EFFECT OF NITROGEN AND PHOSPHORUS ON SEED YIELD OF BUSH BEAN

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CERTIFICATE

This is to certify that the thesis entitled, ***"Effect of Nitrogen and Phosphorus on seed yield of bush bean"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN HORTICULTURE*** *embodies the result of a piece of bona fide research work carried out by* ***RIMA AkTHER; Registration No. 10-04108,*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information, as has been availed of during the course of this investigation have been duly acknowledged.

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Dated: June, 2016
Dhaka, Bangladesh

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Dedicated to

My Beloved Parents

*At first the author expresses all praises to the '**Almighty Allah'** who enables her to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Horticulture.*

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SAU, Dhaka ***The Author***

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Abstract

The experiment was conducted at Horticultural Farm, Sher-e-Bangla Agricultural University, during the period from November 2015 to March 2016 to study the Effect of Nitrogen and Phosphorus on seed yield of Bush bean. The experiment consists of two factors. Factor A: four levels of four levels of Nitrogen, N_0: 0 kg N/ha (control), N_1: 80 kg N/ha, N_2: 120 kg N/ha, N_3: 160 kg N/harespectively. Factor B: four levels of phosphorus,P_0:0 kg P/ha, P_1: 50 kg P/ha, P_2: 100 kg P/ha and P_3:150 kg P/hawere used for the present study. The experiment was laid out in RCBD with three replications.Results showed that highest seed yield of bush bean (3.18 t) was found from N_2 (120 kg N/ha) treatment and lowestseed yield (1.90t) was found from N_0(control)treatment. Fordifferent levels of Phosphorus,highest seed yield of bush bean (2.90 t) was found from P_2 (100 kg P/ha) treatment and lowestseed yield (2.50 t) was found from P_0(control)treatment. Due to combined effect thehighest seed yield of bush bean (3.43 t) was produced fromN_2P_2(120 kg N/ha and 100 kg P/hatreatment) combination and lowest seed yield (1.72 t) was found from N_0P_0(control) treatment.From economic point of view, the treatment combination of 120 kg N/ha with 100 kg P/ha appeared to be the best for cultivation of bush bean under Sher-e-Bangla Agricultural University Farm condition with gross return, net return and benefit cost ratio of Tk 3,44,000, Tk 2,01,666 and 2.42 respectively.

LIST OF CONTENTS

TABLE OF CONTENTS (Continued)

CHAPTER	TITLE	PAGE NO.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LISTS OF ABBREVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
BCR	=	Benefit Cost Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER I

INTRODUCTION

French bean or Bush bean (*Phaseolus vulgaris*L.) is an herbaceous annual plant. Itis ashort duration high yielding grain legume crop and it can be used both as pulseand vegetable. It has been cultivated in different countries of the world from timesimmorial. It was originated in Mexico and Central America (Smart,1976) between2300 to 4000 B.C. (Lue*et al*.,1990). It is a vegetable crop belonging to thefamily Leguminosae and subfamily Papiolionaceae(Swiader*et al.*,1992*)*. Various varieties of beans are popular for theirvarious qualities. Some are grown for their seeds whereas some are preferred as greenvegetables. It is also known as farashi Seem, kidney bean, snap bean, pinto bean, greenbean, raj bean, navy bean, pole bean, wax bean,string bean and bonchi (Duke, 1983*;* Salukhe*et al.*,1987: Tindall,1988*)*. In ourcountry, it is known as Farashi Seem (Rashid, 1993).

InBangladesh, bush bean ismainly used as green vegetable. In Asia, bush bean has been extensively cultivated in India,34% of thecultivated area(Lue*et al*., 1990). It has been newly introduced as a wintervegetable crop in Bangladesh. It is cultivated in Sylhet, Cox'sBazar, Chittagong Hill Tracts and some other parts of the country.According to the recent FAO statistics, bush bean including other related species of the genus *Phaseolus vulgaris*L.occupied 27.08million hectares of the world's cropped area, (FAO, 2000) andChina produces the largest quantity of green beans.Both pods and seeds of bush bean are nutritionally rich.

Dry bean contains 336 calories for energy with 12 % moisture, 21.7 g of protein, 1.5 g of lipid, 60 gCHO, 120 mg of Ca, 8.2 mg of Fe, 0.37mg of Thiamin and 2.4mg of Niacin. (Schoonhoren and Rovset, 1993).The cultivation of bush bean is gaining popularity in Bangladesh during the recent years mainly because of its export demand

and increasing consumer preference. HortexFoundation of Bangladesh already started to export bush bean (BARI, 2001) as vegetable. Hortex Foundation exported 23.86 tons of vegetable bush bean during July–December.2001 (Anonymous, 2001). Its dry seeds are used in preparations with fish, meat and other vegetables.

Bush bean has high nitrogen requirement for expressing their genetic potential. However, as bean has the ability to fix and use atmospheric nitrogen with regards to soil fertility and mineral nutrition requirement, phosphorus is considered as the first and nitrogen as the second limiting plant nutrient for bean yield in the tropical zone of cultivation

Various problems, however, hamper bush bean production in Bangladesh. Fertilizer specially nitrogenous and phosphorus are the most critical input for increasing crop production and had been recognized as the key element for agricultural development (Mukhopadhyay*et al.*, 1986).Nitrogen is one of the key elements for growth and development of a crop plants (Tanaka *et al*.,1984).

Nitrogen deficiency constraints leaf area expansion, enhances leaf senescence, inhibits photosynthetic rate in most of the crops and consequently reduces the crop productivity (Machler*et al*., 1988 and Wolfe *et al*.,1988). Bush bean also responds well to phosphorus application (Siddiqui, 2010).

Phosphorus deficiency triggers many morphological, biochemical and molecular changes in plants. It affects on nodulation, nitrogen fixation and plant growth in legume crops. 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). Phosphorus makes its contribution through seed formation (Buckmandand Brady, 1980).

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). 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-

1) To find out optimum doses of nitrogen and phosphorus for maximizing growth and seed yield of bush bean.
2) To find out suitable combination of nitrogen and phosphorus fertilizers on growth and seed yield of bush bean.
3) To identify the economic benefits with the consideration of different nitrogen and phosphorus fertilizers of bush bean.

CHAPTER II

REVIEW OF LITERATURE

Bush bean (*Phaseolus vulgaris* L.) is a popular and important vegetable crop of the world. 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. But in Bangladesh, available literature regarding effect of nitrogen and phosphorus on bush bean is insufficient and sometimes conflicting. However, some of the literatures relevant to effect of nitrogen and phosphorus on bush bean production are reviewed in this chapter.

2.1 Review in relation to nitrogen

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

Virender*et al.* (2000) carried out an experiment with French bean in India and found higher yield obtained with application of nitrogen up to 120 kg/ha and phosphorus up to 60 kg/ha.

Singh and Singh (2000) carried out a field trial in India with different nitrogen levels on yield and yield components of French bean (0, 40, 80 or 120 kg N/ha). They observed that Seed yield and 100-seed weight increased with increasing N rate.

Neuvel*et al.*(1994) found that pod yield of snap beans were 12.9, 13.9, 15.0 and 15.8 ton/ hawith 0, 50, 100 and 150 kg N /ha,respectively.

Ivanove*etal.* (1987) reported that the pod yield of French bean was increased with the increase N levels upto 150 kg /ha.

Sharma *et al.* (2013) conducted an experiment on French bean (*Phaseolus vulgaris* L.) varieties under different N, P, K and S levels for growth, yield and economics. They found among fertilizer levels, (100:80:80:50kg/ha NPKS) resulted in highest growth parameters, yield parameters and yield of pods.

In India, Tewari and Singh (2000) conducted an experiment on French bean to determine the optimum and economical dose of nitrogen (0, 40, 80, 120 and 160 kg/ha) for better growth and seed yield. They reported that application of 120 kg N/ha produced significantly higher number of pods per plant, weight of speeds per plant, number of seeds per pod and seed yield, whereas 160 kg N/ha significantly reduced seed yield.

Arya*et al*. (1999) conducted an experiment in India to investigate the effect of N, P and K on French bean. They used different doses of NPK combinations. It was concluded that N promoted growth and suggested 25 kg N/ha, 75 kg P_2O_5 /ha and 50 kg K_2O/ha as the best combination in terms of economics and seed yield.

Baboo*et al*. (1998) conducted an experiment in Uttar Pradesh, India on response of nitrogen in French bean. Number of branch and seed yield were increased with the increase of nitrogen and it was higher with 120 kg N/ha.

Rana*et al.* (1998) conducted a 2-year field experiment in India to study the effect of N (0, 40, 80 and 120 kg N/ha) on dry matter production and uptake of N in French bean. Dry matterproduction increased significantly up to 120 kg N/ha. Uptake of N was significant also up to 120 kg N/ha.

Calvache*et al*. (1997) found significant increase in seed yield, pod numbers/plant, number of seeds/pod and harvest index in French bean through increased nitrogen application.

Durge*et al*. (1997) stated that the highest yield (957 kg/ha) of French bean was obtained with 150 kg N/ha. Parthiban and Thamburaj (1991) conducted an experiment in India and recorded increased grain yield with nitrogen fertilization up to 50 kg/ha in French bean. Number of pods and grain yield per plant increased significantly with nitrogen fertilization over the control. In India, Singh *et al.* (1990) studied the response of French bean to nitrogen application. They reported that number of pods per plant and 100-seed weight increased with increase in N rate

Srinivas and Naik (1990) conducted an experiment at Bangalore, India to investigate the growth, yield and nitrogen uptake in vegetable French bean as influenced by nitrogen. Nitrogen was applied at 0, 40, 80, 120 and 160 kg/ha. They observed that application of nitrogen increased plant growth, nutrient uptake and yield of green pods.

Hedge and Srinivas (1990) worked in India on plant water relation and nutrient uptake in French bean and observed that nitrogen application increased green pod yield, nutrient uptake and water use efficiency.

In India, Hedge and Srinivas (1989) conducted an experiment in India to study the effect nitrogen on growth and yield of French bean. In their trial, the crop received 0, 40, 80 or 120 kg/ha of nitrogen. The green pod yield was the highest (124.3-132.3

q/ha) at 120 kg N/ha.Kuccy (1989) noted that addition of nitrogen at 30 mg/kg soil had stimulatory effect on plant growth.

Srinivas and Naik (1988) carried out an experiment at Bangalore, India to study the response of nitrogen on vegetable French bean. Nitrogen was applied at 0, 40, 80, 120 and 160 kg/ha. They reported that pod yields were increased with increasing fertilizer rate, from 3927 kg/ha at 0 kg N/ha to 13169 kg/ha at 160 kg N/ha.

Ali and Tripathi (1988) worked with an experiment in Uttar Pradesh, India to observe the influence of nitrogen levels (0-60 kg N/ha) on French bean and noticed that number of pods/plant, 100-seed weight, seed yield and seed protein content increased with increasing nitrogen rate. Chandra *et al*. (1987) reported that plant growth was increased with increasing rate of nitrogen in French bean.

Sa *et al*. (1982) observed that the application of various N fertilizer doses, pod number per plant was significantly influenced. Srinivas and Naik (1988) reported that increasing N fertilizer increased the pod yield in French bean.

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 (*Phaseolusvulgaris* L.) cv. BARI JharSheem-l. 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 $Mo_{0.5.}$ 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) on field bean. Nitrogen fertilizer exerted a significant and positive effect on pod number, rain 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.

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}.

Rajesh *et al*. (2001) carried out a field experiment in India to evaluate the effects of N (80, 160 and 240 kg/ha) and S (0, 20, 40 and 60 kg/ha) on the nutrient uptake and grain yield of French bean (*Phaseolus vulgaris* cv. HUR 137). The highest grain yield (2091 kg/ha) was recorded at N level of 240 kg/ha and that of straw yields (3331 kg/ha). Sulfur (S) at 40 kg/ha recorded the highest grain yield (1811 kg/ha).

Daba and Haile (2000) conducted a field experiment in Ethiopia on French bean cv. Red Wolaita, Rico-2, A-176 and A-250. They reported that Rhizobium inoculation and N significantly increased grain yield, nodule number and dry matter yield of French bean.

Prajapati*et al*. (2004) conducted an experiment in SardarKrushinagar, Gujarat, India, to study nutrient uptake and yield of French bean as affected by weed control methods and nitrogen levels (0. 40, 80 and 120 kg ha^{-1}). They reported that highest yield obtained from 120 kg ha^{-1}.

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 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 (IIUR 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 500x 103 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.

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 (*Phaseolusvulgaris*cv. PDR 14) under late-sown conditions of eastern Uttar Pradesh, India (Singh and Verma2002). 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}).

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.

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.Rabi Naddan and Prasad (1998) reported that response of irrigation and nitrogen fertilization on French bean (*Phaseolusvulgaris*). 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}.

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 per ha (yield 1.41 t) and the row spacing of 30 cm (yield 1.13t).

Reddy *et al*. (2010) reported that increased nitrogen levels from 75 to 150 kg per haimproved the yield attributes and seed yield (520 kg ha^{-1}) over 125, 100, 75 kg N ha^{-1}, respectively.

2.2 Review in relation to phosphorus

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

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 and observed that pod yield was highest (07.69 t/ ha) with 120 kg P/ ha.

Sexena*et al.* (1996) appliedP_20_5at 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 $P_20_{5.}$They also reported that seed yield was positively correlated with leaf area, dry matter 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_20_5gave 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_20_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}.

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}. Addition of phosphorus and zinc up to certain level increased the yield of green grain (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.Brar (1987) conducted an experiment in Haryana, India and found increasing number and size of nodules with the application of phosphorus in mug bean.

Alt *et al.* (1999) conducted an experiment to study the effect of different rates of P (0, 19, 34 and 58 kg/ha) fertilizers on the yield of selected vegetable crops. They found that *Phaseolusvulgaris*showed strong response to P and K.

Dash and Dash (1987) conducted a field experiment to observe the response of French bean (*Phaseolus vulgaris*) to different levels of Phosphorus (0,50 and 100 kg P_20_5/ha) and different spacing in sandy loam soil in Vanarash, Uttar Pradesh, India during 1986-87. They found that most of the growth and yield characters of French bean had been influenced by phosphorus. They reported that 100 kg P_20_5/ha gave the highest yield 15 ton/ha.

Subhan (1989) conducted an experiment in Indonesia to investigate the effect of plant distance and phosphate fertilizer on growth and yield of *Phaseolus vulgaris* L. He observed that yields were highest at 250 kg P_2O_5/ha.

Fageria (1989) reported that P treatments significantly affected growth and yield of common bean but the response is variable for different cultivars. Maximum seed yield was obtained with 125 -150 mg P.

Devender*et al.* (1998) carried out an experiment to study the effect of nitrogen and phosphorus on the yield of French bean and stated that application of nitrogen upto 150 kg and 60 kg P_2O_5/ha significantly increased seed per pod and seed yield.

Kanaujia*et al*. (1999) conducted an experiment of French bean treated with Phosphorus at 0, 40, 80 or 120 kg P_2O_5/ha and K at 0, 30, 60 or 90 kg K_2O/ha. Highest plant height, number of branches per plant, pod length and girth, number of pods per plant, green pod yield among P rates were recorded for P at 80 kg/ha.

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

Begum *et al*(2003) found that the highest fertilizer treatment NPK (90-50-120) resulted in the highest pod length (15.76 cm), pod weight (82.33 gm/ plant) and pod yield(13.99 q/ ha) of French bean

Landa*et al.* (2002) reported that application of NPK significantly influenced the growth, vigor and advanced the harvesting date of green beans.Thirumalai*et al.* (1993) reported that the best yield of *Phaseolusvulgaris* was obtained by applying 62.5 kg N +100 kgP_2O_5 +75 kg K_2O/ha.

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) for higher growth and seed yield ofFrench 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 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 kgP_2O_5/ha. The combination of 120 kg P_2O_5 along with 60 kg K_20 ha^{-1} gave the highest seed yield.

Sushant*et al.* (1999) conducted an experiment in India to investigate the effect ofN (0, 50 or l00 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 $P_2O_{5.}$ 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.

Gajendra and Singh (1998) conducted a field experiment at Lalchaoti in India. They reported that 120 Kg N+90 kg P_2O_5 and 45 kg K_20 ha^{-1} gave higher grain yield of French bean.

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}produccd 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_20 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}.

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. The mean increases in seed yield with 120 kg Nha^{-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/ $ha^{/}$andat 0-120 kg$P_2O_{5//}$ha, plus a basal dose of 50 kg K_20/ ha. They found that the optimum dose of NP was 67.3: 79.7 kg/ ha. Popescu*et al*. (1992) reported that NPK significantly increased the seed yield of P and the highest yield was given at 75 kg N, 80 kg$P_2O_5$and 120 kg K_2O/ha.

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 kgP_2O_5 /ha. However, the optimum combination was found to be 80 kg N and 123 kgP_2O_5 ha^{-1}. Singh *et al.* (1981) reported that seed yields of *Phaseolusvulgaris*L.increased significantly with increasing N andP_2O_5. From the above finding it may be concluded that both nitrogen and phosphorus play an important role on vegetative growth and yield of French bean.

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 Frenchbean (*Phaseolus vulgaris* L.) were investigated in Uttar Pradesh. India during 2002-03 by Lal(2004). Nitrogen at 40 kg ha^{-1} was optimum for obtaining the maximum pea and bean seed yield. Seed yield of both crops increased with increasing P rates up to 60 kg ha^{-1}.

Varennes*et al.* (2002) reported that the application of P at 0, 50, 100, 150 kg/ha and N at 0, 50, 100 kg/ha significantly increased the plant height, leaf number, root number and pod yield. Phosphorus at 150 kg/ha gave the highest yield and nitrogen at 100 kg/ha gave the highest yield.

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 *Phaseolus vulgaris*cultivars. The yield and growth characters increased with increasing N: P fertilizer level and the highest value (15.93 q ha^{-1}) was observed at 120:75 kg ha^{-1}.

S. S. Kakon*et al*. (2016) conducted a field experiments were conducted during rabi (winter) seasons of 2010-11 and 2011-12 at the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur to study the effects of nitrogen and phosphorus on growth, dry matter production and yield of French bean. They found seed yield significantly increased with the increase in nitrogen and phosphorus level upto 150 kg N and 44 P kg ha^{-1}, respectively.

Parmer *et al*. (1999) reported that French bean was treated with three levels of nitrogen (0, 15 and 30 kg/ha) and four levels of Phosphorus (0, 30, 60 and 90 kg P_2O_5/ha) in a field experiment conducted in Himachal Pradesh, India during summer season. Plant height, number of pods per plant and seed/pod were increased with increasing rate of N and P.Sadhu and Roy (1991) reported that application of phosphorus, nitrogen and potassium significantly increased the growth and yield of kidney bean. They got highest plant height (48 cm) and highest yield (12.5 ton/ha) with the combination of 120 kg N + 75 kg P_2O_5+ 60 kg K_2O/ha.

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

Sharangiand Paria (1995) conducted a field experiment on French bean with phosphorus fertilizer at 0, 60, 120 and 160 kg/ha and potassium at 0, 60 and 120 kg/ha. Nitrogen was applied at 100 kg/ha. They found that the shoot growth and yield were increased with the increasing rate of phosphorus and potassium and got highest yield (13.0 ton/ha) at the combination of 160 kg P and 120 kg K/ha.

CHAPTER III

MATERIALS AND METHODS

The materials and methods used in conducting the experiment have been presented in this chapter under the following heads:

3.1 Description of the experimental site

3.1.1 Location

The research work was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka, to study the effectof nitrogen and phosphorus on seed yield of bush bean during the period from November,2015 to March, 2016.

3.1.2 Characteristics of soil

The land was Agro- ecological zone of Modhupur tract (AEZ no. 28). It was deep red brown terrace soil and belongs to “Noadda” cultivated series. The altitude of the location was 8 m above the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207. The amount of organic carbon, total N, available P and K were 1.25%, 0.08%, 20 ppm and 0.20 mg/l00g soil, respectively. The physical and chemical characteristics of the soil have been presented in Appendix II.

3.1.3 Climate

The experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high humidity, high temperature and relatively long day period during “kharif’ season (April-August) and scarce rainfall, low humidity, low temperature and short day period during “Rabi” season (October-March). This climate is also characterized by distinct season viz., the monsoon or rainy season extending from May to October, the winter or dry season from November to February and pre-monsoon period or hot season from March to April. The meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and soil temperature for the entire experimental period have been shown in Appendix- 1

3.2 Experimental details

3.2.1 Planting materials

The cultivar of bush bean used in the experiment was “BARI JharSheem- 1”. The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.2.2 Treatments of the experiment

The experiment involved two factors, namely,

Factor A: Different nitrogen level and Factor B: Different phosphorus level.

Factor A: Nitrogen

It consisted four levels of Nitrogen.

i. 0 kg N/ha (N_o)
ii. 80 kg N/ha (N_1)
iii. 120 kg N/ha (N_2)
iv. 160 kg N/ha (N_3)

Factor B: Phosphorus

Four levels of Phosphorus.

i. 0 kg P/ha (P_o)
ii. 50 kg P/ha (P_1)
iii. 100 kg P/ha (P_2)
iv. 150 kg P/ha (P_3)

Treatment combinations:

$T_1 = N_0P_0$	$T_2 = N_0P_1$
$T_3 = N_0P_2$	$T_4 = N_0P_3$
$T_5 = N_1P_0$	$T_6 = N_1P_1$
$T_7 = N_1P_2$	$T_8 = N_1P_3$
$T_9 = N_2P_0$	$T_{10} = N_2P_1$
$T_{11} = N_2P_2$	$T_{12} = N_2P_3$
$T_{13} = N_3P_0$	$T_{14} = N_3P_1$
$T_{15} = N_3P_2$	$T_{16} = N_3P_3$

3.2.3 Design and layout of the experiment

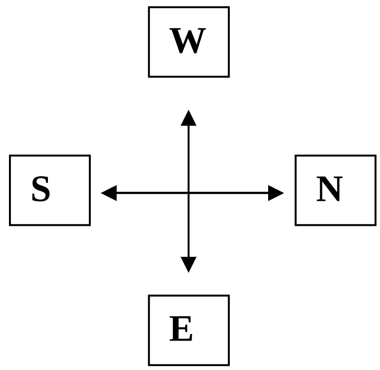
The two factors experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into equal 3 blocks and each consists of 16 plots. Each unit plot was 1.2 m x 0.9 m in size. All together there were 48 unit plots in experiment. Distance between replication was 1 m and plot to plot was 0.5 m. The treatments were randomly assigned to each of the block.

3.2.4 Land preparation

At first the land was ploughed with a power-tiller on 2 November, 2015 and kept open to sunlight. Afterwards the experimental plot was prepared by live ploughings and cross ploughings followed by laddering to break the clods and to level the soil. The weeds and stubble of previous crops were collected and removed from the soil. These operations were done to bring the land under good tilth for sowing of seeds.

N_3P_1	N_3P_0	N_2P_0
N_0P_0	N_2P_1	N_3P_1
N_1P_3	N_0P_0	N_1P_3
N_2P_0	N_3P_1	N_3P_3
N_2P_3	N_1P_2	N_1P_1
N_3P_2	N_1P_0	N_2P_2
N_1P_1	N_3P_3	N_0P_1
N_3P_0	N_2P_0	N_0P_3
N_2P_1	N_1P_3	N_0P_0
N_3P_3	N_0P_1	N_3P_2
N_0P_1	N_1P_1	N_3P_0
N_1P_0	N_0P_2	N_2P_3
N_0P_2	N_2P_2	N_0P_2
N_0P_3	N_2P_3	N_1P_0
N_2P_2	N_3P_2	N_1P_2
N_1P_2	N_0P_3	N_2P_1

Legend



Treatments:

Factor A: Nitrogen

N_0 = 0 kg/ha
N_1 = 80 kg/ha
N_2 = 120kg/ha
N_3 = 160 kg/ha

Factor B: Phosphorus

P_0 = 0 kg/ha
P_1 = 50 kg/ha
P_2 = 100 kg/ha
P_3 = 150 kg/ha

Experiment layout:

Plot to plot distance = 0.5 m
Block to block distance =1 m.
Plot size = 1.2×0.9 m^2
Replication = 3

Fig.1. Layout of the experimental field

3.2.5 Manuring and fertilization

Half amount of MP (160 kg ha^{-1}), full amount of gypsum (220 kg/ha) and cow-dung (15 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 specified plots. Nitrogen fertilizer (as urea) was applied in the specified plots in 4 splits. One third as the basal doze, another One third at 15 days interval,another One third at 15 days interval and the last one dose at 15 days interval.

Fertilizer and manures	**Application (100%)**			
	Basal	**15 DAS**	**30 DAS**	**45 DAS**
CD	100 %			
Urea	25 %	25 %	25 %	25 %
TSP	100 %			
MP	50 %	25 %	25%	
Gypsum	100 %			

3.2.6Sowing of seeds

Two treated seeds were sown each hill at a depth of 3.0 cm. Seeds were treated with Bavistin to protect from seed borne diseases. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 18 November,2015 in rows and at spacing of 30 cm x 15 cm. The seeds were covered with loose soil. Bush bean was sown as border crops to reduce border effects.

3.3Intercultural operations

3.3.1 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. Seedlings of about 15 cm in height were transplanted from border rows with roots plunged 5 cm below the soil in hills in the evening and when watering was done to protect the seedlings from wilting. All gaps were filled up within two weeks after germination of seeds.

3.3.2 Thinning

One seedling was kept in each hill and remaining was uprooted after 15 days of emergence.

3.3.3 Weeding

The experimental plots were kept weed free by hand weeding as and when necessary. Weeding done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of seedlings whenever it is necessary. Weeding and mulching were done three times at 20, 30 and 40 DAS.

3.3.4 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation was given four times at an interval of 10 days.

3.3.5 Plant protection

a. Insect pests

At the early stage of growth, some plants were attacked by insect pests (mainly aphids) and Malathion 57 EC was sprayed at the rate of 2 ml/liter at an interval of 15 days.

b. Diseases

Seedlings were attacked by damping off and Dithane M-45 was sprayed at the rate of 2 ml/liter at an interval of 15 days. Some plants were attacked by bean common mosaic virus (BCMV) which was an important disease of bush bean. These plants were removed from the plots and destroyed immediately.

3.3.6Harvesting

The pods were harvested at mature stage when all leaves and pods become yellow and fully dry. Seed which is harvested too early will not grow into healthy plants. Do not leave the beans to dry in the field it can be affected by diseases, insects and animals. The seeds were collected from the dry pods and spread out in a thin layer in direct system, when the moisture percentage of seed attained 7-8 %, then the seeds were ready to store.

3.4Collection of data

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

3.4.1 Plant height

The plant height was recorded at 15, 30,45, 60 and 90 days after sowing (DAS). The plant height was taken from ground level to the tip of the largest leaf of the plants. Plant heights were recorded from 5 randomly sampled plants and mean was calculated in centimeter (cm).

3.4.2 Number of leaves per plant

The number leaves of 5 randomly selected plants from each unit plot at 15, 30, 45, 60 and 90 days after sowing (DAS) was counted and mean were calculated.

3.4.3 Leaf length

Leaf length (cm) was measured by using measuring scale of 5 randomly selected plants from each unit plot at 15, 30, 45 and 60days after sowing (DAS) and mean was recorded.

3.4.4 Leaf diameter

Diameters of leaf of 5 randomly selected plants from each unit plot were measured in cm with the help of slide calipers and their average was taken.

3.4.5 Number of branches per plant

Average number of branches per plant was found from 5 randomly selected plants from each unit plot at 30, 40, 50 and 60days after sowing (DAS)and mean was recorded.

3.4.6 Days of first flowering

Date of first flowering for different treatments were recorded.

3.4.7 Days of 90% flowering

Date of 90% flowering for different treatments were recorded.

3.4.8 Number of flowers per plant

From 5 randomly selected plants from each unit plot numbers of flowers were counted and their mean values were founded.

3.4.9 Number of pods per plant

From 5 randomly selected plants from each unit plot numbers of pods were counted and their mean values were founded.

3.4.10 Length of dry pod

Fivedry pods from each randomly selected plant were measured using centimeter scale and the mean value was calculated and was expressed in centimeter.

3.4.11 Diameter of dry pod

Diameters of dry pod of 5 randomly selected plants from each unit plot were measured in cm with the help of slide calipers and their average was taken.

3.4.12 Number of seeds per dry pod

Number of seeds per dry pod was recorded from 5 randomly selected plants and the mean value was calculated.

3.4.13Weight of 100 seed

One hundred dry seeds from 5 randomly selected plants plot^{-1}were weighed and their average was taken in gram (g).

3.4.14 Length of seed

Fiveseedfrom each randomly selected plant were measured using centimeter scale and the mean value was calculated and was expressed in centimeter.

3.4.15 Diameter of seed

Diameters of seed of 5 randomly selected plants from each unit plot were measured in cm with the help of slide calipers and their average was taken.

3.4.16 Dry matter content of shoot

One hundred gram fresh weight of shoot was taken from five randomly selected plants from each experimental plot. This 100g shoot was cut with a fine knife, thereafter, dried under room condition and kept in an oven at 70^0C for drying in 72 hours until the constant weight was reached. The percentage of dry matter of shoot was calculated by the following formula-

$$\text{Dry matter content of shoot (\%)} = \frac{\text{Dry weight of shoot}}{\text{Fresh weight of shoot}} \times 100$$

3.4.17 Seed yield plant^{-1}

Seeds from 5 randomly selected plants wereweighed and their average was taken in gram (g).

3.4.18 Seed yield

Harvesting was done at different interval and total seed were recorded in each unit plot and expressed in kilogram (kg). Finally seed yield per plot was converted to seed yield per hectare and expressed in ton.

3.5Statistical analyses

Statistical analyses were done by using MSTATcomputer package program. The analyses of variance for the characters under study were performed by F variance test. The mean differences were adjudged by using the Duncan’s Multiple Range Test at 5% level of probability for the interpretation of results.

3.6Economic analyses

Economic analyses were done in order to find out the most profitable treatment combinations.

3.6.1Gross return

Gross return was calculated on the sale price of marketable seed of bush bean. The price of seed in the market was considered at Tk.100.00 /kg.

3.6.2Net return

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

3.6.3Benefit cost ratio (BCR)

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

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

CHAPTER IV

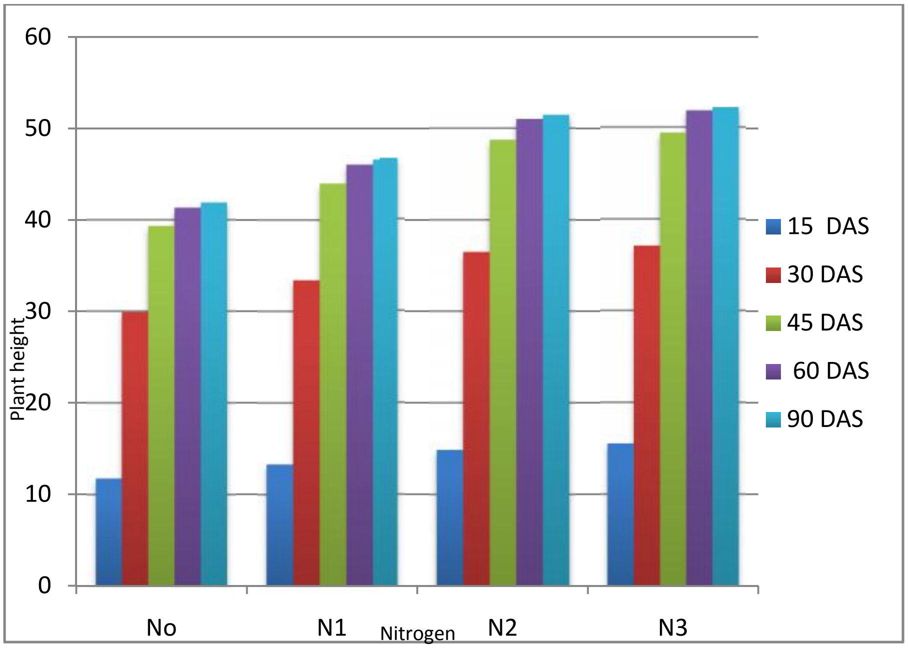
RESULTS AND DISCUSSIONS

The present research work was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2015 to March, 2016to investigate the effect of nitrogen and phosphorus on seed yield of bush bean. The analysis of variance (ANOVA) of the data on yield contributing characters and yield of bush bean had been shown in AppendixIII-XI.The result of the experiment have been presented and discussed in this chapter under the following headings:

4.1 Plant height

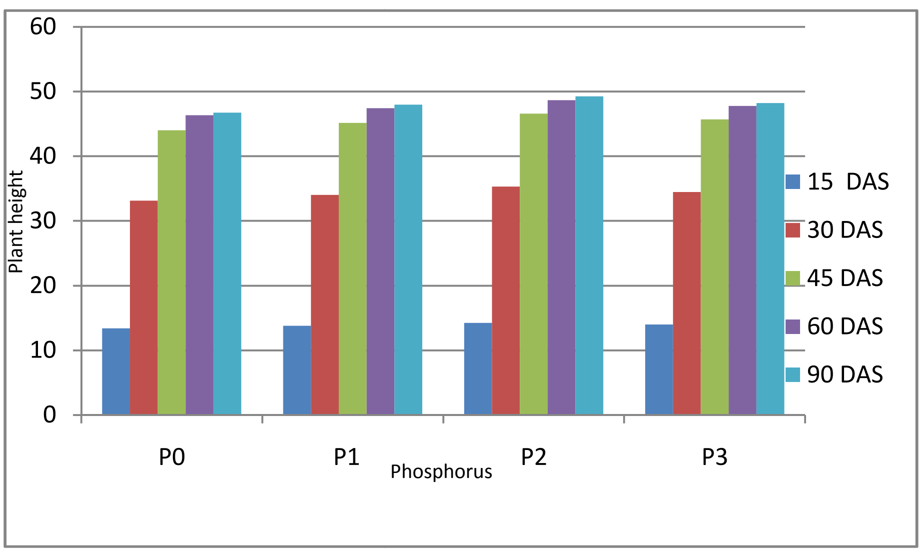
Plant height is an important character of a plant, which is closely related proper growth and development of a plant and finally produced higher yield.Plant height of bush bean varied significantly at 15, 30, 45 ,60 and 90 days after sowing (DAS) due to different nitrogen levels (Fig. 2 and Appendix III). At 90 DAS, the longest (52.17 cm) plant was produced fromN_3(160 kg N/ha) treatmentand the shortest (41.90 cm) was found from N_0(control) treatment.The increase in height may be due to the influence vis-a-vis absorption of nutrients and more particularly nitrogen might have played a dominant role in it. The present result also agrees well withMoniruzzaman (2009),who obtained the highest plant height 46.7 cm.

Plant height of bush bean varied significantly at 15, 30, 45 ,60 and 90 days after sowing (DAS) due to different levels of phosphorus (Fig. 3 and Appendix III). At 90 DAS, the highest plant height (49.26 cm) was produced from P_2 treatment (100 kg P/ha). The shortest (46.75 cm) plant was produced in (control) P_0 treatment. The results also indicate that the increasing rate of phosphorus significantly increase the plant height. The present result also agrees well with that of Parmer *et al.* (1999), who obtained the highest plant height, highest no. of pod and seed of bush bean with increasing rate of nitrogen and phosphorus.



Here, N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Fig 2.Effect of nitrogen on plant height at different days after sowing of bush bean



Here, P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Fig3.Effect of phosphorus on plant height at different days after sowing of bush bean.

Table 1. Combined effect of nitrogen and phosphorus on plant height afterdifferent days after sowing of bush bean

Treatments	Plant height(cm)				
	15 DAS	30 DAS	45 DAS	60 DAS	90 DAS
N_0P_0	11.34 f	28.86 h	37.92 k	40.08 k	40.59 l
N_0P_1	11.72 f	29.67 gh	39.04 j	41.22 j	41.71 k
N_0P_2	12.10 e	31.13 f	40.80 i	42.46 i	43.22 j
N_0P_3	11.80 f	30.07 g	39.65 j	41.59 j	42.03 k
$N_1 P_0$	12.91 e	32.26 e	42.62 h	44.82 h	45.23 i
N_1P_1	13.28 e	33.13 de	43.77 g	45.88 g	46.58 h
N_1P_2	13.65 e	34.70 c	45.39 f	47.26 f	47.88 g
N_1P_3	13.35 e	33.63 d	44.12 g	46.25 g	46.83 h
N_2P_0	14.47 d	35.07 c	47.45 e	49.75 e	50.18 f
N_2P_1	14.82 cd	36.44 b	48.61 cd	50.95 d	51.44 de
N_2P_2	15.21 b-d	37.51 a	49.77 ab	52.13 ab	52.62 b
N_2P_3	15.04 b-d	36.99 ab	49.16 bc	51.30 cd	51.70 cd
N_3P_0	14.91 cd	36.34 b	48.18 de	50.64 d	51.00 e
N_3P_1	15.40 bc	36.95 b	49.23 bc	51.74 bc	52.13 bc
N_3P_2	16.07 a	37.87 a	50.33 a	52.91 a	53.31 a
N_3P_3	15.76 ab	37.26 ab	49.85 ab	51.99 bc	52.25 bc
CV%	5.56	5.98	7.25	7.98	6.41
LSD (0.05)	0.763	0.951	0.845	0.788	0.611

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Combined effect of nitrogen and phosphorus on Plant height was observed statistically significant due to different days after sowing(Table. 1 and Appendix III). At 90 DAS, the highest (53.31 cm) plant was produced from N_3P_2 treatment (160 kg N/ ha and 100 kg P/ha) and shortest (40.59 cm) plant was produced in (control) N_0P_0 treatment combination.

Hence it may be inferred that the increase in plant height may be due to the favorable influence and balanced absorption of nitrogen and phosphorus, increased role of photosynthesis, reduced transpiration and stimulation of root system.Sadhu and Roy (1991) got highest plant height (48 cm) with the combination of 120 kg N + 75 kg P_2O_5+ 60 kg K_2O/ha. Chandra *et al*. (1987), Arya*et al*. (1999),Tewari and Singh (2000)reported that plant height was increased by using treatment combination of 160 kg N and 120 kg P_2O_5.

4.2 Number of leaves per plant

Number of leaves per plant is an important parameter of crop plant because of its physiological role in photosynthetic activities. Number of leaves is directly related to the bush bean yield. Number of leaves per plant of bush bean varied significantly at 15, 30, 45 ,60 and 90 days after sowing (DAS) due to different nitrogen levels (Table. 2 and Appendix IV). At 90 DAS,the highest number of leaves (19.73) per plant was obtained from N_3 treatment (160 kg N/ha) and the lowest (15.95) from (control) N_0 treatment. An accumulation of reserve substances in the leaves resulting from the additional supply of nitrogen perhaps enhanced the number of leaves which ultimately increased the leaf number. This finding is an agreement with the result of Sexena and Varme (1995). 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 upto 120 kg N/ha.

Number of leaves per plant of bush bean varied significantly at 15, 30, 45 ,60 and 90 days after sowing (DAS) due to different phosphorus levels (Table. 3 and Appendix IV). At 90 DAS, the highest (18.65) number of leaves per plant was obtained from P_2 treatment (150 kg P/ha) and the lowest (17.76) from (control) P_0 treatment.

Table 2.Effect of nitrogen on number of leaves per plant at different days after sowingof bush bean.

Treatments	Number of leaves per plant				
	15 DAS	30 DAS	45 DAS	60 DAS	90 DAS
No	2.60 c	8.30 d	13.50 d	15.48 d	15.95 d
N_1	2.96 b	9.88 c	15.23 c	17.35 c	17.50 c
N_2	3.48 b	11.66 b	16.03 b	18.22 b	18.65 b
N_3	3.60 a	11.91 a	17.11 a	19.48 a	19.73 a
CV%	8.77	7.33	9.48	8.29	10.11
LSD (0.05)	0.11	0.23	0.78	0.31	0.28

Here,N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Table 3.Effect of phosphorus on number of leaves at different days after sowing of bush bean.

Treatments	Number of leaves per plant				
	15 DAS	30 DAS	45 DAS	60 DAS	90 DAS
Po	3.00 c	10.01 c	15.26 c	17.36 c	17.76 c
P_1	3.15 ab	10.40 b	15.68 b	17.80 b	18.16 b
P_2	3.33 a	10.83 a	16.10 a	18.28 a	18.65 a
P_3	3.16 b	10.52 b	15.83 b	17.95 b	18.30 b
CV%	8.77	7.33	9.48	8.29	10.11
LSD (0.05)	0.15	0.14	0.26	0.28	0.28

Here, P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Table 4. Combined effect of nitrogen and phosphorus on number of leaves at differentdays after sowing of bush bean

Treatments	Number of leaves per plant				
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**90 DAS**
N_0P_0	2.46 h	7.93 h	13.06 g	15.13 h	15.60 g
N_0P_1	2.33 gh	8.26 gh	13.46 fg	15.46 gh	15.93 fg
N_0P_2	2.80 fg	8.60 g	13.86 f	15.80 g	16.20 f
N_0P_3	2.60 gh	8.41 gh	13.60 f	15.53 gh	16.06 fg
$N_1 P_0$	2.80 fg	9.46 f	14.73 e	16.60 f	17.00 e
N_1P_1	2.93 ef	9.86 ef	15.20 de	17.13 ef	17.47 de
N_1P_2	3.13 de	10.27 e	15.60 d	17.60 e	17.93 d
N_1P_3	3.00 ef	9.93 ef	15.40 d	17.33 e	17.60 d
N_2P_0	3.33 cd	11.13 d	16.53 c	18.71 d	19.13 c
N_2P_1	3.46 bc	11.60 b-d	17.00 a-c	19.20 b-d	19.5 bc
N_2P_2	3.60 a-c	12.13 ab	17.46 a	19.80 ab	20.20 a
N_2P_3	3.53 a-c	11.80 a-c	17.1 3 ab	19.33 a-d	19.73 ab
N_3P_0	3.40 b-d	11.53 cd	16.7 3 bc	19.00 cd	19.33 bc
N_3P_1	3.66 ab	11.86 bc	17.06 b	19.40 bc	19.73 b
N_3P_2	3.80 a	12.34 a	17.46 a	19.93 a	20.26 a
N_3P_3	3.53 bc	11.93 ab	17.20 ab	19.60 ab	19.80 ab
CV%	8.77	7.33	9.48	8.29	10.11
LSD (0.05)	0.301	0.637	0.522	0.62	0.57

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

The combined effect of nitrogen and phosphorus was significant for number of leaves per plant of bush bean (Table. 4 and Appendix- IV). Number of leaves per plant of bush bean was the lowest in control at all days of data collection. At 90 DAS, the highest (20.26) number of leaves per plant was recorded from the treatment of N_3P_2(160 kg N/ha and 100 kg P/ha) which was statistically identical to (20.20) interaction of N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment, which was statistically similar (19.80) tothe treatment of N_3P_3 (160 kg N/ha and 150 kg P/ha), which was also statistically similar (19.73) tothe treatment of N_2P_3 (120 kg N/ha and 150 kg P/ha) and the lowest (15.60) was found from (control) N_0P_0 treatment combination. The results of the present study indicated that highest levels of nitrogen and phosphorus fertilizers combination might have induced better growing condition, perhaps due to supply of adequate plant nutrients which ultimately led to the production of more leaves per plant.The result obtained fromthe present study supported by Varenneset al. (2002), Varma and Singh (2000) in respect of number of leaves per plant.

4.3 Leaf length

The productivity of field crops depends mainly on the size of leaf, the photosynthesis system as well as on the length of leaf. Variation in leaf length was significant at 15, 30, 45 and 60 DAS due to application of different level of nitrogen (Table. 5 and Appendix V). The highest leaf length (14.11 cm) was found from (160 kg N/ha) N_3 treatment, where the shortest (11.13 cm) was observed from N_0(control) treatment at 60 DAS. The results indicate that the increasing rate of nitrogen significantly increase the leaf length. It may be additional supply of N perhaps enhanced the size and shape of the leaves.

Variation in leaf length was significant at 15, 30, 45 and 60 DAS due to application of different level of phosphorus (Table. 6 and Appendix V). Highest leaf length (13.39 cm)was found from P_2 treatment (100 kg P/ha), where the shortest (12.55 cm) was observed from P_0 (control) treatment at 60 DAS. The optimum phosphorus levels might have induced stronger physiological activity in the production of largest length of leaf. The result of the present study agrees with of Varenneset al. (2002), who reported that application of 150 kg P/ha and 100 kg N/ha significantly increased the leaf number and length of bush bean.

Table 5. Effect of nitrogen on leaf length at different days after sowing of bush bean.

Treatments	Leaf length (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
No	5.60 d	7.40 d	10.86 d	11.13 d
N_1	6.64 c	8.62 c	12.18 c	12.65 c
N_2	7.79 b	9.77 b	13.58 b	13.98 b
N_3	7.97 a	9.91 a	13.85 a	14.11 a
CV%	6.91	7.58	9.77	8.79
LSD (0.05)	0.14	0.12	0.26	0.12

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Table 6.Effect of phosphorus on leaf length at different days after sowing of bushbean

Treatments	Leaf length (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
Po	6.65 c	8.53 c	12.20 c	12.55 c
P_1	6.93 b	8.83 b	12.53 b	12.89 b
P_2	7.36 a	9.35 a	13.04 a	13.39 a
P_3	7.075 b	8.92 b	12.70 b	13.04 b
CV%	6.91	7.58	9.77	8.79
LSD (0.05)	0.18	0.17	0.28	0.28

Here, P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Table 7. Combined effect of nitrogen and phosphorus on leaf length at different days after sowing of bush bean

Treatments	Leaf length (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
N_0P_0	5.33 k	6.94 j	10.41 j	10.68 k
N_0P_1	5.51 k	7.20 j	10.71 j	11.00 jk
N_0P_2	5.91 ij	7.91 h	11.36 hi	11.59 hi
N_0P_3	5.66 jk	7.56 i	10.94 ij	11.27 ij
$N_1 P_0$	6.26 hi	8.14 gh	11.72 gh	12.08 gh
N_1P_1	6.53 gh	8.44 fg	12.06 fg	12.52 fg
N_1P_2	7.04 ef	9.21 e	12.65 de	13.19 de
N_1P_3	6.72 fg	8.68 f	12.30 ef	12.81 ef
N_2P_0	7.42 de	9.44 de	13.15 cd	13.66 cd
N_2P_1	7.76 b-d	9.74 b-d	13.51 bc	13.96 a-c
N_2P_2	8.04 b	10.05 ab	13.88 ab	14.28 ab
N_2P_3	7.95 bc	9.83 bc	13.78 ab	14.04 a-c
N_3P_0	7.60 cd	9.62 cd	13.54 bc	13.78 bc
N_3P_1	7.92 bc	9.92 a-c	13.84 ab	14.11 a-c
N_3P_2	8.43 a	10.24 a	14.25 a	14.50 a
N_3P_3	7.96 bc	9.88 bc	13.77 b	14.04 bc
CV%	6.91	7.58	9.77	8.79
LSD (0.05)	0.38	0.34	0.56	0.55

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Significant variation of leaf length was observed at 15, 30, 45 and 60 DAS due to combined effect of different nitrogen and phosphorus level (Table.7 and Appendix V). At 60 DAS, the longest (14.50 cm) leaf length was produced from N_3P_2 (160 kg nitrogen per hectare and 100 kg phosphorus per hectare) treatment, which was statistically similar to N_2P_2 (120 kg nitrogen per hectare and 100 kg phosphorus per hectare) treatment, where the shortest (10.68 cm) leaf length was observed in N_0P_0 (control) treatment. It can be said from this result that, higher amount of nitrogen in combination with optimum levels of phosphorus increase the vegetative growth of plant by increasing the photosynthetic rate and maximum utilization of natural resources and also increase the leaf length.

4.4 Leaf breadth

Leaf breadth of a leaf has a great role to play in the crop production, as it is the protected means of trapping solar energy and converting it into food and other useful materials.Variation in leaf breadth was significant at 15, 30, 45 and 60 DAS due to application of different level of nitrogen (Table. 8 and Appendix VI). The highest leaf breadth (5.89 cm) was found from 160 kg N/ha(N_3 treatment),where the shortest (4.19 cm) was observed from N_0 (control) treatment at 60 DAS.It was observed in the present study that higher levels of N application increased leaf breadth. It might be due to the preserves of higher amount of nitrogen hastened better growth which increase the breadth of leaf.

Table 8: Effect of nitrogen on leaf breadthat different days after sowing of bush bean.

Treatments	Leaf breadth (cm)			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
No	3.71c	5.10 d	5.76d	4.19 d
N_1	4.35 b	5.80 c	6.64 c	4.98 c
N_2	5.00 b	6.55 b	7.53 b	5.75 b
N_3	5.13a	6.74 a	7.77 a	5.89 a
CV%	9.67	8.81	7.92	10.52
LSD (0.05)	0.12	0.18	0.1172	0.13

Here,N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Table 9.Effect of phosphorus on leaf breadthat different days after sowing of bush bean.

Treatments	Leaf breadth (cm)			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
Po	4.35 c	5.81 c	6.64 d	4.94 d
P_1	4.51bc	5.98 bc	6.85 c	5.13 c
P_2	4.75 a	6.27 a	7.19 a	5.42 a
P_3	4.57 b	6.12 b	7.04b	5.30 b
CV%	9.67	8.81	7.92	10.52
LSD (0.05)	0.18	0.17	0.10	0.14

Here,

P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Variation in leaf breadth was significant at 15, 30, 45 and 60 DAS due to application of different level of phosphorus (Table. 9 and Appendix VI). Highest leaf breadth (5.45 cm) was found from P_2(100 kg P/ha) treatment, where the shortest (4.94 cm) was observed from P_0 (control) treatment at 60 DAS.

Significant variation of leaf breadth was observed at 15, 30, 45 and 60 DAS due to combined effect of different nitrogen and phosphorus level (Table. 10 and Appendix VI). At 60 DAS, the longest (6.10cm)leaf breadth was produced from N_3P_2(160kg nitrogen per hectare and 100 kg phosphorus per hectare) which was statistically similar to (5.96 cm)from N_3P_3 (160 kg N/ha and 150 kg P/ha) treatment, where the shortest (3.93cm)leafbreadthwas observed in N_0P_0 (control).Sexena and Varme (1995) reported that combined application of nitrogen (120 kg/ha) and phosphorus (120 kg/ha) significantly increase all growth parameter.

Table 10. Combined effect of nitrogen and phosphorus on leaf breadth at different daysafter sowing of bush bean

Treatments	Leaf breadth (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
N_0P_0	3.53h	4.83i	5.53 k	3.93k
N_0P_1	3.66gh	5.00i	5.70jk	4.13jk
N_0P_2	3.93fg	5.40 gh	5.97 i	4.43hi
N_0P_3	3.73gh	5.16 hi	5.86ij	4.27 ij
$N_1 P_0$	4.13ef	5.56 fg	6.23h	4.63gh
N_1P_1	4.26 d-f	5.73 e-g	6.50g	4.83 g
N_1P_2	4.60cd	6.03 de	7.03ef	5.33ef
N_1P_3	4.40de	5.86 ef	6.80f	5.13f
N_2P_0	4.80bc	6.33cd	7.26de	5.53de
N_2P_1	5.00 ab	6.50 bc	7.50 cd	5.73 b-d
N_2P_2	5.13ab	6.73ab	7.73 bc	5.93 a-c
N_2P_3	5.06 ab	6.66 a-c	7.63 bc	5.83 a-c
N_3P_0	4.97 a-c	6.53bc	7.53 c	5.66 cd
N_3P_1	5.13ab	6.70ab	7.70bc	5.83 bc
N_3P_2	5.33 a	6.93a	8.03 a	6.10a
N_3P_3	5.10 ab	6.80ab	7.86ab	5.96 ab
CV%	9.67	8.81	7.92	10.52
LSD(0.05)	0.36	0.36	0.23	0.29

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

4.5 Number of branches per plant

Significant variation in number of branches per plant of bush bean was observed at 30, 40, 50 and 60 DAS due to application of different levels of nitrogen (Table. 11 and Appendix VII). Highest number of (12.71) branch was found from N_3(160 kg N/ha) treatment, where the lowest (8.76) was observed from (control)No treatment at 60 DAS.

Variation of number of branches per plant of bush bean was observed at 30, 40, 50 and 60 DAS due to application of different levels of phosphorus (Table. 12 and Appendix VII). Highest number of (11.60) branch was found from P_2 treatment (100 kg P/ha) where the lowest (10.43) was observed from (control) Po treatment at 60 DAS. It was observed in present study that increasing phosphorus rates increase number of branches per plant of bush bean. It can be said that phosphorus play a vital role in several physiological processes, *viz*, photosynthesis, respiration, energy store and transfer, cell division which will significantly enhance the axillary stalk or branching of plants. The results are supported by Dash and Dash (1987). They found that most of the growth and yield characters of bush bean influenced by phosphorus.

Significant variation of number of branches per plant was observed at 30, 40, 50 and 60 DAS due to combined effect of different nitrogen and phosphorus level (Table. 13 and Appendix VII). At 60 DAS, the highest no. of (13.13) branch was recorded from N_3P_2(160 kg N/ha and 100 kg P/ha) treatment, which was statistically similar to (12.80) N_2P_2treatment (120 kg N/ha and 100 kg P/ha). The lowest (8.13) was observed from (control) N_0P_0treatment.Sharma *et.al* (2013) found highest 12.28 branches bush bean.Tewari and Singh (2000),Sexena and Varme (1995) reported that number of branches increased with increasing rate of nitrogen and phosphorus combination.

Table11.Effect of nitrogen on number of branches per plant at different

daysaftersowing of bush bean.

Treatments	Number of branches per plant			
	30 DAS	40 DAS	50 DAS	60 DAS
No	0.96 c	5.13 d	8.53d	8.76 d
N_1	1.23 b	6.35 c	9.96c	10.65 c
N_2	1.26 b	7.06 b	10.70b	12.16 b
N_3	1.38 a	7.23a	10.92a	12.71 a
CV%	9.25	10.95	6.64	6.49
LSD (0.05)	0.11	0.15	0.24	0.44

Here, N_0= 0 kg/ha, N_1= 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Table12.Effect of phosphorus on number of branches per plant at different days after sowing of bush bean.

Treatments	Number of branches per plant			
	30 DAS	40 DAS	50 DAS	60 DAS
Po	1.11 c	6.11 c	9.66c	10.43 c
P_1	1.21bc	6.43 b	9.98 b	10.98 b
P_2	1.35 a	6.73a	10.36 a	11.60 a
P_3	1.26 b	6.60 b	10.10 b	11.18 b
CV%	9.25	10.95	6.64	6.49
LSD (0.05)	0.11	0.17	0.23	0.25

Here,

P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Table 13.Combined effect of nitrogen and phosphorus on number of branches per plant at different days after sowing of bush bean

Treatments	Number of branches per plant			
	30 DAS	**40 DAS**	**50 DAS**	**60 DAS**
N_0P_0	0.86 h	4.73 j	7.92 j	8.13k
N_0P_1	0.93gh	5.06ij	8.40ij	8.66 j
N_0P_2	1.06 e-h	5.46gh	9.06gh	9.33i
N_0P_3	1.00 f-h	5.26hi	8.73hi	8.93ij
$N_1 P_0$	1.13 d-g	5.80 g	9.53fg	10.00h
N_1P_1	1.20 c-f	6.33 f	9.93 ef	10.61g
N_1P_2	1.33 a-d	6.73 de	10.33 c-e	11.13 f
N_1P_3	1.26 b-e	6.53 ef	10.06 de	10.86fg
N_2P_0	1.20 c-f	6.93 cd	10.46b-d	11.66e
N_2P_1	1.40 a-c	7.13a-c	10.66 bc	12.20cd
N_2P_2	1.46ab	7.33ab	10.93 ab	12.80 ab
N_2P_3	1.40 a-c	7.26 a-c	10.73bc	12.40b-d
N_3P_0	1.26 b-e	7.00 b-d	10.73 bc	11.93 de
N_3P_1	1.33 b-d	7.20 bc	10.93 ab	12.46bc
N_3P_2	1.53a	7.40a	11.13 a	13.13a
N_3P_3	1.40 a-c	7.33ab	10.86 ab	12.53bc
CV%	9.25	10.95	6.64	6.49
LSD(0.05)	0.24	0.36	0.49	0.51

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

4.6 Day to first flower initiation

Flowering time is the most important time because it plays a vital role in life cycle of plant. From flower initiation to fruit set time is important phenological character, which is not only dependent on environmental factors, but also intrinsic factors like variety, fertilizer application, translocation of metabolites. Day to first flower initiation was showed statistically significant variation due to the nitrogen application (Table. 14 and Appendix VIII).The longest period (42.11days)required for first flower initiation fromN_2 (120 kg N/ha) treatment which was statistically identical to N_3 (160 kg N/ha) treatment.The shortest period (36.68 days) required for first flower initiation from (control) N_0 treatment.

Table 14.Effect of nitrogen on first flower initiation,90% flower initiation and number of flowers per plantin bush bean.

Treatments	First flower Initiation	90% flower initiation	Number of flowers per plant
No	36.68c	48.50c	29.66d
N_1	39.51b	52.25b	36.83 c
N_2	42.11 a	55.43 a	42.61 a
N_3	42.03a	55.22a	42.050 b
CV%	8.45	7.88	9.33
LSD (0.05)	0.48	0.43	0.54

Here, N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Day to first flower initiation was showed statistically significant variation due to the phosphorus application (Table. 15 and Appendix VIII). The longest period (40.63 days) was required for first flower initiation from P_3 (150 kg P/ha)treatment which was identical to P_2 (100 kg P/ha) treatment. On the other hand, the shortest period (39.26 days) for first flower initiation from Po(control) treatment.

Table 15.Effect of phosphorus on first flower,90% flowerinitiationand number of flowers per plantin bush bean.

Treatments	First flower initiation	90% flower initiation	Number of flowers per plant
Po	39.26c	51.83c	35.80d
P_1	39.88b	52.70 b	37.28c
P_2	40.56 a	53.61a	39.58 a
P_3	40.63a	53.25a	38.40 b
CV%	8.45	7.88	9.33
LSD (0.05)	0.610	0.85	0.48

Here,

P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Day to first flower initiation was showed statistically significant variation due to the combined effect nitrogen and phosphorus application (Table. 16 and Appendix VIII). The longest period (42.86days) required for first flower initiation from N_2P_2(120 kg N/ha and 100 kg P/ha) treatment which is similar N_3P_2 (160 kg N/ha and 100 kg P/ha) treatment. On the other hand, theshortest period (35.73 days) required for first flower initiation from N_0P_0(control) treatment. Kakon (2016) observed Day to first flower initiation was started at 37.67 days in control treatment and 44.83 days required for first flower initiation in best nitrogen and phosphorus combination.

Table 16. Combined effect of nitrogen and phosphorus on first flower initiation, 90% flower initiation and Number of flowers per plant in bush bean

Treatments	First flower initiation	90% flower initiation	Number of flowers per plant
N_0P_0	35.73k	47.13 j	27.33m
N_0P_1	36.33jk	48.06i	29.13l
N_0P_2	37.00ij	48.93i	31.66j
N_0P_3	37.66hi	49.86h	30.53k
N_1P_0	38.40gh	50.86g	34.20 i
N_1P_1	39.13fg	51.80f	36.20h
N_1P_2	39.93ef	52.73e	39.13 f
N_1P_3	40.60de	53.60e	37.80g
N_2P_0	41.33cd	54.53d	40.533e
N_2P_1	42.00bc	55.53bc	41.73cd
N_2P_2	42.86a	56.73 a	44.93a
N_2P_3	42.26bc	54.93 cd	42.86b
N_3P_0	41.60bc	54.80 cd	41.13 de
N_3P_1	42.06bc	55.40 b-d	42.06b-d
N_3P_2	42.46ab	56.06ab	42.60bc
N_3P_3	42.00bc	54.61d	42.40bc
CV%	8.45	7.88	9.33
LSD(0.05)	0.96	0.86	0.96

Here,
N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha
P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

4.7 Day to 90% flower initiation

Day to 90% flower initiation was showed statistically significant variation due to the nitrogen application (Table. 14 and Appendix VIII). The longest period (55.43 days) required for 90% flower initiation from N_2(120 kg N/ha) treatment, which is identical to N_3 (160 kg N/ha) treatment. The shortest period (48.50 days) required for 90% flower initiation from N_0 (control) treatment.

Day to 90% flower initiation was showed statistically significant variation due to the phosphorus application (Table. 15 and Appendix VIII). The longest period (53.61 days) requiredfor 90% flower initiation from P_2 (100 kg P/ha) treatment which is identical to P_3 (150 kg P/ha). The shortest period (51.83 days) required for 90% flower initiation from P_0 (control) treatment.

Day to 90% flower initiation was showed statistically significant variation due to the interaction effect nitrogen and phosphorus application (Table. 16 and Appendix VIII). The longest period (56.73 days) required for 90% flower initiation from N_2P_2 (120 kg N/ha and 100 kg P/ha) which is similar N_3P_2(160 kg N/ha and 100 kg P/ha). The shortest period (47.13 days) for 90% flower initiation from N_0P_0(control) treatment.

4.8 No. of flowers per plant

Number of flowers per plant varied significantly due to application of nitrogen (Table. 14 and Appendix VIII). The highest number of (42.61) flowers per plant of bush bean was found from N_2 (120 kg N/ha). The lowest number (35.80) of flowers per plant of bush bean was observed in N_0(control) treatment.

Number of flowers per plant varied significantly due to application of phosphorus (Table.15 and Appendix VIII). The highest number of (39.58) flowers per plant of bush bean was found from P_2(100 kg P/ha) treatment. The lowest number (35.80) of flowers per plant of bush bean was observed in P_0 (control) treatment.

Number of flowers per plant varied significantly due to combined application of nitrogen and phosphorus (Table.16 and Appendix VIII). The highest number of (44.93) flowers per plant of bush bean was found from N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment. The lowest number (27.33) of flowers per plant of bushbean was observed in N_0P_0 (control) treatment.S. S. Kakon (2016) observed highest number of flowers per plant(45.03) in best nitrogen and phosphorus combination.

4.9 Number of pods per plant

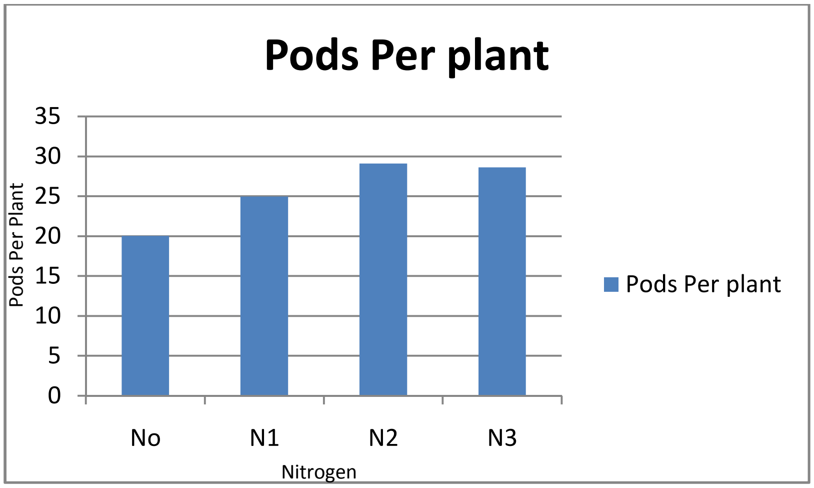
Number of pods per plant varied significantly due to application of nitrogen (Fig. 4 and Appendix VIII). The highest (29.08) number of pods per plant of bush bean was found due to application of N_2 (120 kg N/ha) treatment. The lowest (20.03) number of flowers per plant of bush bean was observed in N_0 (control) treatment.

Table 17: Effect of nitrogen onPod length,Pod diameterand Seeds per podin bush bean.

Treatments	Pod Length (cm)	Pod diameter (cm)	Seeds per pod
No	12.31 d	0.68 c	5.51 c
N_1	14.27 c	0.71 b	6.11 b
N_2	16.63 a	0.74 a	6.60 a
N_3	16.24 b	0.74 a	6.56 a
CV%	10.68	9.40	11.79
LSD (0.05)	0.34	0.016	0.14

Here,

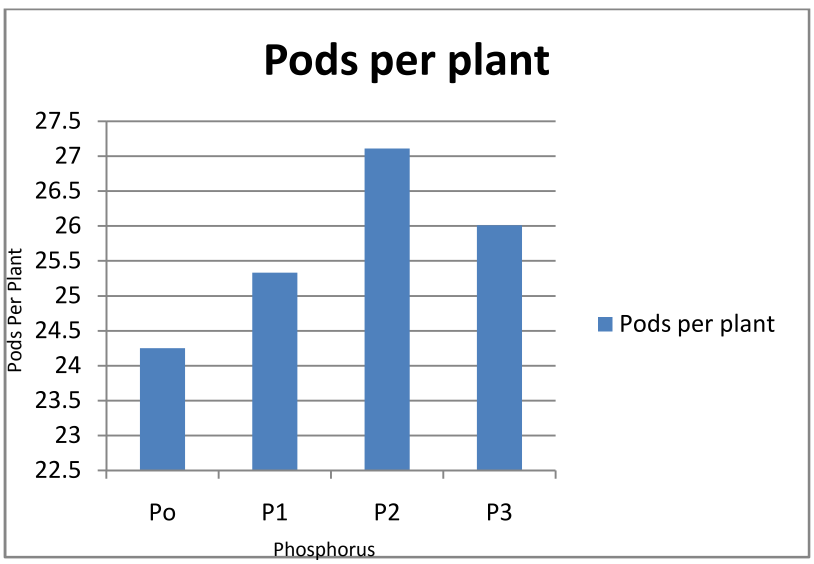
N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha



Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Fig 4.Effect of nitrogen on pods per plant at different days after sowing of bushbean



Here,

P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Fig. 5. Effect of phosphorus on number of pods per plant in bush bean

Table 18.Effect of phosphorus on Pod length,pod diameterand seeds per podin bush bean.

Treatments	Pod Length (cm)	Pod diameter (cm)	Seeds per pod
Po	14.31 c	0.71 c	6.01 c
P_1	14.83 b	0.71 b	6.13 bc
P_2	15.36 a	0.73 a	6.41 a
P_3	14.97 b	0.72 b	6.23 b
CV%	10.68	9.40	11.79
LSD (0.05)	0.32	0.011	0.14

Here,

P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Number of pods per plant varied significantly due to application of phosphorus (Fig. 5 and Appendix VIII). The highest (27.11) number of pods per plant of bush bean was found from P_2 (100 kg P/ha) treatment. The lowest (24.25) number of flowers per plant of bush bean was observed in P_0 (control) treatment.

Number of pods per plant varied significantly due to application of nitrogen andphosphorus (Table. 19 and Appendix VIII). The highest (31.00) number of pods per plant of bush bean was found due to application of N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment. The lowest (18.40) number of flowers per plant of bush bean was observed in N_0P_0 (control) treatment. The result obtained from the present supported by Parmer *et al*. (1999), Sa *et al.* (1982), Calvache (1997)in respect of number of pods per plant.

Table 19. Combined effect of nitrogen and phosphorus on number of pods per plant, Pod length,Pod diameterand Seeds per pod in bush bean

Treatments	Number of pods per plant	Pod Length (cm)	Pod diameter (cm)	Seeds per pod
N_0P_0	18.40 l	11.73i	0.67i	5.33g
N_0P_1	19.60k	12.19hi	0.67hi	5.40g
N_0P_2	21.46i	12.89g	0.69 f-i	5.73ef
N_0P_3	20.66j	12.42gh	0.68 g-i	5.60fg
$N_1 P_0$	22.80h	13.60f	0.70 e-h	5.86ef
N_1P_1	24.53g	14.15ef	0.71 d-g	6.00de
N_1P_2	26.93 e	14.84d	0.72 b-e	6.40 bc
N_1P_3	25.66f	14.50de	0.71 c-f	6.20 cd
N_2P_0	27.73d	15.90c	0.73 b-e	6.40 bc
N_2P_1	28.66 bc	16.48 a-c	0.74 a-c	6.53b
N_2P_2	31.00 a	17.06 a	0.76 a	6.86a
N_2P_3	28.93b	16.68 ab	0.74 a-c	6.60ab
N_3P_0	28.06 cd	16.00 c	0.73 de	6.46bc
N_3P_1	28.53 bc	16.49 a-c	0.74 b-d	6.60ab
N_3P_2	29.06 b	16.67 ab	0.75 ab	6.66ab
N_3P_3	28.10 b	16.30 bc	0.74 b-d	6.56b
CV%	9.85	10.68	9.40	11.79
LSD(0.05)	0.64	0.64	0.032	0.29

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120 kg/ha, N_3 = 160 kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

4.10Length of dry pod

A Significant variation on length of dry pod of bush bean was observed due to application of different levels of nitrogen (Table. 17 and AppendixVIII). The longest (16.63 cm) length of dry pod of bush bean was from N_2 (120 kg N /ha) treatment. The shortest (12.31cm) dry pod of bush bean was observed in N_0 (control) treatment.

A Significant variation on length of dry pod of bush bean was observed due to application of different levels of phosphorus (Table. 18 and AppendixVIII). The longest (15.36 cm) length of dry pod of bush bean was found from P_2 (100 kg P /ha) treatment. The shortest (14.31 cm) dry pod of bush bean was observed in P_O (control) treatment.

A Significant variation on length of dry pod of bush bean was observed due to application of different levels of nitrogen and phosphorus (Table. 19 and Appendix VIII). The longest (17.06 cm) length ofdry pod of bush bean was observed due to application of N_2P_2 (120 kg N /ha and 100 kg P/ha), which was similar to N_2P_3 (120 kg N /ha and 150 kg P/ha), similar to N_3P_2(160 kg N /ha and 100 kg P/ha) treatment. The shortest (11.73 cm) dry pod length of bush bean was observed in N_0P_0 (control) treatment.Begum *et al* (2003) got the same result in pod length.

4.11 Diameter of dry pod

Significant difference was observed in diameter of dry pod due to application of nitrogen (Table. 17 and AppendixVIII). The highest (0.74 cm) diameter of dry pods were observed due to application of N_2 (120 kg N/ha) which statistically identical withN_3 (160 kg N/ha) and the lowest (0.68cm) was obtained from N_0 (control) treatment.

Significant difference was observed in diameter of dry pod due to application of phosphorus (Table. 18 and AppendixVIII). The highest (0.73 cm) diameter of dry pods were observed from P_2 (100 kg P/ha) treatment and the lowest (0.71 cm) was obtained from P_0 (control) treatment.

A Significant variation on diameter of dry pod of bush bean was observed due to application of different levels of nitrogen and phosphorus (Table. 19 and AppendixVIII). The longest (0.76 cm)diameter ofdry pod of bush bean was observed due to application of N_2P_2 (120 kg N /ha and 100 kg P/ha) treatment, which was statistically similar to N_3P_2(160 kg N /ha and 100 kg P/ha) treatment. The shortest (0.67cm)diameter of dry pod of bush bean was observed in N_0P_0 (control) treatment.

4.12 Number of seeds per pod

A significant variation was found in number of seeds per pod of bush bean due to application of nitrogen (Table. 17 and Appendix IX). The highest (6.60) number of seeds per dry pod of bush bean was found from N_2 (120 kg N/ha)treatment, which identically followed by N_3 (160 kg N /ha) treatment. The lowest (5.31) number of seeds per dry pod of bush bean was observed in control.

A significant variation was found in number of seeds per pod of bush bean due to application of phosphorus (Table. 18 and Appendix IX). The highest (6.35) number of seeds per pod of bush bean was found due to application of 150 kg P/ha which identically (6.35) followed by 100 kg P /ha. The lowest (6.0833) number of seeds per dry pod of bush bean was observed in control.

A significant variation was found in number of seeds per dry pod of bush beandue to application of different levels of nitrogen and phosphorus (Table.19 and Appendix IX). The highest (6.86) number of seeds per pod of bush bean was found from N_2P_2(120 kg N /ha and 100 kg P/ha)treatment, which is statistically similar to N_2P_3(120 kg N/ha and 150 kg P/ha) treatment,which is statistically similar to N_3P_1 (160 kg N/ha and 50 kg P/ha) treatment and N_3P_2(160 kg N/ha and 100 kg P/ha) treatment. The lowest (5.33) number of seeds per pod of bush bean was observed in N_0P_0 (control) treatment. Tewari and Singh (2000), Levender*et al*. (1988) found that interaction of nitrogen and phosphorus applications have positive result on seeds per pod.

4.13 100 seed weight

A significant variation was found in 100 seed weight of bush bean due to application of nitrogen (Table. 20 and Appendix IX). The highest (23.98 g) 100 seed weight of bush bean was found from N_2(120 kg N/ha) treatment. The lowest (16.17 g) 100seed weight of bush bean was observed inN_0 (control) treatment.

Table 20.Effect of nitrogen on 100 seed weight,seed length, seed diameterand dry weight of shoot in bush bean

Treatments	100 seed weight (g)	Seed length (cm)	Seed diameter (cm)	Dry matter % of shoot
N_0	16.17d	1.09 d	0.32 d	23.63 d
N_1	19.90 c	1.31 c	0.40c	25.09 c
N_2	23.98 a	1.56 a	0.48 a	26.92 a
N_3	23.41 b	1.54 b	0.46 b	26.60b
CV%	10.40	6.28	5.16	8.11
LSD (0.05)	0.413	0.017	0.016	0.317

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

A significant variation was found in 100 seed weight of bush bean due to application of phosphorus (Table 21 and Appendix IX). The highest (21.71 g) 100 seed weight of bush bean was found from P_2(100 kg P/ha) treatment. The lowest (19.95 g) 100 seed weight of bush bean was observed inP_0(control) treatment.

Table21.Effect of phosphorus on 100 seed weight,Seed length, Seed diameter and dry weight of shoot in bush bean

Treatments	100 seed weight (g)	Seed length (cm)	Seed diameter (cm)	Dry matter %of shoot
P_0	19.95d	1.30c	0.39d	24.18d
P_1	20.78c	1.36b	0.41 c	25.57c
P_2	21.71a	1.44a	0.44a	26.05a
P_3	21.24b	1.39b	0.43 b	25.54 b
CV%	10.40	6.28	5.16	8.11
LSD (0.05)	0.424	0.046	0.011	0.317

Here,

P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

A significant variation was found in 100 seed weight of bush bean due to application of different levels of nitrogen and phosphorus in combination(Table. 22 and Appendix IX). The highest (24.78 g) 100 seed weight of bush bean was found due to application of N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment, which was statistically similar to(24.20 g) followed by N_2P_3(120 kg N /ha and 150 kg P/ha)treatment, which was statistically similar to (24.18 g) followed by N_3P_2 (160 kg N /ha and 100 kg P/ha) treatment and which was also statistically similar to (23.96 g) followed by N_3P_3 (160 kg N /ha and 150 kg P/ha) treatment. The lowest (15.22 g) 100 seed weight of bush bean was observed in N_0P_0 (control) treatment.Kakon (2016) observed highest 100 seed weight (23.38 g) in best nitrogen and phosphorus combination.

Table 22. Combined effect of nitrogen and phosphorus 100 seed weight, seed length, seed diameter and dry weight of shoot in bush bean

Treatments	100 seed weight (g)	Seed length (cm)	Seed diameter (cm)	Dry matter% of shoot
N_0P_0	15.22j	1.00 k	0.30 k	23.16 g
N_0P_1	16.02ij	1.06 jk	0.32 jk	23.50 g
N_0P_2	16.99 h	1.13 hi	0.35 hi	24.00 fg
N_0P_3	16.48hi	1.12ij	0.33ij	23.86fg
$N_1 P_0$	18.70 g	1.22gh	0.37 gh	24.63ef
N_1P_1	19.71f	1.30fg	0.39fg	25.06de
N_1P_2	20.88 e	1.40de	0.43de	25.73cd
N_1P_3	20.32ef	1.34ef	0.41ef	24.93de
N_2P_0	22.80 d	1.48cd	0.43 cd	26.43 bc
N_2P_1	23.77bc	1.55 bc	0.47 bc	26.90a-c
N_2P_2	24.78 a	1.60a	0.50 a	28.33a
N_2P_3	24.20 ab	1.57 ab	0.48 ab	27.03ab
N_3P_0	23.11 cd	1.51 bc	0.46 bc	26.50bc
N_3P_1	23.61 b-d	1.54 bc	0.48 ab	26.83b
N_3P_2	24.18 ab	1.58 ab	0.49 ab	27.13 ab
N_3P_3	23.96 ab	1.54 bc	0.49 ab	26.33 bc
CV%	10.40	6.28	5.16	8.11
LSD(0.05)	0.8487	0.0925	0.0249	0.904

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120 kg/ha, N_3 = 160 kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

4.14 Seed length

A significant variation was found in seed length of bush bean due to application of nitrogen (Table. 20 and Appendix IX). The highest (1.56 cm) seed length of bush bean wasfound from N_2 (120 kg N/ha) treatment. The lowest (1.09 cm) seed length of bush bean was observed in N_0 (control) treatment.

A significant variation was found in seed length of bush bean due to application of phosphorus (Table. 21 and Appendix IX). The highest (1.44 cm) seed length of bush bean was found due to application of P_2 (100 kg P/ha)treatment. The lowest (1.30 cm) seed length of bush bean was observed in P_0 (control) treatment.

A significant variation was found in seed length of bush bean due to application of different levels of nitrogen and phosphorus (Table. 22 and Appendix IX). The highest (1.61 cm) seed length of bush bean was found from N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment, which was statistically similar to (1.57 cm) followed by N_2P_3 (120 kg N /ha and 150 kg P/ha) treatment, which was statisticallysimilar to (1.58 cm) followed by N_3P_2 (160 kg N /ha and 100 kg P/ha) treatment. The lowest (1.00 cm) seed length of bush bean was observed in N_0P_0 (control) treatment.

4.14 Seed diameter

Different levels of nitrogen significantly influenced the seed diameter of bush bean (Table. 20 and AppendixIX). The highest (0.48 cm) seeddiameter of bush bean was found from N_3(160 kg N/ha) treatment. The lowest (0.32 cm) seed diameter of bush bean was observed in N_0 (control) treatment.

Different levels of phosphorus significantly influenced the seed diameter of bush bean (Table. 21 and Appendix IX). The highest (0.44 cm) seed diameter of bush bean was found from P_2(100 kg P/ha) treatment. The lowest (0.39 cm) seed diameter of bush bean was observed in P_0 (control).

A significant variation was found in seed diameter of bush bean due to application of different levels of nitrogen and phosphorus in combination (Table. 22 and Appendix IX). The highest (0.50 cm) seed length of bush bean was found from N_2P_2 (120 kg

N/ha and 100 kg P/ha) treatment, which was statistically similar toN_3P_2 (160 kg N/ha and 100 kg P/ha) treatment and N_3P_3 (160 kg N/ha and 150 kg P/ha) treatment andwhich was statistically similar to followed by N_3P_1 (160 kg N/ha and 50 kg P/ha) treatment and N_2P_3 (120 kg N/ha and 150 kg P/ha) treatment. The lowest (0.30 cm) seed diameter of bush bean was observed in N_0P_0 (control) treatment.

4.16 Dry matter ofshoot(%)

A significant variation was found in dry shoot percentage of bush bean due to application of nitrogen (Table. 20 and Appendix IX). The highest (26.93 %) dry shoot of bush bean was found from N_2 (120 kg N /ha) treatment. The lowest (23.63 %) dry shoot of bush bean was observed in N_0 (control) treatment.

A significant variation was found in dry shoot percentage of bush bean due to application of phosphorus (Table. 21 and Appendix IX). The highest (26.05 %) dry shoot of bush bean was found from P_2 (100 kg P/ha) treatment. The lowest (24.18 %) dry shoot of bush bean was observed in P_0 (control) treatment.

A significant variation was found in dry shoot percentage of bush bean due to application of nitrogen and phosphorus (Table. 22 and Appendix IX). The highest (28.33 %) dry shoot of bush bean was found from N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment, which was statistically similar followed by N_2P_3 (120 kg N /ha and 150 kg P/ha) treatment, which was statistically similar followed by N_3P_2 (160 kg N /ha and 100 kg P/ha) treatment. The lowest (23.16 %) dry shoot of bush bean was observed in N_0P_0(control) treatment.

4.17 Seed yield per plant

Yield is the ultimate economic product of the crop, which is determined mainly by seed weight, number of seeds, fruits per plant. It was observed different levels of nitrogen application significantly effect on the seed yield per plant of bush bean (Table. 23 and Appendix X). The highest (18.71 g)seed yield per plant was found from N_2(120 kg N/ha) treatment. The lowest (11.89 g) seed yield per plant was observed in N_0 (control) treatment.Rabi and Prasad (1998) reported that plant height, no. of branches per plant and seed yield increased due to increase in nitrogen level from 40 to 120 kg N/ha.

Table 23.Effect of nitrogen on seed yield per plant andseed yield per plot onbush bean

Treatments	Seed yield per plant (g)	Seed yield per plot (kg)
No	11.89 d	0.32 d
N_1	15.11 c	0.45 c
N_2	18.717 a	0.56 a
N_3	18.49 b	0.54 b
CV%	10.03	9.14
LSD (0.05)	0.213	0.026

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Different levels of phosphorus significantly influenced the seed yield per plant of bush bean (Table 24. and Appendix X). The highest (16.85 g)seed yield per plant was found from P_2 (100 kg P/ha) treatment. The lowest (15.11 g) seed yield per plant was observed in P_0 (control) treatment.

Table 24.Effect of phosphorus on seed yield per plant andseed yield per plot on bush bean

Treatments	Seed yield per plant (g)	Seed yield per plot (kg)
Po	15.11 d	0.43 d
P_1	15.96 c	0.46 c
P_2	16.85 a	0.51 a
P_3	16.39 b	0.48 b
CV%	10.03	9.14
LSD (0.05)	0.416	0.0151

Here, P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Different levels of nitrogen and phosphorus significantly influenced the seed yield per plant of bush bean (Table. 25 and Appendix X). The highest (19.60 g)seed yield per plant was found from N_2P_2(120 kg N/ha and 100 kg P/ha) treatment, which was similar followed by N_3P_2 (160 kg N/ha and 100 kg P/ha) treatment, similar followed by 160 kg N/ha and 100 kg P/ha. The lowest (11.01 g) seed yield per plant was observed in control. The result obtained from the present supported by Shamima (2005) in respect of seed yield per plant of bush bean.

4.18 Seed yield per plot

Different levels of nitrogen significantly influenced the seed yield per plot of bush bean (Table. 23 and Appendix X).The highest (0.56 kg) seed yield per plotwas found from N_2(120 kg N/ha) treatment. The lowest (0.32 kg) seed yield per plotwas observed in N_o (control) treatment.

Table 25. Combined effect of nitrogen and phosphorus on seed yield per plant,seed yield per plot and seed yield per hain bush bean.

Treatments	Seed yield per plant (g)	Seed yield per plot (kg)	Seed yield per ha (t)

N_0P_0	11.01 j	0.27i	1.72j
N_0P_1	11.70ij	0.30i	1.85ij
N_0P_2	12.62h	0.36 h	2.07 h
N_0P_3	12.25 hi	0.34h	1.96 hi
$N_1 P_0$	13.77 g	0.40 g	2.24 g
N_1P_1	14.93 f	0.44f	2.53 f
N_1P_2	16.07e	0.50e	2.85 e
N_1P_3	15.66ef	0.47e	2.64 f
N_2P_0	17.61d	0.53d	2.98 de
N_2P_1	18.69bc	0.56 b-d	3.15 bc
N_2P_2	19.60a	0.61 a	3.43 a
N_2P_3	18.96ab	0.57 bc	3.18 bc
N_3P_0	18.05 cd	0.54cd	3.05 cd
N_3P_1	18.48bc	0.55 cd	3.12 b-d
N_3P_2	19.01ab	0.57bc	3.25 b
N_3P_3	18.70bc	0.56 b-d	3.13 bc
CV%	10.03	9.14	9.08
LSD(0.05)	0.832	0.0302	0.1544

Here,

N_0= 0 kg/ha, N_1 = 80 kg/ha, N_2= 120 kg/ha, N_3 = 160 kg/ha

P_0= 0 kg/ha, P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Different levels of phosphorus significantly influenced the seed yield per plot of bush bean (Table. 24 and Appendix X). The highest (0.51 kg) seed yield per plotwas found from P_2 (100 kg P/ha) treatment. The lowest (0.43 kg) seed yield per plotwas observed in P_0 (control) treatment.

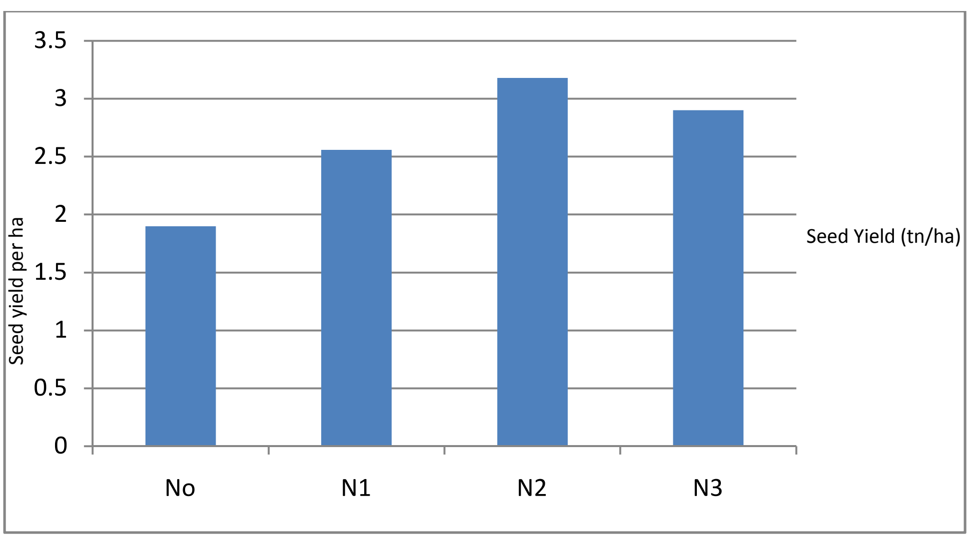
Different levels of nitrogen and phosphorus significantly influenced the seed yield per plot of bush bean (Table. 25 and Appendix X).The highest (0.61 kg) seed yield per plotwas found from N_2P_2 (120 kg N/ha and 100 kg P/ha)treatment. The lowest (0.27 kg) seed yield per plotwas observed in N_0P_0 (control) treatment.

4.19 Seed yield per hectare

Different levels of nitrogen significantly influenced the seed yield per hectare of bush bean (Fig. 6 and Appendix X).The highest (3.18 ton) seed yield per hectarewas found from N_2(120 kg N/ha) treatment. The lowest (1.90 ton) seed yield per plotwas observed in N_0 (control) treatment.

Different levels of phosphorus significantly influenced the seed yield per hectare of bush bean (Fig. 7 and Appendix X).The highest (2.90 ton) seed yield per hectare was found from P_2(100 kg P/ha)treatment. The lowest (2.50 ton) seed yield per plotwas observed in P_0 (control) treatment.

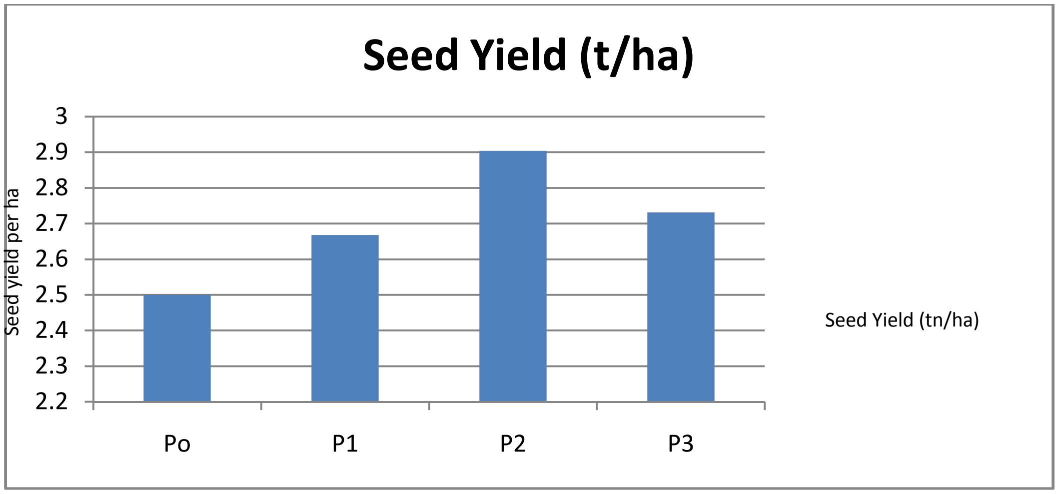
Different levels of nitrogen and phosphorus significantly influenced the seed yield per hectare of bush bean (Table. 25 and Appendix X). The highest (3.43 ton) seed yield per hectare was found from N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment.The lowest (1.72 ton) seed yield per plotwas observed in N_0P_0 (control) treatment. Tewari and Singh (2000)found that 160 kg N ha^{-1}significantly reduced seed yield.Application of 120 kg N ha^{-1} produced significantly higher seed yield.



Here,

N_0= 0 kg/ha, N_1= 80 kg/ha, N_2= 120kg/ha, N_3 = 160kg/ha

Fig 6. Effect of nitrogenon seed yield per ha on bush bean.



Here, P_0= 0 kg/ha P_1 = 50 kg/ha, P_2= 100 kg/ha, P_3 = 150 kg/ha

Fig 7. Effect of phosphorus onseed yield per ha on bush bean.

4.20 Economic analysis

Input costs for land preparation, cost of seed, fertilizer and manpower required for all the operations from sowing to harvesting of bush bean seed were recorded for unit plot and converted into cost per hectare. Fixed cost for all the treatment was same. The total cost of production was the total cost of input and fixed cost (Appendix IX-XII.) The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings:

4.20.1 Gross return

In the combination of different nitrogen and phosphorus application showed various gross return (Appendix XII). The highest gross return (TK.3.43,000/ha) was obtained from the N_2P_2(120 kg N/ha and 100 kg P/ha) treatment combination and the second highest gross return (TK.3,25,000/ha) was obtained in N_3P_2(160 kg N/ha and 100 kg P/ha) treatment combination. The lowest gross return (TK.1,72,000/ha) was obtained from the N_0P_0(control) treatment combination(Appendix-XII).

4.20.2 Net return

In case of net return, different treatment combination showed different type of netreturn. The highest net return (TK.2,01,666/ha) was obtained from N_2P_2 (120 kg N/ha and 100 kg P/ha) treatment combination and the second highest net return (TK. 1,94,256/ha) wasobtained N_3P_2 (160 kg N/ha and 100 kg P/ha) treatment combination. The lowest net return (TK. 41,800/ha) wasobtained from the N_0P_0(control) treatment combination (Appendix XII).

4.20.3 Benefit Cost Ratio

The combination of different nitrogen and phosphorus application for benefit cost ratio was different in all treatment combination (Appendix XII). The highest benefit cost ratio (2.42) was obtained from the treatment combination N_2P_2 (120 kg N/ha and 100 kg P/ha) and the second height benefit cost ratio (2.31) was obtained from N_3P_2(160 kg N/ha and 100 kg P/ha) treatment combination. The lowest benefit cost ratio (1.32) was obtained from the N_0P_0 (control) treatment combination. From the economic point of view, it was apparent from the above results that the treatment combination of N_2P_2 (120 kg N/ha and 100 kg P/ha) was more profitable than rest of treatment combinations.

Appendix XII: Economic performances regarding gross return, net return and benefit cost ratio (BCR) ofbush bean

Treatment	Cost of production (Tk/ha)	Yield (t /ha)	Gross return (Tk./ ha)	Net return (Tk./ ha)	BCR
N_0P_0	130200	1.72	172000	41800	1.32
N_0P_1	131533	1.85	185000	54467	1.41
N_0P_2	132864	2.07	207000	66136	1.49
N_0P_3	134196	1.96	196000	78804	1.59
$N_1 P_0$	136817	2.24	224000	92183	1.67

N_1P_1	138148	2.53	253000	105852	1.77
N_1P_2	139480	2.85	285000	119520	1.86
N_1P_3	140812	2.64	265000	142188	2.00
N_2P_0	138470	2.98	298000	164530	2.19
N_2P_1	139802	3.15	315000	193198	2.29
N_2P_2	142334	3.43	343000	201666	2.42
N_2P_3	142450	3.18	318000	188550	2.26
N_3P_0	140079	3.05	305000	171921	2.23
N_3P_1	141482	3.12	312000	185518	2.27
N_3P_2	142744	3.25	325000	194256	2.31
N_3P_3	144076	3.13	313000	185924	2.28

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APPENDICES

Appendix I. Monthly records of temperature, rainfall, and relative humidity of the experiment site during the period from November 2015 to March 2016

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2015	November	29.5	18.6	24.0	69.5	0.0	233.2
	December	26.9	16.2	21.5	70.6	0.0	210.5
2016	January	24.5	13.9	19.2	68.5	1.0	194.1
	February	28.9	18.0	23.4	61.0	2.0	221.5
	March	33.6	29.5	31.6	72.7	3.0	227.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-121

Appendix II.The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand : 40 %
Silt : 40 %
Clay :20 %
Texture : Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.09
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.09
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.38
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.85

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix III.Analysis of variance of the data of plant height affected by combined effect of different nitrogen and phosphorus on bush bean

Source of variation	Degrees of freedom	Mean square of plant height (cm)				
		15 DAS	30 DAS	45 DAS	60 DAS	90 DAS
Replication	2	20.701	0.041	5.472	249.51	2.290
Factor A (N)	3	94.121**	1.262*	101.372**	1406.03**	29.637**
Factor B (P)	3	104.005**	4.093**	125.430**	5201.43**	24.808**
A x B	9	78.951*	1.406*	61.426*	411.14*	19.771*
Error	30	31.059	0.643	21.988	132.67	7.142

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NSNon-significant

Appendix IV.Analysis of variance of the data of number of leaves affected by combined effect of different nitrogen and phosphorus on bush bean

Sources of variation	Degrees of freedom	Mean square of number of leaves per plant				
		15 DAS	30 DAS	45 DAS	60 DAS	90 DAS
Replication	2	2.108	0.021	5.533	66.809	0.353
Factor A(N)	3	64.250**	6.195**	57.377**	88.242**	7.767**
Factor B(P)	3	75.811**	9.876**	63.576**	95.986**	12.098**
A x B	9	35.811*	3.697*	31.049*	67.771*	4.026*
Error	30	23.237	1.005	11.566	21.538	1.152

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix V.Analysis of variance of the data of leaf length affected by combined effect of different nitrogen and phosphorus on bush bean

Source of variation	Degrees of freedom	Mean square of leaf length (cm)			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	0.486	3.021	0.787	8.902
Factor A(N)	3	13.380**	36.481**	30.896**	75.875**
Factor B(P)	3	17.015**	46.095**	49.280**	85.623**
A x B	9	12.704*	22.282*	19.005*	55.516*
Error	30	4.713	7.458	6.046	17.932

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix VI.Analysis of variance of the data of leaf diameter affected by combined effect of different nitrogen and phosphorus on bush bean

Source of variation	Degrees of freedom	Mean square of leaf diameter (cm)			
		15 DAS	**30 DAS**	**45 DAS**	**60 DAS**
Replication	2	34.176	23.042	46.382	0.108
Factor A(N)	3	124.404^{**}	126.647^{**}	132.332^{**}	9.543^{**}
Factor B(P)	3	111.871^{**}	113.002^{**}	125.010^{**}	11.631^{**}
A x B	9	80.167^{*}	59.758^{*}	129.268^{**}	7.807^{*}
Error	30	26.971	19.452	38.018	2.064

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix VII.Analysis of variance of the data of number of branches per plant affected by combined effect of different nitrogen and phosphorus on bush bean

Source of variation	Degrees of freedom	Mean square of number of branches per plant			
		30 DAS	**40 DAS**	**50 DAS**	**60 DAS**
Replication	2	0.503	4.257	4.887	0.021
Factor A(N)	3	36.348^{**}	44.867^{**}	29.143^{**}	5.368^{**}
Factor B(P)	3	61.646^{**}	86.432^{**}	37.028^{**}	3.705^{**}
A x B	9	20.677^{*}	31.977^{*}	14.582^{*}	0.429^{**}
Error	30	6.009	9.296	4.259	0.010

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix VIII.Analysis of variance of first flower initiation, 90% flower initiation, number of flowers per plant, number of pods per plant, pod length and pod diameter affected by combined effect of different nitrogen andphosphorus on bush bean.

Source of variation	Degrees of freedom	Mean square of number of					
		First flower initiation	90% flower initiation	Number of flowers per plant	Number of pod per plant	Pod length	Pod diameter
Replication	2	0.032	0.087	1.643	2.245	3.734	2.541
Factor A(N)	3	3.481**	4.639**	44.122**	51.730**	88.619**	75.213**
Factor B(P)	3	1.080**	1.510**	21.049**	30.125**	53.015**	43.649**
A x B	9	0.085*	0.237*	10.959*	19.453*	33.876*	24.440*
Error	30	0.022	0.053	3.100	5.960	8.917	7.557

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant.

Appendix IX.Analysis of variance of the data of seed per pod, 100 seed weight, seed length,seed diameter and dry shoot affected by combined effect of different nitrogen and phosphorus on bush bean

Source of variation	Degrees of freedom	Mean square of				
		Seed per pod	100 seed weight	Seed length	Seed diameter	Dry shoot (%)
Replication	2	0.922	1.661	1.749	1.193	0.286
Factor A(N)	3	43.775**	61.928**	66.560**	94.259**	30.940**
Factor B(P)	3	30.285**	74.730**	46.343**	72.732**	22.398**
A x B	9	8.414**	7.534**	12.114*	14.926*	10.354**
Error	30	1.583	1.388	3.138	3.665	2.362

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix X. Analysis of variance of the data of seed yield per plant, seed yield per plot and seed yield per ha affected by combined effect of different nitrogen and phosphorus on bush bean

Source of variation	Degrees of freedom	Mean square of		
		Seed yield per plant	**Seed yield per plot**	**Seed yield per ha**
Replication	2	9.991	0.184	443.5
Factor A(N)	3	79.014**	1.504**	2409.3**
Factor B(P)	3	82.570**	1.251**	45510.2**
A x B	9	44.302*	1.488**	6428.8**
Error	30	15.549	0.196	535.4

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NSNon-significant

Appendix XI. Cost of production of bush bean per hectare

Treat ments	**Labo ur**	**Plough Ing**	**seed**	**Irriga tion**	**Pesti cides**	**Cowd ung**	**Fertilizer**				**Subtotal Input cost(A)**
							Urea	TSP	MP	Gypsum	
NoPo	25000	10000	15000	8000	6000	30000	---	---	2400	880	99280
NoP_1	25000	10000	15000	8000	6000	30000	---	1200	2400	880	100480
NoP_2	25000	10000	15000	8000	6000	30000	---	2400	2400	880	101680
NoP_3	25000	10000	15000	8000	6000	30000	---	3600	2400	880	102880
N_1Po	30000	10000	15000	8000	6000	30000	2960	---	2400	880	105240
N_1P_1	30000	10000	15000	8000	6000	30000	2960	1200	2400	880	106440
N_1P_2	30000	10000	15000	8000	6000	30000	2960	2400	2400	880	107640
N_1P_3	30000	10000	15000	8000	6000	30000	2960	3600	2400	880	108840
N_2Po	30000	10000	15000	8000	6000	30000	4450	---	2400	880	106730
N_2P_1	30000	10000	15000	8000	6000	30000	4450	1200	2400	880	107930
N_2P_2	30000	10000	15000	8000	6000	30000	4450	2400	2400	880	109130
N_2P_3	30000	10000	15000	8000	6000	30000	4450	3600	2400	880	110330
N_3Po	30000	10000	15000	8000	6000	30000	5900	---	2400	880	108180
N_3P_1	30000	10000	15000	8000	6000	30000	5900	1200	2400	880	109380
N_3P_2	30000	10000	15000	8000	6000	30000	5900	2400	2400	880	110580
N_3P_3	30000	10000	15000	8000	6000	30000	5900	3600	2400	880	111780

Labour cost @ Tk. 300/Man/day

Cowdung 10 t/ha @ Tk. 2/Kg

Urea @ Tk. 12/Kg

TSP @ Tk. 18/Kg

MP 160 Kg/ha@ Tk. 15/Kg

Gypsum 220 Kg/ha @ Tk. 22/Kg

ii. Overhead cost (B)

Treatment Combination	**Miscellaneous cost (Tk. 5% of the input cost)**	**Cost of lease for 4 months land rent**	**Interest onrunning capital for 6 months (Tk. 12% of cost/year)**	**Subtotal Overhead cost(B)**
NoPo	4964	20000	5956	30920
NoP_1	5024	20000	6029	31053
NoP_2	5084	20000	6100	31184
NoP_3	5144	20000	6172	31316

N_1Po	5262	20000	6315	31577
N_1P_1	5322	20000	6386	31708
N_1P_2	5382	20000	6458	31840
N_1P_3	5442	20000	6530	31972
N_2Po	5336	20000	6404	31740
N_2P_1	5396	20000	6476	31872
N_2P_2	5456	20000	6548	32004
N_2P_3	5516	20000	6620	32120
N_3Po	5409	20000	6490	31899
N_3P_1	5469	20000	6563	32012
N_3P_2	5529	20000	6635	32164
N_3P_3	5589	20000	6707	32296