GROWTH AND YIELD OF FRENCH BEAN AS INFLUENCED BY NITROGEN AND POTASSIUM

SURAIYA AKTER

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2016

GROWTH AND YIELD OF FRENCH BEAN AS INFLUENCED BY NITROGEN AND POTASSIUM

SURAIYA AKTER

REGISTRATION NO.: 10-04091

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2016

Approved by:

…….	……
Md. Hasanuzzaman Akand	**Dr. Md. Ismail Hossain**
Professor	**Professor**
Dept. of Horticulture	Dept. of Horticulture
Sher-e-Bangla Agricultural University	Sher-e-Bangla Agricultural University
Dhaka	Dhaka
Supervisor	**Co-Supervisor**

……

Prof. Dr. Tahmina Mostarin
Chairman
Examination Committee

ACKNOWLEDGEMENTS

*All praises are due to the Almighty and Merciful **"Allah SubhanaWa Ta La"** the supreme ruler of the universe who kindly enabled me to complete the thesis for the degree of Master of Science (M.S) in Horticulture.*

*I would like to express my deepest sense of gratitude to the honorable course supervisor, **Md. HasanuzzamanAkand** Professor, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic guidance, support, encouragement and valuable suggestions for successful completion of the research work and writing the manuscript.*

*I also express my respect to the honorable Co-Supervisor, **Dr.Md.IsmailHossain** Professor, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his co-operation, patience guidance, constructive comments, valuable suggestions and encouragement during the study period.*

*I feel proud to express and boundless indebtedness to Chairman **Dr. TahminaMostarin**, Associate Professor, Department of Horticulture and all the teachers of the Department of Horticulture, Sher-e-Bangla Agricultural University(SAU), Dhaka, Bangladesh for their valuable teaching, co-operation and inspirations throughout the course of this study.*

I express my special thanks to Higher Education Quality Enhancement Project (HEQEP), CP-3643, World bank, UGCB for funding to this research work.

I express my gratefulness to my elder brother, sisters, relatives, well wishers and friends for their co-operations and inspirations for the successful completion of the study.

Finally, I express my ever gratefulness and indebtedness to my beloved parents for their great sacrifice, endless prayers, blessing and support to reach me at this level of higher education.

The Author

GROWTH AND YIELD OF FRENCH BEAN AS INFLUENCED BY NITROGEN AND POTASSIUM

BY

SURAIYA AKTER

ABSTRACT

This field experiment was conducted at the Horticulture farm of Sher-e- Bangla Agricultural University, Dhaka during the period of november 2015 to February 2016 to investigate the effect of different levels of nitrogen and potassium on the growth and yield of French bean. The experiment consisted of four levels of nitrogen viz.N_0: control N_1: 50 kg/ha, N_2: 90 kg/ha, N_3:130 Kg/ha and three levels of potassium, viz. K_0: Control; K_1: 60kg/ha, K_2: 90Kg/ha and BARIZhar sheem-1 was used as french bean variety. The experiment was laid out in Randomized Complete Block Design with three replications. Nitrogen had significant effect on the plant height, number of branch, leaf size, number of flower, number of pod per plant and pod yield per hectare. However, incase of nitrogen the highest yield(13.28 t/ha) was obtained from N_2 and lowest yield (10.41t/ha) was obtained from N_0.For potassium the highest yield (14.91 t/ha) was obtained from K_2 and lowest yield (10.78 t/ha) from K_0.Among all treatment combinations highest yield (18.04 t/ha) was obtained from N_2K_2 and lowest yield (9.61 t/ha) was obtained from N_0K_0. So, 90kg N/ha and 90 kg K/ha may be used for french bean cultivation.

CONTENTS

Chapter	Title	Page No.
	ACKNOWLEDGEMENT	I
	ABSTRACT	II
	LIST OF CONTENTS	III
	LIST OF TABLES	IV
	LIST OF FIGURES	V
	LIST OF APPENDICS	VI
	ABBREVIATION AND ACRONYMS	VII
I	**INTRODUCTION**	1
II	**REVIEW OF LITERATURE**	4
III	**METHOD AND MATERIALS**	3
	3.1 Location	9
	3.2 Characteristics of the soil	9
	3.3 Climate and weather	9
	3.4 Planting materials	9
	3.5 Treatments of the experiment	9
	3.6 Design and layout of the experiment	10
	3.7 Land preparation	12
	3.8 Sowing of the seeds	12
	3.9 Fertilizers and Manure application	12
	3.10 Intercultural operations	12
	3.10.1 Gap filling	12
	3.10.2 Thinning	13
	3.10.3 Weeding	13
	3.10.4 Irrigation	13
	3.11 Plant protection	13
	3.11.1 Insect pests	13
	3.11.2 Diseases	13
	3.12 Harvesting	13
	3.13 Collection of data	13

	3.13.1 Plant height	14
	3.13.2 Number of leaves per plant	14
	3.13.3 Leaf length	14
	3.13.4 Leaf breadth	14
	3.13.5 Number of branches per plant	14
	3.13.6 Number of flowers per plant	14
	3.13.7 Number of pods per plant	14
	3.13.8 Length of the green pod	14
	3.13.9 Diameter of the green pod	14
	3.13.10 Weight of the pods per plant	15
	3.13.11 weight of single pod	15
	3.13.12 Percentage of dry matter content	15
	3.13.13 Yield per plot	15
	3.13.14 Yield per ha	15
	3.14 Statistical analysis	15
IV	**RESULTS AND DISCUSSION**	
	4.1 Plant height	16
	4.2 Number of leaves per plant	18
	4.3 Leaf length	23
	4.4 Leaf breadth	23
	4.5 Number of branches per plant	23
	4.6 Number of flowers per plant	24
	4.7 Number of pods per plant	24
	4.8 Length of the green pod	24
	4.9 Diameter of the green pod	25
	4.10 Weight of pod /plant	26
	4.11 single pod weight	26
	4.12 Percentage of dry matter content of the pod	28
	4.13 Yield per plot	28
	4.14 Yield per hectare	28
V	**SUMMARY AND CONCLUSION**	31
	REFFERENCES	36
	APPENDICES	41

LIST OF TABLES

Sl. No.	Title	Page No.
1	Combined effect of nitrogen and potassium on plant height of French bean	18
2	Combined effect of nitrogen and potassium on number of leaves at different days after sowing	21
3	Main effect of nitrogen on different parameters of French bean	22
4	Main effect of potassium on different parameters of French bean	22
5	Combined effect of nitrogen and potassium on different parameters of French bean	24
6	Main effect of nitrogen on yield contributing characters of French bean	28
7	Main effect of potassium on yield contributing characters of French bean	28
8	Combined effect of nitrogen and potassium on yield contributing characters of French bean	30

LIST OF FIGURES

Sl. No.	Title	Page No.
1	Field layout of the two factors experiment in the Randomized Complete Block Design (RCBD)	11
2	Effect of Nitrogen in plant height of French bean	17
3	Effect of potassium in plant height of French bean	17
4	Effect of Nitrogen on No. of leaves per plant of French bean	20
5	Effect of potassium on No. of leaves per plant of French bean	20
6	Effect of Nitrogen on yield (t/ha) of French bean	29
7	Effect of potassium on yield (t/ha) of French bean	29

LIST OF APPENDICES

Sl. No.	Title	Page No.
1	Characteristics of the soil of the experimental field analyzed by soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka	41
2	Analyses of variance of the data on plant height and number of leaves of French bean as influenced by Nitrogen and Potassium	42
3	Analyses of variance of the data on leaf length, leaf breadth, number of branches per plant, number of flowers per plant, number of pod per plant, length of the green pod	43
4	Analyses of variance of the data on diameter of pod, weight of pod per plant, single pod weight, percentage of dry matter content of pod, yield per plot and yield per hectare.	44

ABBREVIATION AND ACRONYMS

% = Percentage

AEZ =Agro-Ecological Zone

BARI = Bangladesh Agricultural Research Institute

BAU = Bangladesh Agricultural University

CV% = Coefficient of variation

DAS = Days after sowing

FAO = Food and Agricultural Organization of United Nations

LSD = Least Significant Difference

MP = Muriate of potash

N = Nitrogen

K = Potassium

RCBD = Randomized Complete Block Design

SAU = Sher-e-Bangla Agricultural University

SRDI = Soil Resources Development Institute

t = Ton

CHAPTER I

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family of Fabaceae and grown throughout the world. It is originated from South America. It is also grown in Europe, Italy, Africa, India, Peru, Mexico, Bangladesh etc. It has others name such as bush bean, kidney bean, snap bean, raj bean, common bean, basic bean, navy bean, haricot bean, pole bean, wax bean, string bean and bonchi (Salunkhe *et al*. 1987). In our country it is known as "Farashi Sheem" (Rashid, 1993). The green pods and mature seeds are used as cooked vegetable in our country. Seeds are also used as pulse in Sylhet, Moulvibazar, Sonamgonj, Habigonj, Brahmmanbaria, Feni, Coxs bazar, Chittagong etc. It is widely cultivated in many parts of the tropical, subtropical and throughout the temperate regions (Pursglove, 1987). But it is more suitable as a winter (rabi) crop in the northern eastern plain of India . According to the FAO (2013) statistics, French bean including other related species of the genus *Phaseolus* occupied 32.08 million hectares of the world cropped area and the production of pods was about 23,139,004 tons (FAO, 2013). Brazil is the largest French bean producing country in the world. In Bangladesh there is no statistics about the information of area and production of this crop. Now it is not new a crop in our country and is cultivated in Sylhet, Cox's bazar, Chittagong Hill Tracts and some other parts of the country in a limited scale. Recently Hortex Foundations and BRAC are trying to extend the production area because French bean is now exportable vegetable among others. Recently, Bangladesh earns about US$ 15 million per annum be exporting fresh horticultural produces where French bean shares a large amount. Immature green pods are also marketed as fresh, frozen or canned. The dry seeds have a good market price. The protein which is obtained from bean and seeds are easily transportable and absorbed in human body compare to animal protein. Foliage of the French bean may also provide hay silage and green pod. Plants of French bean can be used as feed to cattle, sheep and horses etc. Its pods also edible and supply protein, carbohydrate, fat, fiber, thiamine, riboflavin, calcium and iron etc. The seed contains sufficient amount of thiamine, niacin, folic acid as well as fiber. In recent times cultivation of French bean is gaining popularity in Bangladesh for its demand as a commodity for send abroad. Hortex foundation exported 330 metric tons of fresh French bean during the year 2012-2013 (Anonymous, 2013). Islam *et al.* (2004) found that due to application of potassium exerted a

positive effect on plant growth characteristics and also on the yield of French beans. Projapoti *et al* (2004) observed higher pod yield of French bean from 120 kg N ha-1. Begum *et al* reported that the highest fertilization (90-50-12 gm/plant) resulted highest pod length, pod weight and pod yield of French bean. Sharma (2001) recorded highest plant height, the number of branches /plant and green pod yield of French bean ha^{-1} with 120 kg N ha^{-1}. He also found longest plant and the number of branches $plant^{-1}$ with 60 kg P ha^{-1}. The combined interaction between N and P was also significant.The highest pod yield was obtained at a treatment combination of 120 kg N and 60 kg P ha^{-1}. Dhanjal *et al* (2001) observed that branches number varied significantly $plant^{-1}$ at 120 kg N ha^{-1}. Singh (2000) reported that larger pod length obtained from the application of 125 kg N/ ha . Singh and Singh (2000) also found that yield and yield attributing value of French increases with the increasing nitrogen level, where 80 kg per ha gave highest value. Srinivas and Naik (1998) observed that nitrogen and phosphorus fertilizers application on French bean 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. Supply of plant nutrients specially nitrogen, phosphorus and potash through fertilization is one of the best methods to increase the French bean growth and yield. The present study was, therefore conducted to investigate the effect of various levels of nitrogen, phosphorus and potash on the growth parameter and green pod yield of French bean and also to furnish economically sound fertilizer recommendations for French bean production in Bangladesh as high as 120 kg/ha (Srinivas and Naik,1990 and Rana *et al*. 1998). French bean is an important vegetable grown both for tender pod which source of crude protein (21.25%) and carbohydrate (70%). Besides it also contains 0.16 mg iron,1.76 mg calcium and 3.34 mg zinc per 100gm edible part. French bean is insufficient in symbiotic nitrogen fixation as it lacks nodulation due to the absence of NOD gene regulator. So nitrogen requirement of the crop can be met by nitrogen fertilizer application. The optimum and economic level of nitrogen (0, 40, 80, 120 and 160 kg/ha) for better growth and seed yield but application of 120kgN/ha significantly increased the pod number per plant, number of seed per plant,weight of seeds per plant and seed yield, whereas 160kgN /ha reduced seed yield (Tewari and Singh, 2000). Pod number per plant, 100 seed weight, seed yield and protein content increased with increasing nitrogen rate (Ali and Tripathi, 1998). Dry matter production of French bean significantly increased due to the application of nitrogen fertilizer @120kg/ha (Rana *et al.*1998). Potassium also has significant role on the productivity on French bean. It is essential for cell organization and structure of cell wall. It enhances plants ability to resist diseases, cold and other adverse condition such as poor flower development

and poor pod setting. Potassium and phosphorus significantly influence the French bean yield and highest yield obtained @100kg P_2O_5 and 80kg K_2O/ha(Sharma *et. al.*1997). Spilt application potassium fertilizer on French bean increased the yield and it was obtained by application of 50% of K at sowing and 50% 15 days later (Soares *et.al.* 1990). When French bean plant receive higher level of potassium then relative water content and transpiration rate increase (Islam *et.al.*2004). Therefore, the present investigation will carry out to find out the suitability of selected nitrogen and potassium and the proper use and effectiveness of selected potassium, nitrogen and also their suitable combinations for successful French bean production in Bangladesh

Objectives:

i. to find out the optimum level of nitrogen and potassium on growth and yield of French bean.

ii. to determine the suitable combination of nitrogen and potassium for ensuring the maximum growth and higher yield of French bean.

CHAPTER II

REVIEW OF LITERATURE

French bean (*Phaseolus vulgaris* L.) is a popular legume vegetable crop in the world. In the aspect 0f Bangladesh it is mainly grown during Rabi season and it has two varities like a.BARI bush bean -1 and b. BARI bush bean -2 has been released by Bangladesh agriculture research institute. A lot of research has been done of the world to study the effect of nitrogen and potassium on the growth and yield of French bean. But in Bangladesh available literature regarding effect of nitrogen and potassium is insufficient and sometimes conflicting. However, some of the relevant literatures are presented below to know the effect of nitrogen and potassium on French bean growth and yield.

EFFECT OF NITROGEN ON GROWTH AND YIELD OF FRENCH BEAN

Singh and Singh (2000) conducted a field trial in India with different nitrogen levels on yield and yield components of French bean(0,40,80 or 120 kg N/ha).The findings of that experiment was seed yield corresponding to 100 seed weight increased with the increasing of nitrogen rate

In India Rajesh *et al*. (2001) studied with French bean to evaluate the effect of N (80,160 and 240 kg/ha) and S(0,20,40 and 60 kg/ha) on the nutrient uptake and grain yield of French bean(*phaseolus vulgaris* cv.) HUR137. At N level of 240kg/ha (2091kg/ha) which gave highest grain yield and highest straw yield (3331kg/ha) and the highest total N (90.70 kg/ha) and s (6.58kg/ha) uptake. The highest grain yield (1811 kg/ha) was recorded by the application of sulphur at the rate of 40 kg/ha and the highest total N (77.45kg/ha) and S (6.06kg/ha) uptake

Gonazal *et al.* (1985) reported-the seed yield of french bean was (230g) with the application of 160 kg N,60 kg p_2o_5 and 90 kg k_2o/ha in 1980-81 and 240.7 g with 200kg N,60 kg p_2o_5 and 90 kg k_2o/ha in 1981-82 . But yield or 1000-seed weight was not affected by the application of K_2o

.

Daba and Haile (2000) carried a field trial in Ethiopia on French bean cv. Red Wolaita, Rico-2, A-176 and A-250. They observed that *Rhizobium* inoculation and N mostly increased grain yield, nodule number and dry matter yield content of French bean.

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

Virender *et al.* (2000) conducted a field experiment with French bean in India and observed that higher yield was obtained with application of nitrogen up to 120 kg/ha and phosphorus up to 60 kg/ha.

In India,Tewari and Singh (2000) carried experiment on French bean to find out the most advantageous and reasonable dose of nitrogen (0, 40, 80, 120 and 160 kg/ha) for better growth and seed yield. They reported that application of 120 kg N/ha produced significantly higher number of pods per plant, weight of speeds per plant, number of seeds per pod and seed yield, whereas 160 kg N/ha extensively abridged seed yield.

Arya *et al.* (1999) studied a trial in India to investigate the effect of N, P and K on French bean. They used different level of NPK combinations. It was resulted that N increased growth and marked 25 kg N/ha, 75 kg P2O5 /ha and 50 kg K^O/ha as the best combination in terms of economics and seed yield. Baboo *et al.* (1998) carried an experiment in Uttar Pradesh, India on response of nitrogen in French bean. Number of branch and seed yield were increased with the increase of nitrogen and it was higher with 120 kg N/ha.

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

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

Parthiban and Thamburaj (1991) conducted an experiment in India and recorded increased grain yield with nitrogen fertilization up to 50 kg/ha in French bean. Number of pods and grain yield per plant increased significantly with nitrogen fertilization over the control.

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

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

Srinivas and Naik (1988) carried out an experiment at Bangalore, India to study the response of nitrogen on vegetable French bean. Nitrogen was applied at 0, 40, 80, 120 and 160 kg/ha.

Ibeawuchi *et al*. (2006) reported that in a degraded soil of Nigeria, poultry manure application increased the residual soil N, K, Ca, Mg and organic matter. The high organic matter with increase in other soil chemical components is an indication that poultry manure has high potential of gradual nutrient release to the soil that can help to improve the fertility of a degraded soil thereby sustaining yield in a continuous cropping system.

Santos *et al.* (2000) conducted an experiment to evaluate the effect of levels and sources of organic matter on French bean in Brazil. Treatments comprised 4 sources of organic matter, such as, poultry manure or cow dung (0, 5, 10, 15 and 20 ton ha-1), cattle manure, goat manure and earthworm compost (0, 10, 20, 30 and 40 ton ha-1). They found that pod length increased linearly with the levels of poultry, cattle and got manure, but the average weight of pod only by poultry manure or cow dung. They also found that pod yield was the highest when poultry manure or cow dung was applied at the rate of 20 ton ha-1.

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

Chandra *et al.* (1987) reported that plant growth was increased with increasing rate of nitrogen in French bean.

Saores *et al.* (1982) observed that the application of various N fertilizer doses, pod number per plant was significantly influenced.

Srinivas and Naik (1988) reported that increasing N fertilizer increased the pod yield in French bean.

Effect 0f potassium on growth and yield of French bean

Islam *et al*. (2004) carried a field trial at the Bangabandhu Sheikh Majibur Rahaman Agricultural University,Gazipur to find out the effect of potassium on growth, yield and water relation of bush bean under water stress conditions. The findings of that irrespective of the levels of soil moisture, potassium released beneficial effect on plant growth characteristics including yield. When plant absorbed high level of potassium it exhibited a higher relative water content and transpiration rate. Lower diffusion resistance incase of lower absorption of potassium.

Khan and Arvanitoyannis (2003) carried a field at the University of Thessaly to investigate the effect of potassium and nitrogen on the growth and yield of yield of green bean .They observed that nitrogen absorption depend on potassium eg, the plant growth as well as pod yield partially increased by potassium absorption.

Nemesskeri and Nagy (2003) conducted an experiment in Hungary to observe the effect of potassium on growth factors and yield of dry bean .Three levels of K_2O (0,100 and 150 kg/ha) applied that resulted potassium had no significant effect on pod number per plant and seed per plant but the number of disease infected seeds by the application of higher level of potassium

Nemeskeri and Nagy (2003) reported that potassium level had significant effect on disease incidence .The plant diseases decreased by higher level of potassium (60 kg/ha).

Kanaujia *et al. (*1999) carried an field experiment in Himachal Pradesh, India to observe the effect of p and k on growth, yield and quality French bean cv.contender. They applied 0,40, 80 and 120 kg p2o5/ha and 0,30,60 and 90 kg k2o/ha and obtained the highest plant height, green pod yield and protein content among them potassium rates were obtained from 80 kg p2o5/ha. with the increasing level of potassium level upto 60 kg k_2o/ha increased the plant height, number of branches per plant, pod length, pod girth, number of pod per plant and protein content.

Landa *et al*. (2002) found that the growth, vigour significantly influenced by the application of NPK and also advanced the harvesting date of green bean .

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the Farm of Sher-e Bangla Agricultural University,Sher-e Bangla Nagar,Dhaka-1207.The experiment was conducted to know the Effect of Nitrogen and potassium on the growth and yield of French bean during the period from November 2015 to January 2016.The method and materials which was used in conducting the experiment have been presented in this chapter under following subtitles

3.1 Location

It was located in 24°09' N latitude and 90°26' E longitudes. The altitude of the location was 8 m high from the sea level (The Meteorological department of Bangladesh, Agargoan, Dhaka).

3.2 Characteristics of Soil

The soil of the experiment was collected from the horticulture farm. The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot of soil was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil used the experiment were analyzed in the Soil Testing Laboratory, Soil Resources Development Institute (SRDI) Farmgate, Dhaka and details soil characteristics were presented in Appendix I.

3.3 Climate and weather

The climate of the experimental area was sub-tropical in nature. It is characterized by its high temperature and heavy rainfall during kharif season i.e. April to September and scanty rainfall associated with moderate temperature during robi season i.e. October to March (Anonymous, 1989).

3.4 planting Materials

BARI Zar sheem 1 has been used as planting materials. The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Treatments of the Experiment

The experiment involved two factors, namely,

Factor A: Nitrogen and

Factor B: Potassium

Factor A: Four levels of Nitrogen

I. N_0: 0kg/ha

II.N_1: 50 kg/ha

III.N_2: 90 kg/ha

IV.N_3: 130 kg/ha

Factor B: Three levels of potassium

I .K_0:0 kg/ha

II.K_1:60 kg/ha

III.K_2:90 kg/ha

Combination of Treatments:

N_0K_0 N_2K_0

N_0K_1 N_2K_1

N_0K_2 N_2K_2

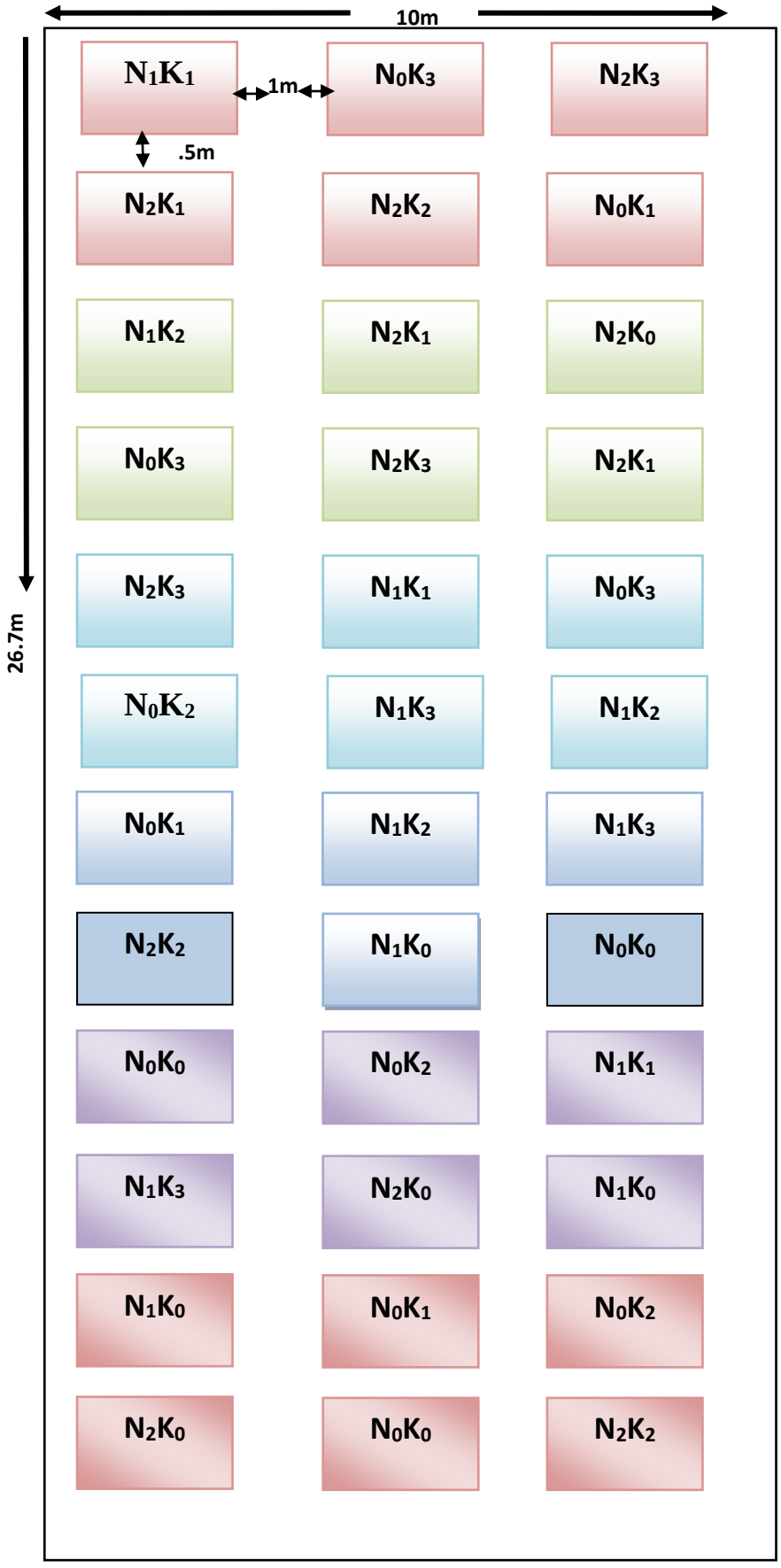
N_1K_0 N_3K_0

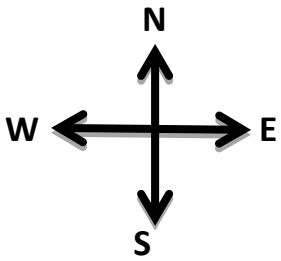
N_1K_2 N_3K_1

N_1K_3 N_3K_2

3.6 Design and layout of the experiment

The two factors experiment was laid out in the Randomized Complete Block Design (RCBD) which consists with three replications. The experimental plot was divided into equal 3 blocks and each consists of 12 plots. Each unit plot was 2 m x1.6 m in size. All together there were 36 unit plot and required 267 m^2 land. Distance between replication was 1 m and plot to plot was 0.5 m. The treatments were randomly assigned to each of the block.





Plot Size=2.m×1.6m

Plot Spacing=0.5m

Factor A:

I.N_0:0kg/ha

II.N_1:50 kg/ha

III.N_2:90 kg/ha

IV.N_3:130 kg/ha

Factor B:

I .K_0:0 kg/ha

II.K_1:60 kg/ha

III.K_2:90 kg/ha

Fig. 1: Layout of the Experimental Plot.

3.7 Land preparation: Firstly, the land was ploughed with a power tiller at 2 November, 2015.Then land was kept open to dry sunlight. Doing ploughing and cross ploughing the experimental plot was prepared. Laddering was done to break the clods that makes the soil level. The land was cleaned by removing weeds and big clods.

Above operations resulted good tilth conditions of the soil and make suitable for sowing the seed.

3.8 Fertilizers and manures application

Total amount of well composed cow dung, triple supper phosphate(TSP) and muriate of potash (MP) were applied and mixed with the soil during land preparation .Urea was applied as a source of nitrogen. During final land preparation 1/3 amount of urea was applied and rest amount was applied in two instalments at 15 and 30 days after sowing .The fertilizers which were applied mixed in appropriate portion with the plot soil.

The following manure and fertilizers were applied

Manure and fertilizer	Dose/ha	Dose/plot
Cow dung	10 ton	10 kg
Urea	As per treatment	As per treatment
TSP	160 kg	42 gm
MOP	As per treatment	As per treatment

3.9 Sowing of seeds

Two treated seeds were sown per hill and depth was 3.00 cm. For seed treatment Bavistin was used to protect seed from seed borne diseases .The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 18 November, 2015 in rows and at spacing of 50 cm x 40 cm. The seeds were covered with loose soil. French bean was sown as border crops to reduce border effects.

3.10 INTERCULTURAL OPERATION

3.10.1 Gap filling

During seed sowing, some seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap in case of failure of seed germination. Watering was done from protecting the seedling from wilting. Within two weeks of seed germinations all gaps were filled.

3.10.2 Thinning

After well-established of the plants, kept one healthy plant in each hill and rests were removed.

3.10.3 Weeding

The experimental plots were kept free from weed .weeding can be done by hand weeding. Weeding was done three times at 20, 30 and 40 days after sowing.

3.10.4 Irrigation

Irrigation was given as requirement with the help of watering cane irrigation was given into young plant. After all, irrigation should be given at 10 days interval.

3.11 Plant protections

3.11.1 Insect pests

At early stage of growth of French bean, some plants were attacked by insects, pests such as aphid infestations. Melathion 57 EC at the rate of 2ml/litter at an interval of 15 days were sprayed.

3.11.2 Diseases

Some seedlings were attacked by damping off diseases .To protect seedlings DithaneM-45 was sprayed @ 2ml/litter of water at an interval of 15 days. Bean common mosaic virus was also found in few plants which were removed immediately and destroyed.

3.12 Harvesting

At tender stage immature green pods were harvested through hand picking and estimated the weight of the fresh green pods.

3.13 Collection of data

Ten plants were selected randomly that helps to avoid effect. Consequently the outer two lines and the outer plants of the middle lines in each plot were avoided .The details of data procedure are given below

3.13.1 Plant height

The plant height was recorded at 15, 30, 45 and 60 days after sowing .The plant height was taken from the ground level to the tip of the largest leaf of the plants. Randomly sampled plants were used to record the plant height in terms in centimetre (cm).

3.13.2 Number of leaves per plant

The number of leaves of 10 selected plants from each unit plot was counted at 15 days interval at 30 to 60 DAS

3.13.3 Leaf length

Leaf length of 10 randomly plants were measured by using measuring scale from each unit of plot at 60 DAS and mean was counted.

3.13.4 Leaf breadth

Leaf breadth of ten randomly selected plants were measured by the help of measuring scale from each unit of plot at 60 DAS

3.13.5 Number of branches

At 45 DAS the average number of branches was counted from ten randomly plants.
DAS and mean was recorded.

3. 13.6 Number of flower /plant

The number of per plant from each unit of plot was collected from ten randomly selected plants and their mean value taken.

3.13.7 Number of pod /plant

The number of pod from each unit of plot was taken from ten randomly plants and average was taken.

3.13.8 Length of green pod

Ten pod was taken from each selected plant and each unit of plot. Then using centimetre scale measured their length and their average value was taken.

3.13.9 Diameter of green pod

Diameter of ten randomly selected plants were taken from each unit of plot and measured in slide callipers scale .Their average mean were recorded.

3.13.10 Weight of pod per plants

Weight of pod per plant were taken from 10 plants of each unit plot and measured weight and taken their average weight was taken in grams (g).

3.13.11 Weight of single pod

Weight of single pod was taken from selected plants from each unit of plot and their weight was recorded.

3.13.12 Percentage of dry matter content of pod

Percentage of dry matter content of pods from 10 selected randomly plants were collected and recorded

3.13.13 Yield of pod per plot

Per plot yield was from selected plants from each unit of plot and their weight was measured.

3.13.14 Pod yield/ha

The green pod yield per plot was converted to yield per hectare and expressed in terms of ton (t).The following formula was used to estimate the value yield per hectare

=yield per plot (kg) x 1000/area of the plot in square x 100

3.14 Statistical analysis

The data obtained different attribute were analysed by MSTAT-C computer software to find out the different significance levels for nitrogen and potassium application .The variance of the analysis for the attribute under the study of F test variance .The mean differences were adjusted by Duncan's Multiple Range Test (Gomez and Gomez ,1984)

Chapter IV

RESULTS AND DISCUSSION

4.1 Plant height

Plant height of French bean varied significantly at 30,45 and 60 days after sowing (DAS) due to application of different levels of nitrogen expect at 15 DAS (Fig.2 & Appendix II).However, at 15 DAS, the highest (22.32 cm) plant was recorded at 90 kg N/ha and lowest (18.39 cm) plant was observed due to control treatment. At 30 DAS, the longest (30.50 cm) plant was recorded due to application of 90kg/ha of nitrogen which was identical (28.76 cm) to 130kg N/ha and the shortest (26.88 cm) plant was obtained from control treatment. At 45DAS and 60 DAS, nitrogen application resulted similar pattern. At 45 DAS, the longest (39.76 cm) plant was obtained due to the application of 90kg N/ha and the shortest (36.39 cm) plant was found due to control treatment. At 60 days after sowing the highest (45.19 cm) plant was observed by the application 90 kg N/ha and shortest (43.06 cm) for control treatment (Fig 2). Arya *et al.* (1999) observed that nitrogen application promotes plant growth of French bean. Vishwakarma *et al.* (2002) also reported that nitrogen application increase plant height.

Plant height varied significantly at 30,45 and 60 DAS due to application of different levels of potassium) expect 15 DAS (Fig.3 & Appendix II).At 15 DAS, the highest (20.58 cm) plant was observed due application of 90 kg K_2O /ha and lowest (19.92 cm) plant was found due to control treatment. At 30 days after sowing ,the longest (30.12 cm) plant was obtained due to the application of 90 kg K_2O/ha and the shortest (23.99 cm) plant was obtained due to control treatment. At 45 DAS, the highest (38.68 cm) plant was obtained due to application of 90 kg K_2O and lowest (37.48 cm) plant was found due to control treatment. At 60 DAS, the longest (44.59 cm) plant was observed due to the application of 90 kg K_2O/ha and the shortest (43.23 cm) plant was observed from the control treatment. Plant height varied significantly at 30, 45 and 60 days after sowing due to combined interaction of nitrogen and potassium expect at 15 DAS (Table 1 and appendix II). At 15 days after sowing the highest plant (22.95 cm) was found due to 90 kg N/ha application that was identical to 130kg N and 90 kg potassium and the shortest (17.92 cm) plant was observed control treatment. At 30 DAS, the longest (30.12cm) was found due to application of 90 kg N/ha which was identical to (29.14cm) to 130 kg N/ha and 90 kg K/ha whereas shortest (23.99 cm) plant was produced in control

condition. At 45 DAS, the highest (39.35 cm) plant was produced at 90 kg N/ha which was identical (39.12 cm) to130 kg N/ha and 90 kg K/ha whereas the shortest (35.15 cm) plant was obtained from control condition. At 60 DAS, the highest (45.12 cm) was obtained due to application of 90 kg N/ha and 90 kg K/ha which was identical to (44.05 cm) at 130kg N and 90kg K. The shortest (40.95cm) was observed in control condition.

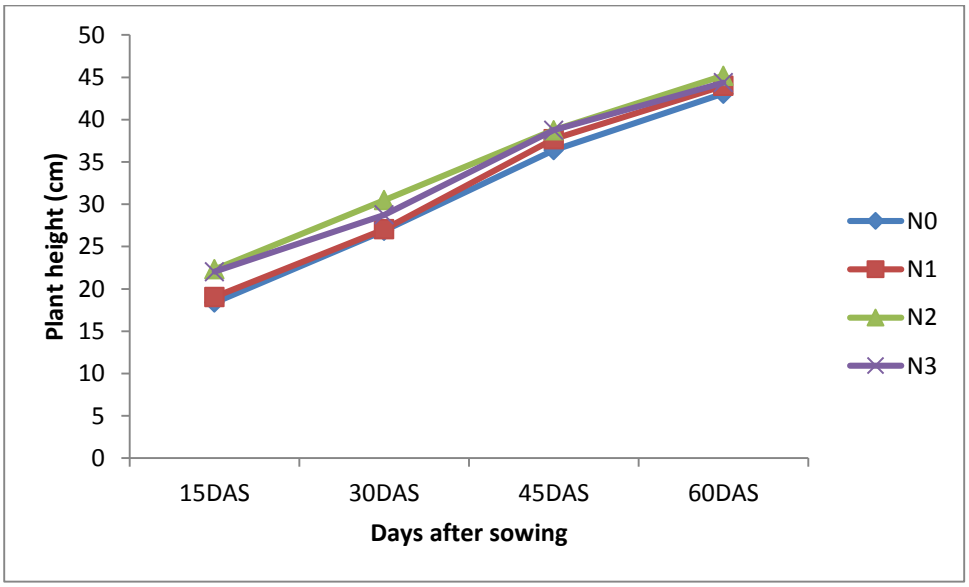


Figure 2: Effect on nitrogen on French bean plant height (cm)

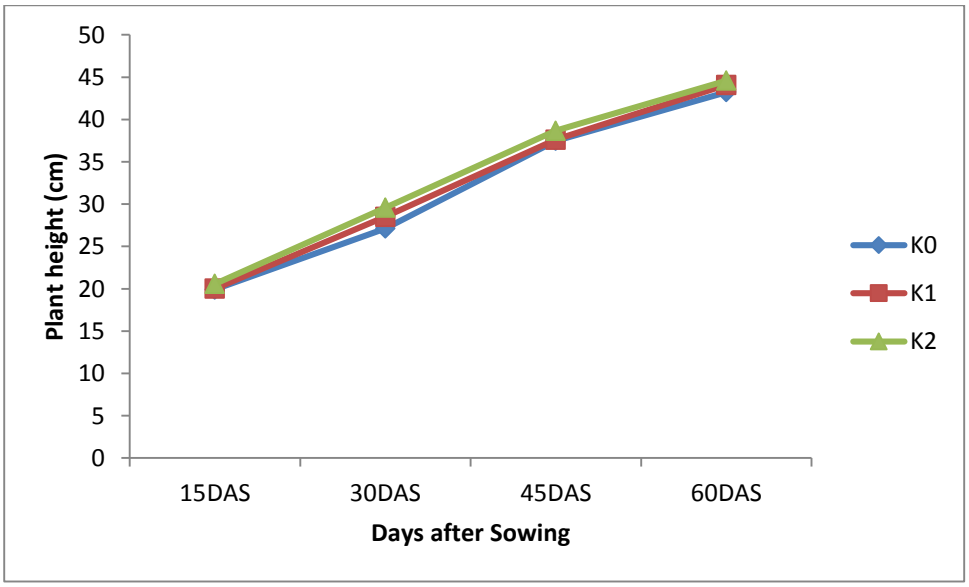


Figure 3: Effect of potassium on French bean plant height (cm)

Table 1: Combined effect of nitrogen and potassium on plant height

Treatment	Plant height (cm) at			
	15 DAS	30 DAS	45 DAS	60 DAS
N_0K_0	17.92	23.99 d	35.15e	40.95e
N_0k_1	18.24	26.49 c	35.75de	41.85de
N_0k_2	18.72	26.92bc	35.92de	42.32cd
N_1K_0	19.02	25.65cd	36.02cde	41.92de
N_1K_1	20.55	26.35c	36.85bcde	42.59cd
N_1K_2	20.75	27.55bc	37.95abcd	43.35bc
N_2K_0	19.72	27.85abc	36.82bcde	42.69cd
N_2K_1	21.85	28.19abc	37.55abcd	43.15bc
N_2K_2	22.59	30.12a	39.35a	45.12a
N_3K_0	19.39	26.52c	37.02bcde	42.75cd
N_3K_1	20.95	29.12ab	38.29abc	43.92b
N_3K_2	22.95	29.14ab	39.12ab	44.05ab
LSD (0.05)	6.96	2.247	2.070	1.137
Level of significance	NS	**	**	**
CV (%)	9.71	10.12	9.69	8.86

N_0:0kg/ha

N_1:50 kg/ha

N_2:90 kg/ha

N_3:130 kg/ha

K_0:0 kg/ha

K_1:60 kg/ha

K_2:90 kg/ha

4.2 Number of leaves per plant

Number of leave per plant of French bean varied significantly at 30, 45 and 60 days after sowing (DAS) due to application of Nitrogen (Fig.4 & Appendix II) expect 15 DAS .At 15 DAS, the number of leaves was not significant. However, at 15 DAS the highest (3.85) number of leaves was recorded due to application of 90 kg nitrogen and the lowest (3.50) number of leaves was observed due to control treatment. At 30 DAS, the highest (9.37) number of leaves per plant were recorded due to application of nitrogen 90 kg/ha and the lowest (8.25) from control treatment. At 45 DAS, the highest (12.75) number of leaves per plant were recorded due to application of nitrogen 90 kg/ha and the lowest (11.30) number of

leaves from control treatment. At 60 DAS, the highest (21.50) number of leaves and the lowest (16.83) number of leaves per plant was recorded due to application of nitrogen 90 kg/ha and from control treatment respectively (Figure 4). Application of 90 kg/ha nitrogen at all stages the highest number of leaves were found.

Number of leaves per plant of French bean varied significantly at 30,45 and 60 days after sowing due to application of different levels of potassium application expect at 15 and 30 DAS (Figure 5) . However, at 15 days after sowing, the highest (4.11) number of leaves were recorded at the application of 90 kg K_2O/ha and the lowest (3.50) number of leaves was obtained from the control the treatment. At 30 DAS, the highest (8.98) number of leaves were observed due to application of 90 kg K_2O/ha and the lowest number (8.73) number of leaves from control treatment. At 45 DAS, the highest (12.34) number of leaves was recorded due to application of 90kg K_2O/ha and lowest (10.93) number of leaves was obtained from control treatment. At 60 DAS the highest number (19.38) of leaves was recorded due to application of 90 kg K_2O/ha and the lowest number (16.77) of leaves from control treatment.

The combined effect of nitrogen and potassium showed significant variation at the number of leaves at 45 and 60 DAS expect 15 and 30 DAS (Table 2 and Appendix-II). At 15 DAS the number of leaves per plant was not significant. At 30 DAS the highest (9.60) number of leaves was found due to the combined interaction of nitrogen @ 90 kg/ha and 90 kg K_2O/ha whereas the lowest (8.07) number of leaves due to control treatment. At 45 DAS, the highest (13.05) number of leaves were recorded due to combined effect of nitrogen @ 90kg/ha and 90 kg/ha K_2O application and lowest (10.55) number of leaves per plant were produced from control treatment. At 60 DAS the highest number (21.40) of leaves per plant were recorded due to combined interaction of Nitrogen (90kg/ha) and potassium (90 kg/ha) and lowest (16.62) number of leaves were obtained from control treatment. Kanaujia *et al. (*1999) also reported similar trend of results. The number of leaves increased with the application of nitrogen and potassium.

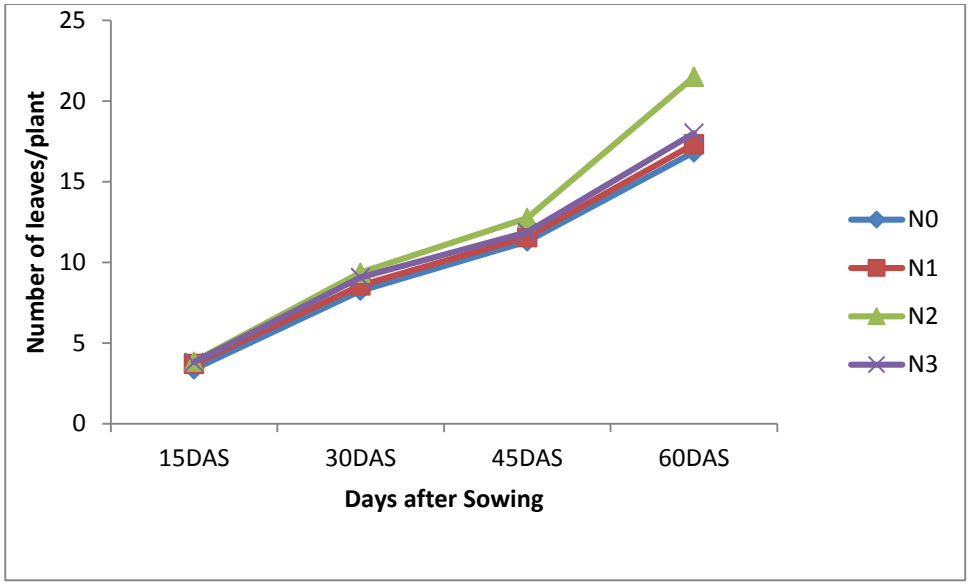


Figure 4: Effect of nitrogen on the number of leaves of French bean

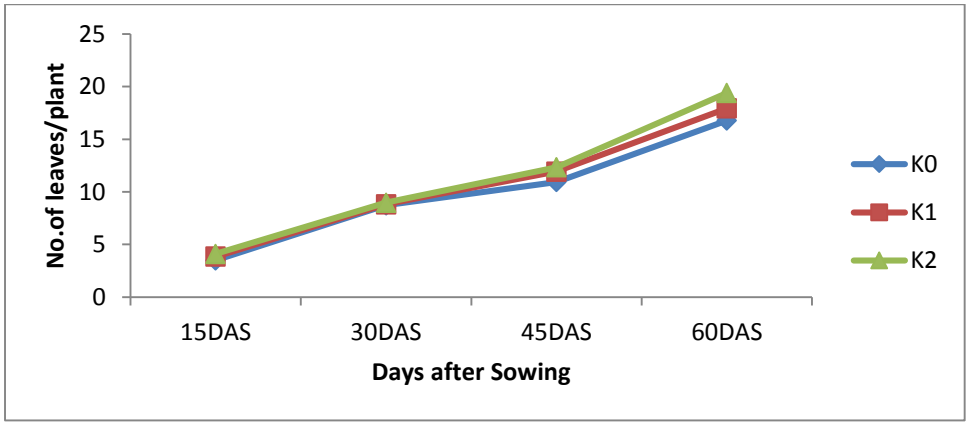


Figure 5: Effect of potassium on number of leaves/plant

Table 2: Combined effect of nitrogen and potassium on number of leaves and different days after sowing

Treatments	**Number of leaves at**			
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS (At harvest)**
N_0K_0	3.44	8.07d	10.55f	16.62h
N_0K_1	3.54	8.70cd	10.92ef	17.32gh
N_0K_2	3.04	8.80bc	11.02ef	18.22efg
N_1K_0	3.70	8.77bc	11.19def	18.82def
N_1K_1	3.74	9.07abc	11.55cde	19.55bcd
N_1K_2	3.76	9.40ab	11.87bcd	20.12bc
N_2K_0	3.76	8.78bc	11.85bcd	17.72fgh
N_2K_1	3.87	9.27abc	12.02bcd	20.32abc
N_2K_2	4.10	9.60a	13.05a	21.40a
N_3k_0	3.77	9.00abc	11.57cde	18.42defg
N_3K_1	3.81	9.03abc	12.35ab	19.56bcd
N_3K_2	3.92	9.50a	12.38ab	20.62ab
LSD	0.881	.689	0.8203	1.510
Level of significance	NS	*	**	**
CV (%)	8.42	9.47	7.87	9.94

N_0:0kg/ha

N_1:50 kg/ha

N_2:90 kg/ha

N_3:130 kg/ha

K_0:0 kg/ha

K_1:60 kg/ha

K_2:90 kg/ha

Table 3:Effect of Nitrogen and potassium on leaf length, leaf breadth, number of branches per plant, number of flower per plant, number of pod per plant and length of green pod in French bean Effect of Nitrogen

Treatment(s)	Leaf length(cm)	Leaf breadth(cm)	Number of leaves/plant	Number of flower/plant	Number of pod /plant	Length of green pod (cm)
N_0	9.90c	67.70c	15.18c	41.20c	20.2d	15.2d
N_1	10.16bc	67.70b	15.83c	42.14c	21.6c	16.24c
N_2	12.23a	8.87a	18.57b	47.64a	22.87a	16.80a
N_3	11.09b	8.67a	20.01a	46.38b	22.00b	16.52b
LSD(0.05)	1.12	0.875	1.38	1.07	0.63	0.1162
Level 0f Significance	**	**	**	**	**	**
CV (%)	7.78	8.80	9.19	10.04	9.16	7.12
K_0	8.68c	5.72c	12.20c	38.80c	20.01c	15.70
K_1	9.78b	7.92b	16.17b	43.95b	21.3b	15.95
K_2	10.86b	8.56b	17.76a	45.59a	23.25a	16.65
LSD(0.05)	0.29	0.58	1.530	1.02	2.22	2.96
Level of significance	**	**	**	**	**	NS
CV (%)	7.78	8.80	9.19	10.04	9.16	7.12

N_0:0kg/ha

N_1:50 kg/ha

N_2:90 kg/ha

N_3:130 kg/ha

K_0:0 kg/ha

K_1:60 kg/ha

K_2:90 kg/ha

4.3 Leaf length

Leaf length varied apparently due to application of nitrogen (Table 3 & Appendix III).The highest (12.23cm) leaf length was recorded due to application of nitrogen (90 kg /ha) and the lowest (9.90 cm) was obtained from control condition. Leaf length also varied significantly due to application of nitrogen resulted longest leaf than control condition .This findings similar to Ghosal *et al.* (2000) results.

A Significant variation was found on leaf length due to application of different levels of potassium application. The longest (10.86cm) leaf was recorded due to application of 90 kg K_2O/ha whereas shortest (8.68cm) was obtained from control treatment. Subhan (1989) found similar trend of result that supported this experiment.

The combined effect of nitrogen and potassium also showed variation (Table 4 & Appendix III).The longest(14.03 cm) leaf was found with the 90kg N/ha and 90 kg K_2O/ha. The shortest (8.73 cm) leaf length was recorded at control treatment.

4.5 Leaf breadth

Leaf breadth varied significantly due to applications of various levels of nitrogen (Table 3 & Appendix III).The highest (8.87 cm) leaf breadth was recorded by the application of 90kg N/ha and the lowest (6.80) due to control treatment. At 45 DAS, the highest (15**.**18cm) leaf breadth was observed as a result of control treatment. Leaf breadth variation also depends on different level of potassium application which was shown in (Table 3 and Appendix III).

The highest (8.56cm) leaf breadth was recorded from the application of 90kg K_2O/ha and lowest (5.72 cm) leaf breadth was recorded control condition.

The largest (9.98cm) leaf breadth was obtained from the combined effect of nitrogen and potassium. The smallest (5.60cm) leaf breadth was obtained from control condition.

4.6 Number of branches per plant

Due to application nitrogen the number of branches per plant of French bean varied significantly which was shown (Table 3 & Appendix III). The highest (20.01 cm) number of branches were recorded due to application of 130 kg N /ha and lowest (15.18) number of branches were obtained from control treatment.

The number of French bean branches due to application of nitrogen application. Similar trend of result was found from the experiment of Baboo *et al*. (1998).

The application of 90 kg K_2O/ha) resulted highest (17.76 cm) number of branches and lowest (16.17) number of branches was recorded from control treatment. A significant variation was found due to the combined interaction of nitrogen and potassium application (Table 4 &

Appendix III). The highest (17.37 cm) number of branches were recorded at the application of 90 kg N/ha and 90 kg K_2O/ha and lowest (9.77 cm) number of branches were obtained from control treatment.

4.7 Number of flowers per plant

Number of flower varied significantly due to application of nitrogen (Table 3 & Appendix III).The highest (47.64 cm) of number flower was observed due to the 90 kg N/ha and lowest (41.20 cm) from control treatment. Application of potassium also influenced the flower number.

The highest number (45.59 cm) of flower was observed at the application of 90 kg potassium per ha and lowest (41.20 cm) number of flower was obtained from control treatment. A significant variation was also found due to combined interaction of nitrogen and potassium on the number of flowers of French bean (Table 4 & Appendix III). The highest (50.35 cm) number of flowers were recorded due to application of 90 kg N/ha and 90 kg K_2O/ha where lowest (36.75) number of flower was observed at control condition.

4.8 Number of pod per plant

The number of pod varied significantly per plant due to application of nitrogen (Table 3 &Appendix III). The highest (21.6 cm) number of pods were obtained by the application of 90kg N/ha).The lowest (20.2 cm) number of pods were recorded from control treatment. This result also support Hedge and Srinivas (1989) experiment result.

Significant variation was also observed due to application of different levels of potassium (Table 3 & Appendix III).The highest (22.25) number of pods were obtained due to the application 90 kg K_2O/ha where the lowest(20.33) no of pods per plant were recorded from control treatment .

The combined effect of nitrogen and potassium was also noteworthy (Table 4 & Appendix III).The highest (24.00 cm) number of pods were found by the application of 90 kg N/ha and 90 kg K/ha and lowest (20 cm) from control treatment.

4.9 Length of green pod

Green pod length varied significantly with the application of nitrogen (Table 3 &Appendix III). Application of 90 kg N/ha resulted longest (16.80 cm) pod and lowest (15.20 cm) length of green pod was obtained from control treatment. Green pod length formations largely depend on the potassium application. So, green pod length varied significantly due to application of different levels of potassium (Table 3 & Appendix III).

The combined interaction of nitrogen and potassium created significant variation in the formations of green pod length (Table 4 & Appendix III).The longest (17.27 cm) green pod was obtained from 90 kg N/ha and 90 kg K_2O/ha. The shortest (14.27 cm) green pod was obtained from control treatment. Gonazalez *et al.* (1985) supported the present study.

Table 4: Combined effect of nitrogen and potassium on leaf length, leaf breadth, number of flower/plant, number of pods /plant, number of branches/plant, length of green pod (cm) of French bean

Treatment(s)	Leaf length (cm)	Leaf breadth (cm)	Number of flower /plant	Number of pod/plant	Number of branches/plant	Length of green pod (cm)
N_0K_0	8.73g	5.60	36.75f	20.00	9.77f	14.27d
N_0K_1	9.90e	7.57e	41.65e	20.10	16.83cde	15.80bc
N_0K_2	10.03e	8.20d	42.49de	20.50	16.02de	15.82bc
N_1K_0	9.03fg	5.94h	37.83f	20.00	10.37f	14.97cd
N_1K_1	10.73cd	8.10de	41.86e	21.30	17.93bcd	16.47ab
N_1K_2	11.00c	8.93c	43.78cd	23.50	19.53ab	15.67bc
N_2K_0	10.50d	6.84f	41.82e	20.60	16.03dc	16.27ab
N_2K_1	11.70b	9.27b	44.12cd	22.00	19.13abc	17.27a
N_2K_2	14.03a	9.98a	50.35a	24.00	17.37bcd	15.57bc
N_3K_0	9.90f	6.43g	44.05c	20.70	14.70e	16.50ab
N_3K_1	11.93b	9.90a	48.36b	21.50	16.63cde	16.75ab
N_3K_2	12.07	9.93a	50.18a	21.00	19.73ab	16.65ab
LSD(0.05)	0.379	0.200	2.3	1.743		
Level of significance	**	**	**	**	**	**
CV(%)	7.78	8.80	10.04	9.16	9.19	7.12

N_0:0kg/ha
N_1:50 kg/ha
N_2:90 kg/ha
N_3:130 kg/ha

K_0:0 kg/ha
K_1:60 kg/ha
K_2:90 kg/ha

4.10 Diameter of Green Pod

Green pod diameter also varied significantly due to the applications of various levels of nitrogen (Table 5 & Appendix IV). Application of 90 kg N/ha that resulted largest (1.45 cm) pod was obtained and the lowest (1.25 cm) was recorded from control treatment.

Pod diameter also significantly varied due to applications of various levels potassium which was shown in (Table 5).The highest (1.40 cm) pod was obtained due to application of 90 kg K_2O and lowest (1.23 cm) pod was obtained from control treatment.

A significant variation also observed due to the combined interaction of Nitrogen and Potassium (Table 5 & Appendix IV).The highest (1.55) pod diameter was obtained from 90 kg N/ha and 90 kg K_2O/ha. The lowest (1.15 cm) pod was obtained from control condition.

4.11 Weight of pods/plant

Pod weight of per plant significantly varied with the application of nitrogen (Table 5 & Appendix IV). The highest (265.52 g) pod weight was recorded due to the application of nitrogen (90kg/ha) and lowest (208.26 g) pod weight was obtained from control treatment.

Pod weight significantly varied with the application of various levels of potassium which was shown in (Table 5).This experiment's result showed similar trend of Srinivas and Narik (1988) experiment result.

Pod weight also significantly varied with the application of various level of potassium (Table 5).The highest (298.10 g) pod weight was recorded at the application 90 kg K/ha and lowest (215.59 g) pod weight from control condition.

The combined effect of nitrogen and potassium had significant effect on pod weight which was shown in (Table 6).The highest (360.72g) pod weight was observed at 90 kg N/ha and 90 kg K_2O/ha and lowest (192.20 g) pod weight was obtained from without any nitrogen and potassium treatment.

4.12 Single pod weight

A significant variation was observed on the single pod weight of French bean due to application of various level of nitrogen (Table 5 & Appendix IV). The highest (12.20 g) single pod weight was found for the application of 130 kg N/ha and the lowest (10.30 g) single pod weight from without nitrogen and potassium treatment. Chawdhuri *et al.* (2001) supported this experiment result.

Application of potassium significantly varied the single pod weight (Table 5 & Appendix IV).Application of 90 kg K/ha gave highest (13.31g) single pod weight and lowest (10.60 g) single pod weight was obtained from control treatment. Sharangi and paira (1995) showed similar trend of results that obtained from this experiment.

The combined effect of nitrogen and potassium showed significant variation in case of single pod weight (Table 5).The highest (15.03g) single pod weight was recorded at 90 kg N/ha and 90 kg K/ha and lowest (9.61 g) was obtained from control treatment.

4.13 Percentage of dry matter content of pod

Dry matter content significantly varied with the application of various levels of nitrogen application (Table 5 & Appendix IV).The highest (9.64%) dry matter content of pod was observed at the application 90 kg N/ha and lowest (8.46%) dry matter content was observed from control treatment. Dry matter content of pod also varied significantly with the various level of potassium application which was shown in (Table 5 & appendix IV).

The highest (9.30%) dry matter content of pod was observed at the application of 90 kg K_2O/ha and the lowest (7.87%) dry matter content of pod was observed under control condition.

Dry matter content also significantly varied under combined interaction of nitrogen and potassium (Table 6 & Appendix IV). The highest (10.35 %) dry matter content of pod was recorded at 90 kg N/ha and 90 kg K_2O/ha. Lower (7.62) percentage was observed under control condition.

4.14 Yield per plot

Yield per plot varied with different level of nitrogen application which shown (Table 5 & Appendix IV). The highest (4.25 kg) pod yield was obtained from per plot under 90 kg N/ha and lower (3.33kg) pod yield per plot amount was recorded from control treatment.

Pod yield per plot varied significantly due to various level potassium application (Table 5 & Appendix IV). The highest (4.77 kg) pod yield per plot was obtained from 90 kg K_2O/ha and the lowest (3.45kg) was obtained from control condition.

The combined interaction of nitrogen and potassium significantly varied the pod yield per plot (Table 6 & Appendix IV). The Highest (5.77 kg) pod yield per plot was recorded at the application of 90 kg N/ha and 90 kg K_2O/ha .The lowest (3.08 kg) pod yield per plot was recorded from control condition.

4.15 Yield per hectare

Significant variation was observed on the yield per hectare due to application of various level of nitrogen application (Fig.7 & Appendix IV). The highest (13.28 ton/ha) yield was recorded of French bean due to the application of nitrogen (90 kg N/ha) and the lowest (10.41 ton/ha) yield was obtained from control treatment which supported the singh *et al.*(1996) experiment.

Potassium also significantly varied the yield of green pod of French bean (Fig.7 & Appendix IV).The highest (14.91 ton/ha) yield of green pod was obtained from 90kg K_2O/ha and lowest (10.78 ton/ha) from control treatment.

Combined interaction of nitrogen and potassium also varied significant (Table 6 &Appendix IV) .The highest (18.04 ton/ha) yield was recorded due to the application of 90 kg N/ha and 90 kg K_2O/ha and the lowest (9.61 ton/ha) yield was recorded from control treatment.

Table 5: Effect of Nitrogen and potassium on diameter of pod, weight of pod per plant, Single pod weight, % dry matter of pod, yield per plot

Treatment(s)	Diameter of pod (cm)	Weight of pod/plant (g)	Single pod weight (g)	% dry matter of pod	Yield/plot(kg)
N_0	1.25d	208.26d	10.30a	8.46c	3.33d
N_1	1.35c	212.46c	10.51a	8.78bc	3.40c
N_2	1.42b	265.52a	12.30a	9.31ab	4.25a
N_3	1.45a	233.21b	12.20a	9.64a	3.73b
LSD(0.05)	0.020	19.52	2.04	0.821	0.188
Level of significance	**	**	**	**	**
CV(%)	7.03	8.99	9.83	6.66	7.47

Treatment(S)	Diameter of pod (cm)	Weight of pod /plant(g)	Single pod weight (g)	% dry matter content of pod	Yield/plot (kg)
K_0	1.23c	215.59c	10.60a	7.87c	3.45b
K_1	1.35b	271.06b	12.72a	8.59b	4.34ab
K_2	1.40a	298.10a	13.31a	9.30a	4.77a
LSD (0.05)	0.040	19.52	4.41	0.684	0.451
Level of significance	**	**	**	**	**
CV (%)	7.03	8.99	9.83	6.66	7.47

N_0:0kg/ha

N_1:50 kg/ha

N_2:90 kg/ha

N_3:130 kg/ha

K_0:0 kg/ha

K_1:60 kg/ha

K_2:90 kg/ha

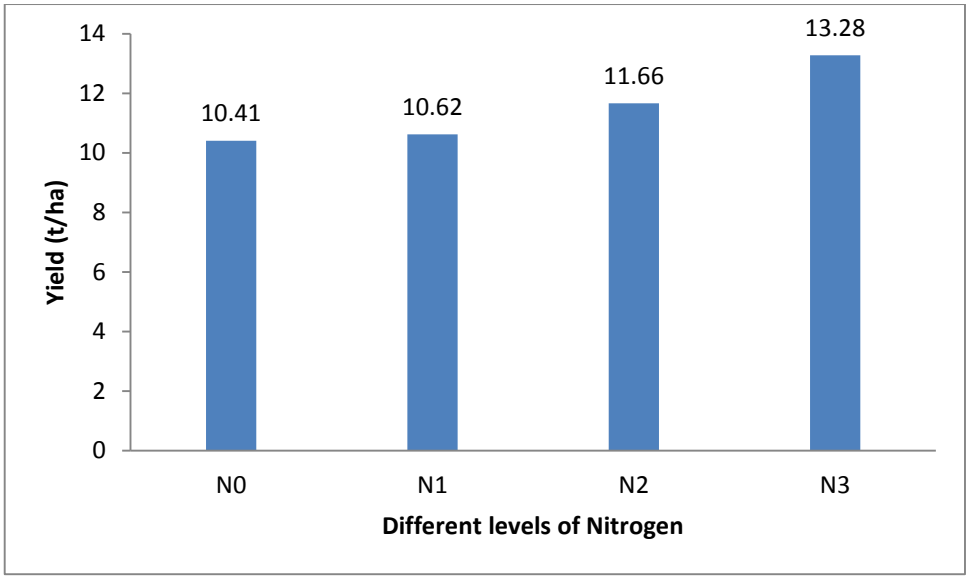


Figure 6: Effect of nitrogen on French bean yield (t/ha)

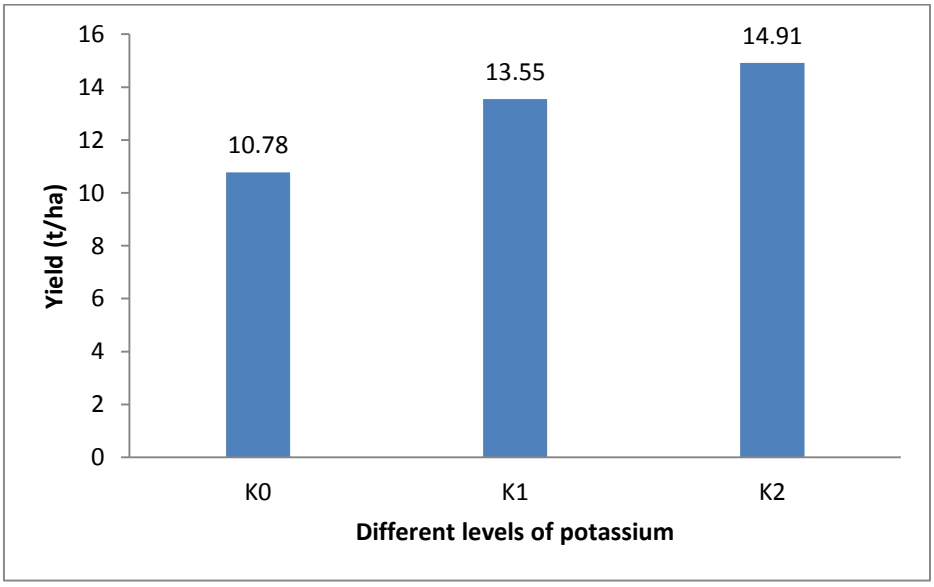


Figure 7: Effect of potassium on French bean yield (t/ha)

Table 6: Combined effect of Nitrogen and Potassium on pod diameter, weight of pods/plant, Single pod weight, % dry matter content of pod, yield /plot, yield/ha

Treatment(s)	**Diameter of pod (cm)**	**Weight of pods/plant(g)**	**Single pod Weight (g)**	**%dry matter content of pod**	**Yield/plot (kg)**	**Yield (t/ha)**
N_0K_0	1.15e	192.20f	9.61e	7.62e	3.08f	9.61f
N_0K_1	1.33cd	203.81f	10.14d	8.62cd	3.26f	10.19f
N_0K_2	1.36bc	228.78e	11.16c	8.82c	3.66e	11.44e
N_1K_0	1.17e	204.80f	10.24d	7.92e	3.28f	10.24f
N_1K_1	1.37bc	266.04d	12.49b	9.03c	4.26d	13.30d
N_1K_2	1.40bc	325.71b	13.86ab	9.32bc	5.21b	16.29b
N_2K_0	1.31cd	247.82de	12.03b	8.12de	3.97d	12.39de
N_2K_1	1.41bc	298.76c	13.58ab	9.29bc	4.78c	14.94c
N_2K_2	1.55a	360.72a	15.03a	10.35a	5.77a	18.04a
N_3K_0	1.24de	217.56ef	10.51cd	8.08de	3.48ef	10.88ef
N_3K_1	1.40bc	315.62bc	14.68a	9.11c	5.05b	15.78bc
N_3K_2	1.45ab	277.20d	13.2ab	9.92ab	4.44cd	13.86d
LSD (0.05)	1.070	19.52	2.58	0.6198	0.4420	1.08
Level of significance	**	**	***	**	**	**
CV (%)	7.03	8.99	9.83	6.66	7.47	9.18

N_0:0kg/ha

N_0:50 kg/ha

N_2:90 kg/ha

N_3:130 kg/ha

K_0:0 kg/ha

K_1:60 kg/ha

K_2:90 kg/ha

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University,Dhaka, to know the effect of nitrogen and potassium on the growth and yield of French bean during the period November 2015 to March 2016.The land belongs to the Agro ecological zone of Modhupur tract (AEZ no.28).The selected site of the experimental plot was high land and draining system was well developed. The experiment used included two factor, Namely, Factor A: 4 level of nitrogen (0, 50, 90 and 130 kg/ha) and Factor B: 3 level of potassium (0, 60 and 90 kg/ha).The layout of the experiment was at Randomized complete block Design (RCBD) and the size of the each plot was 2m x1.6m.The total number of treatment12 and total number of plot 36. BARI Zhar- Sheem-1 was as variety .The French bean seed was collected from Bangladesh Agricultural Research Institute, joydebpur, Gazipur. At first the land was ploughed with a power tiller on 3 November, 2015 and kept open to sunlight. The experimental plot was prepared by five ploughings and cross ploughings followed by laddering that helps to break the clods and level the soil. The weeds were removed from the soil .The stubble of the previous crops were also removed from the soil. These operations were done of the land to get good tilth condition of the soil for sowing the seeds. According to the experimental design the plots were laid out. Cow dung, triple super phosphate and muriate of potash were applied at the rate 10 t/ha,160kg/ha and 160kg/ha, respectively as basal dose. Nitrogen and potassium were applied according to the treatment allotted for each plot in the form the urea and muriate of potash. The ½ amount of Urea was applied during final land preparation and rest amount of urea in two instalments at 15 and 30 days after sowing the seed. Two seeds were sown in each hill at 3.00 cm depth. Just after sowing the seeds were covered with pulverized soil and pressed with hand gently. At 19 November 2015, the sowing was done and spacing the row was 50 cm X 40 cm. Intercultural operations were done as per requirement. To control insect Malathion57 EC was sprayed @2ml/litter at an interval of 15 days. Immature green pods were harvested by hand picking. The fresh pod yield weight was estimated. Border plant avoided in case of plant selection. The data were collected from these parameters. Such as-Plant height, number of leaves per plant, leaf length, leaf breadth, number of branches per plant, number of flower per plant, number of pod per plant, length of green pod, diameter of pod, weight of pod per plant, single pod weight, % of dry matter content of pod, yield per plot and yield per ha .The

analyses of variance for the character under trial were performed by F variance test and mean differences were adjusted by ANOVA. Maximum parameter were significantly affected by the application of nitrogen and potassium expect plant height at 15 DAS and combined effect of nitrogen and potassium showed the same that means at 15 DAS plant height was not significant, number of leaves at 15DAS was not significant for single effect of potassium, nitrogen as well as combined effect. Plant height, leaves number was significant at 30, 40 and 60 days after sowing. Leaf length, leaf breadth, number of branches per plant, number of flowers per plant, number of pods per plant ,length of green pod, diameter of pod ,weight of pod per plant, weight of single ,% dry matter content, yield per plot and yield per hectare was significant.

At 60 days after sowing the highest (45.39 cm) plant was observed due to the application of 90 kg N/ha and the shortest (43.06 cm) plant height was observed at control condition. Same trend of results were also observed in all others (15, 30 and 60) observations. The highest number of leaves per plant was found at all stages (15, 30, 45 and 60 DAS) due to application of 90 kg N/ha and the lowest from control treatment. Leaf length also varied significantly due to application of 90 kg N. The longest (12.23 cm) was found due to application of 90 kg N and shortest (9.90 cm) from control treatment. The highest (8.87 cm) leaf breadth was observed due to application of 90 kg N and the lowest (6.80 cm) from control treatment. The highest (20.01) number of branches were recorded due to application of 90 kg N and lowest (15.18) number of branches were recorded from control condition. The maximum (47.64) number of flowers per plant was found due to application of 90 kg N and the minimum (41.20) number of flowers were recorded due to control treatment. The longest (16.52cm) green pod was obtained due to application of 90 kg N and lowest (15.20cm) green pod was found from control treatment. The diameter of pod varied significantly due to application of nitrogen. The largest (1.45 cm) pod diameter was obtained due to application of 90 kg N and smallest (1.25 cm) from control condition. The pod weight of per plant varied significantly due to application of N. The highest (265.52 g) pod weight was recorded from 90 kg nitrogen and lowest (208.26 g) from control treatment. The highest (298.10 g) single pod weight was obtained from 90 kg N and the lowest (215.59 g) from control treatment. Dry matter content of pod varied significantly due to application of N. The highest (9.64 %) dry matter content was obtained from 90 kg N and the lowest (8.46 %) from control treatment. The highest (17.27 t/ha) yield was recorded from 90 kg N application and the lowest (13.08 t/ha) was recorded from control treatment.

The longest (44.59 cm) plant was found due to application of 90 kg K_2O and the shortest (43.23 cm) plant was found from control treatment at 60 DAS. Similar trend of results were observed at (15, 30 and 45 DAS).Number of leaves per plant varied significantly due to application of potassium. The highest (19.38) number of leaves was recorded from 90 KG K_2O and the lowest (16.77) was recorded from control condition. Leaf length and breadth was also significantly varied due to application of potassium .The longest (10.86 cm) leaf length was found due to application of 90 kg K_2O and shortest (18.68 cm) leaf was recorded from control treatment. The highest (8.56 cm) leaf breadth was recorded from 90 kg K_2O application and the lowest (5.27 cm) leaf breadth was obtained control condition. Number of branches per plant varied significantly due to application of potassium. The highest (17.76) number of branches was recorded from 90 kg K_2O application and the lowest (12.20) from control treatment. The highest (45.59) number of flowers per plant was recorded from 90 kg K_2O and the lowest (38.80) number of flower was recorded from control treatment. The number of pod per plant varied significantly due to application of potassium. The highest (34.05) number of pod per plant was observed due to application of 90 kg K_2O and lowest (27.33) from control treatment. The length of green pod was varied significantly due to application of potassium. The longest (16.65cm) green pod was observed due to application of 90 kg K_2O and the shortest (15.70cm) green pod was recorded from control condition. Pod diameter also varied significantly due to application of potassium .The largest (1.40 cm) pod diameter was recorded from 90 kg K_2O and smallest (1.23 cm) from control condition. The pod weight per plant varied significantly due to application of potassium .The highest (15.43g) pod weight per plant was found due to application of 90 kg K_2O and the lowest (11.00 g) was obtained from control treatment. Dry matter content of pod varied significantly due to application of potassium. The highest (9.30%) dry matter was obtained due to application of 90 kg K_2O and lowest (7.87%) dry matter was obtained from control condition. The highest (16.09 t/ha) yield was obtained due to application of 90 kg K_2O and lowest (13.03) from control condition.

Significant variation was observed due to combined application of nitrogen and different levels of K_2O. The highest (45.12 cm) plant height was obtained due to combined interaction of 90 kg N and 90 kg K_2O and shortest (40.95 cm) plant was produced from control treatment. The number of leaves was highest due to combined application of nitrogen and potassium .The highest (21.42) number of leaves were observed due to application of 90 kg N and 90 kg K_2O. The shortest (16.62) number of leaves was produced from control treatment.

The longest (14.03 cm) leaf was obtained due to combined effect of 90 kg nitrogen and 90kg K_2O and shortest (8.73 cm) was obtained from control treatment. The largest (9.98 cm) leaf breadth was obtained from combined interaction of 90 kg N and 90 kg K_2O and the shortest (5.00 cm) leaf breadth was obtained from control treatment. The highest (50.35) number of flower was obtained due to combined interaction of 90 kg N and the lowest (36.75) number of flower was obtained from control condition. The pod number was obtained highest (44.98) from 90 kg N and 90 kg K_2O and the lowest (26.58) in control condition. The highest (17.37) number of branches was obtained from 90 kg N and 90 kg K_2O and lowest (9.77) number of branches in control condition. The highest (17.27 cm) green pod was obtained from interaction of 90 kg N and 90 kg K_2O and the lowest (14.27cm) in control. The highest (1.55 cm) pod diameter was obtained due to the application of 90 kg N and 90 kg K_2O and lowest (1.15 cm) in control condition. The highest (360.72 g) pod weight per plant was obtained due to combined interaction of 90 kg N and 90 kg K_2O and lowest (192.20g) from control treatment. The highest (10.35%) dry matter was obtained due to application of 90 kg N and 90 kg K_2O and the lowest (7.62 %) in control condition. The highest (5.77 kg) yield per plot was obtained due to application of 90 kg N and 90 kg K_2O and lowest (3.08 kg) in control condition. The highest (18.04 ton/ha) yield was obtained due to application of 90 kg N and 90 kg K_2O .The lowest (9.61 t/ha) yield was obtained from control treatment.

CONCLUSION

Above the all findings, we are concluded that 90 kg nitrogen (195 kg urea) and 90kg potassium (180 kg MoP) per ha ensured the higher yield in French bean. The experiment was carried in AEZ no. 28 for one season. Further such type of research may be done in different Agro-ecological zones of Bangladesh for more confirmation. So this hypothesis should be done by conducting more trials.

REFERENCES

Ali, M. and Tripathi, A.(1988). Dry matter accumulation and yield of winter French bean as influenced by genotype, nitrogen level and plant population. *Indian.J.Agril.Sci.,***58** (4):263-267.

Anonymous. (1989). Annual Report 1987-88. *Bangladesh Agricultural Research Council* p:45

Anonymous. (2001). HORTEX-promoted export during Oct-Dec 2001 compared with corresponding period last year. *Hortex News Letter*, **1**(4): 1-4.

Anonymous. (2013). HORTEX-promoted export during Oct-Dec 2013 application. Annals of Agricultural Research. **22**(1):130-132.application. Pertanika Journal of Tropical Agricultural Science. **19**(1):61-67.

Arya, P. S., Sagar, V. and Singh, S.R. (1999). Effect of N, P and K on seed yield of French bean *{Phaseolus vulgaris L.)* var. Contender. *Haryana J. Hort. Sci.,* **16** (8): 146-152.

Baboo, R., Rana, N. S. and Pantola, P. (1998). Response of French bean to nitrogen and phosphorus. Ann. Agril. Res.,**19** (1): 81-82.

Begum,A., A.Ahad, M.O. Kaisar, M.M.Islam and M.K.Anam.(2003). Effect of sowing dates and fertilizer.

Calvache, A. M., Reichcardt, E. and Bacchi, O. O. S. (1997). Effect of water stress and nitrogen efficiency in bean. Scientia Agricola, **54** (3): 232-240 [Cited from Hort. Abst., 68(1): 53, 1998],

Chandra, R.,C.B.S Rajput, K.P Singh and S.J.P Singh (1987). A note on the effect of nitrogen phosphorus and Rhizobium culture of the growth and yield of French bean (*Phaseolus vulgaris L*.) cv. Contender Haryana J. Hort. Sci., **16** (3): 146:-147.
compared with corresponding period last year. *Hortex News Letter*, **3**(2): 1-4.

Daba, S and Haile, M. (2000). Effect of Rhizobial inoculant and nitrogen fertilizer on yield and nodulation of common bean. *J. Plant Nutr*., **23**(5): 581 -591.

Dhanjal, R., Prakash, O. and Ahlawat, I. P. S. (2001). Response of French bean (*Phaseolus vulgaris* L.) varieties to plant density and nitrogen application. *Indian J Agron* **46**(2), 277-281.

Dhanjal, R., Prakash, O. and Ahlawat, I. P. S. (2001). Response of French bean (*Phaseolus vulgaris* L.) varieties to plant density and nitrogen application. *Indian J Agron* **46**(2), 277-281.factors in French bean. Legume Research. **23**(1):33-36.

FAO. (1988). Production Year Book. *Food and Agricultural Organizations of the United Nations. Rome, Italy*, pp: 190-193.

FAO. (2013). Production Year Book. Food and Agricultural Organization of the United Nations, Rome, Italy. **54**:108.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedure for Agricultural Research (2nd edn.). *Int. Rice Res. Inst., A Willey Int. Sci*., pp. 28-192.

Ghosal, S; Singh. O. N. and Singh. R. P. (2000). Effect of rate and time of application of nitrogen on growth and productivity of French bean. Legume Res., **23** (2): 110-113.

Hedge, D. M. and Srinivas, K. (1989). Effect of irrigation and nitrogen on growth. Yield land water use of French bean. *Indian. J. Agron.,* **34** (2): 180-182.

Hortex Foundation.(2005). Production technology and management of French bean (*Phaseolus vulgaris* L.) for Export. Horticultural Export Development Foundation, p.3.

Islam, M.S., Haque. M. M. and Karim.M.A. (2004). Effect of potassium on growth, yield and water relations of French bean under water stress condition *Japanes,J.Trop.Agri.* , **48** (1):1-9.

Ibeawuchi, I. I., Onweremadu, E. U. and Oti, N. N.(2006). Effects of poultry manure on green (*Amaranthus cruentus*) and waterleaf (*Talinum triangulare*) on degraded ultisols of Owerri Southeastern. *Nigeria. J. Anim*. Vet. Adv., **5 (1)**: 53-56.

Kanaujia,s.p.,Narayan,Raj,sumati-Narayan,Narayan.R. and Narayan.S.(1999). Effect of potassium and phosphorus on growth ,quantity and yield of French bean(Phaseolus vulgaris L.)cv,contender,veg sci.,**26**(1):91-92.

Khan,E.M and Arvanitoyannis,I.S.(2003).Yield and nutrient content of green French bean are affected by N:K ratios .J.food,**1**(3):17-26.

Kuccy, R. M. N. (1989). The influence of time and rate of mineral N application on yield and N2 fixation by field bean. *Canadian J. Plant Sci.,* **69** (2):427-436.

Landa,R.,Rayas,A.,Gonazalez D.L and Graz J.A.(2002).Effect of NPK on the growth and yield of French bean.Centro Agricola,**29** (3):26-29.

Leelavathi, G. S. W. S., Subbaiah, G. V. and Pillai, R. N. (1991). Effect of different levels of nitrogen on the yield of green grass (*Phaseolus vulgaris* L. Wilezek). *Andhra Agril. ,J.* (India), **38** (1): 93-94.

Parthiban, S. and Thamburaj, S.(1991). Influence of *Rhizohium* culture and nitrogen fertilization of French bean. *South Indian Hort.,* **39** (3): 137-138.

Prajapoti, M. P., Patel, H. A., Prajapati, B. A. and Patel, L. R.(2004). Studies of nutrient uptake and yield of French bean (*Phaseolus vulgaris* L.) as affected by weed contrl methods and nitrogen levels. *Legume Res* **27**(2), 99-102.

Rashid, M. M .(1993). Sabji Biggan (in Bengali). 1st ed. Bangla Academy, Bangladesh, pp. 387-390.

Rashid, M.M.(1999). Sabji Biggan (in Bengali). 2nd ed. Rashid Publishing Flouse, Dhaka, pp. 396-399.

Rana, N. S., Baboo, R. and Pantola, P. (1998). Response of French bean to nitrogen and phosphorus. *Ann.Agril.Res.*, **19** (1):81-82.

Rajesh-Singh, Singh,O.N., Singh, R. S. and Singh, R.(2001). Effect of nitrogen and sulphur application on its uptake and grain yield in French bean *(Phaseolus vulgaris* L.). *Indian. /. Pulses Res.,* **14**(2): 154-155.

Rana, N. S., Singh, R. and Ahlawat, I. P. S.(1998). Dry-matter production and nutrient uptake in French bean *(Phaseolus vulgaris* L.) as affected by nitrogen and phosphorus application. *Indian J. Agron.,* **43** (1): 114-117.

Sangakkara, U.R. 1996. Response of French bean (*Phaseolus vulgaris L*.) to rate and ratio of potassium fertilizer

Santos, G. M., Oliveira, A. P., Silva, J. A. L., Alves, E. U. and Costa, C.C.(2000) Characteristics and yields of French bean pods in relation to sources and levels of organic matter. *Hort Brasileira*, **19** (I): 30-35 [Cited from CAB Abst., Vol. Id: CABIA 012, 2002].

Saxena, K. K., Aruh, S. and Singh, R. B.(2003). Response of French bean to nutrients Application (NPK) in relation to physiological traits and their consequent effect on yield *Farm Sci. J.,* **12**(2): 150-152.

Salunkhe, D. K., Desai, B. B. and Bhat, N. R. (1987). Leguminous vegetables (Peas and Beans). In: Vegetable and Flower Seed Production, Agricole Publishing Academy, New Delhi, pp.265- 302.

Singh, D. P., Rajput, A. L. and Singh, S. K. (1996). Response of French bean *(Phaseolus vulgaris* L) to spacing and nitrogen levels. *Indian .J. Agron*., **41** (4): 608-610.

Sharangi,A.B.and Paria.N.C.(1997).Response of French bean to various levels of Phosphorus and potassium.Hort.J**., 8(**3):251-255.

Sharma, A., Singh, S. P. and Singh, N.R.(1997). Response of potassium and phosphorus to the yield of French bean. *Indian J.Hort*.,**45 (**3):235-239.

Sharma, S.K.(2001). French bean green pod and seed production as influenced by nitrogen and phosphorus

Sharma,A., Singh,S.P. and Singh,N.R.(1997).Response of potassium and phosphorus to the yield of French bean.indian j.Hort.,**45**(3):235-255.

Singh , R.V.(2000). Response of French bean (*Phaseolus vulgaris L*.) to plant spacing and nitrogen, phosphorous fertilization. Indian J Hort **57(**4), 338-341.

Singh, A.K, and S.S. Singh.(2000). Effect of planting dates, nitrogen and phosphorus levels on yield contributing

Singh, D. P., Rajput, A. L. and Singh, S. K. (1996). Response of French bean *(Phaseolus vulgaris* L) to spacing and nitrogen levels. *Indian .J. Agron*., **41** (4): 608-610.

Soares, R., Lima de and Bull, L. T. (1990). Spilting of Potassium fertilizer application in production of bean ,maize and soyabean crops on a red-yellow latostol. *Revista-de-agric-Piracicaba,* **65**(1):55-52. [Crited from Agron Abstr., **25** (3):550,1992].

Srinivas, K. and Naik, L. B. (1988). Response of vegetable French bean (*Phaseolus vulgaris* L.) to nitrogen and phosphorus fertilization. *Indian J. Agril. Sci.,* **58** (9): 707-708.

Subhan,(1989).The effect of nitrogen ,potassium fertilizer and sulphur on kidney bean on podzolic soil,Buletin-Penelitian-Hortikultura.**18**(1):39-43.

Tewari, J. K. and Singh,S.S. (2000). Effect of nitrogen and phosphorus on growth and yield of French bean (*Phaseolus vulgaris* L.). *Vegeta.Sci*., **27** (2):172-175. treatments on the reproductive variability of French bean (*Phaseolus vulgaris*) Pak. J. of Biological Sci.

UNDP (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. *Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome*. p: 212.

Virender, S.; K. K. Dhingra, S. M., Gill, J. 1. Singh and V. Sardana (2000). Production technology of French bean *(Phaseolus vulgaris* L.) cultivation. Agril. Rev., 21 (3): 141-154.

Vishwakarma, B., Singh, C. S., Rajesh-Singh and Singh, R.(2002). Response of French bean *(Phaseolus vulgaris* L) varieties to nitrogen application. *Res. Crops.*, **3** (3): 529-532.

APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	**Characteristics**
Location	Horticulture 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
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the experimental field

Characteristics	**Value**
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	13.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	33

Source: SRDI, 2013

Appendix II: Analyses of variance of the data on plant height and number of leaves of French bean as influenced by nitrogen and potassium

Source of variation	Degrees of freedom	Mean square							
		Plant height (cm) at				Number of leaves at			
		15DAS	30DAS	45DAS	60DAS	15DAS	30DAS	45DAS	60 DAS
Replication	2	0.55	0.96	5.05	6.29	1.67	1.76	2.17	1.96
Nitrogen (factor :A)	3	35.16 NS	185.85 **	384.10 **	111.70 **	10.10 NS	5.83*	8.88**	12.23 **
Potassium (factor: B)	2	40.42 Ns	137.87 **	481.0**	322.22 **	0.96NS	12.89 NS	7.79*	10.70 **
Interaction(AXB)	6	10.14 NS	8.02*	12.35**	19.52**	9.281 NS	61.63*	72.88*	61.03 **
Error	22	1.03	0.98	0.16	0.82	0.69	0.76	0.66	0.71
Total	35								

**=Level of significance of 1%

*=Level of significance of 5%

Appendix III: Analyses of variance of the data on leaf length, leaf breadth, number of branches per plant, number of flower per plant, number of pod per plant, length of green pod.

Source of variation	Degrees of freedom	Mean square					
		Leaf length (cm)	Leaf breadth (cm)	No. of branches/plant	No. of flowers/plant	No. of pod per/plant	Length of green pod(cm)
Replication	2	2.85	1.99	3.37	4.44	10.81	0.21
Nitrogen (factor: A)	3	29.52 **	8.92 **	48.41 **	199.82 **	460.83 **	6.92**
Potassium(factor: B)	2	52.53 **	22.22 **	180.06 **	185.53 **	190.09 **	1.67NS
Interaction(AXB)	6	2.63 **	0.890 **	2.89 **	1.77 **	39.42 **	0.83**
Error	22	0.82	0.73	0.66	0.68	0.55	0.46
Total	35						

**=level of significance at 1% and *=level of significance of at 5%

Appendix IV: Analyses of variance of the data on diameter of pod, weight of pod per plant, Single pod weight, % dry matter content of pod, yield per plot and yield per hectare

Source of variation	Degrees of freedom	Mean square					
		Diameter of pod (cm)	Weight of pods/plant	Single pod weight (g)	% dry matter content of pod	Yield/plot (kg)	Yield of pod (t/ha)
Replication	2	0.06	0.56	0.09	0.08	1.46	2.06
Nitrogen (Factor:A)	3	0.92**	4.49 **	6.63 **	8.23**	185.82 **	170.74 **
Potassium (Factor:B)	2	0.18**	5.55 **	8.92 **	5.44 **	51.71 **	87.38 **
INTERaction (AXB)	6	0.08**	4.19 **	7.72 **	8.96 **	4.57 **	5.63 **
Error	22	0.08	0.39	0.55	0.82	0.73	0.99
Total	35						

**= level of significance at 1%

* =level of significance at 5%