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

SHAHNAZ PARBHIN

DEPARTMENT OF SOIL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY

SHAHNAZ PARBHIN

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APPROVED BY:

Prof. Dr. Mohammad Mosharraf Hossain **Supervisor** **Department of Soil Science** **Sher-e-Bangla Agricultural University**	**Prof. Dr. Alok Kumar Paul** **Co-Supervisor** **Department of Soil Science** **Sher-e-Bangla Agricultural University**

Prof. A .T. M. Shamsuddoha
Chairman
Examination committee
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207


DEDICATED
TO MY
BELOVED PARENTS

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka – 1207
PABX: +88029144270-9
Fax: +88029112649
Web site: www.sau.edu.bd

CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF FRENCH BEAN (Phaseolus vulgaris L.)"*** *submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of Master of Science in Soil Science, embodies the result of a piece of bona fide research work carried out by* ***SHAHNAZ PARBHIN*** *Registration No.* ***19-10047*** *under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2021
Place: Dhaka, Bangladesh

Professor. Dr. Mohammad Mosharraf Hossain
Supervisor
Department of Soil Science

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ABSTRACT

An experiment was carried out at the Soil Science research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2019 to April 2020 to find out the effect of N and P on growth and yield of French bean. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (Four nitrogen doses) viz. N_0 = No Nitrogen applied. i.e. control; N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen; N_2 = 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen and Factor B (Three phosphorus doses) viz. P_0 = No Phosphorus applied. i.e. control; P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus. Significant variation was found in all parameter due to the combined effect of different amount N and P fertilizer application. In case of nitrogen effects, the maximum plant height (38.94 cm), number of leaves/plant (23.52) at 60 DAS were obtained in N_1 treatment. As well as maximum yield (7.10 t ha^{-1}) was also obtained in N_1 treatment, which was not statistically similar to N_2 treatment giving yields of 6.32 t ha^{-1}. The lowest plant height (28.32 cm) and number of leaves/plant (15.81) were observed from the control nitrogen treatment (N_0). And also lowest yield 4.57 t ha^{-1} was recorded from plot where no nitrogen was applied (control). On the other hand, the highest plant height (37.44 cm), number of leaves/plant (21.62) at 60 DAT and yield (6.99 t ha^{-1}) were recorded from 100 % RDF of phosphorus (P_3). Meanwhile, the lowest plant height (28.12 cm) and number of leaves/plant (15.77) at 60 DAS and yield (4.27 t ha^{-1}) was observed in those plots where no phosphorus was applied (P_0). And finally, the combined effect of nitrogen and phosphorus on French bean showed the highest plant height (44.25 cm) and number of leaves/plant (27.64) at 60 DAS as well as grain yield (7.61 t ha^{-1}) was produced when the crop was fertilized with N_1P_1 treatment and was statistically similar to N_1P_2 (7.47 t ha^{-1}) treatment. The lowest plant height (25.99 cm) and number of leaves/plant (14.32) at 60 DAS and also grain yield (2.42 t ha^{-1}) was recorded in the combine treatment of N_0P_0 (control). The findings of the present investigation clearly indicated that the appropriate use of N and P fertilizers and growing French bean is a viable option for improved cultivation.

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LIST OF ACRONYMS

Abbreviation	=	Elaboration
%	=	Percent
N	=	Nitrogen
P	=	Phosphorus
RDF	=	Recommended doses of fertilizer
@	=	At the rate
°C	=	Degree Centigrade
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
CV	=	Coefficient of variance
cv.	=	Cultivar (s)
DAI	=	Days after inoculation
HSD	=	Honestly significant difference
e.g.	=	(For example) example gratia
et al.	=	Latin phrase et alia, meaning “and others.”
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram
hr	=	Hour (s)
i.e.	=	That is
IRRI	=	International Rice Research Institute
ISTA	=	International Seed Testing Agency
kg	=	Kilogram
LSD	=	Least Significant Difference
no.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment

NPK	=	Nitrogen, Phosphorus and Potassium
t/ha	=	Ton per hectare
UNDP	=	United Nation Development Program
$^{w}/_{v}$	=	Weight per volume
$^{w}/_{w}$	=	Weight per weight
wt.	=	Weight
BE	=	Biological efficiency
MRR	=	Mycelium Running Rate
NMDEC	=	National Mushroom Development and Extension Center
MCC	=	Mushroom Culture Centre
mg	=	Milligram
CHO	=	Carbohydrate
Conc.	=	Concentration

CHAPTER I
INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is one of the important leguminous vegetable crops. It is commonly known as common bean which is grown worldwide. The crop thrives well in diverse environments of the world ranging from tropical to temperate regions (Mongi *et al.,* 2016). Its 2n =22, which is a short duration vegetable crop and is one of the precious and highly relished vegetables in North India. It is a traditional temperate region crop. Its pods are used as a green vegetable, green shelled, or dry as pulses according to stage of harvest. It is commonly known by different names such as snap bean, string bean, kidney bean, haricot bean, fresh bean, navy bean etc. French bean is an excellent source of protein. The pods are cooked fresh or processed as frozen. Hundred grams of green pods contain 1.7 g protein, 4.5 g carbohydrates, 221 I.U. vitamin A, 11 mg vitamin C, 50 mg Calcium (Gopalakrishnan, 2007). It can be grown in all types of soils ranging from sandy loam to clay soils but can't withstand under waterlogging conditions. Although this crop is not widely grown in Bangladesh, it has a great export potential. Because, the fresh green pod has recently been taken a place in the list of fresh vegetables exported from Bangladesh.

Production of French bean depends on many factors such as quality of seed, variety, fertilizers, mulch materials and proper management practices. Various problems hamper French bean production in Bangladesh. As per the recent estimates the production of dry beans at global level is 19,393 million metric tons cultivated in an area of 26.603 million hectares with a productivity of 729 kg/ha. It is an important under-utilized vegetable in Bangladesh (Rahman *et al*., 2002).In Bangladesh there is no statistics about the area and production of French bean. However, it is not entirely new crop in this country and is grown in Sylhet, Cox's Bazar, Chittagong, Chittagong Hill Tracts and some other parts of this country on very small scale in winter season. French bean can easily be grown in the field as well as in the homestead garden if the soil is managed properly. As a legume roots of French bean root system has nodules with nitrogen fixing bacteria. It can also be used in the crop rotation system in the field. Soil nutrient content and nutrient management is a key factor for crop production. The modern day intensive crop cultivation requires the use of chemical fertilizers. But, the price of inorganic fertilizers has gone up considerably which in turn has increased the cost of production. So, the use of chemical fertilizers boosted the agricultural production but the farming communities are not using it judiciously and hence it results in the

loss of soil productivity. Although all 16 essential nutrients are required in appropriate proportion for optimum pod yield, NPK nutrients are required in major quantities. It is found that it responds very well to applied nitrogen and phosphates on Bangladesh soils.

Crop yields, vegetative growth and reproduction depend on access to adequate supplies of mineral nutrients, and among these nutrients, N, P, and K are essential for high plant productivity (Hawke *et al*., 1988 and Zaman *et al*., 2015). N, P, and K applications play important roles in the growth and quantitative characteristics of adzuki bean (Liu *et al*., 2012 and Zhang *et al*., 2016). Adzuki bean has a strong physiological demand for N, and the appropriate application of N fertilizer at different stages can increase nutrient absorption, plant growth, and yields (Zhao *et al*., 2003; Kimura *et al*., 2004 and Zaman *et al*., 2015). Increasing the amount of N applied during the early growth period promotes vegetative growth, which leads to high yields. As plants grow, the abundance of rhizobia increases, and their ability to fix atmospheric N improves; however, excessive applications of N fertilizer inhibit rhizobial activity and impede flower bud differentiation and yield formation (Bethlenfalvay*et al*., 1982 and Yanni*et al*., 2001) Moreover, P affects root morphology and growth followed by water and nutrient uptake, resulting in effective drought mitigation and improved yields (Zafar *et al*., 2013; Jian *et al*., 2015 and Hansel *et al*., 2017).

However, it is reported that in UK it responds well to applied N rather than applied P. This may be probably due to variations in nutrient reserves in soils. Further it is reported that a ratio of 3:2:1 for application of NPK may be appropriate based on previous several years' experience (Gane *et al.,* 1975). French bean is characteristically shy of nitrogen fixation and hence require larger amount of nitrogen. Being a fertilizer responsive crop, French bean responds well to nutrition, while excess nitrogen results in poor pod yield. Like other legumes it also fixes atmospheric nitrogen and improves soil fertility (Adsule *et al.,* 1998). Islam *et al*. (2004) reported that application of potassium exerted a beneficial effect on plant growth characteristics and also on the yield of beans. Sirnivas and Naik (1988) reported that nitrogen and phosphorus fertilization of French bean resulted in increased pod yield. Chandra *et al*. (1987) found that the plant growth and yield of French bean increased with the increasing rates of nitrogen and phosphorus. Continuous cropping without the proper application of plant nutrients to the soil causes a substantial decrease in crop yield. Supply of plant nutrients, especially nitrogen, phosphorus and potassium through fertilizer application is one of the best methods to increase the French bean growth and yield.

Fertilizer is a necessary input in agricultural production. However, the un scientific use of fertilizers is a serious threat to sustainable agriculture production systems, and excess fertilizer residue disturbs the soil-nutrient balance and inhibits healthy plant growth. Sustainable crop production can be achieved with appropriate fertilizer by changing the amount of fertilizer applied and using suitable fertilizers (Kubo, 2010; Vanlauwe *et al*., 2010; Kumar *et al*., 2014 and Rusinamhodzi *et al*., 2013). Appropriate fertilizer refers to the application of fertilizers at the proper rate, time, and place; when fertilizers are applied appropriately to soils and when their application is accompanied by suitable agronomic implementations, crops can respond to N and P fertilizers without other constraints that limit crop growth (He, 1993).

The present study was therefore conducted to monitor the effect of various levels of nitrogen and phosphorus on the growth parameters and green pod yield of French bean and also to furnish cost effective fertilizer recommendations for French bean production in Bangladesh. Research on fertilizer management for French bean in Bangladesh is in preliminary stage. Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

1. To investigate the effect of N and P fertilizers application on growth and yield attributes of French bean.
2. To determine the optimum doses of N and P fertilizers for the proper growth and development of French bean.

CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the available information in home and abroad regarding the study on integrated effect of N and P on growth and yield of French Bean (*Phaseolus vulgaris* L.). Many research organizations of our country has limited information about the effect of N and P on French bean as well as other beans. But in foreign countries there are more numbers of relevant data. A review of the previous research and findings of researchers having relevance to this study which were gathered from different sources like literature, journals, thesis, reports, newspaper etc. were presented in this chapter. However, some of the literatures related to this investigation are reviewed in this chapter which are given below:

3.1 Effect of N for growth and development of French bean

Dhanjal *et al*., 2001 found significantly higher branches plant^{-1} at 120 kg N ha^{-1}. Singh (2000) got maximum pod length form the application of 125 kg N ha^{-1}.

Prajapoti *et al*. (2004) recorded higher pod yield of French bean from 120 kg N ha^{-1}.

Neuve *et al*., (1994) found that pod yield of snap bean was 12.9, 13.9, 15.0 and 15.8 tonha^{-1} with 0, 50, 100 and 150 kg N ha^{-1}, respectively.

Ivano *et al*., 1987 reported that the pod yield of French bean increased with the increase N of levels upto 150 kg ha^{-1}.

Pod yield increased significantly with each successive increment in N up to 120 kg/ha were reported by Baboo *et al*. (1998).

Application of higher doses of nitrogen especially for seed crop of French bean is imperative for realizing its potential yield (Sardana *et al*., 2000).

Mohamed Ali Addow *et al*. (2020) conducted a field experiment to evaluate the effects of nitrogen and potassium on the growth and yield of French bean. From the results of the experiment it was found that the main effect of nitrogen had significant effects on the plant

height, number of compound leaves per plant, leaf length, number of branches per plant, length of green pod, diameter of green pod and number of pods per plant. But there was no significant effect on the diameter of green pod of French bean. The maximum green pod yield (6.53 t/ha) was obtained from the plot where 150kg N/ha was used. The result of experiment revealed that most of the parameters studied were significantly influenced by different potassium levels. The highest pod yield (6.10 t/ha) was obtained from the plot where 120kg K_2O/ha was used. Interaction effect of nitrogen and potassium exhibited significant variation on most of the characters studied, but showed insignificant influence on leaf length, length of green pod, diameter of green pod, number of seeds per plant. Application of 150kg N/ha with 120kg K_2O/ha gave the highest branches and compound leaves per plant, number of flowers per plant, weight of pods per plant and pod yield (6.69 t/ha). This information will help the farmer to grow French bean with better yield.

3.2 Effect of P for growth and development of French bean

Phosphorus is the most important element for adequate grain production (Brady and Weil, 2002). For instance, high seed production of legumes primarily depends on the amount of P absorbed Khan *et al*., 2003 P\ sufficiency for crop growth does not always exist in most soils because of losses due to erosion and high fixation (Miller and Donahue, 1995; Brady and Weil, 2002). Kumar *et al*., 2009 reported that under black soil (Vertisols) low productivity of French bean the main problem as a result of both nitrogen and phosphorus deficiency.

Eden (2003) reported by lowest plant height (78.6cm) was recorded at high application of P rate, this confirms with the lowest plant height was recorded at application rate of P 69 kg ha^{-1}.The highest rate of P application at the study site had no effect on plant height. This might be due to high dose of phosphorus fertilizer which tends to form nutrient interaction and may affects the availability of other nutrients which are essential for growth of the bean.

Phosphorus is a major essential plant nutrient. Parodi *et al*, (1977) observed that 50 kg P ha^{-1} was the maximum requirement for French bean. Eira *et al*, (1974) found in an experiment that the economic rate of P application for French bean was 55 kg ha^{-1}.

Shubhashree (2007) reported that significantly higher number of branches per plant is recorded with high application rate of phosphorous. The Mean of P fertilizer applied revealed significantly higher number of branches per plant over control.

Veeresh (2003) observed significant number of pods per plant of common bean at application rate phosphorous.

Also Singh and Singh (2000) reported significant increase in number of pods per plant, due to increased P fertilization. Thus the increment of number of pods per plant due to application of P fertilizer confirms with P fertilizer promotes the formation of nodes and pods in legumes.

Shubhashree (2007) who reported that number of seeds per pod increased significantly to levels of phosphorus were added. The increment of seeds per pod with increasing P fertilizer application up to optimum level might be P fertilizer for nodule formation, protein synthesis, fruiting and seed formation.

Again Shubhashree (2007) who reported bean yield accumulation increase with application of phosphorus rates. Similarly, significant and linear increase in total bean yield production of haricot bean plant was observed due to increased phosphorus (Veeresh, 2003).

French bean grow poorly when grown in P-deficient soil and its low level led to low bean productivity (Kanwar, 1982).

3.3 Combined effect of N and P for growth and development of French bean

Rehana *et al.* (2017) reported an experiment entitled "Influence of Integrated nitrogen management (INM) on French bean (*Phaseolus vulgaris L.*) Var. Contender and its effect on physico-chemical and biological properties of soil under temperate conditions of Kashmir Valley" was carried out during kharif season 2014 at research farm of SKUAST-K, Shalimar and Srinagar under Temperate Kashmir conditions. The experiment was laid out in randomized block (RDF) design with 13 treatments and 3 replications. The combination of dalweed compost and vermicompost with bio-fertilizer (rhizobium) and reduced dose of chemical fertilizers were tested in comparision with RDF. The soil under study was clay loam in texture, medium in available nitrogen (310.10 $kgha^{-1}$), phosphorus (22.92 $kgha^{-1}$) and potassium (249.10 $kgha^{-1}$) with neutral pH (7.2). The physical, chemical and biological parameters of soil were found to be significantly improved under INM practices than organic and chemical management practices. The results revealed that application of 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed) recorded maximum NPK (374.33, 33.53 and 270.35$kgha^{-1}$ N, P and K

respectively). Further the integrative use of organic and inorganic fertilizers along with bio-fertilizers improved physio-chemical and biological properties of soil as compared to other treatments. Thus, it may be concluded that integrated nitrogen management (INM) improved the soil fertility.

Jayashri *et al.* (2017) was carried out during rabi season at avegetable farm, College of Horticulture, Mandsaur (Gwalior) to study the effect of integrated nutrient management on growth, yield parameters and yield in French bean. The treatments comprised six nutrient levels N_1, N_2, N_3, N_4, N_5 and N_6 and three varieties viz., Arka Komal (V_1), Contender (V_2) and Swarna Priya (V_3). It was noticed that application of nutrient levels and varieties had significant influence on growth, yield and yield parameters. Nutrient level N_4 [Vermicompost (10t/ha) + N (50kg/ha) + Rhizobium (15g/kg seed) + PSB (15g/kg seed) + P_2O_5 (80kg/ha) + K_2O (80kg/ha)] recorded the maximum plant height (57.92cm), fresh weight of shoot (43.70g), dry weight of shoot (11.33g), number of pod per plant (31.81), pod length (15.55cm), shelling percent (76.87%), harvest index (26.82%), seed yield per plant (17.35g) and seed yield per hectare (25.22q). The maximum days for 50 per cent flowering were taken with the application of N_6 nutrient level which was significantly higher over other nutrient levels. Among the varieties Swarna Priya (V_3) recorded the highest growth, yield parameters and yield in French bean. Earliest 50% flowering was recorded in variety Contender followed by Arka Komal.

Qazi *et al*. (2015) conducted a study at the farm of Agricultural Research Station, Baffa (Mansehra) during August 2006 to monitor the effect of various levels of fertilizer treatments on plant height, number of branches plant^{-1}, pod length, pod weight and pod yield of French bean variety (Paulista). The experimental results revealed that all the fertilizer treatments increased the plant height, number of branches plant^{-1}, pod length, pod weight and pod yield of French bean significantly over control treatment. Maximum plant height (39.03 cm), number of branches plant^{-1} (18.25), pod length (14.10 cm), pod weight (5.37 gm) and pod yield (8.26 t ha^{-1}) were recorded in the treatments receiving 120 kg N, 90 kg P_2O_5 and 90 kg K_2O ha^{-1}. The economics of fertilizers were also worked out on the basis of current market prices and it was found that use of fertilizer was profitable. The cost benefit ratio ranged between 4.90 and 6.05.

Muhammad Shahid *et al.* (2015) conducted an experiment at the farm of Agricultural Research Station, Baffa (Mansehra) during August 2014 to monitor the effect of various levels of fertilizer treatments on plant height, number of branches plant^{-1} , pod length, pod weight and pod yield of French bean variety (paulista). The experimental results revealed that that all the fertilizer treatments increased the plant height, number of branches plant^{-1}, pod length, pod weight and pod yield of French bean significantly over control treatment. Maximum plant height (39.03 cm), number of branches plant-1(18.25), pod length (14.10 cm), pod weight (5.37 gm) and pod yield (8.26 t ha^{-1}) were recorded in the treatment receiving 120 kg N, 90 kg P_2O_5 and 90 kg K_2O ha^{-1}. The economics of fertilizers were also worked out on the basis of current market prices and it was found that use of fertilizer was profitable. The cost benefit ratio ranged between 4.90 and 6.05.

Begum *et al*. (2015) found that the highest fertilizer treatment (90-50-120) resulted in the highest pod length (15.76 cm), pod weight (82.33 gm plant^{-1}) and pod yield (13.99 q ha^{-1}) of French bean.

Rahman *et al*. (2007) conducted a field experiment on French bean in Old Brahmaputra Floodplain Soil of Jamalpur and Grey Terrace Soil of Joydebpur during 2005-2006 to find out the optimum rates of N and P for yield maximization of French bean. Four levels of nitrogen (0, 100, 150 and 200 kg ha^{-1}) and 3 levels of phosphorus (0, 40 and 60 kg ha^{-1}) were used in the experiment. Potassium (K) 80 kg, 10 kg Sulphur (S) and 5 ton cowdung ha^{-1} were applied as a blanket dose. The experiment was laid out in a randomized complete block design with 12 treatments replicated 4 times. Nitrogen and phosphorus alone significantly influenced the pod yield of French bean. Among the N levels, the highest pod yields (13.33 tha^{-1} at Jamalpur & 14.68 tha^{-1} at Joydebpur) were obtained with 150 kg N ha^{-1}. Among the P levels, the highest pod yield (12.35 tha^{-1} at Jamalpur & 13.69 tha^{-1} at Joydebpur) was obtained with 60 kg P ha-1. Interaction effect was not significant. However, highest pod yield (13.60 tha^{-1} at Jamalpur & 15.05 tha^{-1} at Joydebpur) was obtained from 150 kg N plus 60 kg P ha^{-1}. Economic analysis showed that 150 kg N plus 40 kg P ha^{-1} gave the highest gross margin of Tk. 1,66,684/ha.

Sharma (2001) recorded maximum plant height, the number of branches plant^{-1} and green pod yield of French bean ha^{-1} with 120 kg N ha^{-1}. He also recorded maximum plant height and the number of branches plant^{-1} with 60 kg P ha^{-1}. The interaction effect between N and P was

significant. Highest pod yield was obtained at a treatment combination of 120 kg N and 60 kg P ha^{-1}.

Moniruzzaman *et a*l., 2008 conducted a field experiment on French bean taking the variety BARI Jhar Shim-2 conducted with five levels of Nitrogen (0, 40, 80, 120 and 160 kg N ha^{-1}) and four levels of each of phosphorous (0, 40, 80 and 120 kg P_2O_5 ha^{-1}), potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) and sulfur (0, 10, 20 and 30 kg S ha^{-1}), three levels of each of zinc (0, 4 and 8 kg Zn ha^{-1}) and boron (0, 1 and 1.5 kg B ha^{-1}) at the Agricultural Research Station, Raikhali, Rangamati Hill District during Rabi (winter) seasons of 2005- 2006 and 2006-2007. The experiment was conducted in Randomized Complete Block Design with three replications. Yield and yield components of French bean were significantly influenced by different fertilizer treatments containing macro and micronutrients separately. Results showed significant effect of fertilizers on plant height, number of branches and leaves per plant, pod length, number of green pods and pod weight per plant and green pod yield during both years. The highest pod yield of 23.14 t ha^{-1} (average of 2005-2006 and 2006-2007) was obtained with 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung per hectare that was closely followed by 120-80-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung per hectare. The response equations indicated an optimum level of 138.6 kg N, 131.5 kg P_2O_5, 63.4 kg K_2O and 17.4 kg S ha^{-1} for higher green fruit yield of French bean. The economic doses of nutrients came out to be 135.8-123.3-60-17.4 kg of N-P_2O_5-K_2O-S ha^{-1}. Application of 136-123-60-17-4-1 kg N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha^{-1} along with 10 tons cowdung per hectare might be considered as profitable dose for growing French bean in South-Eastern hilly region of Bangladesh.

Singh and Singh (2000) reported that the yield and yield component values of French bean increased with increasing N rates, but were generally highest with 80 kg P ha^{-1}.

DATh *et al.* (2019) carried out an experiment entitled “Effect of Integrated Nutrient Management on Growth, Yield and Yield attributing parameters of French bean (*Phaseolus vulgaris L.*)” was carried out during Rabi season of 2018-19 at the research plot of All India Coordinated Research Project (AICRP) on Vegetable Crops of Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha, India. The experiment was laid out in Randomized Block Design (RBD) with eight treatments replicated thrice. All the

recommended package of practices except nutrient management was given uniformly to all the treatments to raise a good crop. In this investigation, the results revealed that application of 75% NPK through inorganic source along with 25% N through vermicompost (T_3) recorded significantly higher growth parameters viz., plant height (47 cm), number of primary branches (5.53), leaf area (169.55 cm^2); yield and yield attributing parameters viz., pod length (13.58 cm), pod girth (1.17 cm), average pod weight (6.45 g), number of pods per plant (23.95) and pod yield (97.89 q ha^{-1}). The next best treatment was T_2 where 75% NPK through inorganic source along with 25% N through FYM was applied.

Excess and imbalanced use of nutrients has caused nutrient mining from the soil, deteriorated crop productivity and ultimately soil health. Replenishment of these nutrients through organics sources has a direct impact on soil health and crop productivity (Sharma *et al.,* 2013).

French bean requires large quantity of nitrogenous fertilizer. Increasing cost of inorganic fertilizers and reduction in soil health with chemical fertilizers, it is essential to replace inorganic fertilizers through organic for sustainable agriculture. Organic sources of the plant nutrients have been reported to improve growth, yield attributes, yield and soil fertility status. In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for integrated use of alternate sources of nutrients for sustaining the crop productivity (Dar *et al*., 2014). The integration of organic and inorganic sources of plant nutrients has proved superior to individual components with respect to growth, yield and quality of pulses (Ghosh *et al*., 2014; Datt *et al.,* 2013)

Mohanty *et al.* (2017) reported an experiment on integrated nutrient management in French bean. On the course of investigation, it was observed that the number of pods per plant was highest in T_8 (15.00) and T_9 (15.00) followed by T_7 (14.10), length of pod was highest with T_8 (13.80 cm) followed by T_9 (13.20 cm), dry weight of pod per plant was highest in T_8 (50.10 g) followed by (48.00 g) in T_9, number of seeds per plant was highest in T_5 (78.40) followed by T_8 (74.52) and dry weight of seeds per plot was highest in T_8 (1653.00 g) followed by T_9 (1587.00 g). However, the seed yield per hectare was highest in T_8 (18.00 q/ha) followed by 16.65 q/ha in T_9 and 16.56 q/ha in T_6 and the lowest seed yield of 11.76 q/ha was obtained in T_{11}. It can be concluded that application of 75% RDF along with 25% vermicompost and lime application produced a good environment supporting very good

growth of French bean to produce significantly higher marketable seed yield during rabi season under coastal agro climatic condition of Odisha.

Zhi-chaoYin *et al.* (2019) observed that Nitrogen (N), phosphorus (P), and potassium (K) exert various effects on adzuki bean yields. This research conducted in a semi-arid area, and four test sites were established in environments that have chernozem or sandy loam soils. The model subsequently demonstrated that the yield and the yield components were more sensitive to N and K fertilizer than to P fertilizer. Moreover, the yield and yield components increased. These yield increases were intense in response to the 0.5 to 1.34 levels in terms of the single effects; interaction effects; and the effects of combinations of N, P, and K fertilizers. Moreover, the effects of combinations of N, P, and K fertilizers were more significant on yield than were the single or interaction effects of N, P, and K fertilizers. The optimal fertilizer combination that resulted in high yields (≥1941.53kgha−1) comprised 57.23–68.43kgha^{-1} N, 36.04–47.32kgha^{-1} P_2O_5 and 50.29–61.27kgha^{-1} K_2O. The fertilizer combination that resulted in the maximum yield was 62.98 kgha^{-1} N, 47.04 kgha^{-1} P_2O_5 and 59.95 kgha^{-1} K_2O (N: P_2O_5:K_2O=1:0.75:0.95), which produced the model-expected yield in trials at multiple sites. An economical fertilizer combination was determined on the basis of the best fertilizer measures in consideration of the cost of fertilizer and seed; this combination achieved yields of 2236.17kgha^{-1}, the profit was 15,653.16 Yuan ha^{-1}, and the corresponding rates were 57.60 kgha^{-1} N, 47.03 kgha^{-1} P_2O_5, and 31.64 kgha^{-1} K_2O (N: P_2O_5:K_2O=1:0.82:0.55).

CHAPTER III

MATERIALS AND METHODS

This chapter briefly describes the materials and methods that are used in performing the research work. The chapter is presented under the following heads: Location, Soil characteristics, Climate and weather, Planting material, Land preparation, Treatments under investigation, Experimental design, Layout of the experimental plots, Fertilizer application, Seed collection, sowing of seeds, Intercultural operations, Sampling and harvesting, Data collection, post-harvest soil sampling, Analysis of soil sample and Statistical analyses.

3.1 Location of the experiment

The field experiment was conducted at the Soil Science research field, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2019 to April 2020. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone "AEZ-28" of Madhupur Tract (BBS, 2011). The location of the experimental site has been shown in Appendix I.

3.2 Soil characteristics

The soil of the research field is slightly acidic in reaction with low organic matter content. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done in Soil Science lab in Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka. The experimental plot was also high land, having pH 5.6. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix II.

3.3 Climate and weather

The climate of experimental site is sub-tropical, characterized by three distinct seasons, the monsoon during November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix III.

3.4 Planting material

In the experiment planting material used as BARI Jhar Shim-1 that was developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Treatments under investigation

The study consisted of following factors and treatments: Factor A: Four nitrogen doses and Factor B: Three phosphorus doses.

Factor A: Four Nitrogen doses viz.

N_0 = No Nitrogen applied. i.e. control

N_1 = 100 % Recommended doses of fertilizer (RDF) of nitrogen

N_2 = 75 % Recommended doses of fertilizer (RDF) of nitrogen

N_3 = 50 % Recommended doses of fertilizer (RDF) of nitrogen

Factor B: Three phosphorus doses viz.

P_0 = No Phosphorus applied. i.e. control

P_1 = 100 % Recommended doses of fertilizer (RDF) of phosphorus

P_2 = 50 % Recommended doses of fertilizer (RDF) of phosphorus

Treatment combinations

N_0P_0 = No nitrogen and phosphorus applied i.e. control

N_0P_1 = 100 % RDF of phosphorus with no nitrogen

N_0P_2 = 50 % RDF of phosphorus with no nitrogen

N_1P_0 = 100 % RDF of nitrogen with no phosphorus

N_1P_1 = 100 % RDF of nitrogen with 100 % RDF of phosphorus

N_1P_2 = 100 % RDF of nitrogen with 50 % RDF of phosphorus

N_2P_0 = 75 % RDF of nitrogen with no phosphorus

N_2P_1 = 75 % RDF of nitrogen with 100 % RDF of phosphorus

N_2P_2 = 75 % RDF of nitrogen with 50 % RDF of phosphorus

N_3P_0 = 50 % RDF of nitrogen with no phosphorus

N_3P_1 = 50 % RDF of nitrogen with 100 % RDF of phosphorus

N_3P_2 = 50 % RDF of nitrogen with 50 % RDF of phosphorus

3.6 Layout of the experimental plots

Total number of plots	: 36
Individual plot size (2m×2m)	: 4 m^2
Space between block to block	: 0.75 m
Space between plots to plot	: 0.5 m

Combine Treatments : 12

Replication : 3

Drainage size : 0.38 m

The layout of the experimental plots shown in figure 1

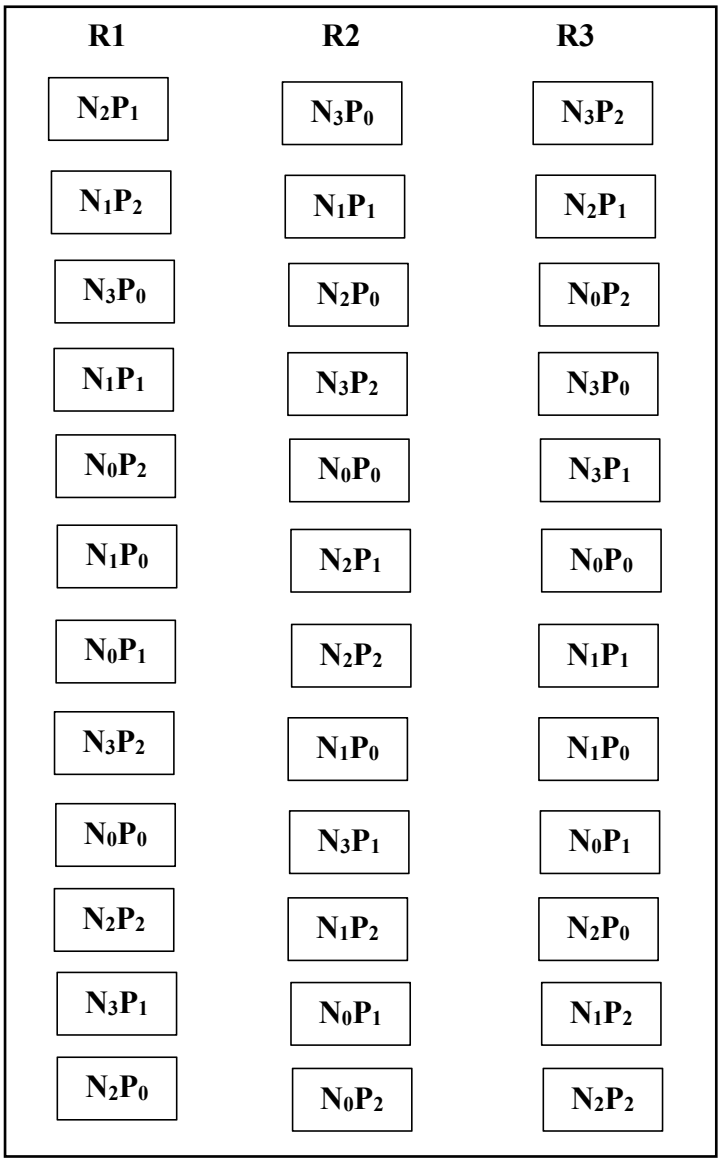

Fig. 1. Field layout of the experiment

3.7 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD). All the treatments were replicated three times. There were altogether 36 = (12×3) unit plots.

3.8 Land preparation

The land was irrigated before ploughing. After having 'joe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth

by 3 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 5st December and 08th December, 2019, respectively. Experimental land was divided into unit plots following the design of experiment.

3.9 Fertilizer application

The whole amount of TSP (as per treatment) as the sources of phosphorus was applied during the final land preparation. Urea and Mop were applied as the sources of nitrogen and potassium, respectively. Doses of nitrogen and MoP were applied as per treatments of the experiment. Urea and MoP were applied in two equal installments at 15 and 30 days after sowing (DAT) of seed. The fertilizers were mixed thoroughly with the soil by hand. Recommended doses of Potassium, Sulphur, Zink fertilizers were used as basal doses during land preparation.

3.10 Sowing of seeds in the field

Two seed were sown in each hill at a depth of 3 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The sowing was done on 08 December, 2019 in rows and at a spacing of 30cm x 15cm. The seeds were covered with loose soil. French bean seeds were also sown as border crop to reduce border effects.

3.11 Intercultural operations

3.11.1 Gap filling

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

3.11.2 Thinning

When the plants got established, one healthy plant per hill was kept and remaining one was removed.

3.11.3 Weeding

The experimental plots were kept weed free by hand weeding. Weeding and mulching were done two times as and when necessary.

3.11.4 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Besides this, irrigation, was given five times at an intervals were depending on soil moisture content.

3.12 Plant protection

3.12.1 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 2ml/L at 15 days' interval.

3.12.2 Diseases

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

3.13 Sampling and harvesting

Maturity of crop was determined when 95 % of the pods become brown in color. Five sample plants were collected from each plot before harvesting for taking yield attributes data. The plants of central 1 m^2 area were harvested by placing quadrates at random for recording yield data. Harvesting was done on 20 February, 2020. The harvested crops from each plot were tied up into bundles separately, tagged and brought to the clean threshing floor.

3.14 Data collection

Five plants in each plot were selected and tagged. All the growth parameters (except dry weight) were recorded from those five selected plants.

The following data were collected –

I. Plant height (cm)
II. Number of leaves $plant^{-1}$
III. Number of branches $plant^{-1}$
IV. Number of pods $plant^{-1}$
V. Pod length (cm)
VI. Pod weight $plant^{-1}$ (g)
VII. Number of seeds pod^{-1}
VIII. 1000-Seed weight (g)
IX. Yield (kg $plot^{-1}$)

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

XI. Straw yield (t ha^{-1})

XII. Biological yield (t ha^{-1})

XIII. Harvest Index (%)

3.15 Procedure of data collection

3.15.1 Plant height (cm)

The plant height was recorded at 30, 45 and 60 days after sowing (DAT). The plant height was taken from the ground level to the tip of the largest leaf of the plants. Plant height was recorded from 10 randomly sampled plants, and the mean was calculated and recorded in centimeter (cm).

3.15.2 Number of leaves $plant^{-1}$ (no.)

The number of compound leaves of 5 randomly selected plants was counted from each unit plot at 15 days' interval from 30 to 60 DAT and the means were calculated.

3.15.3 Number of branches $plant^{-1}$ (no.)

Average number of branches per plant was found from 5 randomly selected plants per unit plot and the means were found out.

3.15.4 Number of pods $plant^{-1}$ (no.)

Number of flowers from 5 randomly selected plants was counted, and their mean values were recorded.

3.15.5 Pod length (cm)

Ten pods from each randomly selected plant were measured using a centimeter scale, and the mean value, were calculated and expressed in centimeter.

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

Pods from 5 randomly selected plants were weighed, and their average was recorded in gram (g).

3.15.7 1000-Seed weight (g)

Thousand grains were counted from threshed clean grains of each treatment and then were weighed with the help of highly sensitive electronic balance to record thousand grain weight.

3.15.8 Number of seeds pod^{-1} (no.)

Number of pods from 5 randomly selected plants was counted, and their mean values were recorded.

3.15.9 Yield (kg plot^{-1})

Green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval, the total weight of pods was recorded for each for each unit plot, and was expressed in Kilogram (kg).

3.15.10 Yield (t ha^{-1})

The green pod yield per plot was finally converted to yield per hectare, and was expressed in ton (t).

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

Straw obtained from each unit plot including the straw of five sample plants were dried in the sun and weighted to record the final straw yield per plot and then converted to t ha^{-1}.

3.15.12 Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula:

Biological yield (t ha^{-1}) = Yield (t ha^{-1}) + Straw yield (t ha^{-1}).

3.15.13 Harvest Index (%)

The harvest index (%) was calculated with the following formula-

$$\text{Harvest index (\%)} = \frac{\text{Yield}}{\text{Biological yield}} \times 100$$

Here, Biological yield = Seed yield + straw yield

3.16 Post harvest soil sampling

After harvest of crops soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.17 Statistical analysis

The recorded data were compiled and analyzed by two factorial design to find out the statistical significance of experimental results by using the "Analysis of variance" (ANOVA) technique with the help of statistics 10 that was an analysis software.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the performance of French bean under different integrated effect of N and P fertilizer doses on growth and yield are presented in Table no. 1 to 8 and Figure no. 2 to 14. In this chapter, moreover, the findings of the study and interpretation of the results under different critical sections comprising growth, yield contributing characteristics, yield and quality parameters analysis are presented and discussed in this chapter under the following sub-headings.

4.1. Effect of N and P fertilizer on growth, yield contributing characters and yield of French bean.

4.1.1 Plant height (cm)

By measuring plant height growth performance of plant can be considered. Plant height of French bean was recorded from the ground surface to the tip of the leaf in 5 plants of all the treatments. The application of different doses of nitrogen (N) fertilizer showed a positive effect on the plant height of French bean at different days after showing (DAS). The application of N fertilizers significantly increased the plant height of French bean compared to that found in control showed in figure 2.

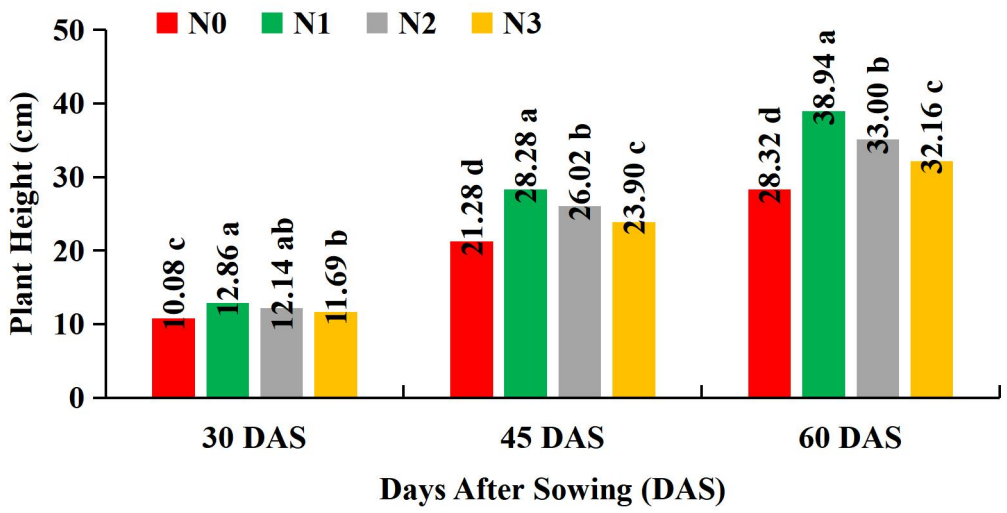

Figure 2: Effect of N fertilizers on plant height (cm) of French bean at different days after sowing (DAS).

Here,
N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen.

At 30 DAS, the highest plant height (12.86 cm) was obtained from the treatment N_1 (100 % RDF of N) which was identical to N_2 (75 % RDF of N) treatment. On the other hand, lowest plant height (10.80 cm) was obtained from N_0 treatment that was control. Again at 45 DAT, the longest plant (28.28 cm) was observed from the treatment N_1 that was followed by N_2 treatment and shortest plant (21.28 cm) was observed where no nitrogen was applied (N_0). And finally at 60 DAS, among nitrogen management treatments, N_1 treatment gave the tallest French bean plant (38.94 cm) which was significantly varied from others, while the shortest plant (28.32 cm) was obtained in N_0 treatment.

Different levels of phosphorus differed significantly in terms of plant height of French bean at 30, 45 and 60 DAS (days after sowing) showed in Figure 3. At 30, 45 and 60 the tallest plant (12.54, 27.39 and 37.44 cm, respectively) was found from P_1 (100 % RDF of P) which were statistically different (12.15, 26.12 and 35.32 cm, respectively) from P_2 (50 % RDF of P), while the shortest plant (10.93, 21.10 and 28.12 cm, respectively) was observed from P_0 (control) treatment.

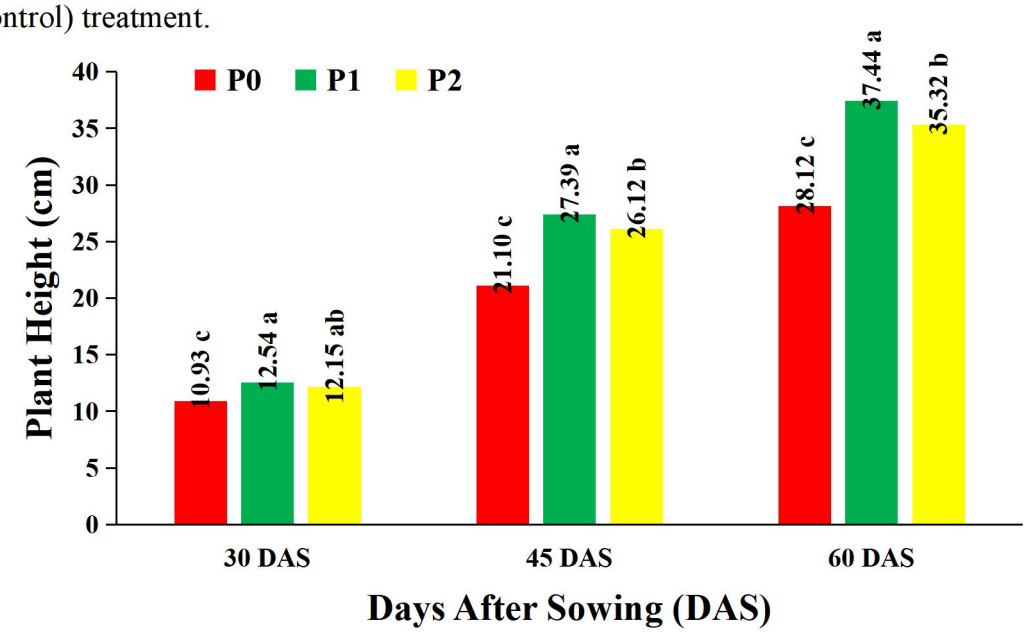

Figure 3: Effect of P fertilizers on plant height (cm) of French bean at different days after sowing (DAS).

Here,
P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

During the growing period plant height gradually increased with time and reached to the maximum at 60 DAS. The findings showed the trend of increase in growth parameters upto optimum level of applied nutrients following the low of dementing return. While beyond this

optimum level adverse effect of nutrients was observed. These results are in agreement with the findings of Sharma (2001). Increase in plant growth parameters as compared to other lower nutrient levels might be due to the increase in NPK availability which might have promoted photosynthesis resulting in more assimilation of food material in plant. Similar results were obtained by Rajput *et al.* (2006) and Ramana *et al.* (2011).

Effect of different levels of nitrogen and phosphorus showed statistically significant variation on plant height of French bean at 30, 45 and 60 DAS. At 30, 45 and 60 DAS, the tallest plant (13.77, 31.74 and 44.25 cm respectively) was recorded from N_1P_1 which are statistically identical to (12.73, 29.83 and 41.13 cm) in N_1P_2. Whereas the shortest plant (9.35, 19.31 and 25.99 cm, respectively) was found from N_0P_0 (control) treatment combination (Table 1).

Table 1: Combined effect of nitrogen and phosphorus fertilizer on plant height (cm) of French bean at different days after sowing (DAT).

Combine Treatments	Plant Height (cm)		
	30 DAS	45 DAS	60 DAS
N_0P_0	9.35 d	19.31 g	25.99 i
N_0P_1	11.70 bc	22.67 ef	30.17 gh
N_0P_2	11.34 bc	21.87 efg	28.80 ghi
N_1P_0	12.07 abc	23.27 ef	31.44 fg
N_1P_1	13.77 a	31.74 a	44.25 a
N_1P_2	12.73 ab	29.83 ab	41.13 b
N_2P_0	11.47 bc	21.27 fg	28.12 hi
N_2P_1	12.53 abc	28.71 bc	39.51 bc
N_2P_2	12.43 abc	28.07 bc	37.55 cd
N_3P_0	10.82 cd	20.57 fg	26.88 i
N_3P_1	12.17 abc	26.42 cd	35.81 de
N_3P_2	12.10 abc	24.71 de	33.78 ef
SE(±)	0.49	0.83	0.85
CV (%)	5.09	4.09	3.09

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
Here, SE= Standard Error and CV= Co-efficient of variance

4.1.2 Number of leaves plant^{-1} (no.)

Number of leaves plant^{-1} is an important growth parameter for evaluating growth characteristics of French bean cultivation. At different days after transplanting (DAS), number of leaves plant^{-1}of French bean was found significantly affected due to the applications of different dose of N and P fertilizer. In case of nitrogen fertilizer application, the highest number of leaves plant^{-1} (6.65, 18.09 and 23.52) was recorded in N_1 (100 % RDF of N) treatment at 30, 45 and 60 DAS, respectively. The lowest number of leaves plant^{-1} (5.78,

12.23 and 15.81 respectively) was recorded in the N_0 treatment, where no nitrogen was applied (Figure 4).

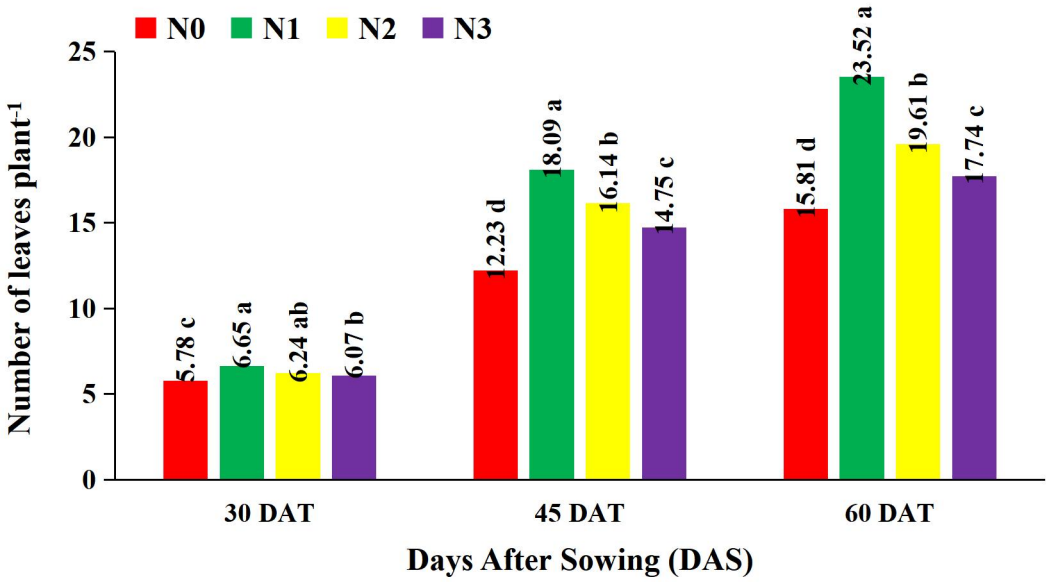

Figure 4: Effect of N fertilizers on number of leaves plant^{-1} (no.) of French bean at different days after sowing (DAS).

Here,
N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen.

On the other hand, at 30, 45 and 60 DAS, the highest number of leaves plant^{-1} (6.50, 17.52 and 21.62, respectively) was recorded in P_1(100 % RDF of P) treatment which was not statistically similar to (6.28, 16.26 and 20.11, respectively) in P_2(50 % RDF of P) treatment. The lowest number of leaves plant^{-1} (5.78, 12.14 and 15.77 respectively) was recorded in the P_0 treatment, where no phosphorus was applied (Figure 5).

From the DAS, it was revealed that all the treatments performed better compared to control treatment. Nitrogen promotes chlorophyll formation and P helps in nutrient absorption by lateral root development. As a result, number of leaves per plant increased. However, there were significant difference among the treatments in producing number of leaves per plant indicating that this character respond well to integrated nutrient management and management practices, environment, edaphic, climatic and nutrition factors had profound influence on this character during the course of investigation. This type of investigation were done earlier by Banu *et al.,* (2013), Singh and Chauhan (2009), Sharma *et al.,* (2015) and Verma *et al.,* (2015)

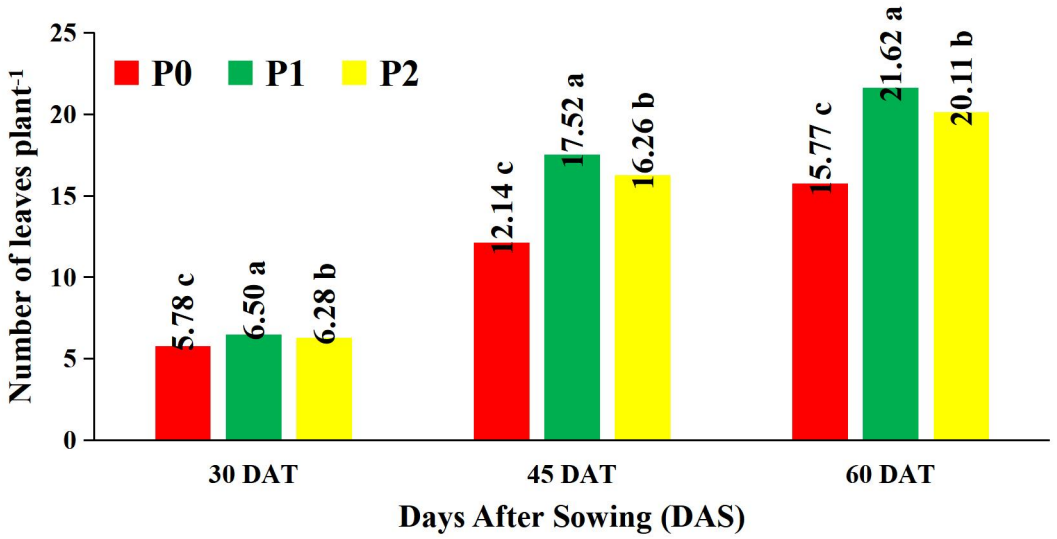

Figure 5: Effect of P fertilizers on number of leaves plant^{-1} (no.) of French bean at different days after sowing (DAS).

Here,
P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

Table 2: Combined effect of nitrogen and phosphorus fertilizers on number of leaves plant^{-1} of French bean.

Combined Treatments	Number of leaves plant^{-1} (no.)		
	30 DAS	45 DAS	60 DAS
N_0P_0	5.40 e	10.87 h	14.32 h
N_0P_1	6.03 bcde	13.48 fg	16.90 efgh
N_0P_2	5.90 cde	12.33 fgh	16.22 efgh
N_1P_0	6.13 bcd	14.07 ef	17.95 defg
N_1P_1	7.13 a	20.94 a	27.64 a
N_1P_2	6.67 ab	19.27 ab	24.96 ab
N_2P_0	5.83 de	11.88 gh	15.83 fgh
N_2P_1	6.60 abc	18.87 abc	22.41 bc
N_2P_2	6.30 bcd	17.68 bcd	20.57 cd
N_3P_0	5.73 de	11.73 gh	14.99 gh
N_3P_1	6.23 bcd	16.77 cd	19.54 cde
N_3P_2	6.23 bcd	15.74 de	18.67 def
SE(±)	0.20	0.58	0.98
CV (%)	3.94	4.68	6.29

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

Combined effect of different levels of nitrogen and phosphorus fertilizer on the numbers of leaves plant^{-1} in French bean showed (Table 2) significant variation on different days. The highest numbers of leaves plant^{-1} (7.13, 20.94 and 27.64 respectively) was recorded from N_1P_1 (100% RDF of N with 100% RDF of P) treatment. Lowest numbers of leaves plant^{-1} (5.40, 10.87 and 14.32 respectively) from N_0P_0 (control) treatment.

4.1.3 Number of branches plant $^{-1}$ (no.)

Number of branches plant^{-1} is an important trait for flowers and pod production and is thereby an important aspect of French bean growth improvement. Effective number of branches plant^{-1} depends primarily on soil physical conditions that were superior due to addition of integrated use of fertilizer. Different doses of N and P showed significant variation on number of branches plant $^{-1}$of French bean (Figure 6, 7 and 8 respectively). In case of nitrogen effect, the number of branches were more with N_1 (100% RDF of N) that was 6.82 and less 4.24 from control treatment (N_0). It may be concluded that when number of branches increases mostly there was increase in number of leaves. These treatments may be ranked in order of $N_1>N_2>N_3>N_0$.

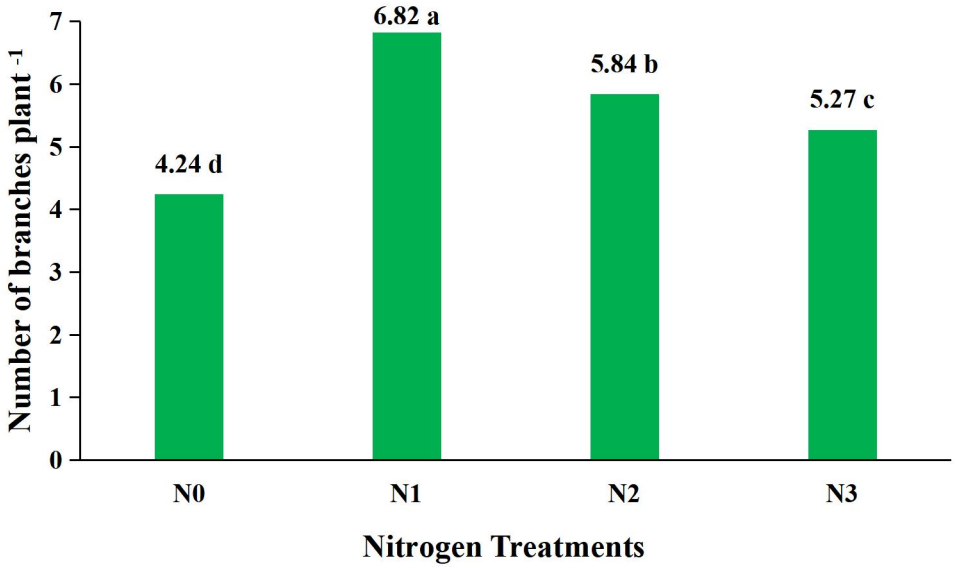

Figure 6: Effect of N fertilizers on number of branches plant^{-1} of French bean

Here,
N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen.

In case of phosphorus effect, different doses of phosphorus fertilizer showed (Figure 7) significant variations in respect of number of primary branches plant^{-1}. Among the different doses of phosphorus P_1 (100% RDF of P) showed the highest number of primary branches

plant^{-1} (6.55) all over the growth period which was statistically different (5.95) from the P_1 (50% RDF of P) treatment. On the contrary, the lowest number of primary branches plant^{-1} (2.33) was recorded in the P_0 treatment where no phosphorus fertilizer was applied. The increased number of primary branches plant^{-1} may be due to positive effects of phosphorus on the vegetative growth and accumulation of growth promoting substances that helped proper growth and development of the French bean.

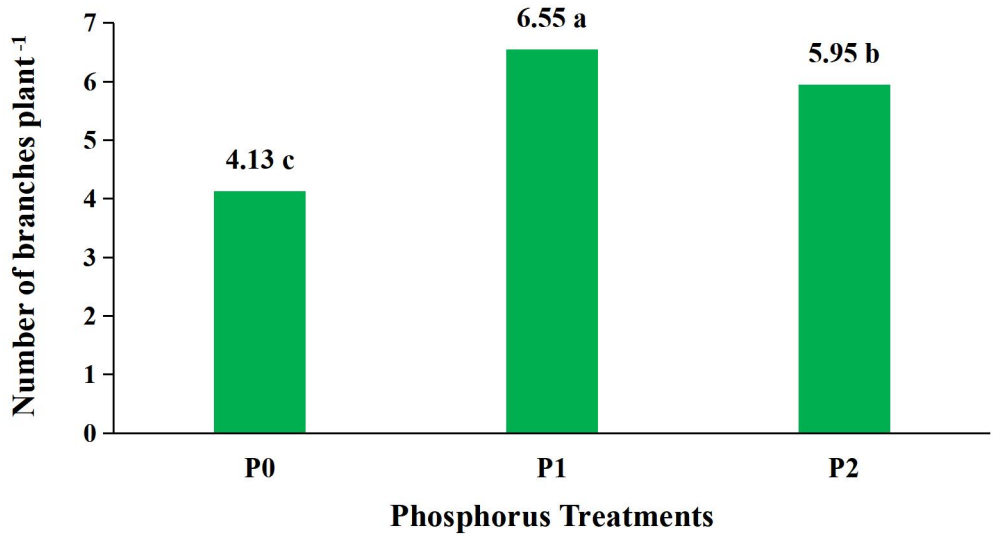

Figure 7: Effect of P fertilizers on number of branches plant^{-1} of French bean

Here,
P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

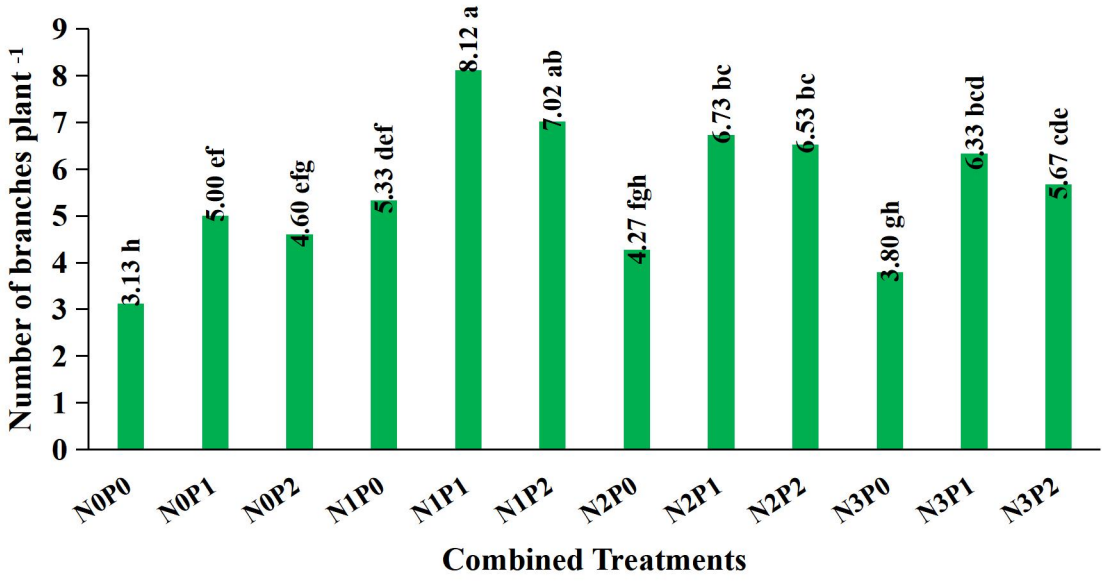

Figure 8: Combined effect of N and P fertilizers on number of branches plant^{-1} of French bean.

Combined effect of different levels of N and P application on number of branches plant^{-1} was also significant (Figure 8). The maximum number of branches (8.12) was recorded from N_1P_1 which was statistically dissimilar with others treatment and minimum branches plant^{-1} (3.13) was observed from N_0P_0.

4.1.4 Number of pods plant $^{-1}$ (no.)

The number of pods plant^{-1} is an important yield deterring factor in French bean. The number of pods plant^{-1} was significantly influenced by the application of different level of N and K fertilizer (Table 3 and 4). In case of nitrogen effect, the maximum pods plant^{-1} (14.49) was found in the treatment N_1 treatment were followed by N_2 treatment which differ when compared among themselves. On the other hand, the lowest pods plant^{-1} (8.00) was obtained in the treatment N_0 (control). From the result of Mohamed Ali Addow *et al*. (2020) experiment it was found that the main effect of nitrogen had significant effect on number of pods per plant. These results are in line with DATh *et al.* (2019); Mohanty *et al.* (2017).

Table 3: Effect of nitrogen fertilizers on number of pods plant^{-1} of French bean.

Nitrogen Treatments	Number of pods plant $^{-1}$ (no.)
N_0	8.00 d
N_1	14.49 a
N_2	12.49 b
N_3	11.18 c
SE(±)	0.43
CV (%)	7.87

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen,

SE= Standard Error and CV= Co-efficient of variance.

Table 4: Effect of phosphorus fertilizers of number on pods plant^{-1} of French bean.

Phosphorus Treatments	Number of pods plant $^{-1}$ (no.)
P_0	7.90 c
P_1	13.88 a
P_2	12.84 b
SE(±)	0.37
CV (%)	7.87

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

SE= Standard Error and CV= Co-efficient of variance

In case of phosphorus effect, the maximum number of pods plant^{-1}of French bean (13.88) was recorded from P_1 which statistically followed by P_2 (12.84) and whereas, the lowest (7.90) was observed from P_0 treatment.

The increased number of pods plant^{-1} may be due to favorable effects of phosphorus on the vegetative growth and accumulation of materials that helped proper growth and development of the French bean pod. Significant number of pods per plant of common bean at application rate phosphorous observed by Veeresh, 2003.

Table 5: Combined effect of nitrogen and phosphorus fertilizers on number of pods plant^{-1} of French bean.

Combined Treatments	Number of pods plant $^{-1}$ (no.)
N_0P_0	4.53 i
N_0P_1	10.47 efg
N_0P_2	9.00 fgh
N_1P_0	11.27 def
N_1P_1	16.68 a
N_1P_2	15.54 ab
N_2P_0	8.33 gh
N_2P_1	14.70 abc
N_2P_2	14.44 abc
N_3P_0	7.47 h
N_3P_1	13.67 bcd
N_3P_2	12.40 cde
SE(±)	0.74
CV (%)	7.87

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

Remarkable variation was found in the number of pods plant^{-1} of French bean when different combined doses of nitrogen and phosphorus were applied (Table 5). The highest number of pods plant^{-1} (16.68) was recorded in N_1P_1 treatment was identical to N_1P_2 treatment that was 15.54 which differ among different treatments. The lowest number of pods plant^{-1}(4.53) was recorded in the N_0P_0 treatment where no fertilizers were applied.

4.1.5 Pod length (cm)

The application of different nutritional treatments affected the length of pods significantly different combined (Figure 9 and 10). In case of nitrogen effect, the highest statistically

superior pod length was 16.48 cm recorded in the treatment N_1. On the other hand, the lowest pod length 13.56 cm was obtained in the treatment N_0 (control). The highest fertilizer treatment (90-50-120) resulted in the highest pod length (15.76 cm) of French bean founded by Begum *et al.* (2015). Singh (2000) got maximum pod length form the application of 125 kg N ha^{-1}. Qazi *et al.* (2015), Jayashri *et al.* (2017), DATh *et al.* (2019) and Shahid *et al.* (2015) also reported similar result in their experiment.

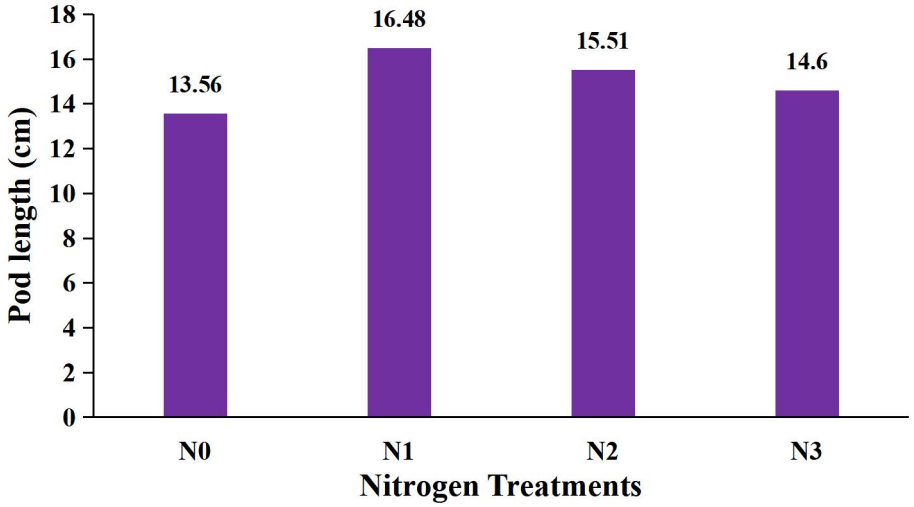

Figure 9: Effect of N fertilizers on pod length (cm) of French bean

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen.

Statistically significant variation was recorded due to different levels of phosphorus in terms of pod length of French bean (Figure 10).

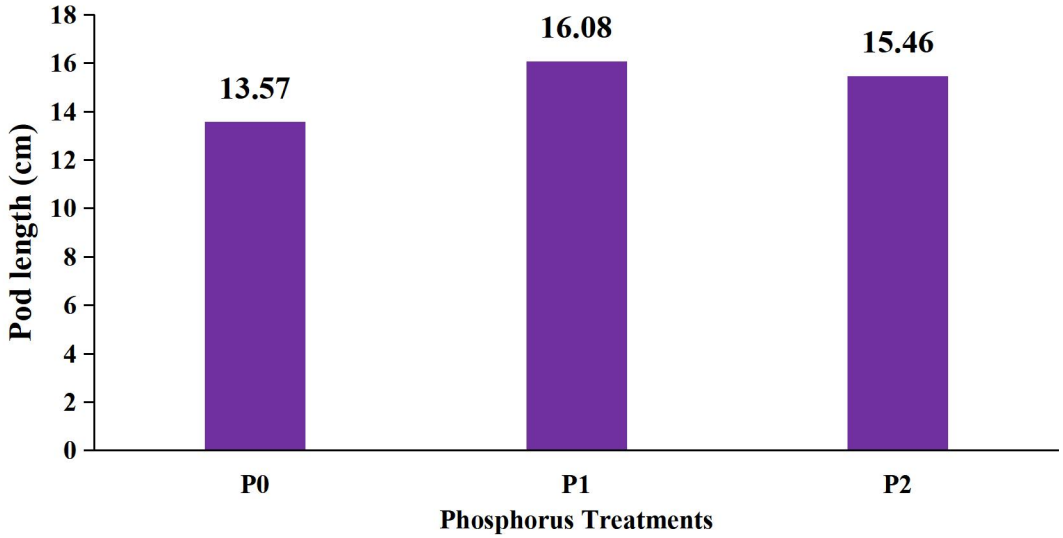

Figure 10: Effect of P fertilizers on pod length (cm) of French bean

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus.

The longest pod (16.08 cm) was observed from P_1(100% RDF of phosphorus), which was statistically different (15.46 cm) from P_2(50% RDF of phosphorus), while the shortest pod (13.57 cm) was found from P_0(No phosphorus applied. i.e. control) treatment.

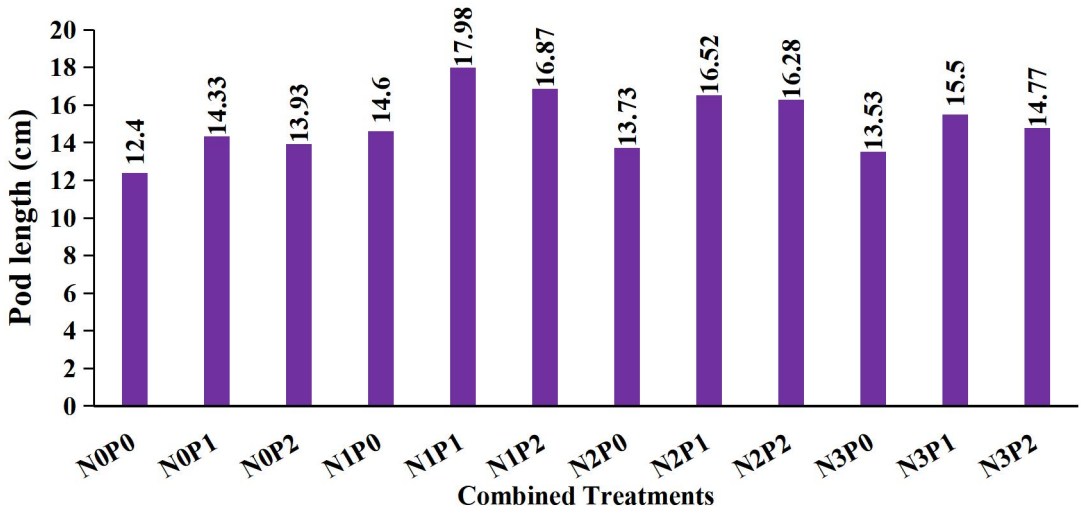

Figure 11: Combined effect of N and P fertilizers on pod length (cm) of French bean

Pod length of French bean showed statistically significant variation due to the interaction effect of different levels of nitrogen and phosphorus. Numerically, the longest pod (17.98 cm) was recorded from N_1P_1, whereas statistically lower with (16.87 and 16.52 cm) were found in N_1P_2 and N_2P_1, respectively. Whereas the shortest pod (12.40 cm) was found from N_0P_0 (control) treatment (Figure 11).

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

Pods from 5 randomly selected plants were weighed, and their average was recorded in gram (g). Different level of N and P fertilization showed highly significant effect on the pod weight per plant. Application of 100 % Recommended Doses of Fertilizer (RDF) of nitrogen gave the maximum pod weight plant $^{-1}$(113.67 g), whereas the minimum pod weight per plant (73.13 g) was obtained from N_0 treatment where no nitrogen fertilizer was applied (Table 6).

In case of phosphorus effect, the highest pod weight plant^{-1} (111.81 g) was recorded from P_1 (100% RDF of phosphorus) treatment. Lowest pod weight plant^{-1}(68.33 g) was from P_0 (where no phosphorus used) treatment (Table 7).

There was a gradual increase in the pod yield per plant with the application of integrated use of N and P fertilizer. Begum *et al*. (2015) found that the highest fertilizer treatment resulted

in the highest pod weight (82.33 gm plant^{-1}) of French bean. These results may be due to the NPK role in pod weight increase that was supported by Qazi*et al*. (2015), Muhammad Shahid*et al.* (2015), Moniruzzaman *et a*l., 2008 and DATh *et al.* (2019).

Statistically significant variation was recorded in terms of pod weight plant^{-1} of French bean due to combined effect of different levels of nitrogen and phosphorus. The highest pod weight plant^{-1}(121.81 g) was found from N_1P_1 which was statistically similar with (119.59 g) N_1P_2 and the lowest weight was found (38.67 g) from N_0P_0 (control) treatment (Table 8).

Table 6: Effect of nitrogen fertilizers on pod weight plant^{-1} (g) and 1000-Seed weight (g) of French bean.

Nitrogen Treatments	Pod weight plant^{-1} (g)	1000-Seed weight (g)
N_0	73.13 d	441.56 d
N_1	113.67 a	516.67 a
N_2	101.20 b	487.89 b
N_3	91.79 c	474.33 c
SE(±)	2.94	2.07
CV (%)	6.57	0.92

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen,

SE= Standard Error and CV= Co-efficient of variance.

Table 7: Effect of phosphorus fertilizers on pod weight plant^{-1} (g) 1000-Seed weight (g) of French bean.

Phosphorus Treatments	Pod weight plant^{-1} (g)	1000-Seed weight (g)
P_0	68.33 c	428.58 c
P_1	111.81 a	513.25 a
P_2	104.69 b	498.50 b
SE(±)	2.54	1.80
CV (%)	6.57	0.92

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

SE= Standard Error and CV= Co-efficient of variance

4.1.7 1000-Seed weight (g)

Weight of 1000 seeds of French bean showed statistically significant variation due to different levels of nitrogen application (Table 6). The highest weight of 1000 seeds (516.67 g)

was recorded from N_1 (100 % RDF on N) treatment. Lowest weight of 1000 seeds (441.56 g) was from N_0 treatment.

In case of phosphorus effect, significant differences of 1000 seed weight were also noted (Table 7). The different treatments are concerned the application of 100 % RDF of P resulted (513.25 g) in maximum and minimum (428.58 g) seed weight was recorded in plots where no phosphorus fertilizer was applied.

Table 8: Combined effect of nitrogen and phosphorus fertilizers on pod weight plant^{-1} (g) and 1000-Seed weight (g) of French bean.

Combined Treatments	Pod weight plant^{-1} (g)	1000-Seed weight (g)
N_0P_0	38.67 f	390.00 i
N_0P_1	98.87 bc	471.00 ef
N_0P_2	81.87 cd	463.67 f
N_1P_0	99.60 bc	481.67 e
N_1P_1	121.82 a	550.00 a
N_1P_2	119.59 a	523.67 b
N_2P_0	73.33 de	428.33 g
N_2P_1	116.54 ab	518.33 bc
N_2P_2	113.71 ab	511.67 bcd
N_3P_0	61.73 e	414.33 h
N_3P_1	110.03 ab	508.33 cd
N_3P_2	103.60 ab	500.33 d
SE(±)	5.09	3.59
CV (%)	6.57	0.92

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

Statistically significant variation was recorded in terms of weight of 1000 seeds of French bean due to combined effect different levels of nitrogen and phosphorus (Table 8). The highest weight of 1000 seeds (550.00 g) was found from N_1P_1 which were statistically different from (523.67 g) N_1P_2 and the lowest 1000 seed weight (390.00 g) was found from N_0P_0 (control) treatment.

4.1.8 Number of seeds pod^{-1} (no.)

The number of seeds pod^{-1} is also an important yield determining factor in French bean. The number of seeds pod^{-1} was significantly influenced by the application of different levels of N and K fertilizer (Table 9 and 10). In case of nitrogen effect, the maximum seeds pod^{-1} (5.17) was found in the N_1 treatment, which is followed by N_2 and N_3 treatment, respectively. On the other hand, the lowest seeds pod^{-1} (4.24) was obtained in the treatment N_0 (control).

In case of phosphorus effect, the maximum number of seeds pod^{-1} of French bean (5.00) was observed from P_1 which followed statistically with P_2 (4.77) and the lowest (4.23) was observed from P_0 treatment. The increased number of seeds pod^{-1}may be due to favorable effects of phosphorus on the vegetative growth and accumulation of materials that helped proper growth and development of the French bean pod.

Table 9: Effect of nitrogen fertilizers on number of seed pod^{-1} (no.) and yield (kg plot^{-1}) of French bean.

Nitrogen Treatments	Number of seed pod^{-1} (no.)	Yield (kg plot^{-1})
N_0	4.24 c	1.83 d
N_1	5.17 a	2.84 a
N_2	4.68 b	2.53 b
N_3	4.58 b	2.29 c
SE(±)	0.10	0.07
CV (%)	4.47	6.57

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen,

SE= Standard Error and CV= Co-efficient of variance.

In case of combined effect, the highest number of seeds pod^{-1} (5.78) was recorded in N_1P_1 treatment and was followed by N_1P_2 treatment that was 5.13, which differ from others. The lowest number of seeds pod^{-1}(3.80) was recorded in the N_0P_0 treatment, where no fertilizers were applied.

Table 10: Effect of phosphorus fertilizers on number of seed pod^{-1} (no.) and yield (kg plot^{-1}) of French bean.

Phosphorus Treatments	Number of seed pod^{-1} (no.)	Yield (kg plot^{-1})
P_0	4.23 c	1.71 c
P_1	5.00 a	2.80 a
P_2	4.77 b	2.62 b
SE(±)	0.09	0.06
CV (%)	4.47	6.57

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

SE= Standard Error and CV= Co-efficient of variance

4.1.9 Yield (kg plot^{-1})

Application of different amount of inorganic fertilizers such as N and P showed significant of variation for grain yield per plot as kilogram. A perusal of table 9 shows that maximum grain yield plot^{-1} (2.84 kg plot^{-1}) was obtained in N_1 treatment which was statistically different from N_2 treatment giving grain yields of 2.53 kg plot^{-1}. The lowest grain yield 1.83 kg was recorded from plot where no nitrogen was applied (control).

In case of phosphorus effect, the highest grain yield (2.80 kg plot^{-1}) was produced when the crop was fertilized with 100 % RDF of phosphorus (P_1) and the lowest (1.71 kg plot^{-1}) was recorded in the control treatment (Table 10).

Table 11: Combined effect of nitrogen and phosphorus fertilizers on number of seed pod^{-1} (no.) and yield (kg plot^{-1}) of French bean.

Combined Treatments	Number of seed pod^{-1} (no.)	Yield (kg plot^{-1})
N_0P_0	3.80 e	0.97 f
N_0P_1	4.53 bcd	2.47 bc
N_0P_2	4.40 cde	2.05 cd
N_1P_0	4.60 bcd	2.49 bc
N_1P_1	5.78 a	3.05 a
N_1P_2	5.13 b	2.99 a
N_2P_0	4.27 de	1.83 de
N_2P_1	4.97 bc	2.91 ab
N_2P_2	4.80 bcd	2.84 ab
N_3P_0	4.27 de	1.54 e
N_3P_1	4.73 bcd	2.75 ab
N_3P_2	4.73 bcd	2.59 ab
SE(±)	0.17	0.13
CV (%)	4.47	6.57

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

In table 11 interaction effect of nitrogen and phosphorus of French bean is showed. The highest grain yield (3.05 kg plot^{-1}) was produced when the crop was fertilized with N_1P_1treatment which was insignificantly followed by N_1P_2 (2.99 kg plot^{-1}) treatment. The lowest grain yield (0.97 kg plot^{-1}) was recorded in the treatment of N_0P_0 (control).

4.1.10 Yield (t ha^{-1})

Grain yield is a function of interaction among various yield components that were affected differentially by the growing conditions and crop management practices. It is clear from the figure 12 that grain yield was significantly less affected by the application of different levels of nitrogen fertilizers. The maximum grain yield plot^{-1} (7.10 t ha^{-1}) was obtained in N_1

treatment which was statistically similar to N_2 treatment giving grain yields of 6.32 t ha^{-1}. The lowest grain yield 4.57 t ha^{-1} was recorded from plot where no nitrogen was applied (control). Application of higher doses of nitrogen especially for seed crop of French bean is imperative for realizing its potential yield (Sardana *et al*., 2000).

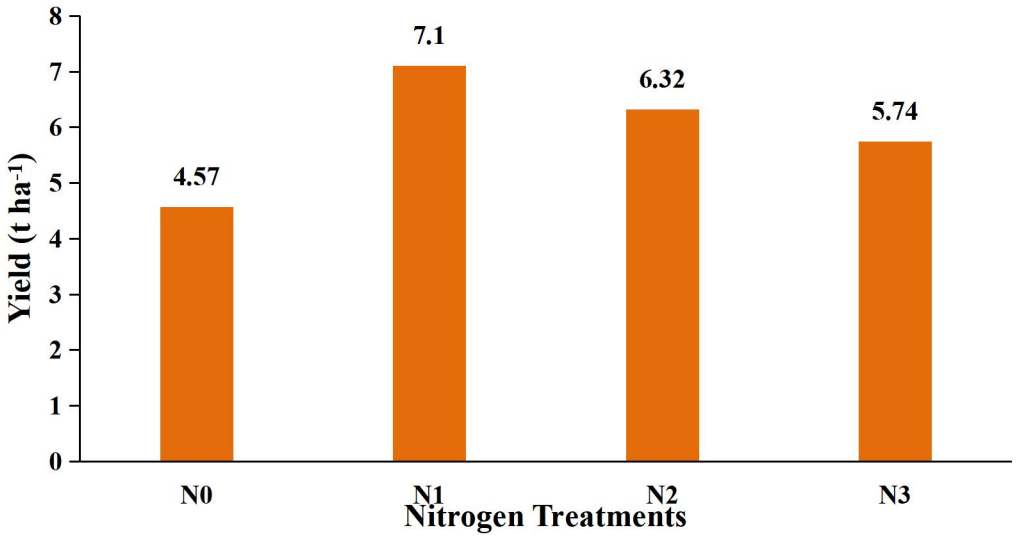

Figure 12: Effect of N fertilizers on yield (t ha^{-1}) of French bean

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen.

In phosphorus effect, the highest grain yield (6.99 t ha^{-1}) was produced when the crop was fertilized with 100 % RDF of phosphorus (P_1) and the lowest (4.27 t ha^{-1}) was recorded in the treatment of control (P_0) (Figure 13).

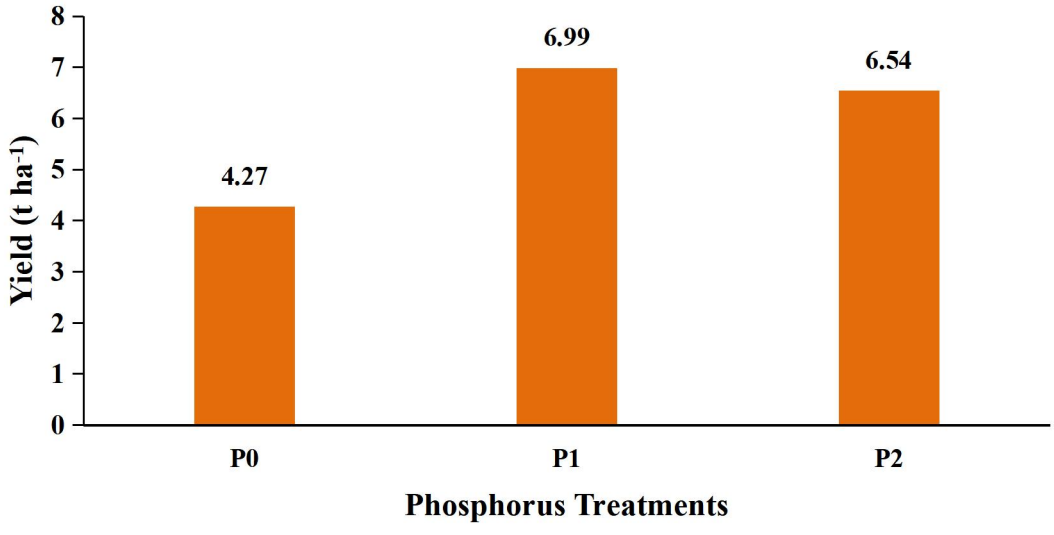

Figure 13: Effect of P fertilizers on yield (t ha^{-1}) of French bean

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus.

The increased grain yield may be due to the positive effects of phosphorus on the vegetative growth and accumulation of plant growth materials that helped proper growth and development of the French bean grain. Shubhashree, 2007 who reported bean yield accumulation increase with application of phosphorus rates.

The interaction effect of nitrogen and phosphorus on French bean has been showen in figure 14. The highest seed yield (7.61 t ha^{-1}) was produced when the crop was fertilized with N_1P_1 treatment which followed by N_1P_2 (7.47 t ha^{-1}) treatment insignificantly. The lowest (2.42 t ha^{-1}) was recorded in the treatment of N_0P_0 (control).

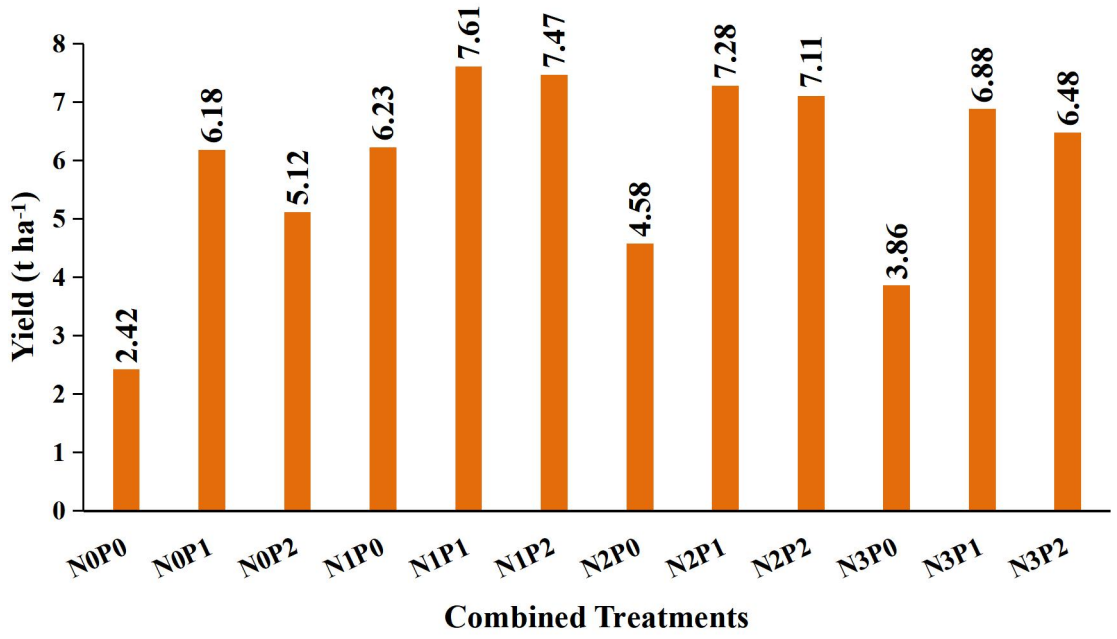

Figure 14: Combined effect of N and P fertilizers on yield (t ha^{-1}) of French bean.

Singh and Singh (2000) reported that the yield and yield component values of French bean increased with increasing N rates, but were generally highest with 80 kg P ha^{-1}. Kanaujia *et al* (1999) who also highlighted higher grain yields weight with increased potassium rates. Nitrogen and phosphorus alone significantly influenced the pod yield of French bean. This information will help the farmer to grow French bean with better yield.

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

Straw yield of French bean had significant variation with different level of N application (Figure 15). Numerically the maximum straw yield of French bean (16.43 t ha^{-1}) was recorded from N_1 while, the minimum (11.82 t ha^{-1}) was found from N_0 (control) treatment.

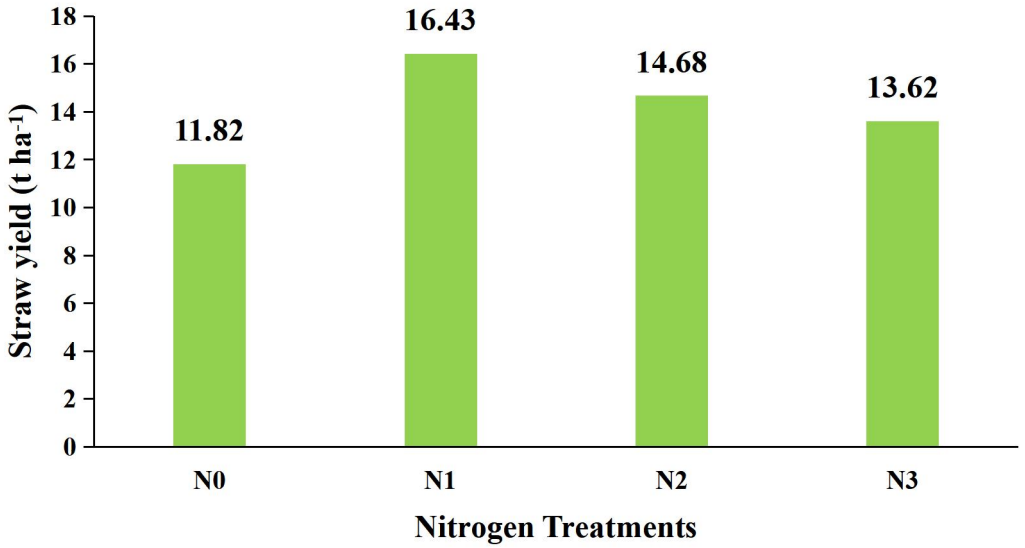

Figure 15: Effect of N fertilizers on straw yield (t ha^{-1}) of French bean

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen.

Straw yield of French bean varied significantly with different levels of phosphorus application (Figure 16). The maximum (15.79 t ha^{-1}) straw yield was recorded from P_1, whereas the minimum (11.09 t ha^{-1}) was statistically followed with P_2 (15.53 t ha^{-1}) was obtained from P_0.

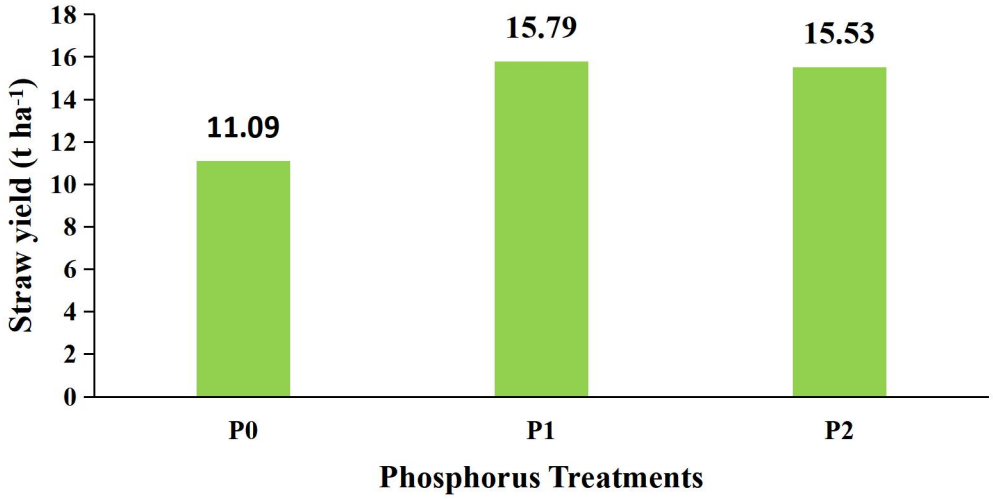

Figure 16: Effect of P fertilizers on straw yield (t ha^{-1}) of French bean

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus.

Different levels of nitrogen and phosphorus varied significantly on straw yield (t ha^{-1}) of French bean (Figure 17). The highest straw yield (16.97 t ha^{-1}) was found from N_1P_1, which was statistically identical (16.90 t ha^{-1} and 16.36 t ha^{-1}) with N_1P_2 and N_2P_1 respectively, whereas the lowest straw yield (7.01 t ha^{-1}) from N_0P_0 (control) treatment.

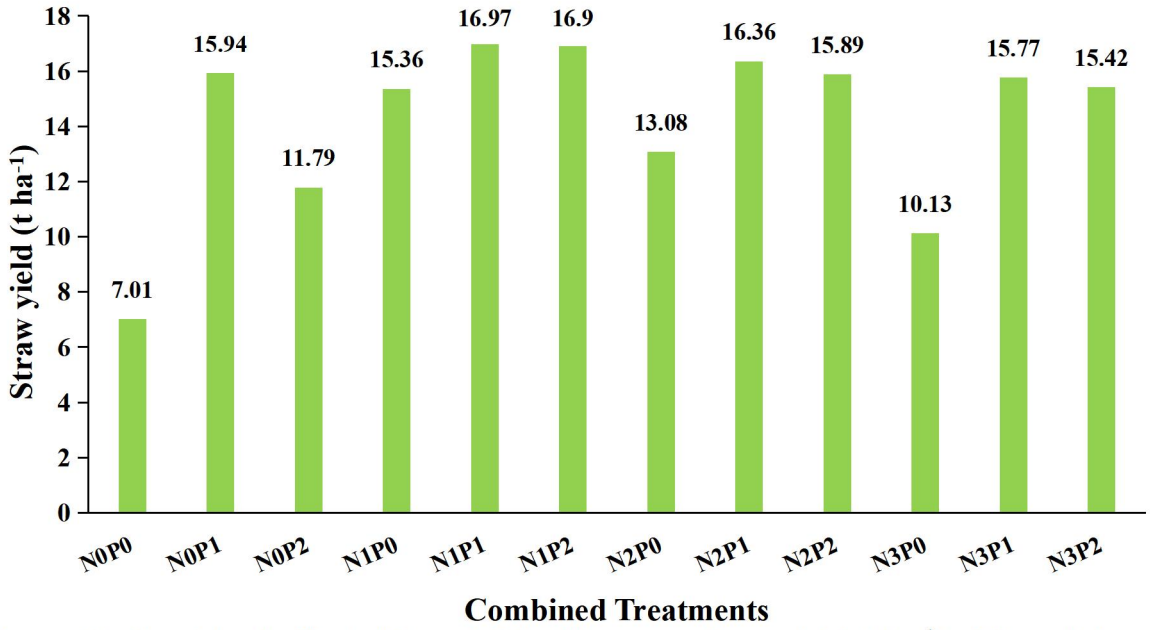

Figure 17: Combined effect of N and P fertilizers on straw yield (*t ha*$^{-1}$) of French bean

4.1.12 Biological yield (t ha^{-1})

Biological yield of French bean varied significantly with different level of N application (Table 12). The maximum biological yield of French bean (23.54 t ha^{-1}) was recorded from N_1 which was statistically identical from N_2 (21.01 t ha^{-1}) and the minimum (16.39 t ha^{-1}) was recorded where, no nitrogen was applied.

Table 12: Effect of nitrogen fertilizers on biological yield (t ha^{-1}) and harvest index (%) of French bean.

Nitrogen Treatments	Biological yield (t ha^{-1})	Harvest index (%)
N_0	16.39 c	27.27 b
N_1	23.54 a	30.16 a
N_2	21.01 b	29.90 a
N_3	19.35 b	29.37 a
SE(±)	0.71	0.49
CV (%)	7.53	3.54

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen,

SE= Standard Error and CV= Co-efficient of variance.

Different level of phosphorus application (Table 13) showed statistically different results in biological yield. The maximum biological yield (22.78 t ha^{-1}) was recorded in P_1 which was statistically similar with P_2 (22.07 t ha^{-1}) and the lowest (15.38 t ha^{-1}) was, however, found in case of control treatment. Generally biological yield increased with increasing rate of fertilizer application. Begum *et al.* (2015) observed biological yield varied significantly due to phosphorus application.

Combined effect of N and P application had significant effect on biological yield of French bean (Table 14). The highest biological yield (24.59 t ha^{-1}) was recorded from N_1P_1 which was statistically similar with N_1P_2 (24.38 t ha^{-1}) and N_2P_2 (23.47 t ha^{-1}) while, the lowest (9.42 t ha^{-1}) was found from N_0P_0 treatment.

4.1.12 Harvest index (%)

Harvest index of French bean varied significantly with different level of N application (Table 12). The maximum harvest index of French bean (30.16 %) was recorded from N_1 which was statistically similar with N_2 (29.90 %) and N_3 (29.37 %). On the other hand, the minimum (27.27 %) was found from N_0 treatment.

Different level of phosphorus application showed the different result in harvest index (Table 13). The maximum HI of French bean (30.64 %) was recorded in P_1 where the level of phosphorus (100 % RDF of P) and the lowest (27.35 %) was, however, found in case of control treatment.

Table 13: Effect of phosphorus fertilizers on biological yield (t ha^{-1}) and harvest index (%) of French bean.

Phosphorus Treatments	Biological yield (t ha^{-1})	Harvest index (%)
P_0	15.38 b	27.35 c
P_1	22.78 a	30.64 a
P_2	22.07 a	29.53 b
SE(±)	0.62	0.42
CV (%)	7.53	3.54

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

SE= Standard Error and CV= Co-efficient of variance

Harvest index of French bean had significant variation with different level of combined nitrogen and phosphorus application (Table 14). The maximum harvest index values (31.52 %) was recorded in N_1P_1 which is statistically similar (31.45 %) with N_2P_1 treatment and the lowest harvest index (25.15 %) was recorded from N_0P_0 treatment. Jayashri *et al.* (2017) was noticed that application of nutrient levels and varieties had significant influence on harvest index.

Table 14: Combined effect of nitrogen and phosphorus fertilizers on biological yield (t ha^{-1}) and harvest index (%)of French bean.

Combined Treatments	Biological yield (t ha^{-1})	Harvest index (%)
N_0P_0	9.42 d	25.15 d
N_0P_1	21.54 ab	28.81 abc
N_0P_2	18.20 bc	28.59 abc
N_1P_0	21.65 ab	28.08 bcd
N_1P_1	24.59 a	31.52 a
N_1P_2	24.38 a	30.68 ab
N_2P_0	16.38 c	27.95 bcd
N_2P_1	23.17 a	31.45 a
N_2P_2	23.47 a	30.29 abc
N_3P_0	13.99 c	27.49 cd
N_3P_1	21.82 ab	30.98 ab
N_3P_2	22.25 ab	29.10 abc
SE(±)	1.23	0.84
CV (%)	7.53	3.54

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, SE= Standard Error and CV= Co-efficient of variance

4.2 Chemical properties of the post-harvest soil

4.2.1 Soil pH

The post-harvest soil was slightly acidic where soil pH ranged from 6.22 to 6.30 due to application of different amount of nitrogen (Table 15). There was insignificant differences in soil pH among the treatments of the post-harvest soil. The highest pH value of post-harvest soil was observed 6.30 in N_1 (100 % Recommended Doses of Fertilizer (RDF) of Nitrogen) and the lowest 6.22 was recorded in control treatment (N_0).

Different levels of phosphorus application showed the non-significant effect on soil pH (Table 16). The maximum soil pH of French bean (6.28) was recorded in P_1 where the level

of phosphorus (100 % RDF of P) and the lowest (6.21) was, however, found in case of control treatment (P_0).

Combined effect of N and P application had no significant effect on soil pH of French bean (Table 17). The highest soil pH (6.30) was recorded from N_1P_1 which was statistically similar with N_1P_2 and N_2P_2 (6.30) while, the lowest soil pH (6.20) was found in N_0P_0, N_2P_0, N_3P_0 and N_0P_2 treatment, respectively. The study revealed that the application of chemical fertilizers slightly increased the soil pH of the post-harvest soil compared to the initial soil (Appendix III).

Table 15: Effect of Nitrogen fertilizers on the soil pH, organic matter content of the post-harvest soil.

Nitrogen Treatments	Soil pH	Organic matter content (%)
N_0	6.22	0.79
N_1	6.30	0.88
N_2	6.27	0.83
N_3	6.24	0.78
LS	NS	NS
CV (%)	0.52	3.51

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen,

LS= Level of Significant and CV= Co-efficient of variance.

Table 16: Effect of Phosphorus fertilizers on the soil pH, organic matter content of the post-harvest soil.

Phosphorus Treatments	Soil pH	Organic matter content
P_0	6.21	0.76
P_1	6.28	0.86
P_2	6.26	0.85
LS	NS	NS
CV (%)	0.52	3.51

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

SE= Level of Significant and CV= Co-efficient of variance

4.2.2 Organic matter content

The application of different amount of nitrogen fertilizers had no significant effect on organic matter content in soil (Table 15). The average soil organic matter content of the initial soil was 0.78 % which was slightly lower than that of the post-harvest soils. The highest and statistically superior soil organic matter content was 0.88 % that was found in the treatment N_1 followed by N_2 treatment. The lowest soil organic matter was 0.79 % was noticed in N_0 treatment.

In phosphorus effect, the highest soil organic matter (0.86 %) was produced when the crop was fertilized with 100 % RDF of phosphorus (P_1) and the lowest soil organic matter (0.76 %) was recorded in the treatment of control (P_0) (Table 16).

Table 17: Combined effect of nitrogen and phosphorus fertilizers on the soil pH, organic matter content of the post-harvest soil.

Combine Treatments	Soil pH	Organic matter content
N_0P_0	6.20	0.78
N_0P_1	6.27	0.81
N_0P_2	6.27	0.80
N_1P_0	6.23	0.84
N_1P_1	6.30	0.88
N_1P_2	6.27	0.86
N_2P_0	6.20	0.70
N_2P_1	6.30	0.84
N_2P_2	6.30	0.83
N_3P_0	6.20	0.79
N_3P_1	6.27	0.82
N_3P_2	6.27	0.81
LS	NS	NS
CV (%)	0.52	3.51

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, LS= Level of Significant and CV= Co-efficient of variance

Combined effect of N and P application had no significant effect on soil organic matter of French bean (Table 17). The highest soil organic matter (0.88 %) was recorded from N_1P_1 which was statistically similar with N_1P_2 (0.86 %) while, the lowest soil organic matter (0.78 %) was found from N_0P_0 treatment. The study revealed that the application of chemical fertilizers slightly increased the soil organic matter of the post-harvest soil compared to the initial soil but the differences were not statistically significant (Appendix III).

4.2.3 Total nitrogen (N) in soil

The total N present in the post-harvest soil varied insignificantly (Table 18). Soil nitrogen content of the post-harvest soil was higher than the initial soil. The total nitrogen content of the post-harvest soil ranged between 0.06 % and 0.08 %. The highest nitrogen (0.08 %) was found in N_1 (100 % Recommended Doses of Fertilizer (RDF) of Nitrogen) treatment. The lowest soil N (0.06 %) content was found in N_0 treatment that was control which was statistically similar with N_3 treatment.

Different levels of phosphorus application showed no statistically different results in total plant N (Table 19) in post-harvest soil. The maximum total N in post-harvest soil of French bean (0.07 %) was recorded in P_1 (100 % RDF of P) which was statistically similar with P_2 treatment and the lowest (0.06 %) was, however, found in case of control treatment.

Combined effect of N and P application had no significant effect on total N in French bean in post-harvest soil (Table 20). The highest total N (0.08 %) was recorded from N_1P_0, N_1P_1 and N_1P_2 while the lowest total N (0.05 %) was found from N_0P_0 treatment.

Table 18: Effect of Nitrogen fertilizers on the total N, available P and exchangeable K of the post-harvest soil.

Nitrogen Treatments	Total N (%)	Available P (ppm)	Exchangeable K (mg 100 g^{-1} soil)
N_0	0.06	15.07 c	1.10
N_1	0.08	17.33 a	1.20
N_2	0.07	16.69 ab	1.19
N_3	0.06	15,83 bc	1.12
LS	NS	*	NS
CV (%)	9.03	6.06	8.24

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, N_0 = No Nitrogen applied. i.e. control, N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen, N_2= 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen,

LS= Level of Significant and CV= Co-efficient of variance.

4.2.4 Available phosphorus (P) in soil

The available phosphorus content of the post-harvest soil varied significantly by different treatments (Table 18). Available phosphorus content in soil varied from 15.07 to 17.33 ppm due to applied different nitrogen fertilizer doses. The maximum phosphorus content 17.33 ppm was observed in case of the treatment N_1 (100 % Recommended Doses of Fertilizer

(RDF) of Nitrogen). The lowest phosphorus content (15.07 ppm) of post-harvest soil was observed in N_0 (No Nitrogen applied) treatment.

Different level of phosphorus application showed the different result in available P (Table 19). The maximum P contain in post-harvest soil of French bean (21.43 ppm) was recorded in P_1 where the level of phosphorus (100 % RDF of P) and the lowest (9.63 ppm) was, however, found in case of control treatment.

Combined effect of N and P application had significant effect on post-harvest soil available P of French bean (Table 20). The highest available P (24.01) was recorded from N_1P_1 while, the lowest post-harvest soil available P (8.45 ppm) was found from N_0P_0 treatment.

Table 19: Effect of Phosphorus fertilizers on the total N, available P and exchangeable K of the post-harvest soil.

Phosphorus Treatments	Nitrogen (%)	Available P	Exchangeable K
P_0	0.06	9.63 c	1.10
P_1	0.07	21.43 a	1.18
P_2	0.07	17.63 b	1.12
LS	NS	*	NS
CV (%)	9.03	6.06	8.24

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, P_0 = No Phosphorus applied. i.e. control, P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus

LS= Level of Significant and CV= Co-efficient of variance

Table 20: Combined effect of nitrogen and phosphorus fertilizers on the total N, available P and exchangeable K of the post-harvest soil.

Combine Treatments	Nitrogen (%)	Available P	Exchangeable K
N_0P_0	0.05	8.45 e	1.10
N_0P_1	0.06	10.43 e	1.14
N_0P_2	0.06	9.90 e	1.13
N_1P_0	0.08	20.13 bc	1.16
N_1P_1	0.08	24.01 a	1.20
N_1P_2	0.08	21.33 ab	1.20
N_2P_0	0.07	16.43 e	1.14
N_2P_1	0.08	20.23 bc	1.17
N_2P_2	0.07	20.03 bc	1.16
N_3P_0	0.06	9.73 e	1.12
N_3P_1	0.06	17.53 cd	1.15
N_3P_2	0.06	16.53 e	1.11

LS	NS	*	NS
CV (%)	9.03	6.06	8.24

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

Here, LS= Level of Significant and CV= Co-efficient of variance

4.2.5 Exchangeable potassium (K) in soil

The exchangeable potassium (K) content of the post-harvest soil slightly influenced due to the environment fact (Table 18). The exchangeable K content of initial soil was 0.10 mg 100 g^{-1} soil and the values of post-harvest soil ranged from 1.10 to 1.20 mg 100 g^{-1} soil due to effects of different nitrogen fertilizer. The highest exchangeable K (1.20 mg 100 g^{-1}) was found in the treatments of N_1 (100 % Recommended Doses of Fertilizer (RDF) of Nitrogen). The lowest value (1.10 mg 100 g^{-1}) was found in the treatments N_0 treatment where 0 % of N fertilizer was applied.

Different levels of phosphorus application showed no significant difference in post-harvest soil exchangeable K (Table 19). The maximum exchangeable K of French bean (1.18 mg 100 g^{-1}) was recorded in P_1 post-harvest soil (100 % RDF of P) and the lowest (1.10 mg 100 g^{-1}) was, however, found in case of control treatment.

Combined effect of N and P application had significant effect on exchangeable K of French bean (Table 20). The highest exchangeable K (1.20 mg 100 g^{-1}) was recorded from N_1P_1 and N_1P_2 which was statistically similar with N_2P_1 (1.17 mg 100 g^{-1}) while, the lowest exchangeable K (1.10 mg 100 g^{-1}) was found from N_0P_0 treatment. The exchangeable K increased in soils due to residual effects of applied K containing fertilizer.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at Soil Science research field, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2019 to April 2020 to evaluate the performance of French bean under different treatments of integrated N and P fertilizers. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (Four nitrogen doses) viz. N_0 = No Nitrogen applied. i.e. control; N_1 = 100 % Recommended Doses of Fertilizer (RDF) of Nitrogen; N_2 = 75 % Recommended Doses of Fertilizer (RDF) of Nitrogen and N_3 = 50 % Recommended Doses of Fertilizer (RDF) of Nitrogen and Factor B (Three phosphorus doses) viz. P_0 = No Phosphorus applied. i.e. control; P_1 = 100 % Recommended Doses of Fertilizer (RDF) of Phosphorus and P_2 = 50 % Recommended Doses of Fertilizer (RDF) of Phosphorus. The total numbers of experimental plots were 36. Phosphorus fertilizer was applied as triple super phosphate and N was applied as urea at recommended doses. Seeds were sown on the 08th December, 2019. The plants were allowed to grow until maturity and was applied intercultural operations such as irrigation, weeding and thinning. Insect and disease control were done whenever required in order to support normal growth of the plant. The fruits were harvested at marketable age from 30th April 2019 to 20th February, 2019. Plot wise yield and yield components were recorded. Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of statistics 10 software. The mean differences were analyzed by Tukey HSD test.

In case of nitrogen effects, the highest plant height (38.94 cm) and number of leaves/plant (25.52) at 60 DAT were recorded from the plot where 100 % RDF of nitrogen (N_1) was applied and the lowest plant height (28.32 cm) and number of leaves/plant (16.22) were observed from the control treatment (N_0). The maximum number of branches plant^{-1}(6.82) and pods plant^{-1} (14.49) were recorded from N_1 (100% RDF of N) treatment and the lowest number of branches plant^{-1}(4.24) and pods plant^{-1} (8.00) were observed from the control treatment (N_0). The longest pod (16.48 cm) was recorded in the treatment N_1 (100% RDF of Nitrogen). On the other hand, the shortest pod (13.56 cm) was obtained in the treatment N_0 (control). The highest pod weight plant^{-1}(113.67 g) and weight of 1000 seeds (516.67 g) were recorded from N_1 (100 % RDF on N) treatment. Lowest pod weight plant^{-1}(73.13 g) and weight of 1000 seeds (441.56 g) were from N_0 treatment. The maximum seeds pod^{-1} (5.17) as well as grain yield per plot as kilogram (3.05 kg/ha) was found in the treatment N_1 treatment were followed by N_2 and N_3 treatment. On the other hand, the lowest seeds pod^{-1} (4.24) as well as grain yield per plot as kilogram (0.97 kg/ha) were obtained in the treatment N_0

(control). Finally, the maximum grain yield plot^{-1} (7.10 t ha^{-1}) was obtained in N_1 treatment which was statistically similar to N_2 treatment giving grain yields of 6.32 t ha^{-1}. The lowest grain yield 4.57 t ha^{-1} was recorded from plot where no nitrogen was applied (control). Numerically the maximum straw yield of French bean (16.43 t ha^{-1}) was recorded from N_1 while, the minimum (11.82 t ha^{-1}) was found from N_0 (control) treatment. The maximum biological yield of French bean (23.54 t ha^{-1}) was recorded from N_1 which was statistically similar with N_2 (21.01 t ha^{-1}) and the minimum (16.39 t ha^{-1}) was recorded where, no nitrogen was applied. The maximum harvest index of French bean (30.16 %) was recorded from N_1 which was statistically similar with N_2 (29.90 %) and N_3 (29.37 %). On the other hand, the minimum (27.27 %) was found from N_0 treatment.

Again, the result of the research was showed that the main effect of phosphorus was significant in respect of above growth and yield characteristics. The highest plant height (37.44 cm) and number of leaves/plant (21.62) at 60 DAT was recorded from 100 % RDF of phosphorus (P_3). On the other hand, the lowest plant height (28.12 cm) and number of leaves/plant (15.77) at 60 DAT was observed in those plots where no phosphorus was applied (P_0). Among the different doses of phosphorus P_1 (100% RDF of P) showed the highest number of primary branches plant^{-1} (6.55) and number of pods plant^{-1} (13.88) over the entire growth period. On the contrary, the lowest number of primary branches plant^{-1} (2.33) and number of pods plant^{-1}(13.88) were recorded in the N_0 treatment where no phosphorus fertilizer was applied. The longest pod (16.08 cm) was observed from P_1(100% RDF of phosphorus), which were statistically identical (15.46 cm) with P_2(50% RDF of phosphorus), while the shortest pod (13.57 cm) was found from P_0 (No phosphorus applied. i.e. control) treatment. Application of 100 % Recommended Doses of Fertilizer (RDF) of phosphorus gave the maximum pod weight plant $^{-1}$(111.81 g) and weight of 1000 seeds (513.25 g), whereas the minimum pod weight per plant (68.33 g) and weight of 1000 seeds (428.58 g) were obtained from where no phosphorus fertilizer applied. The maximum number of seeds pod^{-1}of French bean (5.00) was observed from P_1 which was statistically followed with P_2 (4.77) and whereas, the lowest (4.23) was observed from P_0 treatment. The highest grain yield (2.84 kg plot^{-1}) was produced when the crop was fertilized with 100 % RDF of phosphorus (P_1) and the lowest (1.71 kg plot^{-1}) was recorded in the control treatment. The maximum yield (t ha^{-1}) was recorded from P_1 whereas, the minimum (11.09 t ha^{-1}) which was statistically followed with P_2 (15.53 t ha^{-1}) was obtained from P_0. Finally, the highest grain yield (6.99 t ha^{-1}) and straw yield (15.79 t ha^{-1}) were produced when the crop was fertilized with 100 % RDF of phosphorus (P_1) and the lowest grain yield (4.27 t ha^{-1}) and straw yield

(11.09 t ha^{-1}) were recorded in the treatment of control (P_0). The maximum biological yield (22.78 t ha^{-1}) was recorded in P_1 which was statistically similar with P_2 (22.07 t ha^{-1}) and the lowest (15.38 t ha^{-1}) was, however, found in case of control treatment. The maximum harvest index of French bean (30.64 %) was recorded in P_1 where the level of phosphorus (100 % RDF of P) and the lowest (27.35 %) was, however, found in case of control treatment. Also, interaction effect of different level of nitrogen and phosphorus applications on French bean had significant effect of all variables. However, the height plant height (44.26 cm) and number of leaves/plant (27.64) at 60 DAT were recorded from N_1P_1 (100 % RDF of nitrogen and phosphorus). On the other hand, the shortest plant height (29.99 cm) and number of leaves/plant (14.32) at 60 DAT were observed in N_0P_0 (Control). The maximum number of branches (8.12) and number of pods $plant^{-1}$ (16.68) were recorded from N_1P_1 which was statistically dissimilar with other treatments and minimum branches $plant^{-1}$ (3.13) and number of pods $plant^{-1}$(4.53) were observed from N_0P_0. The longest pod (17.98 cm) and pod weight $plant^{-1}$(121.82 g) were recorded from N_1P_1. Whereas that of the shortest pod (12.40 cm) and pod weight $plant^{-1}$(119.59 g) were found from N_0P_0 (control) treatment. The highest weight of 1000 seeds (550.00 g) and number of seed pod^{-1}(5.78) were found from N_1P_1 and the lowest weight (390.00 g) and number of seed pod^{-1}(3.80) from N_0P_0 (control) treatment. The highest grain yield (3.05 kg $plot^{-1}$) was produced when the crop was fertilized with N_1P_1 treatment. The lowest (0.97 kg $plot^{-1}$) was recorded in the treatment of N_0P_0 (control). And finally, the interaction effect of nitrogen and phosphorus of French bean showed the highest seed yield (7.61 t ha^{-1}) and straw yield (16.97 t ha^{-1}) were produced when the crop was fertilized with N_1P_1 treatment, whereas the lowest seed yield (2.42 tha^{-1}) and straw yield (7.01 t ha^{-1}) from N_0P_0(control) treatment. The highest biological yield (24.59 t ha^{-1}) was recorded from N_1P_1 which was statistically similar with N_1P_2 (24.38 t ha^{-1}) and N_2P_2 (23.47 t ha^{-1}) while, the lowest (9.42 t ha^{-1}) was found from N_0P_0 treatment. The maximum harvest index values (31.52 %) were recorded in N_1P_1 which is statistically similar (31.45 %) with N_2P_1treatment and the lowest harvest index (25.15 %) was recorded from N_0P_0 treatment.

From the findings of this study, it may be concluded that among the four level of nitrogen treatment, 100 % RDF of N gave best performance in terms of total grain yield. Again, among the three phosphorus application packages, 100 % RDF of P gave best grain yield. However, the results of the present investigation revealed that French bean can be grown successfully when the use of 100% recommended doses of nitrogen with 100% recommended doses of phosphorus gave more yield.

The findings of the present investigation clearly indicated that the combined use of N and P fertilizers and growing French bean is a viable option for increasing income of farmers. This results will be help to the local farmers can cultivate French bean in the field and homegarden in both suitable ways for commercially cultivation in Bangladesh and the developed model should be replicated others bean. The present study also opened the avenues for further investigation using the different suitable plants of legume family.

Recommendations: Considering the situation of the present experiment and further studies in the following ideas may be suggested

1. Such study is needed to be conducted in different agro-ecological zones (AEZ) of Bangladesh.
2. The results are required to substantiate further with different varieties of French bean.
3. These findings will later serve as secondary data for the cultivation of other beans.

CHAPTER VI

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CHAPTER VII

APPENDICES

Appendix I: Map showing the experimental site under study

Appendix II: Characteristics of soil of experimental field

A. Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physiological properties of the initial soil

Characteristics	Value
Partical size analysis	
Sand%	25
Silt%	45
Clay%	30
Textural Classes	Silty -Clay
pH	6.3
Organic carbon (%)	0.47
Organic matter (%)	0.78
Total N (%)	0.04
Available P (ppm)	23.00
Exchangeable K (meq/100g soil)	0.1

Appendix III. Monthly average of relative humidity, air temperature and total rainfall of experimental site during the period from December 2019 to April 2020

Month	Average RH%	Average temperature (C^0)		Total Average Rainfall(mm)
		Min.	Max.	
December, 2019	52.41	6.04	23.35	00
January, 2020	59.13	12.45	21.32	00
February, 2020	53.66	16.34	24.12	4.34
March, 2020	46.37	19.41	28.54	1.22
April, 2020	49.16	23.21	31.42	2.17

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix IV: Schedule of cultural operation in the experiment

Serial No.	Cultural preparation	Date
1	Opening of the land	05.12.19
2	Ploughing and cross ploughing	06.12.19
3	Breaking of clods, laddering and weeding	06.12.19
4	Layout of the experimental pit and plot	08.12.2019
5	Applications of 2/3rd of urea and entire of other fertilizer	08.12.2019
6	Sowing of seed	08.12.2019
7	Germination of seed	15.12.2019
8	Gap fillings	16.12.2019
9	1st Irrigation	17.12.2019
10	Thinning	23.12.2020
11	2nd Irrigation	25.12.2019
12	3rd Irrigation	10.01.2020
13	1st Weeding	13.01.2020
14	1st Flowering	17.01.2020
15	4th Irrigation	10.01.2020
16	5th Irrigation	09.02.2020
17	2nd Weeding	14.02.2020
18	Harvesting	20.02.2020
19	Collection post-harvest soil	14.03.2020
20	Analysis of soil sample	25.11.2020

Appendix V. Some photos document during experiment


R_2T_2


Department of Soil Science
Crop: French Bean (Phaseolus Vulgaris)
Plot No.: 33
No. of Replication: 03
No. of Reatment: 08
Total Plot no.: 24
Design: RCBD
Area: 160m²
Location: SAU Farm
Supervisor
Dr. Mohammad Mosharraf Hossain
Professor
Department of Soil Science
Researcher
Shahnaz Parbhin
Reg:19-10047
MS in Soil Science


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