushbean-2



Appendix Fig. -XI Combined effect of Nitrogen and Phosphorus on P uptake by BARI bushbean-2