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

By

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CERTIFICATE

This is to certify that the thesis entitled, "*EFFECT OF NITROGEN AND PHOSPHORUS APPLICATION ON THE GROWTH AND YIELD OF BUSH BEAN (Phaseolus vulgaris L.)*" Submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in Partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE (M.S) in SOIL SCIENCE* embodies the result of a piece of *bona fide* research work carried out by *SHAMIMA NASRIN. Registration No. 23982/00213* 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 available of during the course of this investigation has been duly acknowledged by her.

Dated: 28.12.05
Place: Dhaka, Bangladesh

(Mst. Afrose Jahan)
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Dedicated To My

Beloved Parents

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ABSTRACT

An experiment was carried out during December 2004 to March 2005 to study the effect of nitrogen and phosphorus on the growth and yield of bush bean at research field of Sher-e-Bangla Agricultural University, Dhaka. Treatments consisted of three levels of N viz., 0, 20 and 40 kg/ha and four levels of phosphorus viz., 0, 50, 75 and 100 kg/ha. There were 12 treatment combinations. The experiment was laid out in RCBD with three replications.

The results of the experiment revealed that most of the growth parameters i.e. plant height, plant population as well as yield attributes, viz., pods/plant and grains per pod significantly influenced by different levels of nitrogen and here the highest at 40 kg N/ha. Different levels of phosphorus also significantly exhibited the same trend as shown by nitrogen in respect of almost all parameters.

In this experiment, the highest levels of nitrogen 40 kg/ha produced the highest green pod yield (16.56 t/ha) and seed yield (2.71 t/ha). While crop fertilized with 75 kg P_2O_5 /ha gave pod 15.35 t/ha pod and seed yield 2.58 t/ha.

The combined effect of nitrogen and phosphorus was also significant. The highest green pod yield (18.61 t/ha) was produced from the treatment combination of 40 kg N/ha with 75 kg P_2O_5/ha and seed yield (2.96 t/ha) was produced from the treatment combination of 40 kg N/ha with 50 kg P_2O_5/ha. It was lowest at control.

The economic analysis showed that the highest net return (Tk 168533) and benefit cost ratio (2.52) were obtained from the treatment combination of 40 kg N/ha with 75 kg P_2O_5/ha.

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Chapter 1

Introduction

INTRODUCTION

Bush bean or French bean (*Phaseolus vulgaris*_L.), a vegetable crop belonging to the family leguminosae and sub family papiolionaceae which originated in the Central and South America (Swiader *et al.*, 1992). It is also known as kidney bean, snap bean, pinto bean, green bean, raj bean, navy bean, pole bean, wax bean, string bean and bonchi (Duke, 1983; Salunkhe *et al.* 1987; Tindall, 1988). In Bangladesh, bush bean is mainly used as green vegetable.

It is widely cultivated in the temperate and subtropical regions and also in many parts of the tropics (Perseglove, 1987). French beans are grown intensively in five major continental areas: Eastern Africa, North and Central America, South America, Eastern Asia and Western and South Eastern Europe. It is more suitable as a winter (*Rabi*) crop in the north eastern plants 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 (FAO, 2000). Brazil is the largest bush bean producing country in the world. In Bangladesh there is no statistics about the area and production of this crop. It is not new crop in or country, and is cultivated in Sylhet, Cox's Bazar, Chitlagong Hill Tracts and some other parts of the country in a rather limited scale.

Immature pods are marketed fresh, frozen or canned. The dry seeds also provide hay, silage and green manures. After harvest, plants can be fed to cattle, sheep and horses. Its edible pods supply protein, carbohydrate, fat,

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). 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).

Production of bush bean depends on many factors such as quality of seed, variety, plant spacing, fertilizer and proper management practices.

Bush bean shows high yield potential, but unlike other leguminous crops it does not nodulate with the native rhizobia (Ali and Kushwaha, 1987).

French bean or bush bean is a short durated crop and thus, yield per day is comparatively high, it can fit well in intercropping with other crops such as wheat, maize, sunflower sugarcane (Francis *et al.*, 1977). Various problems, however, hamper Bush bean production in Bangladesh. Fertilizers specially nitrogenous and phosphatic are the most critical input for increasing crop production and had been recognized as the central element or agricultural development (Mukhopadhyay *et al.*, 1986).

Deficiency of phosphorus is now considered as one of the major constraints to successful production of legumes and upland crops in Bangladesh (Islam and Noor, 1982). The most obvious effect of phosphorus is on the root development, particularly of the lateral and fibrous rootlets that 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 increased 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 per plant and seed yield per pod 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 and effects 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 objectives.

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

ii) To find out the best combination of nitrogen and phosphorous for maximizing the productions of bush Bean.

Chapter 2

Review of Literature

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, a 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 production. It encourages vegetative growth and increases leaf area of plants, which helps in photosynthetic activity. It stimulates root growth and development of the plant. Further more 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.

Prajapati *et al.* (2004) conducted an experiment in Sardar krushinagar, Gujarat, India, to studies in nutrient uptake and yield of French bean as affected by weed control methods and nitrogen levels (0, 40, 80 or 120 kg/ha) on the nutrient uptake and yield of *Phaseolus vulgaris* (cv, DPR- 86-6-4), highest n uptake (44.75 kg/ha), P uptake (20.53 kg/ha), K uptake (42.65 kg/ha), grain yield (1211.24 kg/ha), straw yield (2054.33 kg/ha), protein yield (241.20 kg/ha), net returns (12795 rupees/ha) and cost benefit ratio (1:2.73),

Among the N rates, 120 kg/ha recorded the greatest N uptake (56.70 kg/ha), P uptake (18.47 kg/ha), K uptake (37.34 kg/ha), grain yield (1091.77 kg/ha), straw yield (1932.35 kg/ha), protein yield (228.39 kg/ha), net return (10816 rupees/ha) and cost benefit ratio (1:2.44).

Vishwakarma *et al.* (2002) conducted an experiment to determine the response of two French bean (*Phaseolus vulgaris*) cultivars to different nitrogen application rates-0, 30, 60, 90, kg/ha and found that the growth, yield attributes and yield (grain and stoves increased with increasing rates of nitrogen upto 90 kg/ha.

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

Chaudhari *et al.* (2001) conducted an experiment in Nagpur India to study the nutrient management of French bean. They reported that application of nitrogen significantly increased the plant height, pod number and grain yield per plant in French bean.

Rahman (2001) conducted an experiment at 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 and found that plant height, number of branches per plant, green pod length, individual pod weight, pods per plant and green

pod yield per hectare were significantly influenced by higher dose of nitrogen.

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 of CIAT *Rhizobium* isolates 384, 274, 632 and 23 kg N/ha were 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 Jadhav (1995) reported that *Rhizobium* (*Rhizobium phaseoli*) inoculation and nitrogen significantly increased the seed yields and mineral contents, crude fat, crude fibre and iron.

Ravi Nandan and Prasad (1998) reported the response of irrigation and nitrogen fertilization on French bean (*Phaseolus vulgaris*). They observed that plant height, branches per plant, leaves per plant and seed yield increased due to increase in nitrogen level from 40 to 120 kg N/ ha. Calvache *et al.* (1997) also reported that applied N significantly increased seed yield, pod number per plant, seeds per pod and harvest index in French bean.

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. Application of 120 kg N/ha did not result in any further increase in yields compared with the application of 90 kg N/ha. On the other hand, Durge *et al.* (1997) found the highest yield of French bean with the application of 150 kg nitrogen per hectare.

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

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

Dahatonde *et al.* (1992) conducted an experiment to study the effects of irrigation regimes, pan evaporation ratio and nitrogen levels on growth and yield of French bean. They obtained higher grain yield of 0.92 t/ha with 3 irrigations. In case of nitrogen fertilization, the highest grain yield of 0.88 t/ha was found when 120 kg N/ha was applied. 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 were optimum (Leelavathi *et al.*1991).

Srinivas and Naik (1990) reported that the growth and yield of French bean were influenced by nitrogen and phosphorus fertilization. In their trial, the crop received N at 0, 40, 80, 120 and 160 kg/ha and they concluded that N application increased plant growth, nutrient uptake and yield of green pods.

Hegde and Srinivas (1989) conducted a field trial to find out the effect of nitrogen and irrigation on the yield of French bean. Nitrogen was applied at 0, 40, 80 or 120kg N/ha and the crop was irrigated at 4 soil metric potentials. The green pod yield was the highest (124.3-132.3 q/ha) at the highest N rate (120 kg/ha). Similarly Singh *et al.* (1990) reported that N-fertilization and irrigation in French bean increased the number of pods per plant and 100 seed weight with increase in nitrogen level.

Hamid (1988) reported that N and carbofuran increased leaf area and N content, net assimilation rate (NAR), most yield components and seed yield of *Vigna radiata* cv. Muborik grown in a polythene green house. He also reported that in field condition increase attribute to use of urea sprays were some what greater than those resulting from carbofuran sprays.

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

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

Katock *et al.* (1983) obtained the maximum nodule number and nodule weight per plant with 30 kg N/ha in French bean. Singh *et al.* (1981) stated that seed yields of *Phaseolus vulgaris* were increased significantly by application of 20 kg N and 90 kg P_2O_5/ha.

Abu-Shakra and Bassiri (1972) obtained decreased number of nodule per plant due to N-application. Bread and Hoover (1971) found that plant growth without N showed yellowing in early growth, but became dark green later in the season and showed no significant difference in yield. Nodule number was reduced with addition of N at planting but not at flowering.

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

Phosphorus is an important element for increasing crop production. It has pronounced effect on the number of flower and pod formation that progressively increased the yield of French bean.

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, 40, 80, or 120 kg N/ha and 0, 60 of 120 kg P/ha. They observed that yield and yield

component values increased with increasing N rote, but 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 and observed that pod yield was highest (07.69 t/ha) with 120 kg P/ ha.

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 per plant and seeds per pod), seed yield and the N and P uptake. The response of applied P was linear upto 40 kg P/ha.

Saxena *et al.* (1996) applied P_2O_5 at the rates of 0, 30 and 60 kg/ha and K_2O at the rates of 0, 20 or 40 kg/ha. 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 per plant, relative moisture content in leaves, number of branches, number of pods, seed yield per plant, 1000 seed weight and harvest index. Application of 60 kg P_2O_5 gave the highest seed yield (0.95 t/ha). On the other hand Tomar *et al.* (1991) obtained the highest seed yield with the application of 30 kg P_2O_5/ha and rates beyond that did not give further significant increase in yield. However applied P increased the nodule number per plant from 26 to 51, seed and pod number per plant and 1000 seed weight.

Singh and Malik (1990) carried out an experiment in green house using berseem as 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 berseem increased with S and P application.

Noor *et al.* (1990) obtained highest yield from fertilization with 60 kg P_2O_5/ha in lablab bean. They also suggested that the available phosphorus of the experimental soils was below the critical level (1.25 micro gram/ml) 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).

Sairam *et al.* (1989) reported that phosphorus application at the rate of 90 kg/ha 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 on reproductive growth and number of pods per plant, weight of pods per plant, weight of grain per plant, number of grain per pod, number of grain per plant, grain yield per plant and harvest index. They also reported that phosphorus induced early in flowering and maturity.

Brar (1987) conducted an experiment in Haryana, India and found increasing number and size of nodules with the application of phosphorus in moong bean.

Nandal *et al.* (1987) reported that application of 90 kg P_2O_5/ha significantly increased the dry matter accumulation in soybean. But in case of arhar crop, application of 60 and 90 kg P_2O_5/ha only increased the dry matter production significantly over control.

Prabhakar *et al.* (1987) reported that green pod yield of French bean increased with phosphorus fertilization upto 75 kg/ha.

Working with soybean [*Glycine max* (Linn)] Nimje and Seth (1987) stated that grain and straw yield increased significantly with phosphorus application upto 35.2 kg per hectare. Dry matter per plant, primary branches per plant, pods and grain weight per plant increased with the increase of phosphorus. Phosphorus application also increased the number and dry weight of nodule per plant which was attributed to the possible higher photosynthetic activity in soybean plant and thus a better supply of carbohydrate to *Rhizobium* bacteria in soil and consequently higher nodulation (Raikera and Mishra, 1988).

Ahmed *et al.* (1984) found significant increase in grain and straw yield of mung bean with increasing application of phosphorus upto 60 kg/ha. 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 per plant, 100 grain weight were also favourably influenced by the addition of phosphorus upto 60 kg P_2O_5/ha.

Addition of phosphorus and zinc upto 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. Effect of nitrogen and phosphorus on the growth and yield of bush bean

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) and phosphorus (0, 20, 40 or 60 kg/ha) 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 dose of nitrogen and phosphorus. Application of 120 kg N/ha produced significantly higher number of pods per plant, weight of seed per plant, number of seeds per pod and seed yield. Whereas 160 kg N/ha significantly reduced seed yield. The highest value on the above yield attributes were reduced with 60 kg P_2O_5/ha. The combination of 120 kg N, 60 kg P_2O_5 along with 60 kg K_2O/ha gave highest seed yield.

A field experiment was conducted by Chavan *et al.* (2000) to study the uptake of NPK and quality of French bean cultivars (Arka-Komal and

Waghya). Nitrogen was applied with 3 rates of N (0, 25 and 50 kg/ha) and 3 rates of P (0, 25 and 75 kg/ha). Seeds were evaluated for N, P and K contents, total dry matter and protein production. The highest P uptake (6.3 kg/ha) by seeds and straw was reported in both Waghya and Arka Komal. Waghya recorded the highest total dry matter (17.2 q/ha), seed protein production (128.0 kg/ha) and N and K uptake (31.7 and 12.0 kg/ha respectively). The highest total P uptake (8.5 kg/ha) was recorded from the highest N rate (50 kg/ha). Total P uptake increased linearly with increases in P rates.

Arya *et al.* (1999) conducted an experiment to investigate the effect of N, P and K on French bean. They used different doses of NPK combinations. It was concluded that N promoted growth and suggested that 25 kg N, 75 kg P_2O_5 kg and K_2O/ha was the best combination in terms of economics and seed yield.

Singh and Behera (1998) conducted an experiment at Keonjhar during winter season of 1991-1993 and revealed that application of 62.5 : 100: 100 kg N: P_2O_5 : K_2O/ha produced significantly the maximum green pod yield (133.63 q/ha) of Freach bean (*Phaseolus vulgaris* L.) with highest benefit cost ratio (1: 8.23).

Baboo *et al.* (1998) 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. Seed yield increased with the increase of fertilizers and it was higher with 120 kg N and 100 kg P_2O_5/ha.

Devender *et al.* (1998) conducted an experiment to study the effect of nitrogen and phosphorus on yield of French bean. Seeds/pod and seed yield increased significantly with the application of 15 kg N and 60 kg P_2O_5/ha.

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 per hectare gave higher grain yield of French bean.

Rana and Singh (1998) 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 and 0, 50 or 100 kg P_2O_5/ha. The mean increases in seed yield with 120 kg N/ha compared with 0, 40 and 80 kg N/ha were 66.6, 21.7 and 7.0%, respectively.

Sushant *et al.* (1998) conducted a field experiment at Uttar Pradesh in India to investigate the effect of irrigation, nitrogen and phosphorus on the seed yield of French bean and stated that application of nitrogen upto 100 kg/ha and upto 60 kg P_2O_5/ha significantly increased the yield attributes, yield and water use efficiency.

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.

Saxena and Varma (1995) studied the effect 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, leaves number, leaf area, fresh weight, dry weight, branches at harvest and yield significantly up to 120 kg N/ha. Interaction effect of nitrogen and phosphorus was noticed in leaves per plant. Nitrogen @120 kg and 120 kg P_2O_5/ha produced maximum leaves/plant. All the growth attributes were positively 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. Half of N, all the P and basal K_2O at 40 kg/ha were applied at planting and the remaining N applied, 25 days later. They found that both N and P application increased plant growth, nutrient uptake and yield of green pods. In another experiment Srinivas and Naik (1988) reported that pod yield increased with increasing fertilizer rate from 3927 kg/ha at zero N to 13167 kg/ha at 160 kg N/ha.

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

Srinivas and Rao (1984) conducted an experiment in Bangalore, India during *kharif* season and observed that 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_5/ha. However, the optimum combination was found to be 80 kg N and 123 kg P_2O_5/ha. Singh *et al.* (1981) reported that seed yields of *Phaseolus vulgaris* increased significantly with increasing N and P_2O_5. From the above it may be concluded that both nitrogen and phosphorus play an important role on vegetative growth and yield of French bean.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

An experiment was conducted at the research field in Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from December 2004 to March 2005 to find out the effect of N and P application on the growth and yield of bush bean (*Phaseolus vulgaris* L).

3.1 Experimental site

The experimental field is located at 90°335' E longitude and 23°774' N latitude at a height of I meter above the sea level.

3.2 Climate

The annual precipitation of the site is 2152mm and potential evapotranspiration is 1297 mm. The average maximum temperature is 30.34°C and average minimum temperature is 21.21°c. The average mean temperature is 25.17°C. The experiment was done during the *rabi* season . Temperature during the cropping period was ranged between 12.20°C to 29.2°C. The humidity varies from 73.52% to 81.2%. The day length was reduced to 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.

3.3 Soil

The soil of the experimental site lies in the agro-ecological zone of "Madhupur Tract" (AEZ NO. 28), Deep Red Brown Terrace soil, belong to "Tejgoan" cultivated series. Topsoil is silty clay loam in texture. Organic matter content is very low (0.82%) and soil pH varies from 5.80-6.00.

3.4 Soil analysis

Soil pH was determined by a glass electrode pH meter in soil water suspension having soil: water ratio 1:2.5 as described by Jackson (1958).

Total Nitrogen was determined by Micro Kjeldahl method following concentrated sulfuric acid digestion and distillation with 40% sodium hydroxide. The ammonia evolved was collected in 4% boric acid indicator solution and was titrated against 0.02 N H_2SO_4 (Black, 1965). The extractant 1N KCl was used for determination of NH_4-N (Hunter, 1980). The concentration in the soil extract was read at 630 nm wave length in a double beam spectrophotometer (Model 170-30. Ititachi).

Organic carbon was determined by Turin's method (1980). Cation exchange capacity of soil was estimated using Schollenberger's (1980) method. Ammonium aceted solution was added to air-dried soil and allowed to stay over night. After centrifugation the supernatant was decentated and this was repeated to allow the exchangeable cations to be exchanged from the soil particles with NH_4^+ cations. The soil was washed with 80% ethanol and was centrifuged. Finally 1M NaCl was added to the soil to extract ammonium absorbed on the exchanged site. The mixture was centrifuged at 3000 r pm and the supernatant was collected. An aliquot of the collected supernatant

was distilled and the distillate was finally titrated against N/50 H_2SO_4. The analytical results of the collected soil are presented in Table 1.

Table 1. Chemical properties of the soil of experimental site

Soil properties	Analytical data
Soil pH	6.00
Total N (%)	0.043
Organic carbon (%)	0.43
Available P (ppm)	23

3.5 Planting materials

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

The experiment was undertaken to study the effect of 3 different levels of nitrogen and 4 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) 20 kg/ha (N_1)
iii) 40 kg/ha (N_2)

Factor B: Levels of phosphorus

i) 0 kg/ha (P_0)
ii) 50 kg/ha (P_1)
iii) 75 kg/ha (P_2)
iv) 100 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 consisted of 12 unit plots. Thus the total numbers of plots were 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 3m × 4m. A distance of 0.75m between the plots and 1m between the blocks were kept.

3.7 Land preparation

The selected land for the experiment was first opened on 1st December, 2004 by a tractor. The land was well prepared with the tractor followed by harrowing and laddering up to a good tilth. All weeds and stubbles were removed and the land was finally prepared through addition of the basal doses of manure (CD) and potassium chloride (MP) or potash fertilizer.

3.8 Manuring and fertilization

Full amount of MP(80 kg/ha) and cowdung (5 t/ha) were applied as broadcast as basal dose and incorporated during final land preparation. Then the experimental plots were fertilized with N and P in form of urea and TSP

applied as per treatment of the experiment. The fertilizers were mixed thoroughly with the soil.

3.9 Sowing of seeds

Seeds of BARI Jhar sheem were sown on 7 December, 2004 following the spacing 30cm x 10cm. Two seeds were sown at each spot with a depth of 5.0 cm and the seeds were covered with fine soil by hand. Surrounding of the experimental plots three rows of beans was sown as boarder crops to protect the experimental crops from grazing by animals.

3.10 Gap filling

Seedlings were transferred to fill the gap where seeds failed to germinate. Seedlings of about 6 inches in height were transplanted from boarder rows with roots plunged 2 inches below the soil in hills preferably in the evening and then watering was done to protect the seedlings from wilting. All gaps were filled up within two weeks after germination of seeds.

3.11 Thinning of seedlings

After 15 days of sowing one healthy plant at each spot was kept and the others were removed.

3.12 Weeding and mulching

Weeding and mulching were accomplished as and whenever necessary or kept the plots free from weeds for better soil aeration and to break the crust. It also helped in soil moisture conservation.

3.13 Irrigation

Four irrigation were given throughout the growing period by watering cane. The first irrigation was given at 30 days after planting followed by irrigation 15 days after first irrigation respectively.

3.14 Pest management

The crop was protected from the attack of insect pest by spraying of Bavistin, Malathion 57EC, Sumithion, tilth. Malathion 57 EC at the rate of 560 ml/ha at an interval of 15 days. Some plots were attacked by bean common Mosaic virus (BCMV) which is an important disease of bush bean. The affected plants were removed from the plots to control this disease.

3.15 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 harvest was done at 55 days after sowing (DAS) and these plots. 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.

3.16 Collection of data

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

3.16.1 Plant height

The plant height was recorded at 25.45, 55 (DAS) and at harvest by placing a meter scale from ground level to the tip of the largest leaf. Plant height of 5 randomly sample plants were recorded and mean was calculated in centimeter (cm).

3.16.2 Plant population

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

3.16.3 Number of pods per plant

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

3.16.4 Length of green pod

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

3.16.5 Number of seeds per pod

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

3.16.6 Weight of pods per plant (g)

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

3.16.7 Pod yield

Green pods were harvested from each unit 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 and expressed in kilogram (Kg). The green pod yield per plot was finally converted to yield per hectare and expressed in ton (t).

3.16.8 Number of mature seeds per pod

Number of mature seed per pod were recorded from five randomly selected pods and the mean value was calculated.

3.16.9 Seed weight per plot (g)

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

3.16.10 Seed weight per hectare (t)

Seed yield of plot was converted into yield in ton per hectare.

3.17 Soil analysis

3.17.1 Determination of soil pH

Soil pH was determined using a glass electrode pH meter, soil water ratio being 1:2.5 as described by Jackson (1967).

3.17.2 Determination of organic mater

Soil organic carbon was determined volumetrically by wet oxidation method using $K_2Cr_2O_7$ and H_2SO_4 and $FeSO_4$ solution were used for titration as outlined by Jackson (1967). Organic mater content was calculated by multiplying the percent organic carbon with the conventional "Van Bemmelen Factor" of 1.723 (Piper 1950).

3.17.3 Determination of total nitrogen

Total nitrogen in soil was determined by the micro Kjeldahl method by digesting with H_2O_2, concentrated H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$:Se=10:1:0.1) and distilling with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 NH_2SO_4 (Page *et al* 1989).

3.17.4 Determination of available Phosphorus

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ at pH 8.5 the phosphorus in the extract was then determined by developing the blue colour $SnCl_2$ reduction of phosphomolybdate complex and measuring the colour colorimetrically at 660 nm (Olsen *et al* 1954).

3.18 Plant sample analysis

For chemical analysis of plant samples, five plants were collected randomly from each plot at harvest period and oven dried at 72^{0}C for 72 hours. Then dried plant samples were granded by a grinding machine. The plant sample of different treatments were analyzed for N and P. Nitrogen content was estimation through microkjeldahl following colorimeteric

method (Yamakawa, 1993), phosphorus by Vanadomolybdate method (Yamakawa, 1993).

3.19 Statistical analysis

The collected data on various parameters under study were statistically analyzed using MSTAT statistical package programme. The means for all the treatments were calculated and analysis of variances for all the characters were performed by F- variance test. The significance of different between pair of treatment means was evaluated by the least significant Difference (LSD) test (Gomez and Gomez, 1984).

3.20 Economic analysis

Economic analysis was done in order to find out the most profitable treatment combinations. Economic evaluation of different fertilizer combinations was performed through partial budgeting and dominance analysis followed by marginal analysis of the cost undominated treatments as suggested by Perrins *et al* (1979). Gross return and variable cost were calculated considering the following rates:

The interest was calculated @ 13% for six month and miscellaneous cost was considered as 5% of the total input cost. The value of one hectare of land was considered to be 2,50,000 Tk. Gross income was calculated on the sate of the marketable green pod of bush bean. The price of green pod in the market was assumed to be Tk. 15000/t.

Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

The experiment was conducted to observe the effect of different levels of nitrogen and phosphorus and their interaction effects on the growth and yield of bush bean have been shown in the tables, Figures and Appendices. The analysis of variances of different characteristics has been presented in Appendix II. The results of the experiment have been discussed under following headings.

4.1 Plant height

Different levels of nitrogen and phosphorus exhibited significant variation in respect of plant height of bush bean at different days after sowing (Appendix II). In all the dates of observation plant height gradually increased with increasing nitrogen level. At final harvest the maximum plant height (43.82 cm) was obtained from the plant grown with 40kg N/ha and the minimum (37.85 cm) was recorded from control treatment (Table 2). Rabi Nandan and Prasad (1998) observed that plant height increased with increasing N doses upto 120 kg/ha.

Plant height was also significantly influenced by the application of different doses of phosphorus at different growth stages (Appendix II). Plant height was gradually increased with the passing of time up to final harvest. At harvest the tallest plant (41.98 cm) was produced from the plant grown with 100 kg P_2O_5/ha where as smallest (39.83 cm) was found in zero phosphorus(Table 3). Similar results were reported by Rana and Singh (1998). They observed that application of phosphorus upto 100 kg P_2O_5/ha

significantly enhanced plant height. Ahmed *et al.* (1984) also reported similar result.

Plant height was significantly affected by the interaction between nitrogen and phosphorus (Appendix II). At harvest the maximum plant height (44.60 cm) was observed from the treatment combination N_2P_2 (40 kg N with 75 kg P_2O_5/ha) followed by 43.77 cm and 43.53cm produced from N_2P_0 and N_2P_1 treatment combinations respectively. The minimum plant height (35.27 cm) was obtained from control treatment (Table 4). The present result agreement with findings of Rana and Singh (1998).

4.2 Plant population/m^2

The number of plant population per square meter varied significantly due to response of different levels of nitrogen (Appendix II). The maximum number of plant population per square meter (25.50) were recorded at 40kg N/ha and minimum number of plant population per square meter (23.91) were found from the control treatment (Table 2).

Table 2. Effect of Nitrogen on the yield contributing characters of bush bean

Nitrogen kg/ha)	Plant height (cm)	Plant population/m^2	No. of pod /plant	Pod length (cm)	Pod weight /plant	Pod yield (t/ha)	No. of seeds/pod.	1000 seed wt.(g)	Seed yield/plot (kg)	Seed yield (t/ha)
N_0	37.85	23.91	13.22	14.85	48.57	10.04	5.13	225.00	2.65	2.23
N_{20}	41.342	24.67	13.24	16.58	66.93	13.62	5.35	228.50	2.94	2.42
N_{40}	43.83	25.50	3.26	17.51	85.26	16.56	5.85	230.75	3.23	2.71
LSD (0.05)	0.988	0.153	0.0655	0.488	0.065	0.100	0.088	1.955	0.037	0.046

Number of plant population per square meter also had significant variation due to the application of phosphorus. The highest number of plant population per square meter (24.78) which was found from the control (Table 3).

Table 3. Effect of phosphorus on the yield contributing characters of bush bean

Phosphorus (kg/ha)	Plant height (cm)	Plant population/m^2	No. of pod /plant	Pod length (cm)	Pod weight /plant	Pod yield (t/ha)	No. of seeds/pod.	1000 seed wt.(g)	Seed yield/plot (kg)	Seed yield (t/ha)
P_0	39.83	24.78	13.2	16.29	62.10	10.76	5.13	223.33	2.65	2.17
P_{50}	40.66	24.55	13.62	15.93	68.25	13.51	5.44	227.00	2.94	2.48
P_{75}	41.55	24.66	13.12	16.03	72.27	15.35	5.56	236.00	3.08	2.58
P_{100}	41.98	24.77	12.99	16.99	65.08	14.55	5.63	226.00	3.06	2.58
LSD (0.05)	1.142	0.177	0.075	0.564	0.415	0.115	0.102	2.258	0.043	0.053

The minimum number of plant population per square meter (24.55) was recorded at 50 kg P_2O_5/ha.

There was no significant interaction due to different levels of nitrogen and phosphorus on the number of plant population per square meter. The highest number of plant population per square meter was recorded from the treatment combination of N_2P_0 (40 kg N/ha with 0 kg P_2O_5/ha). The lowest number of plant population per square meter was obtained from the treatment combination N_0P_1 and N_0P_3 respectively.

4.3 No. of pods/plant

The number of pods per plant at different levels of nitrogen was found to be significant (Appendix II). The maximum number of pods per plant (13.26) was produced from the 40 kg N/ha. On the contrary, the control treatment produced the minimum number of pod (13.22) per plant (Table 2). It may be due to adequate supply of nitrogen to develop pod bearing branches. This result is in full agreement with Rana and Singh (1998). They reported that pods per plant increased with increasing dose of nitrogen (120 kg N/ha). Similar opinion was put forwarded by Calvanche *et al.* (1997) and Sa *et al.* (1982).

The result showed that there was also significant effect of phosphorus on the number of pods per plant (Appendix II). The number of pods per plant ranged from 12.99 to 13.62. The maximum number of pods per plant (13.62) was obtained from 50 kg P_2O_5/ha. The number of pods per plant was decreased at 75 kg P_2O_5/ha. The minimum number of pods per plant (12.99) was obtained from P_3 (100 kg P_2O_5/ha) (Table 3). This result is in conformity with the findings of Rana and Singh (1998).

The interaction effete of different levels of nitrogen and phosphorus on the number of pods per plant was found to be statistically significant (Appendix II). The maximum number of pods per plant (13.90) was obtained from the treatment combination 40 kg N/ha with 50 kg P_2O_5/ha. The minimum pod number (12.20) was found N_2P_3 (40 kg N/ha with 100 kg P_2O_5/ha) treatment combination (Table 4). Maximum number of pods per

plot was decrease at the highest rates of N and P application. Above 60 kg P_2O_5/ha plant cannot uptake P due to nutritional imbalance.

Table 4. Effects of nitrogen and phosphorus on the growth and yield contributing characters of bush bean

Treatment combinations	Plant height (cm)	Plant population /m^2	No. of pod/plant	Pod length (cm)	Pod weight/plant	Pod yield (t/ha)	No. of seeds /pod	1000 seed weight (g)	Seed yield/plot(kg)	Seed yield (t/ha)
N_0P_0	35.27	24.33	13.20	15.04	40.66	9.22	4.73	211.00	2.21	1.89
N_0P_1	36.33	23.66	13.46	13.56	42.66	9.80	4.97	235.00	2.50	2.13
N_0P_2	39.82	24.00	12.83	15.16	57.71	11.81	5.31	225.00	2.87	2.41
N_0P_3	39.97	23.66	13.33	15.65	53.23	10.93	5.54	231.00	2.91	2.49
N_1P_0	40.46	24.00	12.96	16.09	63.72	10.15	5.22	219.00	2.77	2.19
N_1P_1	41.03	25.00	13.51	16.17	72.95	13.58	5.22	218.00	2.80	2.35
N_1P_2	41.30	24.33	13.53	16.22	71.44	15.63	5.36	227.00	3.16	2.62
N_1P_3	42.57	25.33	13.45	17.82	59.60	15.15	5.58	236.00	3.07	2.52
N_2P_0	43.77	26.00	13.50	17.76	81.93	12.91	5.46	228.00	2.95	2.42
N_2P_1	43.53	25.00	13.90	18.05	89.16	17.14	6.16	229.00	3.53	2.96
N_2P_2	44.60	25.66	13.00	16.71	87.67	18.61	6.01	255.00	3.22	2.73
N_2P_3	43.40	25.33	12.20	17.51	82.28	17.57	5.75	223.00	3.19	2.73
LSD (0.05)	1.978	0.307	0.131	0.977	0.720	0.200	0.177	3.910	0.075	0.092
CV (%)	2.85	1.74	2.59	3.54	3.44	4.87	1.91	3.01	1.52	2.19

4.4 Pod length (cm)

Nitrogen had significant influence in respect of pod length. Pod length was gradually increased due to increasing dose of nitrogen fertilizer. The highest length of green pod of bush bean (17.51 cm) was found in the crop grown with the higher dose of nitrogen (40 kg N/ha) and the lowest (14.85 cm) was observed from the control (0 kg N/ha) treatment (Table 2 and Appendix II).

Length of green pod was also influenced significantly by the different doses of phosphorus (Appendix II). The maximum length of green pod (16.99 cm) was obtained from 100 kg P_2O_5/ha which was statistically similar with 0 kg P_2O_5/ha (16.29 cm). The minimum length of pod (15.93 cm) was found from 50 kg P_2O_5/ha (Table 3).

In was observed that the interaction effect of different does of nitrogen and phosphorus on green pod length was significant (Appendix II). However, the highest pod length (18.05 cm) was recorded from the treatment combination of 40 kg N/ha and 75 kg P_2O_5/ha and the lowest (15.04 cm) was measured from the control (Table 4).

4.5 Pod weight/plant (g)

A significant variation was observed in respect of pod weight per plant at different level of nitrogen (Appendix II). The highest pod weight per plant (85.26g) was obtained from 40 kg N/ha and the lowest pod weight (48.57 g) per plant from the control (Table 2). It was clearly observed that the positive effect of nitrogen. They result is in full argument with Wange *et al.* (1996).

The level of phosphorus was also highly significantly influenced the pod weight per plant of bush bean in the similar way. The highest pod weight (72.27 g) was obtained from the plant, which received from 75 kg P_2O_5/ha and the lowest (62.10g), from the control treatment (Table 3).

The interaction effect of different levels of nitrogen and phosphorus on pod weight per plant was found statistically significant (Appendix II). The maximum (89.16 g) and the lowest pod weight (40.66) were obtained from N_2P_1 the control (N_0P_0)treatment combination respectively (Table 4).

4.6 Pod yield per plot (kg)

There was highly significant variation in respect of pod yield per plot due to different levels of nitrogen (Appendix II). The pod yield per plot ranged from 12.54 kg to 19.82 kg. From the lowest and highest dose of N application respectively (Fig. 1). This increased might be due to increased availability of nitrogen, which accelerate photosynthetic rate and they leading to more production of carbohydrates. The present results are in agreement with that of Rosolar *et al.* (1983).

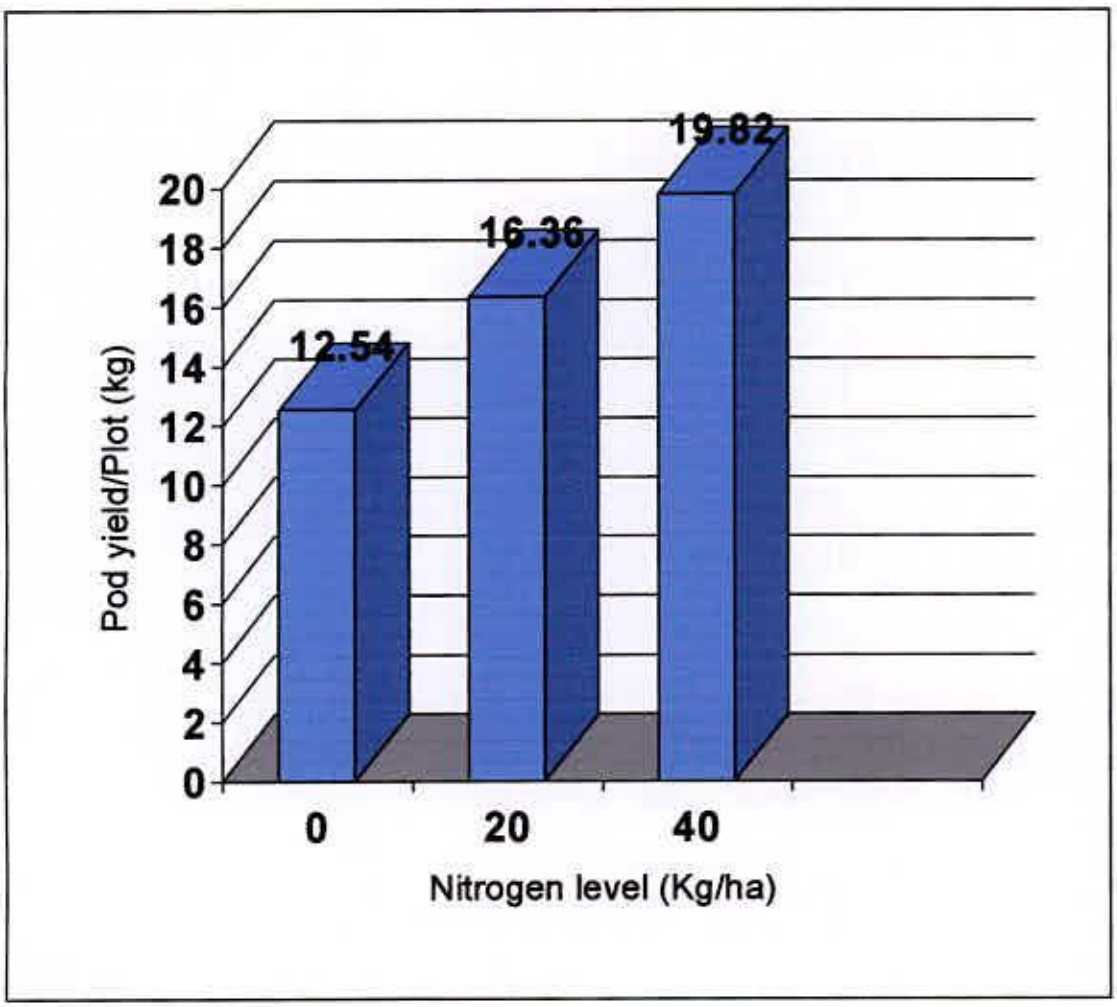

Fig. 1 Effect of Nitrogen on the Pod Yield of bush bean.

The levels of phosphorus were also significantly influenced the pod yield per plot. The pod yield per plot was maximum (18.43 kg) from the addition of 75 kg P_2O_5/ha and it was minimum (12.93 kg) in the control. i. e. 0 kg N/ha and 0 kg P_2O_5/ha (Fig. 2). Sairam *et al.* (1989) obtained similar result.

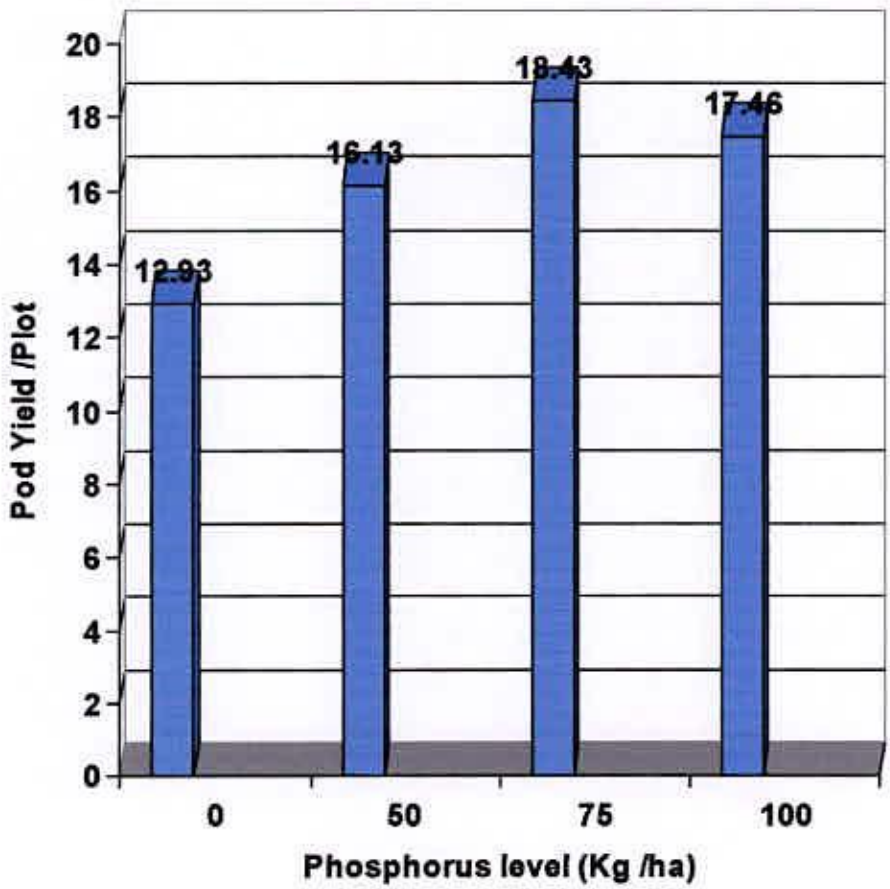

Fig. 2 Effect of Phosphorus on the pod yield of bush bean

The interaction effect different levels of nitrogen and phosphorus on pod yield per plot was significant (Appendix II). The maximum pod yield (22.34 kg) was obtained from the treatment combination of 40kg N/ha with 75kg P_2O_5/ha, which was statistically similar with treatment combination N_2P_3 (21.09 kg) and N_2P_1 (20.33 kg). The lowest pod yield per plot (11.07 kg) was recorded from control treatment combination (Fig. 3).

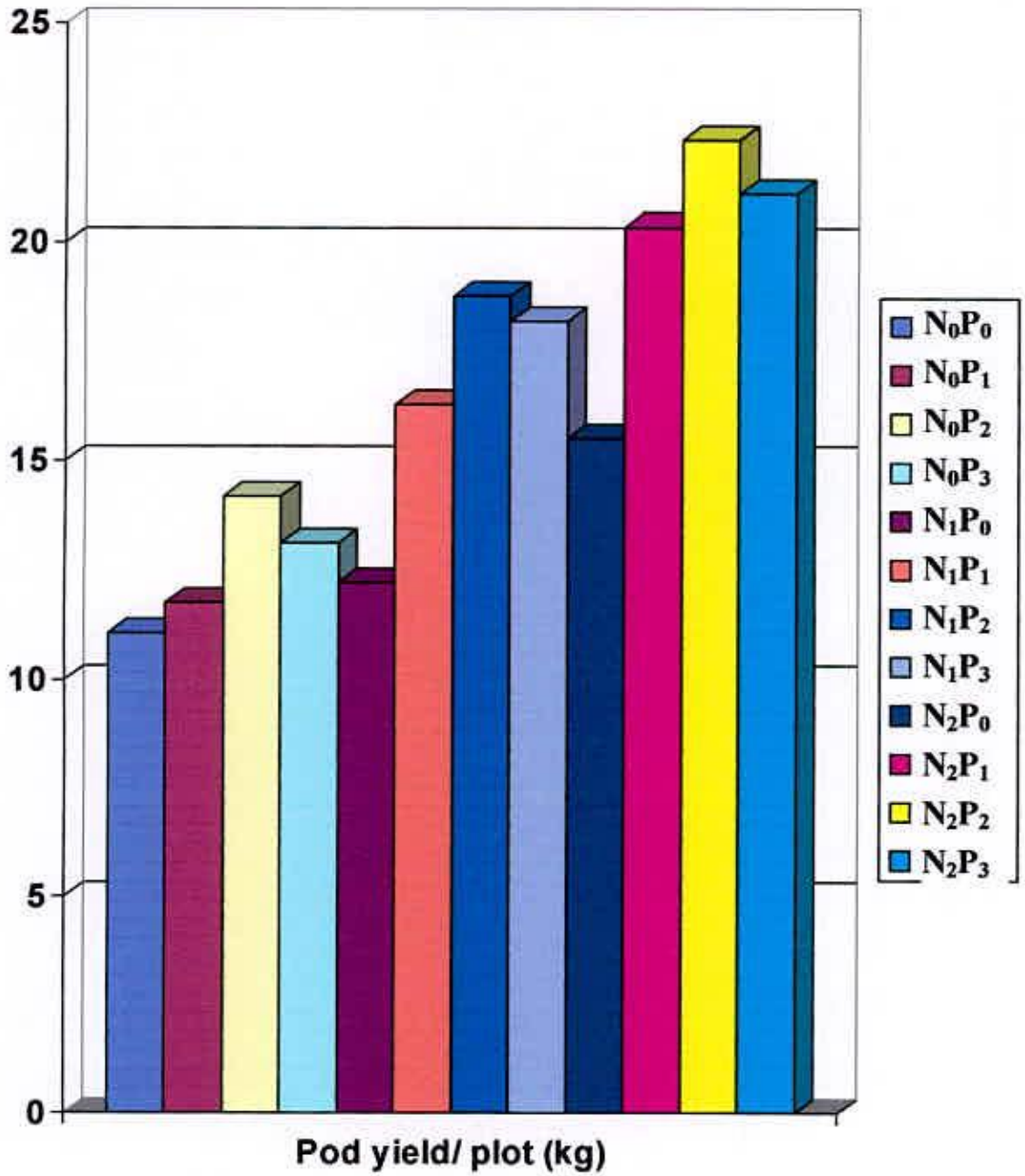

Fig. 3 Combined effect of Nitrogen and Phosphorus on the pod yield of bush bean

4.7 Pod yield (t/ha)

The results indicated that nitrogen had significant effect on pod yield per hectare (Appendix II). The maximum pod yield (16.56 t/ha) was obtained from 40 kg N/ha and the minimum pod yield (10.04 t/ha) in control (Table 2).

Phosphorus also influenced significantly the pod yield per hectare (Appendix II). The maximum pod yield per hectare (15.35 t/ha)was achieved with the 75 kg P_2O_5/ha, while the minimum pod yield per hectare (10.76 t/ha) was achieved from control treatment (Table 3).

The interaction effect of different levels of nitrogen and phosphorus on pod yield per hectare was found to be statistically significant (Appendix II and Table 4). The highest pod yield per hectare (18.61 t/ha) was achieved from the treatment combination of 40 kg nitrogen per hectare with 75 kg P_2O_5 /ha, whereas lowest value per hectare (9.22 t/ha) was found from the control treatment combination.

4.8 No. of seeds/pod

The number of mature seeds per pod was significantly influenced by the application of nitrogen (Appendix II). The highest seed per pod (5.85) was obtained from the plant receiving 40 kg N/ha. The lowest number of mature seed per pod (5.13) recorded from control treatment (Table 2). This result might be due to better growth and development and larger pod formation with higher rate of N application Calvache *et al.* (1997) reported similar result.

Different doses of phosphorus also significantly influenced the number of seeds per pod (Appendix II). Number of seeds per pod increased with increasing rates of phosphorus fertilizers. It was maximum (5.63) at 100 kg P_2O_5/ha, statistically similar results (5.56) were obtained with 75 kg P_2O_5/ha and lowest number of seed (5.13) was obtained with zero phosphorus (Table 3).

There was also significant interaction between nitrogen and phosphorus in respect of seed per pod (Appendix II). The maximum number of seeds per pods (6.16) was recorded from the treatment combination of 40 kg N/ha with 50 kg P_2O_5/ha and statistically similar result (6.01) was found at treatment combination N_2P_2 the minimum seed per pod (4.73) was found from the control treatment (Table 4).

4.9 Thousand seed weight (g)

A significant variation was observed in respect of 1000 seed weight due to different nitrogen levels (Appendix II). Maximum weight of 1000 seed (230.75 gm) was recorded from application of 40 kg N/ha. The addition of 20 kg N/ha also produced (228.50 gm) statistically similar result and the minimum weight of 1000 seed (225.00 gm) was obtained from control (Table 2). The highest weight might be attributed due to the increasing levels of nitrogen.

The levels of phosphorus were also significantly influenced the 1000 seed weight. The highest 1000 seed weight (236.00gm) was recorded at 75 kg P_2O_5/ha while the lowest (223.33gm) was obtained from 0 kg P_2O_5/ha (Table

3). Application of 100 kg P_2O_5/ha produced lower seed weight (226.00g) due to nutrient imbalance condition.

The combined effect of nitrogen and phosphorus was found to be significant. The highest weight of 1000 seed (255.00 gm) was obtained from the treatment combination of 40 kg N/ha with 75 kg of P_2O_5/ha. The lowest 1000 seed weight (211.00gm) was recorded from control treatment (Table 4).

4.10 Seed yield/plot (kg)

The results indicated that nitrogen had significant effect on seed yields per plot (appendix II). Seed yields per plot were varied from 2.65 kg to 3.23 kg. The maximum seed yield per plot was produced from 40 kg N/ha and the minimum seed yield per plot was obtained from the control. The result is in full agreement with Baboo *et al.* (1998). Rabi and Prasad (1998) reported that seed yield significantly increased with increasing application of nitrogen.

Phosphorus also influenced significantly the seed yield per plot (Appendix II). Maximum seed yield per plot (3.08 kg) was achieved with the 75kg P_2O_5/ha while the minimum seed yield per plot (2.65 kg) was achieved from control treatment (Table 3). It was clearly observed that seed was in creased with increasing levels of phosphorus up to 75 kg P_2O_5/ha. Phosphorus application significantly improved the number of pod/plant, grains/pod and finally grain weight/plant (Ali and Kushwaha, 1987).

The interaction effect of different levels of nitrogen and phosphorus on seed yield per plot was found to be statistically significant (Appendix II). The highest yield per plot (3.53 kg) was achieved from treatment combination of

40 kg N/ha with 50 kg P_2O_5/ha, whereas the lowest value was found from the control treatment (Table 4).

4.11 Seed yield (t/ha)

The results indicated that nitrogen had significant effect on seed yield per hectare (Appendix II). The maximum seed yield (2.71 t/ha) was obtained from 40 kg N/ha and the minimum (2.23 t/ha) in control (Table 2).

Phosphorus also influenced significantly the seed yield per hectare (Appendix II). The maximum seed yield per hectare (2.58) was obtaned with the 75 kg P_2O_5/ha and 100 kg P_2O_5/ha respectively while the minimum seed yield per hectare was achieved from control treatment (Table 3).

The interaction effect of different levels of nitrogen and phosphorus on seed yield per hectare was found to be statistically significant (Appendix II). The highest yield per hectare (2.96 t) was achieved from the treatment combination of 40 kg N/ha with 50 kg P_2O_5/ha where as lowest value per hectare was found in the control treatment(Table 4). This result is in close agreement with the findings of Tewari and Singh (2000).

4.12 Effects of different treatments on post harvest soil

4.12.1 Soil pH

The pH value of initial soil was 6.0. The results in Table 5 showed that on the treatment effect on the pH value of the post harvest soils compared to initial soil. The lowest pH value was observed (5.85) in N_1P_0 treatment, the highest pH value was obtained (6.05) in N_1P_1 and N_1P_3 treatments.

4.12.2 Organic matter content

Organic matter content of post harvest soil varied due to influence of different treatments. The highest organic matter content (1.17) was obtained in N_0P_3 and the lowest organic matter contained was observed (0.80) in N_2P_3 treatment. The organic matter content of initial soil was (0.74).

4.12.3 Total nitrogen

The effect of different treatments on total nitrogen of post harvest soils is shown in Table 5. The highest total nitrogen (0.068 %) was recorded in N_1P_0 treatment and the lowest (0.044 %) in post harvest soils was observed in N_2P_3 treatment. The total nitrogen value of initial soil was (0.043 %).

Table 5. Effect of nitrogen on post harvest soil and plant sample

Treatments	Soil sample				Plant sample	
	Soil pH	% Organic Carbon	% of nitrogen	Phosphorus (µg/g)	% of nitrogen	Phosphorus (µg/g)
N_0	6.01	0.59	0.059	0.357	5.05	0.359
N_{20}	5.98	0.59	0.059	0.393	5.82	0.326
N_{40}	5.97	0.55	0.055	0.331	6.43	0.322
LSD (0.05)	0.126	0.018	0.020	0.052	0.483	0.104

4.12.4 Available phosphorus

Available phosphorus of post harvest soil was influenced by the effect of different treatments (Table 6). The highest value of available phosphorus obtained (67.13µg/g) in N_1P_1 treatment and the lowest available phosphorus

(41.42 μg/g) in post harvest soils was observed in N_2P_0 treatment. The available phosphorus of initial soil was (23 ppm).

Table 6. Effect of phosphorus on post harvest soil and plant sample

Treatments	Soil sample				Plant sample	
	Soil pH	% Organic Carbon	% of nitrogen	Phosphorus (μg/g)	% of nitrogen	Phosphorus (μg/g)
P_0	5.96	0.64	0.065	0.30	5.71	0.374
P_{50}	6.02	0.59	0.057	0.319	5.9	0.317
P_{75}	6.01	0.57	0.059	0.374	5.77	0.339
P_{100}	5.98	0.52	0.05	0.377	5.77	0.313
LSD (0.05)	0.145	0.052	0.0028	0.073	0.531	0.120

4.13 Effects of different treatments on post harvest plant sample

Nutrient uptakes by bush bean are presented in Table 7. Nitrogen and phosphorus uptake by plants were statistically significant (Table 5). Nitrogen application improved its uptake by plants as well as favoured higher uptake of P. Similarly a higher uptake of P by plants was found when the crop was properly fertilized with P as well as with N. The highest nitrogen percentage uptake by plant was observed (6.93 %) in N_2P_0 and the lowest nitrogen percentage uptake by plant was obtained (4.93 %) in N_0P_1 treatment.

The highest phosphorus percentage uptake by plant was observed (0.51 μg/g) in N_1P_0 and the lowest phosphorus percentage uptake by plant was obtained (0.19 μg/g) in N_0P_1 treatment.

Table 7. Combined effect of nitrogen and phosphorus on post harvest soil and plant sample

Treatments	Soil sample				Plant sample	
	Soil pH	% Organic Carbon	% of nitrogen	Phosphorus (µg/g)	% of nitrogen	Phosphorus (µg/g)
N_0P_0	6.03	0.66	0.067	47.71	5.05	0.29
N_0P_1	5.99	0.61	0.061	59.99	4.93	0.19
N_0P_2	6.01	0.56	0.056	59.99	5.24	0.44
N_0P_3	6.01	0.56	0.056	52.85	4.98	0.32
N_1P_0	5.85	0.68	0.068	47.13	5.15	0.51
N_1P_1	6.05	0.62	0.060	67.13	5.95	0.19
N_1P_2	5.95	0.56	0.060	54.27	5.84	0.29
N_1P_3	6.05	0.53	0.050	61.42	6.33	0.29
N_2P_0	5.99	0.60	0.062	41.42	6.93	0.42
N_2P_1	6.02	0.54	0.051	42.85	6.50	0.32
N_2P_2	5.98	0.60	0.061	57.13	6.25	0.20
N_2P_3	5.88	0.47	0.044	45.7	6.02	0.43
LSD (0.05)	0.251	0.435	0.005	3.039	0.965	0.207
CV (%)	2.46	13.52	13.02	10.13	9.88	16.96

Nitrogen levels

N_0 = 0kg N/ha

N_1 = 20kg N/ha

N_2 = 40kg N/ha

Phosphorus levels

P_0 = 0kg P_2O_5/ha

P_1 =50 kg P_2O_5/ha

P_2 = 75kg P_2O_5/ha

P_3 = 100kg P_2O_5/ha

4.14 Economic analysis

The details of economic analysis have been presented in Appendix IV. It was found that the highest cost of production (111490 Tk.) in treatment combination 40 kg N/ha with 100 kg P_2O_5/ha while the lowest production cost was obtained when no nitrogen and phosphorus were used. The variation

was due to the cost of different levels of nitrogen (Urea) and phosphorus (TSP). The gross return from different combinations ranged between Tk.107224 and Tk. 111490 per hectare. Gross return was the total income through sale of bush bean (Marketable yield @ Tk. 15000/t). The highest net income of Tk.168533 was obtained from the treatment combination 40 kg N/ha with 75 kg P_2O_5/ha whereas the lowest net income of Tk. 31076 was found from the control treatment combination. The benefit cost ratio was found to be highest (2.52) in the treatment combination of 40kg N/ha with 75 kg P_2O_5/ha. The second and third highest BCRs (2.36 and 2.34) were found from the treatment combinations of 40 kg N/ha with 100 kg P_2O_5/ha and 40 kg N/ha with 50 kg P_2O_5/ha (Table 7).

It was observed that the application of 40 kg N/ha with 75kg P_2O_5/ha was more profitable than all other treatment combinations and control. However, the economic analysis is based on crop yield as well as factors such as cost of inputs and marketable price of the harvested materials which may vary from year to year. Therefore, the economic analysis for a crop grown in particular year may not represent exactly the same with the crop grown in another year.

Table 8. Cost and return of Bush bean due to different doses of nitrogen and phosphorus

Treatments	Pod yield (t/ha)	Gross return (Tk.)	Total cost of production (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
$N_0 P_0$	9.22	138300	107224	31076	1.28
$N_0 P_1$	9.80	147000	108969	38031	1.34
$N_0 P_2$	11.81	177150	109841	67309	1.61
$N_0 P_3$	10.93	163950	110713	53237	1.48
$N_1 P_0$	10.15	152250	107612	44638	1.41
$N_1 P_1$	13.58	203700	109356	94344	1.86
$N_1 P_2$	15.63	234450	110229	124221	2.12
$N_1 P_3$	15.15	227250	111100	116150	2.04
$N_2 P_0$	12.91	193650	108000	85650	1.79
$N_2 P_1$	17.14	257100	109745	147355	2.34
$N_2 P_2$	18.61	279150	110617	168533	2.52
$N_2 P_3$	17.57	263550	111490	152060	2.36

Nitrogen levels

N_0 = 0kg N/ha
N_1 = 20kg N/ha
N_2 = 40kg N/ha

Phosphorus levels

P_0 = 0kg P_2O_5/ha
P_1 =50 kg P_2O_5/ha
P_2 = 75kg P_2O_5/ha
P_3 = 100kg P_2O_5/ha

Price of harvested green pod @ Tk 15000/t; BCR = Gross return ÷ Total cost of production

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2004 to March 2005 to find out the effect of nitrogen and phosphorus on the growth and yield of bush bean. The experiment consisted of two factors namely, (i) three different levels of nitrogen (N) viz., 0, 20 and 40 kg N/ha and (ii) four different levels of phosphorus (P_2O_5) viz., 0, 50, 75 and 100kg P_2O_5/ha. The experiment consisted of 12 treatment combinations and laid in Randomized Complete Block Design (RCBD) with three replications.

The size of each unit plot was 12 m^2 (4m×3m) and the seeds of bush bean were sown on 12 December, 2004. The sample plants were randomly selected from each plot to recorded data on green pot and seed yield and yield contributing characters. 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 showed significantly influenced by nitrogen. Plants grown with higher doses of nitrogen showed gradual increase in height at different dates of observation. The maximum height (43.83cm) at harvest were found from the highest dose of nitrogen (40kg N/ha). There was an increasing significant response on the most of the parameters to increasing levels of nitrogen upto 40kg N/ha. The maximum plant height (43.83cm), number of pods per plant (13.26), the highest pod length (17.51cm), number of seeds per green pod (5.85), pod weight per plant (85.26g), pod yield per plot (19.82kg), seed yield per plot (3.23 kg) and per hectare (2.71 t) were

obtained from the application of 40kg N/ha. The crops fertilized with 40kg N/ha gave highest pod yield (19.82 kg/plot) as well as per hectare (16.56 t) whereas lowest (10.44 t) in control treatment. A similar response was also found in case of seed yield. The maximum number of seeds per pod (5.85), highest weight of 1000 seed (230.75g), the maximum seed yield per plot (3.23kg) as well as per hectare (2.71 t) were achieved from 40kg N/ha.

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. The maximum plant height (41.98cm) at harvest were obtained from 100kg P_2O_5/ha. The highest pod length (16.99cm) and number of seeds per pod (5.63) were recorded from the treatment of 100 kg P_2O_5/ha. The maximum pod weight per plant (72.27 g), pod yield per plot (18.43 kg), pod yield per hectare (15.35t), 1000 seed weight (236.00 g), seed yield per plot (3.08 kg), seed yield per hectare (2.58 t) were obtained from 75kg P_2O_5/ha. The combined effects of nitrogen and phosphorus were significantly influenced all the growth and yield contributing characters of bush bean. The highest plant height 44.60 cm, pod length (18.05 cm), pod weight per plant (89.16g), number of seeds per pod (6.16), 1000 seed weight (255.00g) and seed yield per plot (3.53 kg) at harvest respectively from the treatment combination N_2P_1 (40 kg N with 50 kg P_2O_5/ha). These were statistically similar with the treatment combination N_2P_3 and N_2P_2. The highest number of pod per plant (13.90) were obtained with N_2P_1 (40 kg N/ha, 50 kg P_2O_5 /ha). It was noted that most of the observation showed lowest results in control treatment combination (N_0P_0). In fact, most of yield contributing parameters

showed statistically similar response in treatment combinations of N_2P_2 and N_2P_3.

The highest green pod yield 18.61 t/ha was obtained from the treatment combination of 40 kg N/ha and 50 kg P_2O_5/ha and seed yield 2.96 t/ha was obtained from the treatment combination of 40 kg N/ha and 75 kg P_2O_5/ha which was statistically identical (21.09 kg/plot) and (2.73 t/ha) respectively with N_2P_2 and N_2P_3.

From the above results it may be concluded that both nitrogen and phosphorus significantly influenced on the green pod and seed yield of bush bean. Application of 40 kg N/ha with 75 kg P_2O_5/ha was conductive to higher economic return (Tk. 168533) from bush bean cultivation under Madhupur Tract Agroecological Region of Bangladesh.

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Appendix I. Records of meteorological observation (monthly) at the period of experiment (October, 2004 to February, 2005)

Month	Temp. (Max)	Temp. (Man.)	Humidity (%)	Precipitation (mm)	Potential Evapotranspiration (mm/day)	Solar radiation ($MJ/m^2/d$)	Bright Sunshine (Hours)
October	31.2	23.6	81.2	168	3.612	16.61	6.81
November	29.1	18.6	76.78	31	2.966	15.364	7.48
December	26.2	13.7	75.29	9	2.43	14.089	7.33
January	25.3	12.3	73.52	7	2.387	14.766	7.18
February	25.5	12.7	74.32	7	2.37	14.866	7.28

Source: Weather Yard, Bangladesh Metrological department, Dhaka.

Appendix II. Analysis of variance of data on the growth and yield components of bush bean as influenced by different levels of nitrogen and phosphorus

Sources of variation	Degrees of freedom	Mean sum square										
		Plant height (cm)	Plant population /m^2	No of pod/ plant	Pod length (cm)	Pod weight/ plot	Pod yield/ plot	Pod yield (t/ha)	No. of seeds/ pod	1000 Seed wt (g)	Seed yield/ Plot (kg)	Seed yield (t/ha)
Replication	2	3.000	0.033	0.013	0.332	0.415	0.335	0.307	0.006	5.333	0.003	0.002
Factor A	2	108.234	7.495**	0.146**	21.759**	4039.203**	159.137**	112.243**	1.590**	100.750**	1.092	0.707**
Factor B	3	8.220**	0.103*	0.668**	2.073**	171.608**	51.753**	36.077**	0.432**	272.250**	0.366**	0.347**
A × B	6	6.175**	0.932**	0.692**	1.716**	96.376**	3.589**	2.629**	0.167**	508.750**	0.123**	0.068**
Error	22	1.364	0.033	0.006	0.333	0.181	0.022	0.014	0.011	5.333	0.002	0.003
Total	35	-	-	-	-	-	-	-	-	-	-	-

*** 1% level of significant**
**** 5% level of significant**

Appendix III. Production cost of green pod of Bush bean per hectare

A. Input cost (Material & Non material)

Treatment Combinations	Labour cost (Tk.)	Ploughing cost (Tk.)	Seed cost (Tk.)	Cowdung cost (Tk.)	Urea cost (Tk.)	TSP cost (Tk.)	MP cost (Tk.)	Pesticide cost (Tk.)	Irrigation cost (Tk.)	Total input cost (Tk.)
N_0P_0	32000	3000	34000	9500	-	-	1600	1000	500	81600
N_0P_1	32000	3000	34000	9500	-	1560	1600	1000	500	83160
N_0P_2	32000	3000	34000	9500	-	2340	1600	1000	500	83940
N_0P_3	32000	3000	34000	9500	-	3120	1600	1000	500	84720
N_1P_0	32000	3000	34000	9500	347	-	1600	1000	500	81947
N_1P_1	32000	3000	34000	9500	347	1560	1600	1000	500	83507
N_1P_2	32000	3000	34000	9500	347	2340	1600	1000	500	84287
N_1P_3	32000	3000	34000	9500	347	3120	1600	1000	500	85067
N_2P_0	32000	3000	34000	9500	694	-	1600	1000	500	82294
N_2P_1	32000	3000	34000	9500	694	1560	1600	1000	500	83854
N_2P_2	32000	3000	34000	9500	694	2340	1600	1000	500	84634
N_2P_3	32000	3000	34000	9500	694	3120	1600	1000	500	85414

Note: Labour Tk. 50/ Man/Day. Urea, TSP and MP @ 8.00, 15.00 and 10.00 Tk/kg respectively.

Appendix III. (Contd.)

B. Overhead cost (Tk./ha)

Treatment Combinations	Cost for the land (for 6 month)	Miscellaneous cost (5 % of the input cost)	Interest on the running capital for 6 month (13%)	Sub total (Tk.)	Total cost (Tk.)
N_0P_0	15000	4080	6544	25624	107224
N_0P_1	15000	4158	6651	25809	108969
N_0P_2	15000	4197	6704	25901	109841
N_0P_3	15000	4236	6757	25993	110713
N_1P_0	15000	4097	6568	25665	107612
N_1P_1	15000	4175	6674	25849	109356
N_1P_2	15000	4214	6728	25942	110229
N_1P_3	15000	4253	6781	26033	111100
N_2P_0	15000	4114	6592	25706	108000
N_2P_1	15000	4193	6698	25891	109745
N_2P_2	15000	4232	6751	25983	110617
N_2P_3	15000	4271	6805	26076	111490

Nitrogen level

N_0 = 0 kg N/ha

N_1 =20 kg N/ha

N_2 = 40 kg N/ha

Phosphorus level

P_0 = 0 kg P_2O_5/ha

P_1 = 50 kg P_2O_5/ha

P_2 = 75 kg P_2O_5/ha

P_3 = 100 kg P_2O_5/ha