EFFECTS OF GROWTH REGULATOR AND NITROGEN ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS OF FRENCH BEAN (*Phaseolus vulgaris* L.)

A THESIS

BY

MD. ENAYATH UDDIN CHOUDHURY

DEPARTMENT OF HORTICULTURE AND POSTHARVEST TECHNOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA - 1207

DECEMBER 2007

EFFECTS OF GROWTH REGULATOR AND NITROGEN ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS OF FRENCH BEAN (*Phaseolus vulgaris* L.)

BY

MD. ENAYATH UDDIN CHOUDHURY
REG. NO. 02184

A Thesis
Submitted to the Department of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JULY-DECEMBER, 2007

APPROVED BY:

Md. Hasanuzzaman Akand
Associate Professor
Dept. of Horticulture & Postharvest Technology,
SAU, Dhaka
Supervisor

Prof. A. K. M. Mahtabuddin
Dept. of Horticulture & Postharvest Technology,
SAU, Dhaka
Co-Supervisor

Prof. Md. Ruhul Amin
Chairman
Examination Committee

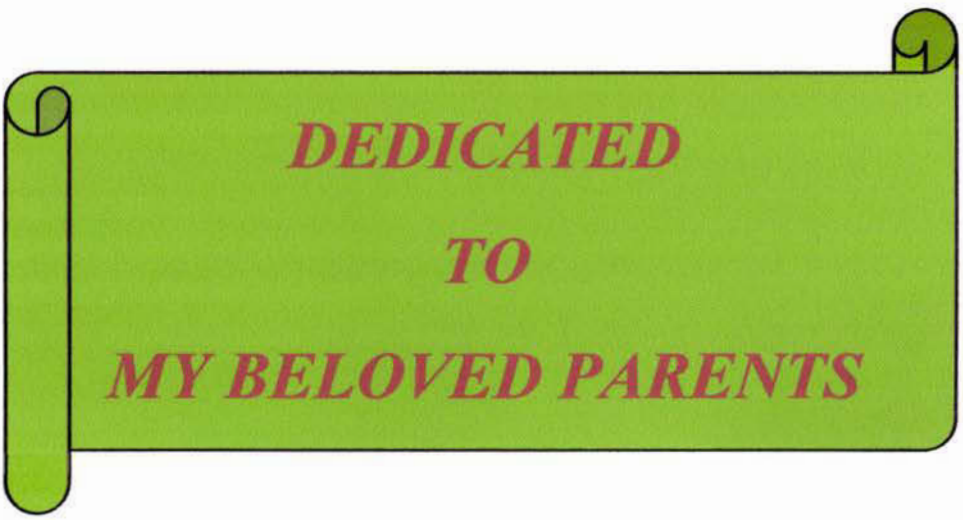
CERTIFICATE

This is to certify that the thesis entitled **"Effects of Growth Regulator and Nitrogen on the Yield and Yield Contributing Characters of French Bean (*Phaseolus vulgaris* L.)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE in HORTICULTURE,*** embodies the result of a piece of bonafide research work carried out by ***MD. ENAYATH UDDIN CHOUDHURY,*** Registration No. **02184** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Md. Hasanuzzaman Akand
Associate Professor
Department of Horticulture and Postharvest Technology,
Sher-e-Bangla Agricultural University, Dhaka
Supervisor

Dated: 31.12.07
Dhaka, Bangladesh.


DEDICATED
TO
MY BELOVED PARENTS

ACKNOWLEDGEMENTS

At first I gratefully express my sincere gratitude Almighty Allah, who kindly enabled me to complete this research work and preparation of this thesis.

I would like to express my heartfelt respect and deepest sense of gratitude to my honorable Supervisor, Md. Hasanuzzaman Akand, Associate Professor, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, for his guidance, encouragement, valuable suggestions and kind advice during the research work and preparation of the thesis.

I feel proud to express my sincere appreciation and profound respect to my honorable Co-supervisor, Prof. A.K.M Mahtabuddin, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his valuable and helpful suggestions during the research work and cooperation in preparing the thesis.

I like to record special word of gratefulness to Professor Md. Ruhul Amin, Chairman, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka.

I take an opportunity to express my cordial thanks and sincere gratitude to the respectable teachers and staff of the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka.

Finally, I express deepest sense of gratitude and heartfelt thanks to my beloved parents, wife, daughters, brothers, sisters and friends for their moral support, encouragement, blessings, constant inspiration and generous help in compiling this thesis.

December, 2007
The Author

Effects of Growth Regulator and Nitrogen on the Yield and Yield Contributing Characters of French bean (*Phaseolus vulgaris* L)

By: Md Enayath Uddin Choudhury

ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka, to study the effect of IAA and nitrogen on the growth, yield and yield components of French bean during the period from November 2006 to February 2007. The experiment included two factors, Factor A: Indole-3 Acetic Acid (0, 5 and 10 ppm) and Factor B: nitrogen (0, 50, 100 and 150 kg/ha). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The cultivar of French bean used in the experiment was BARI Zhar Sheem-1. Germination percentage revealed that application of nitrogen at basal dose inhibited the seed germination to some extent, but it was not statistically significant. Plant height and number of leaves per plant varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to application of IAA, nitrogen and their interactions. Leaf length and breadth varied significantly due to application of IAA and nitrogen. The yield components varied significantly due to application of IAA and nitrogen. The highest pod yield of 18.77 t/ha was obtained from 10 ppm IAA with 100 kg N /ha and the lowest (9.91 t/ ha) yield was obtained from control. The highest (Tk.214905) net return was obtained from application of 10 ppm IAA and 100 kg N/ha and the lowest (Tk.78667) in control treatment. The highest (3.52) benefit cost ratio was obtained due to application of 10 ppm IAA and 100 kg N/ha, while the lowest (1.98) in control treatment. The results revealed that application of IAA and nitrogen at different levels had positive impact on growth, yield and yield components of French bean.

CONTENTS

CHAPTER		
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	CONTENTS	vi
	LIST OF TABLES	viii
	LIST OF FIGURES	ix
	LIST OF APPENDICES	x
	ABBEVIATIONS AND ACRONYMS	xi
1.	INTRODUCTION	1
2.	REVIEW OF LITERATURE	3
	2.1 Effects of Plant Growth Regulators (PGR)	3
	2.2 Effects of nitrogen on the growth and yield of French bean.	4
	2.3 Interaction effects on the growth and yield of French bean	7
3.	MATERIALS AND METHODS	9
	3.1 Description of the experimental site	9
	3.1.1 Location	9
	3.1.2 Characteristics of soil	9
	3.1.3 Climate	9
	3.2 Planting materials	10
	3.3 Treatments of the experiment	10
	3.4 Design and layout of the experiment	10
	3.5 Land preparation	12
	3.6 Manure and fertilizer application	12
	3.7 Application of Indole-3 Acetic Acid (IAA)	12
	3.8 Sowing of seeds	12
	3.9 Intercultural operations	13
	3. 10 Harvesting	14
	3.11 Collection of data	14

3.12 Statistical analyses 16
3.13 Economic analyses 16
4. RESULTS AND DISCUSSION 17
4.1 Germination and Seed Vigour Index 17
4.2 Plant height 17
4.3 Number of leaves per plant 22
4.4 Leaf length 23
4.5 Leaf breadth 25
4.6 Number of branches per plant 25
4.7 Number of flowers per plant 27
4.8 Number of pods per plant 29
4.9 Length of green pod 30
4.10 Diameter of green pod 30
4.11 Number of seeds per green pod 31
4.12 Yield of green pod per hectare 32
4.13 Economic analyses 35
5. SUMMARY AND CONCLUSION 37
REFERENCES 43
APPENDICES 48

LIST OF TABLES

Sl. No.	TITLE OF TABLES	Page No.
Table 1	Seedling emergence, germination and vigor index of French bean under experimentation	18
Table 2	Effects of IAA on plant height, number of leaves/plant, leaf length and leaf breadth of French bean	20
Table 3	Effects of nitrogen on plant height, number of leaves/plant, leaf length and leaf breadth of French bean	20
Table 4	Combined effects of IAA and nitrogen on plant height, number of leaves/plant, leaf length and leaf breadth of French bean	24
Table 5	Effects of IAA on yield and yield contributing characters of French bean	26
Table 6	Effects of nitrogen on yield and yield contributing characters of French bean	28
Table 7	Combined effects of IAA and nitrogen on yield and yield contributing characters of French bean	34
Table 8	Economic analyses of French bean considering different levels IAA (PGR) and nitrogen application	36

LIST OF FIGURES

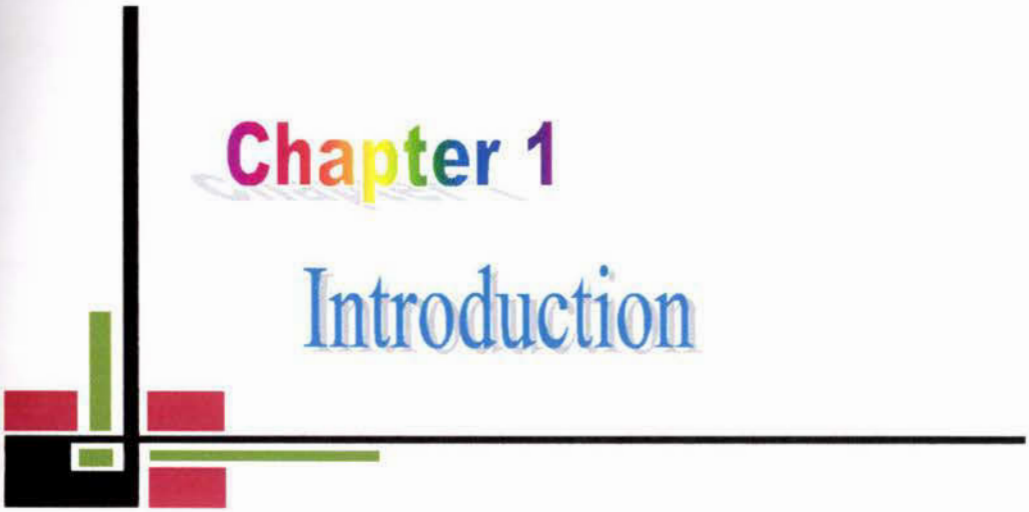
Sl. No.	TITLE OF FIGURES	Page No.
Figure 1	Effects of IAA in Plant height of French bean	21
Figure 2	Effects of Nitrogen in Plant height of French bean	21
Figure 3	Effects of IAA on Yield of French bean	33
Figure 4	Effects of Nitrogen on Yield of French bean	33

LIST OF APPENDIX

Appendix	TITLES	Page No.
I	Results of the mechanical and chemical analyses of soil of the experimental plot a. Mechanical analyses b. Chemical analyses	48
II	Monthly records (Dekadal) of average temperature, rainfall and relative humidity during the period from November 2006 to February, 2007	49
III	Analyses of variance of the data on plant height and number of leaves of French bean as influenced by IAA and nitrogen	50
IV	Analyses of variance of the data on leaf length, leaf breadth, number of branch/plant of French bean as influenced by IAA and nitrogen.	51
V	Analyses of variance of the data on length of green pod, diameter of green pod, seeds/green pod of French bean as influenced by IAA (PGR) and nitrogen.	51
VI	Analyses of variance on number of flowers/plant, pods/plant, yield of French bean as influenced by IAA (growth regulator) and nitrogen.	52
VII.	Production cost of green pod of French bean per hectare	53
	A. Input Cost (Tk/ha)	53
	B. Overhead Cost (Tk/ha)	54

ABBREVIATIONS AND ACRONYMS

BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BCR	=	Benefit Cost Ratio
CV (%)	=	Coefficient of Variation
DAS	=	Days after sowing
EC	=	Emulsifiable concentration
FAO	=	Food and Agriculture Organization
g	=	Gram
GA_3	=	Gibberellic Acid
IAA	=	Indole-3 –Acetic Acid
Kg/ha	=	Kilogram per hectare
LSD	=	Least Significant Difference
Max.	=	Maximum
Min.	=	Minimum
MP	=	Muriate of Potash
N	=	Nitrogen
NS	=	Not significant
Number	=	no.
ppm	=	Parts per million
RCBD	=	Randomized Complete Block Design
RH	=	Relative humidity
SAU	=	Sher-e-Bangla Agricultural University
t/ha	=	Tonne per hectare
TSP	=	Triple Super Phosphate
US $	=	United States of American Dollar



Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family Fabaceae which originated in the Central and South America (Swiader *et al.*, 1992). It is also known as bush bean, kidney bean, snap bean, pinto bean, green bean, raj bean, common bean, basic bean, harcot bean, navy bean, pole bean, wax bean, string bean and bonchi (Duke, 1983; Salunkhe *et al.*, 1987; Tindall, 1988). In our country it is known as "Farashi Sheem" (Rashid, 1993). In Bangladesh, beans are mainly used as green vegetables. Seeds are also used as pulse in Sylhet, Moulvibazar, Sonamgonj, Habigonj, Brahmmanbaria, Feni, Coxsbazar, Chittagong, etc.

It is cultivated in many parts of the tropics, sub tropics and throughout the temperate regions (Purseglove, 1987). But it is more suitable as a winter (rabi) crop in the north eastern plains of India (AICPIP, 1987). According to the recent FAO statistics, French bean including other related species of the genus *Phaseolus,* occupied 27.08 million hectares of the world's cropped area, and the production of dry green pods was about 18.94 million tons with an average yield of 699 kg/ha (FAO, 2000). Brazil is the largest French bean producing country in the world. In Bangladesh there is no statistics about the area and production of this crop. It is not new crop in our country and is cultivated in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country in a rather limited scale. Recently, Hortex Foundation and BRAC are trying to extent the production area because French bean is now an exportable vegetable among other. Bangladesh presently earns about US$ 15 million per anum by exporting fresh horticultural produces, French bean share a big portion.

Immature pods are marketed fresh, frozen or canned. The dry seeds also have a good market demand. Foliage of the crop may also provide hay, silage and green manures. After harvest plants can be fed to cattle sheep and horses. Its edible pods supply protein, carbohydrate, fat, fiber, thiamin, riboflavin, Ca and Fe (Shanmugavelu, 1989) and the seed contains significant amount of thiamin, niacin, folic acid as well as fiber (Rashid, 1999). Recently cultivation of French bean is gaining popularity in Bangladesh mainly because of its demand as a commodity

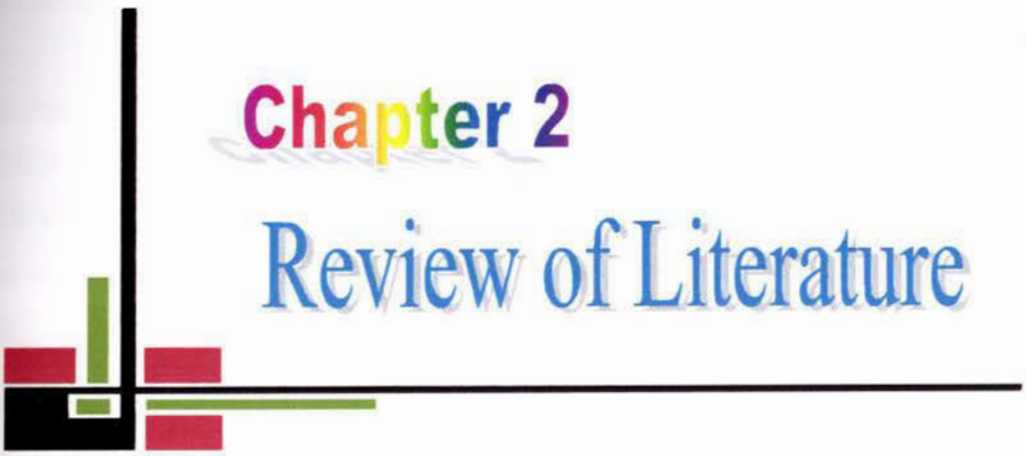
for export. Hortex Foundation exported 99.83 tones of fresh French bean during the year 2000-2001 (Personal Communication).

Application of IAA resulted the higher plant height, large leaf size, short days of curd initiation and heavier curd weight of Cauliflower (Akhter, 2007). The effect of IAA and NAA on tomato reported that it increased growth, fruit set, size and yield of fruit (Singh and Upadhaya, 1967).

Production of French bean depends on many factors such as quality of seed, time of sowing, application of plant growth regulator, fertilizer and proper management practices. Among those factors, fertilizer is an important factor to get high yield. Nitrogen management is played an important role in maximizing yield of French bean. Nitrogen is necessary for its vegetative growth and development. Nutrient requirement for different cultivars usually is similar except on poor soils (Adams, 1984). French bean cultivation requires ample supply of nitrogen. Therefore, it is necessary to find out a suitable nitrogen level for higher yield and economic return as well. However, very limited research was conducted to improve the fruit set and yields by growth regulator application and fertilizer management practices in French bean.

Evidences reveal that IAA (growth regulator) and nitrogen fertilizer may play an important role for French bean production. The yield of French bean may be increased through judicious combination of IAA and nitrogen application. Considering the above facts, the present study was undertaken with the following objectives.

i. To determine IAA (indole-3 acetic acid) concentrations for maximizing the growth and yield of French bean;
ii. To assess the optimum level of nitrogen for maximizing the yield and yield contributing characters of French bean;
iii. To find out the suitable combinations of IAA and nitrogen for ensuring higher yield of French bean.



Chapter 2

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

French bean *(Phaseolus vulgaris* L.*)* is a popular vegetable crop of the world. Many research works have been done in different parts of the world to study the effect of IAA and nitrogen on the growth and yield of French bean. But in Bangladesh, available literature regarding effect of nitrogen on French bean is insufficient and some times conflicting. However, some of the literatures relevant to effect of IAA and nitrogen on French bean production are reviewed in this chapter.

2.1 Effect of Plant Growth Regulators (PGR)

In Pea, Mishriky (1990) found that protein content was increased when 50 ppm GA_3 was applied at 30 days after sowing. The foregoing discussion indicates that growth regulators such as GA_3 and IAA could increase the branches, grain yield as well as protein content of pea. The effectiveness of such growth regulators may, however, is applied as growth regulator of French bean.

Awan and Alizai (1989) reported significant increase in plant height, number of tiller(s)/plant, number of grains/panicle, grain yield and protein content of grain by foliar application of 100 ppm GA_3 or IAA at panicle emergence stage and also significant decrease in sterility percent on rice.

Biswas and Mondal (1988) reported that protein, free amino acid of the seeds and mobilization index for protein in wheat increased from application of IAA with foliar spray.

Pandey and Singh (1973) from that soil application of up to 100 kg N increased the number of pistillate and staminate flower and the yield; the sex ratio was not affected in bottle gourd. Maleic Hydrazide approximately doubled the proportion of female flowers and also increased yield. Combined application of N and Maleic Hydrazide gave a further increased in the proportion of female flowers and the highest yield.

Choudhury *et.al.* (1967) reported that NAA 100 ppm, IAA 100 ppm and 200 ppm and MH 50 ppm and 200 ppm were equally effective in suppressing the male flowers and increasing the number of female flowers in cucumber. The effects subsequently increased the percentage of fruit set and ultimately the yield.

Singh and Upadhaya (1967) studied the effect of IAA and NAA on tomato and reported that the regulators activated growth, increased the fruit set, size and yield of fruit and induced parthenocarpic fruit. The chemicals could be applied on seeds, roots, whole plants or flowers, but foliar application was very effective for increasing the size of fruit and the yield.

Choudhury and Pahatak (1959) reported the effects of growth regulators on sex expression of cucumber. They observed that MH 200 ppm and NAA 100 ppm significantly increased number of female flowers and MH 600 and 800 ppm, NAA 100 ppm and IAA 200 ppm greatly suppressed the number of male flower over control. All treatments increased the female to male flower ratio when compared with the control.

2.2 Effects of nitrogen on the growth and yield of French bean

Rajesh *et al.* (2001) carried out a field experiment in India to evaluate the effects of N (80, 160 and 240 kg/ha) and S (0, 20, 40 and 60 kg/ha) on the nutrient uptake and grain yield of French bean *(Phaseolus vulgaris cv.* HUR 137). The highest grain yield (2091 kg/ha) was recorded at N level of 240 kg/ha and that of straw yields (3331 kg/ha) and the highest total N (90.70 kg/ha) and S (6.58 kg/ha) uptake. Sulphur (S) at 40 kg/ha recorded the highest grain yield (1811 kg/ha) and the highest total N (77.45 kg/ha) and S (6.06 kg/ha) uptake.

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

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

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

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

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

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

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

Rana *et al.* (1998) conducted a 2-year field experiment in India to study the effect of N (0, 40, 80 and 120 kg N/ha) on dry matter production and uptake of N in French bean. Dry 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. Durge *et al.* (1997) stated that the highest yield (957 kg/ha) of French bean was obtained with 150 kg N/ha.

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

In India, Singh *et al.* (1990) studied the response of French bean to nitrogen application. They reported that number of pods per plant and 100-seed weight increased with increase in N rate. Similar experiment was carried out by Leclavathi *et al.* (1991) and reported that the seed yield and dry matter production in French bean were increased up to 60 kg N/ha.

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

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

In India, Hedge and Srinivas (1989) conducted an experiment in India to study the effect nitrogen on growth and yield of French bean. In their trial, the crop received 0, 40, 80 or 120 kg/ha of nitrogen. The green pod yield was the highest (124.3-132.3 q/ha) at 120 kg N/ha. Kuccy (1989) noted that addition of nitrogen at 30 mg/kg soil had stimulatory effect on plant growth.

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

kg/ha. They reported that pod yields were increased with increasing fertilizer rate, from 3927 kg/ha at 0 kg N/ha to 13169 kg/ha at 160 kg N/ha.

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

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

2.3 Interaction effects on the growth and yield of French bean.

Vishwakarma *et al.* (2002) conducted a field experiment in Varanasi, Uttar Pradesh, India, during 1996-97 and 1997-98 to determine the response of two French bean (*Phaseolus vulgaris)* cultivars (Holland 84 and PDR 14) to different application rates (0, 30, 60, 90 kg/ha) of nitrogen. Holland 84 was the tallest, whereas PDR 14 recorded the highest dry matter production per plant as well as pods per plant, grains per pod, grains per plant, pod length and 100-grain weight. The growth, yield attributes and yield increased with increasing rates of nitrogen up to 90 kg/ha.

Koli *et al.* (1996) reported that the influences of row spacing, plant density and N levels on yield of French bean. They stated that the yields were similar at densities of 2, 22,222 plants/ha (yield 1.12 t/ha) and 3, 33,333 plants/ha (yield 1.14 t/ha) and were decreased at the 4, 44,444 plants/ha (yield 1.05 t/ha). They also observed that 60 kg N/ha gave the highest yield of 1.41 t/ha.

Singh *et al.* (1996) conducted an experiment in India to investigate the effects of spacing and nitrogen levels on the yield of French bean and observed that net return was the highest with up to 120 kg N and 30 × 10 cm spacing.

Dwivedi *et al.* (1994) studied the effect of plant densities and N levels on French bean in Bihar, India. Crop was sown at inter row spacing of 30, 45 and 60 cm with an intra row spacing of 8 cm to give densities of 4,00,000, 2,86,000 and 2,00,000 plants/ha, respectively and was given 40, 60, 80 and 100 kg N/ha. Seed yield was the highest at the density of 4,00,000 plants/ha with nitrogen level of 80 kg/ha.

Sentelhas *et al.* (1987) showed that 200 ppm IAA increased the number of panicles/pot, the number of grains/ear and the weight of grains by foliar application with N fertilizer compared with N applied to the soil and found the highest yield with 200 ppm IAA and foliar N, in wheat. The level was too high for Sesamum crop as Sontakey *et al.* (1991) observed increased yield when 100 ppm GA_3, IAA or ascorbic acid applied at 40 days after sowing, the higher concentration being detrimental to yield.

Mangual-Crespo and Torres (1979) found that different varieties needed different spacing for growth and yield of French bean. Isasi and Bustogarcia (1985) found significant interaction between variety and spacing regarding yield of *Phaseolus vulgaris* L.

From the above mentioned literatures, it can be concluded that effect of IAA as growth regulator and nitrogen have significant effect on growth and yield of French bean. It was also observed that pod yield increases with the increase of nitrogen up to certain levels. On the basis of above mentioned facts, the experimental views may be designed to know the effect of IAA and nitrogen on yield and yield contributing characters of French bean at Bangladesh condition.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

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

3.1 Description of the experimental site

3.1.1 Location

The research work was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka, to study the effect of IAA and nitrogen on the growth and yield of French bean during the period from November 2006 to March 2007. The experimental field was located at $90^0$22 longitude and $23^0$41 N latitude and altitude of 8.6 m above the sea level.

3.1.2 Characteristics of soil

The land was Agro ecological zone of Modhupur tract (AEZ no. 28). It was deep red brown terrace soil and belongs to "Noadda" cultivated series. The selected Experimental site was well drained medium high land. The soil was silt loam in texture having p^H 6.12. The amount of organic carbon, total N, available P and K were 1.25%, 0.08%, 20 ppm and 0.20 me/100g soil, respectively. The physical and chemical characteristics of the soil have been presented in Appendix I.

3.1.3 Climate

The experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high humidity, high temperature and relatively long day period during "kharif" season (April-August) and scarce rainfall, low humidity, low temperature and short day period during "Rabi" season (October-March). This climate is also characterized by distinct season viz., the monsoon or rainy season extending from May to October, the winter or dry season from November to February and pre-monsoon period or hot season from March to April (Edris *et al.*, 1979). The meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and soil temperature for the entire experimental period have been shown in Appendix-II.

3.2 Planting materials

The cultivar of French bean used in the experiment was "BARI Zhar Sheem- 1". The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.3 Treatments of the experiment

The experiment involved two factors, namely, (i) Factor A: Indole-3 Acetic Acid (IAA) and (ii) Factor B: Nitrogen.

Factor A: Indole-3 Acetic Acid (IAA)

It consisted of three levels

i. No IAA (H_0)
ii. 5 ppm IAA (H_1)
iii. 10 ppm IAA (H_2)

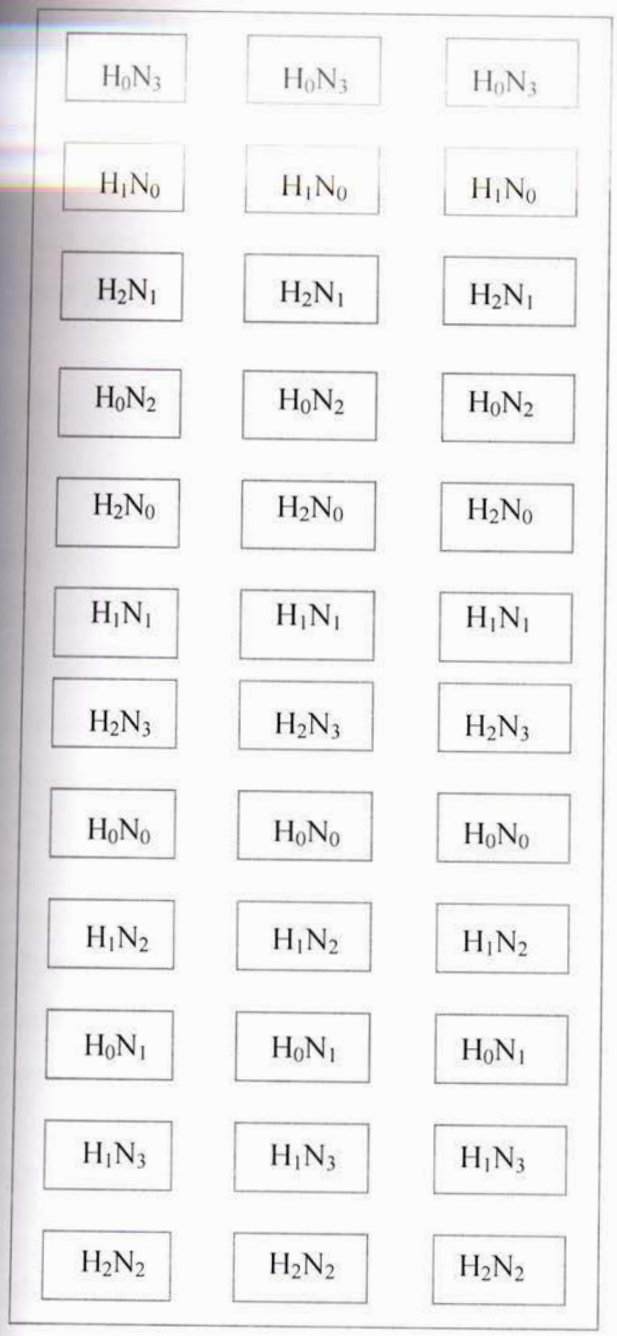
Factor B: Nitrogen

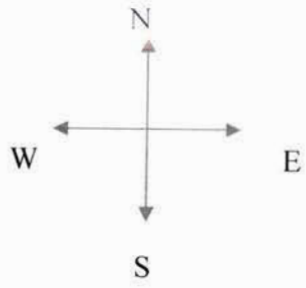
Four levels of Nitrogen

i. 0 kg N/ha (N_0)
ii. 50 kg N/ha (N_1)
iii. 100 kg N/ha (N_2)
iv. 150 kg N/ha (N_3)

3.4 Design and layout of the experiment

The two factors experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into equal 3 blocks and each consists of 12 plots. Each unit plot was 2 m × 1.5 m in size. All together there were 36 unit plots in experiment and required 220.5 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. Each unit plot had 3 rows with 50 cm distance and having 5 cm space in plant to plant (Hortex, 2005).





Plot size : 2.0 m×1.5 m,

Spacing : 50 cm × 5 cm,

Plot spacing : 0.5 m,

Between replication: 1.0 m

Factor A : H_0 = No IAA,

H_1 = 5 ppm IAA,

H_2 = 10 ppm IAA,

Factor B : N_0 = No Nitrogen,

N_1 = 50 kg N/ha.

N_2 = 100 kg N/ha

N_3 = 150 kg N/ha.

Fig. 1. Field layout of the experiment

3.5 Land preparation

At first the land was ploughed with a power-tiller on 2 November, 2006 and kept open to sunlight. Afterwards the experimental plot was prepared by five ploughings and cross ploughings followed by laddering to break the clods and to level the soil. The weeds and stubble of previous crops were collected and removed from the soil. These operations were done to bring the land under good tilth for sowing of seeds.

3.6 Manures and fertilizer application

The following doses of manures and fertilizers were applied in the experimental plot.

Manure/fertilizer	Dose/ha	Dose/plot
Cow dung	10 ton	3.6 kg
TSP	160 kg	57.6 g
MP	160 kg	57.6 g

The entire amount of well-decomposed cow dung, triple super phosphate (TSP) and muriate of potash (MP) were applied and mixed with the soil during final land preparation. Nitrogen was applied as per treatment in the form of urea. The 1/3 amount of urea was applied during final land preparation and rests amount of urea in two installments at 15 and 30 days after sowing the seeds. The applied fertilizers were mixed properly with the soil of the plot.

3.7 Application of Indole-3 Acetic Acid (IAA)

Indole-3 Acetic Acid (IAA) was applied as per treatment at 20, 23, 26 and 29 days after sowing (DAS). IAA was applied by a hand sprayer wetted equally over the plants.

3.8 Sowing of seeds

Two treated seeds were sown each hill at a depth of 3.0 cm. Seeds were treated with Babistin to protect from seed born diseases. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 18 November, 2006 in rows and at spacing of 50 cm × 5 cm. The seeds were covered with loose soil. French bean was sown as border crops to reduce border effects.

3.9 Intercultural operations

3.9.1 Gap filling

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

3.9.2 Thinning

When the plants well established, one healthy plant per hill was kept and remaining one was plucked.

3.9.3 Weeding

The experimental plots were kept weed free by hand weeding. Weeding and mulching were done three times at 20, 30 and 40 DAS.

3.9.4 Irrigation

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

3.9.5 Plant protection

a. Insect pests

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

b. Diseases

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

3.10 Harvesting

Immature green pods were harvested at tender stage through hand picking and weighed to estimate the yield of fresh pod. At harvest, pods were nearly full size, with the seeds still small (about one-quarter developed) with firm flesh (Swiader *et al.* 1992). Pods were soft and smooth during harvesting.

3.11 Collection of data

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

3.11.1 Plant height

The plant height was recorded at 15, 25, 35 and 45 days after sowing (DAS). The plant height was taken from ground level to the tip of the largest leaf of the plants. Plant heights were recorded from 10 randomly sampled plants and mean was calculated in centimeter (cm).

3.11.2 Number of leaves per plant

The number leaves of 10 randomly selected plants from each unit plot at 10 days interval from 15 DAS to 45 DAS was counted and mean were calculated.

3.11.3 Leaf length (cm)

Leaf length (cm) was measured by using measuring scale of 10 randomly selected plants from each unit plot at 45 DAS and mean was recorded.

3.11.4 Leaf breadth (cm)

Leaf breadth (cm) was measured by using measuring scale of 10 randomly selected plants from each unit plot at 45 DAS and mean was recorded.

3.11.5 Number of branches per plant

Average number of branches per plant was found from 10 randomly selected plants from each unit plot at 45 DAS and mean was recorded.

3.11.6 Germination percentage and seed vigour

Germination percentage was calculated from total germinated seeds per plot at 8 days after sowing.

Seed Vigor Index was calculated by the following formula:

Seed Vigor Index = (No. of normal seedlings/ Days required for 1st count) + (No. of normal seedlings/ Days required for 2nd count) + (No. of normal seedlings/ Days required for 3rd count) + + (No. of normal seedlings/ Days required for final count)

3.11.7 Number of flowers per plant

From 10 randomly selected plants from each unit plot numbers of flowers were counted and their mean values were founded.

3.11.8 Number of pods per plant

From 10 randomly selected plants from each unit plot numbers of pods were counted and their mean values were founded.

3.11.9 Length of green pod

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

3.11.10 Diameter of green pod

Diameters of green pod of 10 randomly selected plants from each unit plot were measured in cm with the help of slide calipers and their average was taken and was expressed in cm.

3.11.11 Number of seeds per green pod

Number of seeds per green pod was recorded from 10 randomly selected plants and the mean value was calculated.

3.11.12 Weight of fresh pods per plant

Pods from 10 randomly selected plants were weighed and their average was taken in gram (g).

3.11.13 Pod yield

Green pods were harvested at three days regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval and the total pod weights were recorded in each unit plot and expressed in kilogram (kg). The green pod yield per plot was finally converted to yield per hectare and was expressed in tonne (t).

3.12 Statistical analyses

The statistical analyses were done by using MSTATC statistical package program. The analyses of variance for the characters under study were performed by F variance test. The mean differences were adjudged by using the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3.13 Economic analyses

Economic analyses were done in order to find out the most profitable treatment combinations. Calculation was done in details according to the procedure of Alam *et al.* (1989).

3.13.1 Gross return

Gross return was calculated on the sale price of marketable green pod of French bean. The price of green pod in the market was considered at Tk. 16.00 /kg.

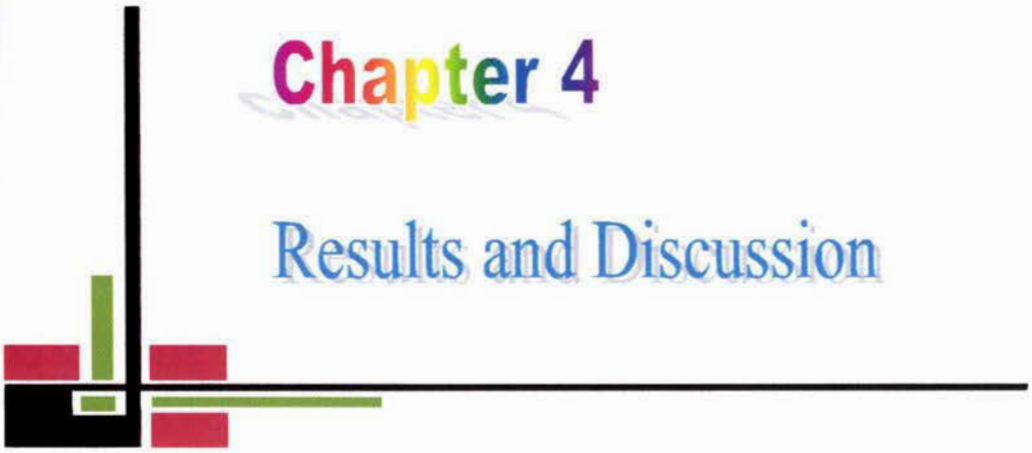
3.13.2 Net return

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

3.13.3 Benefit cost ratio (BCR)

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

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



Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Germination and Seed Vigour Index

Seedling emergences were counted at 4, 5, 6, 7 and 8 days after seed sowing and presented in Table 1. Germination percentage was calculated as per seedling emergence of 8th day. Germination percentage ranged from 86.08 to 95.25. Germination percentage revealed that application of nitrogen at basal dose inhibits the seed germination to some extent but it was not statistically significant. Seed vigour index raged from 27.92 to 38.42.

4.2 Plant height

Plant height of French bean varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to application of Indole-3 Acetic Acid (IAA) (Table 2). At 15 DAS, the longest plant height (16.73 cm) was observed due to application of 10 ppm IAA which was followed (15.30 cm) by 5 ppm IAA. The shortest (14.00 cm) plant was observed due to control treatment. Similar trend was followed at 25, 35 and 45 days after sowing. At 25 DAS, the longest (29.04 cm) plant height was recorded from 10 ppm on IAA which was similar (26.18 cm) to 5 ppm IAA and the shortest (21.36 cm) was found from control treatment. At 35 DAS, the longest (53.16 cm) plant height was found from 10 ppm IAA and the shortest (40.94 cm) was recorded from control (no hormone) treatment. At 45 DAS, the longest (59.18 cm) plant height was obtained due to the application of 10 ppm IAA which was statistically identical (55.56 cm) to 5 ppm IAA and the shortest (53.15 cm) plant height was found from control. Results revealed that the application of IAA had positive impact on plant height of French bean. It might be caused that IAA enhances cell elongation which ultimately increase the plant height.

Table 1. Seedling emergence, germination and vigor index of French bean under experimentation

Treatment combination	Number of Seedling emergence					Germination %	Seed Vigor Index
	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS		
H_0N_0	4.0	15.0	56.7	76.7	112.3	93.58	38.42
H_0N_1	2.0	9.7	37.0	67.0	111.0	92.50	31.49
H_0N_2	1.7	12.0	53.7	65.7	114.3	95.25	35.42
H_0N_3	2.7	10.3	56.3	78.0	112.3	93.58	37.27
H_1N_0	0	8.3	57.0	67.0	113.3	94.41	34.90
H_1N_1	1.3	9.0	43.0	66.0	106.7	88.92	32.03
H_1N_2	1.0	9.3	42.0	71.3	113.6	91.66	33.46
H_1N_3	1.3	7.0	51.0	79.6	105.3	87.75	34.77
H_2N_0	1.3	13.7	50.0	77.0	113.0	94.16	36.51
H_2N_1	0	6.3	30.6	54.0	110.7	92.25	27.92
H_2N_2	0	5.4	44.7	73.3	103.3	89.16	31.88
H_2N_3	0	11.6	54.6	70.7	107.0	86.08	34.91

Levels of IAA
H_0 = No IAA(Control)
H_1 = 5 ppm IAA
H_2 = 10 ppm IAA

Levels of nitrogen
N_0 = 0 kg N/ha
N_1 = 50 kg N/ha
N_2 = 100 kg N/ha
N_3 = 150 kg N/ha

Significant variation of plant height was observed due to application of different level of nitrogen (Table 3). At 15 DAS, the longest (16.38 cm) plant was produced due to application of 150 kg N/ ha which was identical (16.19 cm) to 100 kg N/ha. The shortest (13.92 cm) plant was produced in control treatment. At 25 DAS, the longest (28.79 cm) plant was produced due to application of 150 kg N/ha which was identical (27.93 cm) to 100 kg N/ha and the shortest (22.38 cm) was found from 50 kg N/ha. At 35 and 45 days after sowing, similar patterns of results were observed due to nitrogen application. At 35 DAS, the longest (51.86 cm) plant was produced in 100 kg N/ha. At 45 DAS the longest (58.17 cm) plant and the shortest (53.07 cm) plant were observed due to application of 150 kg N per hectare and control condition, respectively (Table 3). Vishwakarma *et al.* (2002) also observed that the plant height increased due to application of nitrogen in French bean. Arya *et al.* (1999) reported that application of nitrogen promotes the growth of French bean.

Significant variation of plant height was observed due to interaction effect of IAA and nitrogen level (Table 4 and Appendix-III). At 15 DAS, the longest (17.93 cm) plant was produced due to 10 ppm IAA and 150 kg N/ha which was identical to 10 ppm IAA and 100 kg N/ha (17.90 cm). The shortest plant (11.90 cm) was produced in control treatment. At 25 DAS, the longest (31.80 cm) plant was also produced due to 10 ppm IAA and 150 kg N/ha which was identical to 10 ppm IAA and 100 kg N/ha (31.73 cm). The shortest (16.87 cm) plant was produced in control condition. At 35 DAS, the longest (57.70 cm) plants were produced due to interaction effect of 10 ppm IAA and 100 kg N/ha and the shortest (30.53 cm) plant was recorded from the treatment combination of H_0N_0 (no growth regulator and no nitrogen) i.e. control condition. At 45 DAS the longest (63.83 cm) plant was produced from 10ppm IAA and 100kg nitrogen per hectare where as the shortest (50.13 cm) was observed in control.

Table 2. Effects of IAA on number of leaves/plant, leaf length and leaf breadth of French bean

IAA	Number of leaves/ plant at DAS				Leaf length (cm)	Leaf breadth (cm)
	15	25	35	45		
H_0	3.06c	5.98c	10.91b	16.86b	10.03c	6.58c
H_1	3.52b	6.66b	11.21b	16.86b	11.43b	7.48b
H_2	3.93a	7.24a	11.96a	18.42a	12.86a	8.26a
Level of significance	0.05	0.01	0.01	0.01	0.01	0.01
CV (%)	8.12	5.12	3.59	4.31	4.79	7.13

Figure in a column having similar letter(s) do not differ significantly

Levels of IAA (growth regulator):

H_0 = No IAA(Control)
H_1 = 5 ppm IAA
H_2 = 10 ppm IAA

Table 3. Effects of nitrogen on number of leaves/plant, leaf length and leaf breadth of French bean

Nitrogen	Number of leaves/ plant at DAS				Leaf length (cm)	Leaf breadth (cm)
	15	25	35	45		
N_0	3.20b	6.28b	10.66c	16.54c	8.43c	5.48c
N_1	3.43b	6.10b	11.17bc	16.91bc	10.97b	7.31b
N_2	3.44b	6.96a	12.03a	18.19a	13.23a	8.33a
N_3	3.93a	7.18a	11.58ab	17.87ab	13.11a	8.66a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	8.12	5.12	3.59	4.31	4.79	7.13

Figure in a column having similar letter(s) do not differ significantly

Levels of nitrogen

N_0 = 0 kg N/ha
N_1 = 50 kg N/ha
N_2 = 100 kg N/ha
N_3 = 150 kg N/ha

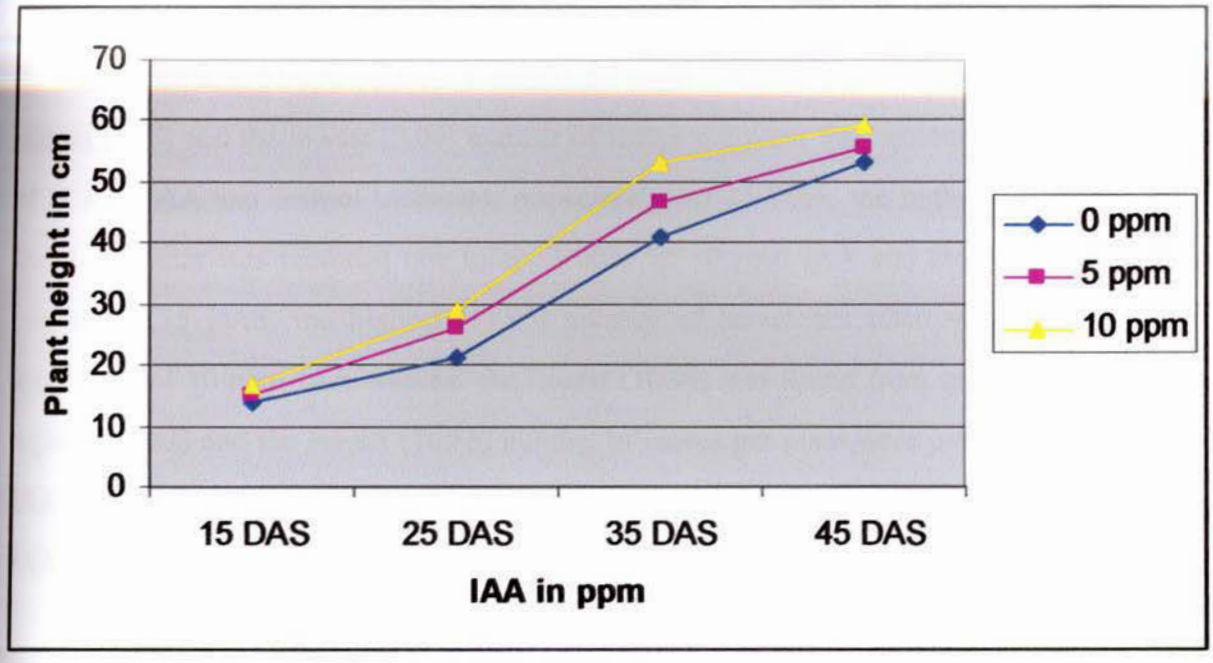


Fig. 1 : Effects of IAA in Plant height of French bean.

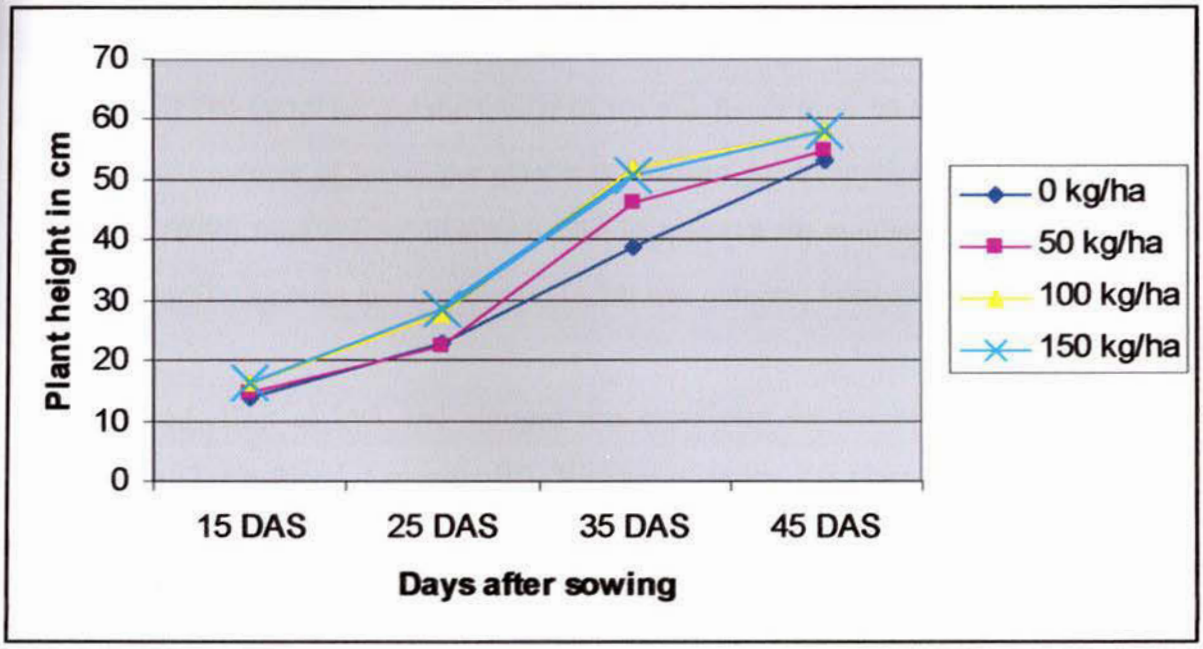


Fig. 2 : Effects of Nitrogen in Plant height of French bean.

4.3 Number of leaves per plant

Number of leaves per plant of French bean varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to application of Indole-3 Acetic Acid (IAA) (Table 2). At 15 DAS, the highest (3.93) and the lowest (3.06) number of leaves per plant was recorded due to application of 10 ppm IAA and control treatment, respectively. At 25 DAS, the highest (7.24) number of leaves per plant was recorded due to application of 10 ppm IAA and the lowest (5.98) from control. At 35 DAS, the highest (11.96) number of leaves per plant was recorded due to application of 10 ppm IAA whereas the lowest (10.91) was found from control treatment. The highest (18.42) and the lowest (16.86) number of leaves per plant were produced from 10 ppm IAA and no application of IAA, respectively at 45 DAS (Table 2). Due to application of 10 ppm IAA at all stages the highest number of leaves were found.

Number of leaves per plant of French bean varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to different nitrogen levels (Table 3). The highest (3.93) number of leaves per plant was recorded due to application of 150 kg N/ha and the lowest (3.20) was recorded from control at 15 DAS. At 25 DAS, the highest (7.18) number of leaves per was recorded due to application of 150 kg N/ ha and the lowest (6.10) was found from 50 kg N/ha. At 35 DAS, the highest (12.03) number of leaves per plant was obtained due to application of 100 kg N/ha and the lowest (10.66) from control treatment. The highest (18.19) number of leaves per plant was recorded from 100 kg N/ha and the lowest (16.54) was obtained from control at 45 DAS.

The combined effect of IAA and nitrogen was significant for number of leaves per plant of French bean (Table 4 and Appendix-III). Number of leaves per plant of French bean was the lowest in control at all days of data collection. At 15 DAS the highest (4.47) number of leaves per plant of French bean was observed due to interaction of 10 ppm IAA and 150 kg N/ha and the lowest (2.33) was found from control.

At 25 DAS, the highest (8.10) number of leaves per plant was found from treatment combination of 10 ppm IAA with 150 kg N/ha and the lowest (5.43) number of leaves per plant produced in the control treatment. The highest (12.80) number of leaves per plant was recorded from the treatment of 10 ppm IAA with 100 kg N/ha and the lowest (10.03) was found from control at 35 DAS. At 45 DAS, the highest (20.00) number of leaves per plant was recorded from 10 ppm IAA with 150 kg N/ha and 10 ppm IAA with 100 kg N/ha where as the lowest (16.35) was obtained from control which was similar to all other observations. Sentelhas *et. at.*(1987) also reported similar trend of results. The number of leaves per plant was increased due to application IAA and nitrogen.

4.4 Leaf length

Leaf length varied significantly due to application of IAA (Table 2). At 45 DAS, the highest (12.86 cm) leaf length was observed due to application of 10 ppm IAA, and the lowest (10.03 cm) was found from control treatment. Probably due to application of IAA, the longest leaf length was observed than control. The result also support to the findings of Singh and Upadhaya (1967).

Variation in leaf length was also significant due to application of different level of nitrogen. The longest (13.23 cm) leaf was recorded from 100 kg N/ha, where as the shortest (8.43 cm) was observed from control (Table 3). Ghosal *et al.* (2000) found similar trend of result which supported to this trial.

The combined effect also showed significant variation due to application different levels of IAA and nitrogen. The longest (14.93 cm) leaf was found from the treatment combination of 10 ppm IAA with 100 kg N/ha and the shortest (7.63 cm) was obtained from control condition. Sentelhas *et.al.* (1987) also reported such trend of result with the application of IAA and nitrogen in wheat.

Table 4. Combined effects of IAA and nitrogen on plant height, number of leaves/plant, leaf length and leaf breadth of French bean

IAA x Nitrogen	Plant height (cm) at DAS				Number of leaves per plant at DAS				Leaf length (cm)	Leaf breadth (cm)
	15	25	35	45	15	25	35	45		
H_0 x N_0	11.90f	16.87e	30.53f	55.33c	2.33c	5.43d	10.03e	16.93b	7.63	5.18
H_0 x N_1	13.97e	18.93e	40.80e	51.30de	3.17b	5.43d	11.20bcd	16.87b	9.10	6.10
H_0 x N_2	14.93cde	24.30d	45.77d	50.73e	3.13b	6.37c	11.10cd	16.67b	11.53	7.28
H_0 x N_3	15.20bcd	25.33cd	46.67d	55.23c	3.60b	6.70c	11.30bcd	16.97b	11.83	7.76
H_1 x N_0	15.00cde	24.83d	39.40e	50.13e	3.43b	6.9bc	10.27de	16.33b	7.83	5.13
H_1 x N_1	14.47de	22.90d	44.83d	53.97cd	3.33b	6.13cd	11.10cd	16.57b	11.47	7.44
H_1 x N_2	15.73bc	27.77bc	52.10c	59.33b	3.57b	6.87bc	12.20ab	17.90b	13.23	8.47
H_1 x N_3	16.00bc	29.23b	50.40c	58.80b	3.73b	6.73c	11.27bcd	16.63b	13.17	8.90
H_2 x N_0	14.87cde	27.33bc	47.00d	53.73cd	3.83ab	6.50c	11.67bc	16.37b	9.83	6.12
H_2 x N_1	16.23b	25.30cd	52.63bc	58.70b	3.80ab	6.73c	11.20bcd	17.30b	12.33	8.40
H_2 x N_2	17.90a	31.73a	57.70a	63.83a	3.63b	7.63ab	12.80a	20.00a	14.93	9.23
H_2 x N_3	17.93a	31.80a	55.30ab	60.47b	4.47a	8.10a	12.17ab	20.00a	14.33	9.30
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NS	NS
CV (%)	4.16	3.05	2.06	1.65	8.12	5.12	3.59	4.31	4.79	7.13

Figure in a column having similar letter(s) do not differ significantly. NS = not significant.

Plot size = 2m×1.5m

Levels of hormone (IAA)
H_0 = No IAA(Control)
H_1 = 5 ppm IAA
H_2 = 10 ppm IAA

Levels of nitrogen
N_0 = 0 kg N/ha
N_1 = 50 kg N/ha
N_2 = 100 kg N/ha
N_3 = 150 kg N/ha

4.5 Leaf breadth

Leaf breadth varied significantly due to application of IAA (Table 2). At 45 DAS, the highest (8.26 cm) leaf breadth was observed due to application of 10 ppm IAA and the lowest (6.58 cm) was recorded from control. The highest leaf breadth was observed due to application of 10 ppm IAA and the lowest in control.

Variation of leaf breadth was also significant due to application of different levels of nitrogen (Table 3). The highest (8.66 cm) leaf breadth was observed due to application of 150 kg N/ha and the lowest (5.48 cm) was found from control treatment. The highest leaf breadth was observed due to application of 150 kg N/ha which was statistically similar (13.11 cm) to 100 kg N/ha.

4.6 Number of branches per plant

Number of branches per plant of French bean varied significantly due to application of IAA (Table 5). The highest (18.07) number of branches per plant of French bean was recorded due to application of 10 ppm IAA and the lowest (14.24) was obtained from control treatment. Number of branches per plant of French bean showed increasing tendency with increasing concentration of IAA. The result also support to the finding of Mishriky (1990).

Significant variation of number of branches per plant of French bean was observed due to application of different levels of nitrogen (Table 6). The highest (19.56) number of branches per plant was observed due to application of 150 kg N/ha and the lowest (11.19) was recorded from control treatment. Baboo *et al.* (1998) reported similar trend of result in case of French bean.

Table 5. Effects of IAA on yield and yield contributing characters of French bean

IAA	Number of branches/plant	Number of flowers/plant	Number of pods/plant	Length of green pod (cm)	Diameter of green pod (cm)	Number of seeds/green pod	Pod yield /plot (kg)
H_0	14.24c	39.28c	26.81c	14.42b	1.27b	5.73b	3.82c
H_1	15.92b	41.78b	29.68b	15.26a	1.36a	6.04ab	4.60b
H_2	18.07a	47.62a	36.68a	15.52a	1.41a	6.24a	5.12a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	4.03	2.61	4.36	2.38	5.64	5.46	4.81

Figure in a column having similar letter(s) do not differ significantly

Levels of hormone (IAA)

H_0 = No IAA(Control)

H_1 = 5 ppm IAA

H_2 = 10 ppm IAA

Variation in number of branches per plant was significant due to interaction of IAA and nitrogen (Table 7 and Appendix-IV). The highest number (21.37) of branches per plant was observed due to application of 10 ppm IAA and 100 kg N/ha which was followed by 10 ppm IAA and 150 kg N/ha treatment (20.93). The lowest number (9.47) of branches per plant was recorded from control condition.

4. 7 Number of flowers per plant

Application of IAA influenced significantly on number of flowers per plant (Table 5). The highest (47.62) number of flowers per plant was recorded due to application of 10 ppm IAA and the lowest (39.28) number of flowers was obtained from control condition. Choudhury *et.al* (1967) also found similar trend of results in cucumber which support the present study.

Number of flowers per plant varied significantly due to application of nitrogen (Table 6). The highest number of (45.77) flowers per plant of French bean was found due to application of 100 kg N/ha which identically (45.53) followed by 150 kg N/ha. The lowest number (38.31) of flowers per plant of French bean was observed in control.

The combined effect of IAA and nitrogen on number of flowers per plant of French bean was also significant (Table 7). The highest (54.23) number of flowers per plant of French bean was observed due to application of 10 ppm IAA and 100 kg N/ha and the lowest (35.97) was found from control condition. Sentelhas *et al.* (1987) also reported similar trend of result which supported to the present study.

Table 6. Effects of nitrogen on yield and yield contributing characters of French bean

Nitrogen	Branches/plant (nos.)	Number of flowers/plant	Number of pods/plant	Length of green pod (cm)	Diameter of green pod (cm)	Seeds/green pod (nos.)	Yield per plot in kg
N_0	11.19d	38.31c	26.04c	14.41b	1.23b	5.24c	3.81b
N_1	15.04c	41.94b	29.73b	15.18a	1.37a	5.89b	4.42a
N_2	18.52b	45.77a	36.54a	15.33a	1.35a	6.34a	4.86a
N_3	19.56a	45.53a	31.90b	15.34a	1.43a	6.54a	4.97a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	4.03	2.61	5.36	2.38	5.64	5.46	4.81

Figure in a column having similar letter(s) do not differ significantly

Levels of nitrogen

N_0 = 0 kg N/ha
N_1 = 50 kg N/ha
N_2 = 100 kg N/ha
N_3 = 150 kg N/ha

4.8 Number of pods per plant

Number of pods per plant varied significantly due to application of IAA (Table 5). The highest (36.68) number of pods per plant was recorded due to application of 10 ppm IAA. The lowest (26.81) number of pods per plant was obtained from control. The result also supported to the findings of Mishriky (1990).

Number of pods per plant varied significantly due to application of nitrogen (Table 6). The highest (36.54) number of pods per plant of French bean was found due to application of 100 kg N/ha. The lowest 26.04 number of flowers per plant of French bean was observed in control condition.

Effect of interaction of IAA and nitrogen on number of pods per plant of French bean was significant (Table 7). The highest number (46.37) of pods per plant of French bean was observed due to application of 10 ppm IAA and 100 kg N /ha and the lowest (24.53) in control.

4.9 Length of green pod

Length of green pod of French bean varied significantly due to application of IAA (Table 5). The highest (15.52 cm) length of green pod of French bean was recorded due to application of 10 ppm IAA and the lowest (14.42 cm) was found from control treatment.

A Significant variation on length of green pod of French bean was observed due to application of different levels of nitrogen (Table 6). The longest (15.34 cm) length of green pod of French bean was observed due to application of 150 kg N /ha which was similar (15.33 cm) to 100 kg N /ha. The shortest (14.41 cm) green pod of French bean was observed in control.

Variation in length of green pod of French bean was significant due to interaction of IAA and nitrogen (Table 7 and appendix-V). The longest (16.23 cm) green pod of French bean was observed due to application of 10 ppm IAA and 100 kg N/ha. The shortest (13.13 cm) green pod of French bean was reported for control. Singh and Upadhaya (1967) observed similar trend of result which supported the present study.

4.10 Diameter of green pod

Diameter of green pod varied significantly due to application of IAA (Table 5). The highest (1.41 cm) diameter of green pods was observed due to application of 10 ppm IAA and the lowest (1.27 cm) was observed from control treatment.

Significant difference was observed in diameter of green pod due to application of nitrogen (Table 6). The highest (1.43 cm) diameter of green pods were observed due to application of 150 kg N/ha and the lowest (1.23 cm) was obtained from control treatment. The diameter was statistically similar in all nitrogen applied treatments.

A significant variation was observed due to combine effect of IAA and nitrogen (Table 7). The highest (1.57 cm) diameter of green pod was recorded from 10 ppm IAA and 100 kg N /ha while the lowest (1.12 cm) was obtained from control condition. Singh and Upadhaya (1967) also found large size tomato with the application of IAA.

4.11 Number of seeds per green pod

Application of IAA influenced significantly on number of seeds per green pod (Table 5). The highest (6.24) number of seeds per green pod was recorded due to application of 10 ppm IAA, where as the lowest (5.73) was observed in control.

A significant variation was found in number of seeds per green pod of French bean due to application of nitrogen (Table 6). The highest (6.54) number of seeds per green pod of French bean was found due to application of 150 kg N/ha which identically followed by 100 kg N /ha. The lowest (5.24) number of seeds per green pod of French bean was observed in control.

Effect of interaction of IAA and nitrogen in number of seeds per green pod of French bean was significant (Table 7). The highest number (6.80) of seeds per green pod of French bean was observed due to application of 10 ppm IAA and 100 kg N/ha and the lowest (4.66) was in control.

4.12 Yield of Green Pod per hectare

Effect of IAA on yield of green pod of French bean was significant (Fig.3 & Appendix- **VI**). The highest (16.79 t/ha) yield of French bean was recorded due to application of 10 ppm IAA and the lowest (12.72 t/ha) was obtained from control treatment. Choudhury (1967) was observed higher yield in Cucumber with the application of IAA. He stated that IAA increases the number of female flowers and suppressed the male flowers.

Yield of green pod of French bean varied significantly due to application of nitrogen (Fig.4 & Appendix- **VI**). The highest (16.19 t/ha) yields were recorded due to application of 100 kg N/ha which was followed (16.15 t/ha) by 150 kg N/ha and the lowest (12.33 t/ha) was found from control. Singh *et al.* (1996) also reported the highest yield with 120 kg N/ha.

Effect of interaction of IAA and nitrogen on yield of green pod of French bean was significant (Table 7 & Appendix-VI). The highest green pod yield (18.77 t/ha) was obtained in 10 ppm IAA and 100 kg N /ha while the lowest (9.91 t/ha) green pod yield was recorded from control treatment.

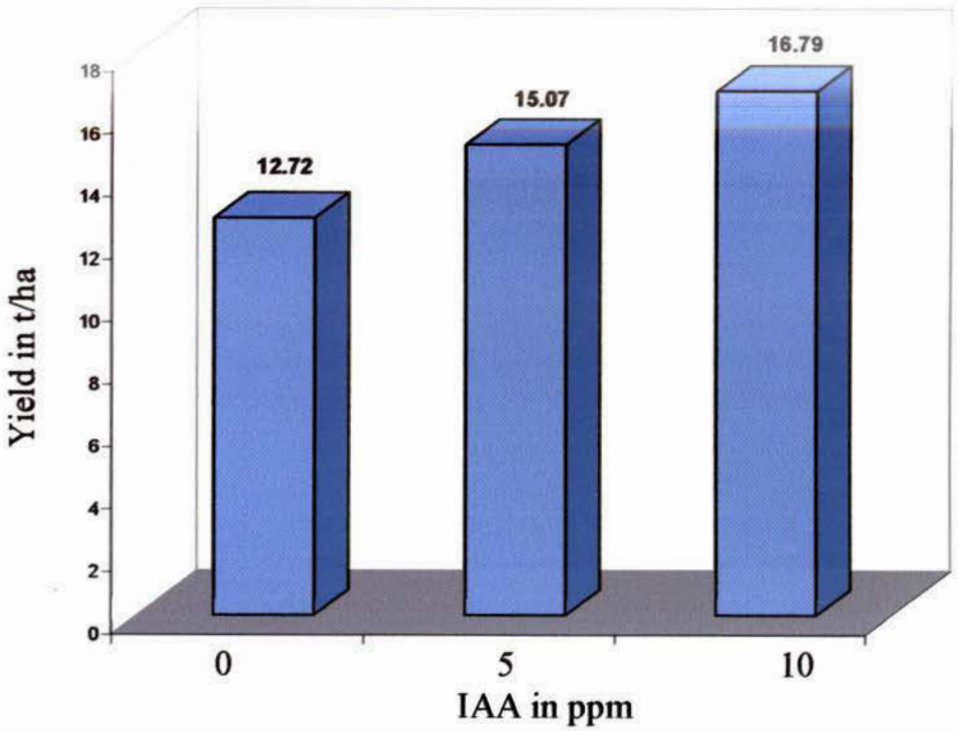


Fig. 3 : Effects of IAA on Yield of French bean

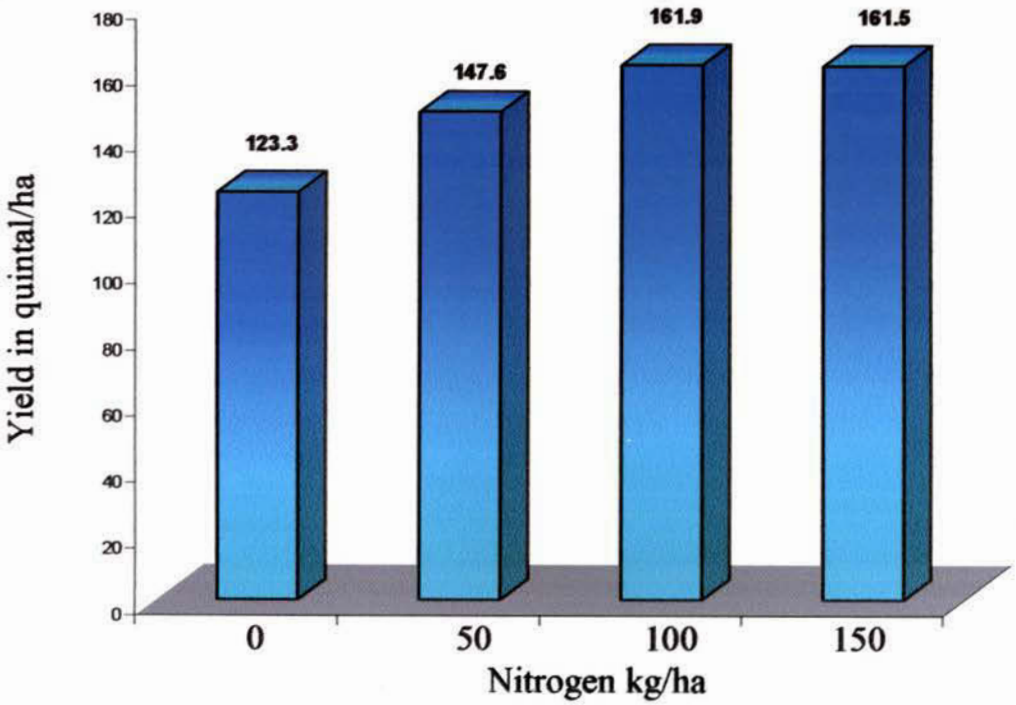


Fig. 4 : Effects of Nitrogen on Yield of French bean

Table-7. Combined effects of IAA and nitrogen on yield and yield contributing characters of French bean

IAA x Nitrogen	Number of branches/ plant	Number of flowers/ plant	Number of pods/plant	Length of green pod (cm)	Diameter of green pod (cm)	Seeds/green pod (no.)	Yield per plot in kg	Yield of green pod (t/ha)
$H_0 \times N_0$	9.47f	35.97g	24.53f	13.13d	1.12d	4.66c	2.97	9.91
$H_0 \times N_1$	13.63e	40.00ef	27.77def	15.07bc	1.38ab	5.96ab	3.82	12.72
$H_0 \times N_2$	15.60d	39.67ef	29.77cd	14.50c	1.14cd	5.63b	4.06	13.53
$H_0 \times N_3$	18.27c	41.47de	25.17ef	14.97bc	1.43ab	6.67a	4.42	14.74
$H_1 \times N_0$	10.56f	37.63fg	24.63f	14.97bc	1.29bcd	5.57b	3.91	13.04
$H_1 \times N_1$	15.07de	41.40de	29.43cd	15.10bc	1.38ab	5.70b	4.66	15.53
$H_1 \times N_2$	18.60c	43.40cd	33.50c	15.27bc	1.33bc	6.60a	4.89	16.29
$H_1 \times N_3$	19.47bc	44.67c	31.13cd	15.70ab	1.44ab	6.30ab	4.96	15.40
$H_2 \times N_0$	13.53e	41.33de	28.97de	15.13bc	1.29bcd	5.50b	4.54	14.03
$H_2 \times N_1$	16.43d	44.43c	32.00cd	15.37bc	1.36b	6.00ab	4.78	16.04
$H_2 \times N_2$	21.37a	54.23a	46.37a	16.23a	1.57a	6.80a	5.63	18.77
$H_2 \times N_3$	20.93ab	50.47b	39.40b	15.33bc	1.41ab	6.67a	5.52	18.31
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	NS	NS
CV (%)	4.03	2.61	5.36	2.38	5.64	5.46	4.81	7.04

Figure in a column having similar letter(s) do not differ significantly

NS = not significant.

Levels of IAA
H_0 = No IAA(Control)
H_1 = 5 ppm IAA
H_2 = 10 ppm IAA

Levels of nitrogen
N_0 = 0 kg N/ha
N_1 = 50 kg N/ha
N_2 = 100 kg N/ha
N_3 = 150 kg N/ha

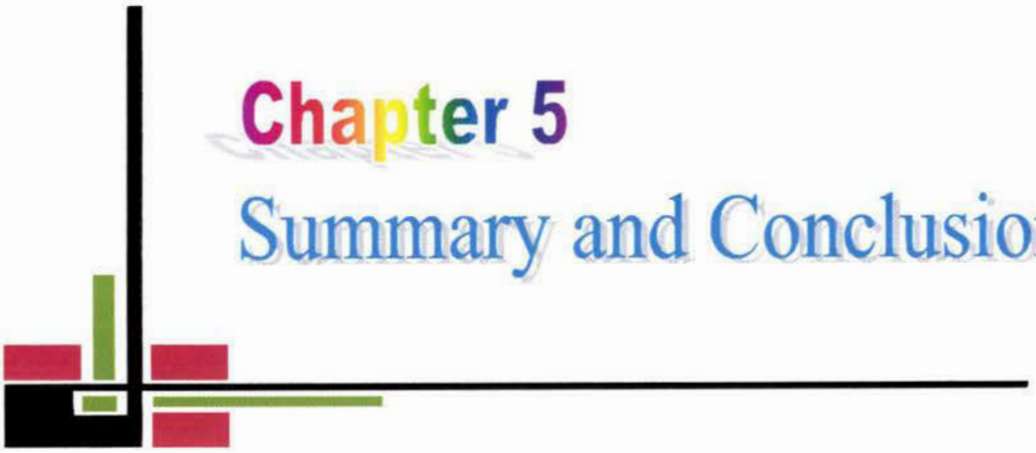
4.13 Economic Analyses

Economic analyses were done on gross return, total cost of production, net return and benefit cost ratio (BCR) as per values of inputs and outputs during experiment. Gross return was calculated from the yield with value of Tk. 16/kg (Table 8). Gross return of French bean ranged from Tk. 158560/ha in control to Tk. 300320/ha in 10 ppm IAA and 100 kg N/ha. Total cost of production of French bean ranged from Tk. 79893/ha in control to Tk. 86304/ha in 10 ppm IAA and 150 kg N/ha. Net return of French bean ranged from Tk. 78667/ha in control to Tk. 214905/ha in 10 ppm IAA and 100 kg N/ha. The highest (3.52) benefit cost ratio was obtained due to application of 10 ppm IAA and 100 kg N/ha while the lowest (1.98) in control. French bean is a short duration crop. The BCR indicates that it is a profitable crop in comparison to other cereal crops.

Table 8. Economic analyses of French bean considering different levels of IAA (PGR) and nitrogen application

Treatments	Pod yield (t/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR)
H_0N_0	9.91	158560	79893	78667	1.98
H_0N_1	12.72	203520	82537	120983	2.47
H_0N_2	13.53	216480	83426	133054	2.59
H_0N_3	14.74	235840	84315	151525	2.80
H_1N_0	13.04	208640	81472	127168	2.56
H_1N_1	15.53	248480	84116	164364	2.95
H_1N_2	16.29	260640	85005	175635	3.07
H_1N_3	15.4	246400	85894	160506	2.87
H_2N_0	14.03	224480	81882	142598	2.74
H_2N_1	16.04	256640	84526	172114	3.04
H_2N_2	18.77	300320	85415	214905	3.52
H_2N_3	18.31	292960	86304	206656	3.39

Note: Price of harvested green pod @ Tk. 16.00/kg
BCR = Gross return ÷ Total cost of production



Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka to study the effect of IAA and nitrogen on the growth, yield and yield contributing characters of French bean during the period from November 2006 to March 2007. The land was belongs to Agro ecological zone of Modhupur tract (AEZ no. 28). The selected experimental site was well drained high land. The soil was silt loam in texture having p^H 6.18. The content of organic carbon, total N, available P and K were 1.25%, 0.08%, 20 ppm and 0.20 me/100g soil, respectively. The experiment included two factors, namely, Factor A: Levels of Indole-3 Acetic Acid (0, 5 and 10 ppm IAA) and Factor B: levels of nitrogen (0, 50, 100 and 150 kg/ha). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each unit plot was 2 m × 1.5 m in size. The variety of French bean used in the experiment was BARI Zhar Sheem 1. The seed was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

At first the land was ploughed with a power-tiller on 2 November, 2006 and kept open to sunlight. Afterwards the experimental plot was prepared by five ploughings and cross ploughings followed by laddering to break the clods and to level the soil. The weeds and stubble of previous crops were collected and removed from the soil. These operations were done to bring the land under good tilth for sowing of seeds. The experimental plots were laid out in accordance with the experimental design.

Cow dung, triple super phosphate and muriate of potash were applied at the rates of 10 t/ha, 160 kg/ha and 160 kg/ha, respectively as basal dose. Nitrogen was applied according to the treatment allotted for each plot in the form of urea. The 1/2 amount of urea was applied during final land preparation and rests amount of urea in two installments at 15 and 30 days after sowing the seeds. Indole-3 Acetic Acid (IAA) was applied as per treatments at 20, 23, 26 and 29 days after sowing (DAS). The IAA was applied by a hand sprayer wetted equally over the plants.

Two seeds were sown each hill at a depth of 3.0 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The sowing was done on 18 November, 2006 in rows with a spacing of 50 cm x 5 cm. Intercultural operations were done as and when necessary.

Malathion 57 EC was sprayed at the rate of 2 ml/liter at an interval of 15 days to control insects. Seedlings were attacked by damping off and Dithane M-45 was sprayed at the rate of 2 ml/liter at an interval of 15 days. Immature green pods were harvested at tender stage through hand picking and weighed to estimate the yield of fresh pod. Ten plants were selected at random in such a way that the border effect could be avoided. Data were taken on plant height, number of leaves per plant, leaf size, number of branches per plant, germination, number of flowers per plant, number of green pods per plant, length of green pod, diameter of green pod, number of seeds per plant. Economic analyses were done for cost of production, gross return, net return and benefit cost ratio (BCR) calculation. The analyses of variance for the characters under study were performed by F variance test and mean differences were adjudged by using the Duncan's Multiple Range Test.

Application of nitrogen at basal dose inhibits the seed germination to some extent. Germination percentage revealed that application of nitrogen decreased the germination but it was not statistically significant. Seed vigour index ranged from 27.92 to 38.42.

Plant height of French bean varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to application of Indole-3 Acetic Acid (IAA) as hormone. At 15 DAS, the longest 16.73 cm plant height was observed due to application of 10 ppm IAA and the shortest 21.36 cm plant was observed in control treatment. Similar trend was followed at 25, 35 and 45 days after sowing.

Significant variation of plant height was observed due to application of different levels of nitrogen at 15, 25, 35 and 45 days after sowing. The longest (16.38 cm) plant height was found from 150 kg N/ha and the shortest (13.92 cm) was observed from control treatment at 15 DAS. At 25 DAS, the longest (28.79 cm) was found from 150 kg N/ha and the shortest (22.38 cm) was obtained from 50 kg N/ha. The longest (58.17 cm) plant height was recorded from 150 kg N/ha and the control treatment showed the lowest (53.07 cm) at 45 DAS. Significant variation on plant height was observed due to interaction effect of IAA and different levels of nitrogen. The longest plant (63.83 cm) was produced due to 10 ppm IAA and 100 kg N/ha. The shortest plant was produced in control treatment.

Number of leaves per plant of French bean varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to application of Indole-3 Acetic Acid (IAA) as growth regulator. At all stages, the highest number of leaves per plant was recorded for 10 ppm IAA and the lowest in control.

Number of leaves per plant of French bean varied significantly at 15, 25, 35 and 45 days after sowing (DAS) due to different nitrogen level. The highest number of leaves per plant was observed due to application of 150 kg N/ha at 15 and 25 DAS. Whereas at 35 and 45 DAS, the highest number leaves per plant was observed in 100 kg N/ha. The control produced the lowest number leaves per plant.

The effect of interaction of IAA and nitrogen was significant on number of leaves per plant of French bean. Number of leaves per plant of French bean was the lowest in control at all days of data collection. Number of leaves per plant of French bean was highest due to interaction of 10 ppm IAA and 150 kg N per hectare. The number of leaves per plant of French bean increased due to application of both IAA and nitrogen.

Leaf length varied significantly due to application of IAA and nitrogen. The longest leaf was produced due to application of 10 ppm IAA and the shortest in control. The longest leaf was observed due to application of 100 kg N per hectare which was identical to 150 kg N per hectare. The shortest leaf was produced in control.

Leaf breadth varied significantly due to application of IAA. The highest leaf breadth was observed due to application of 10 ppm IAA and the lowest in control. Variation of leaf breadth was also significant due to application of different level of nitrogen. The highest leaf breadth was observed due to application of 150 kg N per hectare which was statistically similar to 100 kg N/ha. The lowest leaf breadth was observed in control.

Number of branches per plant of French bean varied significantly due to application of IAA. Number of branches per plant of French bean was 14.24, 15.92 and 18.07 due to application of 0, 5 and 10 ppm IAA, respectively. Number of branches per plant of French bean showed increasing tendency with increasing concentration of IAA. The highest (19.56) number of branches per plant was observed due to application of 150 kg N/ha and the lowest (11.19) in control. The highest number (21.37) of branches per plant was observed due to application of 10 ppm IAA and 100 kg N/ha. The lowest number (9.47) of branches per plant was reported for control.

Application of IAA influenced significantly on number of flowers per plant. Number of flowers per plant was recorded 39.28, 41.78 and 47.62 for application of 0, 5 and 10 ppm IAA, respectively. The highest (45.53) number of flowers per plant of French bean was found due to application of 150 kg N/ha and the lowest (38.31) was observed in control. The highest number (54.23) of flowers per plant of French bean was observed due to application of 10 ppm IAA and 100 kg N/ha and the lowest (35.97) in control.

Number of pods per plant varied significantly due to application of IAA and nitrogen. Number of pods per plant was recorded 26.81, 29.68 and 36.68 for application of 0, 5 and 10 ppm IAA, respectively. The highest (36.68) number of pods per plant was obtained in 10 ppm IAA. The highest number of pods per plant (36.54) of French bean was found due to application of 100 kg N/ha and the lowest (26.04) was observed in control. The highest number (46.37) of pods per plant of French bean was observed due to application of 10 ppm IAA and 100 kg N/ha and the lowest (24.53) in control.

Length of green pod of French bean varied significantly due to application of IAA and nitrogen. The longest length of green pod of French bean was observed due to application of 10 ppm IAA and the shortest in control. Length of green pod of French bean was observed 14.41, 15.18, 15.33 and 15.34 cm due to application of 0, 50, 100 and 150 kg N/ha, respectively. The longest green pod of French bean was observed due to application of 150 kg N/ha. The shortest green pod of French bean was observed in control. The longest green pod (16.23 cm) of French bean was observed due to

application of 10 ppm IAA and 100 kg N/ha (H_2N_2) and the shortest (13.13 cm) were reported for control.

Diameter of green pod varied significantly due to application of IAA and nitrogen. Diameters of green pods were observed 1.27, 1.36 and 1.41 cm for application of 0, 5 and 10 ppm IAA, respectively. The highest diameter was showed in case of 10 ppm IAA which was also statistically similar to 5 ppm IAA. Diameters of green pods were observed 1.23, 1.37, 1.35 and 1.43 cm for application of 0, 50, 100 and 150 kg N/ha, respectively. The highest diameters (1.57 cm) of green pod were recorded in 10 ppm IAA and 100 kg N/ha while the lowest (1.12 cm) in control.

Number of seeds per green pod was recorded 5.73, 6.04 and 6.24 for application of 0, 5 and 10 ppm IAA, respectively. The highest number of seeds per green pod of French bean was found due to application of 150 kg N/ha which was identically followed by 100 kg N /ha. The lowest number of seeds per green pod of French bean was observed in control. The highest number (6.80) of seeds per green pod of French bean was observed due to application of 10 ppm IAA and 100 kg N/ha and the lowest (4.66) in control.

Yield of French bean was recorded 12.72, 15.07 and 16.79 t/ha due to application of 0, 5 and 10 ppm IAA, respectively. The highest (16.79 t/ha) yield was obtained due to application of 10 ppm IAA and the lowest (12.72 t/ha) in control. Yields were recorded 12.33, 14.76, 16.19 and 16.15 t/ha due to application of 0, 50, 100 and 150 kg N/ha, respectively. The highest yield of French bean was obtained due to application of 150 kg N/ha which was identically followed by 100 kg N/ha and the lowest in control. The highest pod yield of 18.77 t/ha was obtained in 10 ppm IAA and 100 kg N/ha and the lowest (9.91 t/ha) in control.

Gross return was calculated from the yield with value of Tk. 16 per kg. Gross return of French bean ranged from Tk. 158560 /ha in control to Tk. 300320 /ha in 10 ppm IAA and 100 kg N/ha. Total cost of production of French bean ranged from Tk. 79893 /ha in control to Tk. 86304 /ha in 10 ppm IAA and 150 kg N/ha. Net return of French bean ranged from Tk. 78667 /ha in control to Tk. 214905 /ha in 10 ppm IAA and 100 kg N/ha. The highest (3.52) benefit cost ratio was obtained due to application of 10 ppm IAA and 100 kg N/ha while the lowest (1.98) in control.

Results revealed that application of IAA and nitrogen at different level had positive impact on growth, yield and yield components of French bean. It was also found that the economic benefit also higher in relation to cereal crops.

Conclusion:

Application of IAA and nitrogen ensured the higher yield in French bean. French bean is one of the promising crops in the global perspective. Its consuming demand is increasing day by day. It stands on an excellent as pod crops for its nutritional values. The experiment was conducted in AEZ no. 28 for one season. Further such type of experiment may be conducted in different Agro-ecological zones of Bangladesh for more confirmation.

REFERENCES

Adams, M. W. 1984. Beans-Cowpea: Production constraints and national programs-Cowpea Collaborative Research Support Program, Michigan State University East Lansing, Michigan. pp. 23-28

AICPIP. 1987. Consolidated report on Rabi Pulse. Directorate of Pulses Research, Kanpur, India. pp. 62-67

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.

Akhter, M. N. 2007. Effect of IAA and GA3 on the growth, curd formation and yield of cauliflower. MS. Thesis, Dept. of Horticulture and Post Harvest Technology, Sher-e-Bangla Agril. University, Dhaka 1207. p-34.

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): 146-147.

Awan, I. and Alizai, H. K. 1989. Effect of plant growth regulators on ripening, grain development and rice quality. IRRN, **14** (3): 30-31.

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

Biswas, A. K. and Mandal, S. K. 1988. Manipulation of senescence, source-sink relationship and yield by growth regulating chemicals. *Indian J. Plant Physiol.*, **31** (2) : 152-157.

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., Rajpul, C. B. S., Singh, K.P. and Singh, S. J. P. 1987. A role on the effect of nitrogen, phosphorus and *Rhizobium* culture on the growth and yield of French bean (*Phaseolus vulgaris* L.) cv. contents. *Haryana J. Hort. Sci.* **16**(8): 146-147.

Choudhury, B. and S. C. Pahatak, 1959. Sex expression and sex ratio in Cucumber *(Cucumis sativus* L.) as affected by plant regulator sprays. *Indian J. Hort.* **17** : 145-153.

Choudhury, B., S. C. Pahatak and A. V. Patil, 1967. Effect of plant regulator sprays on sex, fruits set and fruit development in Cucumber (*Cucumis sativus* L.) Proceedings *Bihar academy of Agril. Sc.* **11** : 251-257.

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.

Duke, J. A. 1983. Hand Book of Legumes of World Economic Importance (Second Ed.), Plenum Press, New York. p. 341.

Dwivedi, D. K., Singh, H., K. M., Shahi, B. and Rai, J. N. 1994. Response of French bean (*Phaseolus vulgaris*L.) to population densities and nitrogen levels under mid-upland situation in north-east alluvial plains of Bihar. *Indian J. Agron.*, **39** (4): 581-583.

FAO. 2000. Production Year book. Food and Agriculture Organization of the United Nations. Rome, Italy. 54: p.108.

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.

Gill. H. S., Pachauri, D. C. and Sharma, S. R. 1976. A note on the spacing requirement of French bean (*Phaseolus vulgaris* L) for seed production. *Indian Hort.*, **33** (2): 187-188.

Gomez, K. A. and Gomez. A. A.1984. Statistical Producer for Agricultural Research. 2nd ed. John Willey and Sons, New York. pp.28-192.

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): 180-184.

Hedge, D. M. and Srinivas, K. 1990. Plant water relations and nutrient uptake in French bean. *Irrigation Sci.*, **11** (1): 51-56.

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

Isasi, M. F. and Bustogarcia, I. 1985. The effect of plant spacing on the yield of common bean (*Phaseolus vulgaris* L*)* cultivars with different growth types. Ciencias de la Agriculture, 23: 127-129. [Cited from *Hort. Abst.*, **57** (50): 3393-3358].

Koli, B. D., Akasheand, V.B. and Shaikh, A. A. 1996. Effects of row spacing, plant density and N level on the yield and quality of French bean. *PKV Res. J.*, **20** (2): 174-175.

Kuccy, R. M. N. 1989. The influence of rate and time of mineral N application on yield and N_2 fixation by field bean. *Canadian J. Plant Sci.*, **69** (2):427-436.

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.

Mangual-Crespo, G. and Torres, C. J. 1979. Response of pole beans (*Phaseolus vulgaris* L.) to various plant densities, 63(4): 465-468 [Cited from Hort. Abst., **50**(4): 357-4234].

Mishriky, J.F. 1990. Effect of GA_3, IAA and chlormequat (ccc) on growth, yield and quality of peas. Bulletin of Faculty of Agricultural University of Cairo, **41**(3):785-797.

Pandey, R. P. and K. Singh 1973. Note on the effect of nitrogen and maleic hydrazide on sex expression, sex ratio and yield of bottle gourd. *Indian, J. Agril. Sc.*, **43** (9) : 882-883.

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

Purseglove, J. W. 1987. Tropical Crops: Dicotyledons. Longman. New York, p. 52.

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 J. 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.

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 House, Dhaka. pp. 396-399.

Sa, M. E. D., Bjuzetti, S., Morello, S. and Deziderio, N. D. 1982. Effects of plant density and phosphate fertilizer on bean production. Centro Nacional de Pesquisa Arroz Feijao, 101-103 [Cited from Field Crop Abst., **28** (2): 44-53, 1983].

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.

Sentelhas, P. C., Caetano, J. R. G. and Teixeira, N. T. 1987. The effect of IAA and foliar nitrogen on wheat, Ecossistema, **12** :123-128. [Plant Growth Regulator Abst., (1991). **17** (3): 102].

Shanmugavelu, K. G. 1989. Production technology of vegetable crops. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. pp. 446-461.

Singh, D. N., Mehar, R. C. and Singhans, M. 1990. Response of French bean *(Phaseolus vulgaris* L.) to irrigation and nitrogen application. *Haryana J. Agron.*, **6**:1, 94-95.

Singh, A. K. Singh, S. R. 2000. Effect of different dates of sowing and nitrogen levels on yield and yield attributing traits of French bean *(Phaseolus vulgaris* L.). *Crop Res. Hissar*, **20** (2): 257-260.

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.

Singh, K. and S. K. Upadhaya 1967. A comparative study on soil and foliar application of indole-3 acetic acid (IAA) and naphthalene acetic acid (NAA) on several responses of tomato (*Lycopersicon esculentum* Mill.). *Horticulturist*, **2**: 3-9.

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.

Srinivas, K. and Naik, L. B. 1990. Growth, yield and nitrogen uptake in vegetable French bean (*Phaseolus vulgaris* L) as influenced by nitrogen and phosphorus fertilization. *Haryana J. Hort. Sci.*, **19** (1-2): 160-167.

Swiader, J. M., Ware, G. W. and McCollum, J. P. 1992. Producing Vegetable Crops. 4th ed. Interstate Publishers. Inc. Danville. Illions. USA, pp. 223-249.

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

Tindall, H. D. 1988. Vegetables in the tropics. McMillan Education Ltd., 527p.

Virender, S.; K. K. Dhingra, S. M., Gill, J. I. 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.

Appendix I. Results of the mechanical and chemical analysis of soil of the experimental plot

Mechanical analyses:

Constituent	Percent
Sand%	33.65
Silt%	60.15
Clay%	6.20
Textural class	Silt loam

Chemical Analyses:

Soil properties	Analytical data
Soil p^H	6.12
Organic Carbon (%)	1.25
Total Nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K (%)	0.2

Source: Soil Testing Laboratory, SRDI, Dhaka.

Appendix II. Monthly records (Dekadal) of average temperature, rainfall and relative humidity during the period from November, 2006 to February, 2007.

Year	Month	Date	Average Temperature (^{0}C)			Total rainfall (mm)	Average relative humidity (%)	Soil temperature at different depth (^{0}C)		
			Max.	Min.	Average			5 cm	10 cm	20 cm
2006	November	1-10	30.13	22.93	26.53	2	72.7	36.36	27.9	27.8
		11-20	30.25	19.50	24.88	1	69.0	24.86	26.32	26.82
		21-30	28.61	17.37	22.99	2	63.0	22.54	23.89	24.83
2006	December	1-10	27.39	15.54	21.47	0	69.6	20.45	22.02	22.82
		11-20	27.11	16.46	21.78	0	70.5	20.60	22.05	22.68
		21-31	26.21	15.53	20.87	0	67.9	20.06	21.37	22.14
2007	January	1-10	21.92	11.52	16.72	0	78.8	17.57	18.49	19.99
		11-20	24.63	11.35	17.99	0	58.4	17.13	19.12	19.40
		21-31	26.90	14.38	20.64	0	67.1	18.77	20.24	20.58
2007	February	1-10	26.43	17.73	22.08	17	79.7	21.70	22.84	22.77
		11-20	25.97	15.63	20.80	13	67.3	20.27	21.65	22.26
		21-28	29.38	16.94	23.18	0	57.5	21.66	23.43	23.90

Source: Bangladesh Meteorological Department, Agargaon, Sher-e-Bangla Nagar, Dhaka-1207.

Appendix-III. Analyses of variance of the data on plant height and number of leaves of French bean as influenced by IAA (Growth regulator) and nitrogen

Source of variation	Degrees of freedom	Mean square							
		Plant height (cm) at DAS				Number of leaves at DAS			
		15	25	35	45	15	25	35	45
Replication	2	0.46	0.79	3.73	1.09	0.03	0.32	0.09	1.66
IAA (A)	2	22.43**	180.96**	448.28**	110.68**	2.29**	4.76**	3.51**	9.71**
Nitrogen (B)	3	12.03**	98.03**	309.29**	56.91**	0.85**	2.43**	3.10**	5.42**
Interaction (A×B)	6	1.34*	4.33**	9.08**	35.69**	0.23*	0.45**	0.61**	3.29**
Error	22	0.40	0.61	0.93	0.85	0.08	0.11	0.16	0.56
Total	35								

** = Level of Significance at 1% and * = Level of Significance at 5%

Appendix-IV. Analyses of variance of the data on leaf length, leaf breadth, number of branch/plant of French bean as influenced by IAA (growth regulator) and nitrogen.

Source of variation	Degrees of freedom	Mean square		
		Leaf length at 45 DAS(cm)	Leaf breadth at 45 DAS(cm)	No. of branch at 45 DAS
Replication	2	1.87	1.15	2.04
IAA (A)	2	24.08**	8.47**	44.10**
Nitrogen (B)	3	45.82**	18.39**	129.11**
Interaction (A×B)	6	0.70^{NS}	0.41^{NS}	1.78**
Error	22	0.30	0.28	0.42
Total	35			

** = Level of Significance at 1% and ^{NS} = Not Significant.

Appendix-V. Analyses of variance of the data on length of green pod, diameter of green pod, seeds/green pod of French bean influenced by IAA and nitrogen

Source of variation	Degrees of freedom	Mean square		
		Length of green pod	Diameter of green pod	Seeds/green pod
Replication	2	0.01	0.02	0.72
IAA (A)	2	3.97**	0.06**	0.78**
Nitrogen (B)	3	1.75**	0.06**	2.99**
Interaction (A×B)	6	0.82**	0.03**	0.45**
Error	22	0.13	0.01	0.11
Total	35			

** = Level of Significance at 1%.

Appendix-VI. Analyses of variance on number of flowers/plant, pods/plant, yield of French bean as influenced by IAA and nitrogen

Source of variation	Degrees of freedom	Mean square		
		Flowers/plant (no.)	Pods/plant (no.)	Yield (t/ha)
Replication	2	1.89	9.32	0.90
IAA (A)	2	219.91**	309.70**	122.08**
Nitrogen (B)	3	111.37**	173.10**	31.56**
Interaction (A×B)	6	17.43**	34.65**	2.56**
Error	22	1.25	2.77	0.24
Total	35			

** = Level of Significance at 1%.

Appendix -VII. Production cost of green pod of French bean per hectare

A. Input cost (Tk. /ha)

Treatment	Labour Cost (Tk.)	Ploughing Cost (Tk)	Seed Cost (Tk.)	IAA Cost (Tk)	Irrigation Cost (Tk)	Pesticidal Cost (Tk)	Cowdung Cost (Tk)	Urea Cost (Tk)	TSP Cost (Tk)	MP Cost (Tk)	Total Input Cost (Tk)
H_0N_0	26000	3000	8000	-	2000	1200	7000	-	3300	2400	52900
H_0N_1	27500	3000	8000	-	2000	1200	7000	760	3300	2400	55160
H_0N_2	27500	3000	8000	-	2000	1200	7000	1520	3300	2400	55920
H_0N_3	27500	3000	8000	-	2000	1200	7000	2280	3300	2400	56608
H_1N_0	27500	3000	8000	350	2000	1200	7000	-	3300	2400	54250
H_1N_1	28500	3000	8000	350	2000	1200	7000	760	3300	2400	56510
H_1N_2	28500	3000	8000	350	2000	1200	7000	1520	3300	2400	57270
H_1N_3	28500	3000	8000	350	2000	1200	7000	2280	3300	2400	58030
H_2N_0	27000	3000	8000	700	2000	1200	7000	-	3300	2400	54600
H_2N_1	28500	3000	8000	700	2000	1200	7000	760	3300	2400	56860
H_2N_2	28500	3000	8000	700	2000	1200	7000	1520	3300	2400	57620
H_2N_3	28500	3000	8000	700	2000	1200	7000	2280	3300	2400	58380

B. Overhead Cost (Tk/ha)

Treatment	Cost for rent of land (6 months)	Miscellaneous cost (5% of the input Cost)	Interest on running capital for 6 month (12%)	Total overhead cost (Tk/ha)	Total input cost (Tk/ha)	Total cost of production (Tk/ha)
H_0N_0	18000	2645	6348	26993	52900	79893
H_0N_1	18000	2758	6619	27377	55160	82537
H_0N_2	18000	2796	6710	27506	55920	83426
H_0N_3	18000	2834	6801	27635	56680	84315
H_1N_0	18000	2712	6510	27222	54250	81472
H_1N_1	18000	2825	6781	27606	56510	84116
H_1N_2	18000	2863	6872	27735	57270	85005
H_1N_3	18000	2901	6963	27864	58030	85894
H_2N_0	18000	2730	6552	27282	54600	81882
H_2N_1	18000	2843	6823	27666	56860	84526
H_2N_2	18000	2881	6914	27795	57620	85415
H_2N_3	18000	2919	7005	27924	58380	86304