GROWTH AND YIELD PERFORMANCE OF YARD LONG BEAN (*Vigna unguiculata* var. *sesquipedalis*) INFLUENCED BY NUTRIENT MANAGEMENT AND AUXIN

RIDWANA AFRIN NAHID
Reg. No. 17-08310

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

DECEMBER, 2018

GROWTH AND YIELD PERFORMANCE OF YARD LONG BEAN (*Vigna unguiculata* var. *sesquipedalis*) INFLUENCED BY NUTRIENT MANAGEMENT AND AUXIN

BY

RIDWANA AFRIN NAHID

Reg. No. 17-08310

A Thesis
Submitted to the Department of Horticulture
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 2018

Approved by

…….	…….
Prof. Dr. Md. Ismail Hossain	**Dr. Jasim Uddin**
Dept. of Horticulture SAU, Dhaka – 1207 **Supervisor**	Assistant Professor Dept. of Horticulture SAU, Dhaka -1207 **Co-Supervisor**

…….

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"GROWTH AND YIELD PERFORMANCE OF YARD LONG BEAN (*Vigna unguiculata* var. *sesquipedalis*) INFLUENCED BY NUTRIENT MANAGEMENT AND AUXIN"** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **Horticulture**, embodies the result of a piece of bonafide research work carried out by **RIDWANA AFRIN NAHID**, Registration No. **17-08310** 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.

December, 2019
Dhaka, Bangladesh

(Prof. Dr. Md. Ismail Hossain)
Department of Horticulture
SAU, Dhaka-1207

Dedicated to
My
Beloved Parents

ACKNOWLEDGEMENTS

The author seems it a much privilege to express her enormous sense of gratitude to the almighty Allah for there ever ending blessings for the successful completion of the research work.

The author wishes to express her gratitude and best regards to her respected Supervisor, ***Prof. Dr. Md. Ismail Hossain****, Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of this thesis.*

The author wishes to express her earnest respect and enormous indebtedness to her Co-supervisor, ***Dr. Jasim Uddin****, Associate Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for providing her with all possible help during the period of research work.*

The author feels to express her heartfelt thanks to the honorable Chairman, ***Prof****.* ***Dr. Mohammad Humayun Kabir ,*** *Department of Horticulture, along with all other teachers and staff members of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their co-operation during the period of the study.*

The author feels proud to express her deepest and endless gratitude to all of her course mates and friends to co-operate and help her during taking data from the field and preparation of the thesis. The author wishes to extend her special thanks to her lab mates, class mates and friends for their heartiest co-operation and encouragement.

The author expresses her heartfelt thanks to her beloved parents. May Almighty bless and protect them all.

The Author

GROWTH AND YIELD PERFORMANCE OF YARD LONG BEAN (*Vigna unguiculata* var. *sesquipedalis*) INFLUENCED BY NUTRIENT MANAGEMENT AND AUXIN

ABSTRACT

The field experiment was conducted at the Horticultural Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from March, 2019 to July, 2019 to study the effects of different levels of nutrient management and growth regulator Auxin on the growth and yield of Yard long bean. The experiment consisted of two factors. Factor A: four levels of nutrient management; i) N_0: control (N_0, P_0, K_0) Kg/ha ; ii) N_1: (N_{12} P_{18} K_{22}) Kg/ha; iii) N_2: (N_{18} P_{27} K_{33}) Kg/ha; iv) N_3: (N_{24} P_{36} K_{44}) Kg/ha. Factor B: three levels of Auxin (Indole acetic acid); i) I_0 : control (0 ppm); ii) I_1: 20 ppm iii) I_2: 40 ppm. The variety of Yard long bean was taken BARI borboti-1. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The results revealed that nutrient management and auxin had significant effect on the plant height, number of leaf, number of branch, number of flower, number of pod per plant, pod yield per hectare. In case of Nutrient management, highest yield (14.5 t/ha) was observed in N_2 treatment and lowest yield (9.61 t/ha) was observed in N_0 treatment. For auxin, the highest yield (12.57 t/ha) was observed from I_2 treatment and the lowest yield (9.83 t/ha) was observed from control treatment I_0. For combined effect, N_2I_2 treatment combination gave the highest yield (16.64 t/ha) and lowest yield (6.37 t/ha) was obtained from N_0I_0 combination treatment. So, from the result, it may be concluded that application of 18 kg N/ha, 27 kg P/ha and 33 kg K/ha with 40 ppm auxin is the best for growth and higher yield of Yard long bean.

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURE

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Yard long bean (*Vigna unguiculata*) is a vegetable crop and widely cultivated in Bangladesh, India, Indonesia, Philippines and Shrilanka (Ullah *et al*., 2011). Yard long bean is also called asparagus bean, chinese long bean, pea bean, string bean, snake bean, snake pea, snap pea, bodi and borboti (Bhagavati *et al.,* 2019). It belongs to the family Fabaceae. It is an important summer vegetable. It is fast growing annual plant. It has dwarf and tall climbing varieties. It has great commercial value at summer season when there is scarcity of vegetables. Yard long bean is one of the most popular vegetables in Bangladesh. It has potentiality for export of fresh and frozen and can grown all year round (Rashid, 1999). Yard long bean is grown through the tropics, but very common in Southern Asia and Southern China. Yard long bean is important for high quality livestock fodder and residual nitrogen suppliers in soil, fixing atmospheric nitrogen (Leikam *et al.,* 2007).

The Yard long bean production of Bangladesh of the year 2016-17 was 25206 MT from 16085 acres of land and the production from Barisal is 894 MT, from chittagong is 7488 MT, from Dhaka is 2842 MT, from Khulna 5881 MT, from Mymenshingh is 1967 MT, from Rajshahi 1463 MT, from Rangpur 2931 MT and from Sylhet 1740 MT (BBS, 2018).

The tender green pods of Yard long bean rich in crude protein (28%), iron (2.5 mg/100g), calcium (80 mg / 100g), phosphorus (74mg / 100g), vitamin A (941 IU /100g), vitamin C (13 mg / 100g) and dietary fibre (2g / 100g) make it an excellent vegetable (Singh *et al*., 2001). The pods contain large quantities of soluble and insoluble fibres. Since the entire green pod is eaten as in green beans, sufficient amount of dietary fiber is obtained in the diet. Dietery fiber helps to protect the colon mucosa by reducing its exposure time to toxic substance as well as by binding to cancer-causing chemicals colon.

Yard long bean is a worm season crop. The optimum growth temperature is 27-30^0 C. It tolerates heat and dry conditions better than common bean or lima bean (Rubatzly and Yamaguchi, 1997).

Although this vegetable crop is cultivated intensively by trailing on to bowers and trellis in view of its poteniat for continuous high yield, problem such as delayed and erratic flowering and low pod set are frequent. Application of plant growth regulators has been widely recommended to overcome problems such as low flowering and poor pod set in vegetable crops (Reshmi and Gopalakrishnan, 2004). Plant growth regulators play an important role in high value horticultural crops to increase yield, enhance crop quality and management (Emonger, 2007). The potential use of nutrients and growth regulators can increase its growth and yield. Treatment with Auxin can increase plants growth and yield. Auxin stimulates cell elongation, root initiation, delays leaf senescence, can induce fruit setting and growth (Salisbury and Ross, 1992).

Phosphorus fertilization is the key component in increasing soil productivity and maximizing yield of crops (Susila *et al.*, 2010). Yard long bean is a nitrogen fixing plants. It requires low nitrogen. Potassium is an essential plant nutrient for proper growth and reproduction of beans. An optimum rate of application of growth regulators and fertilizers can ensure better growth and yield of Yard long bean which ultimately will lead general farmers for commercial application of these substances.

Considering all above factors, the present study was undertaken with the following objectives:

- To determinate the appropriate concentration of Auxin on growth and yield of Yard long Bean.
- To optimize the nutrient level on growth and higher yield of Yard long bean.
- To find out the best combination of Auxin and nutrient level on growth and higher yield of Yard long bean.

CHAPTER II

REVIEW OF LITERATURE

Yard long bean is an important summer vegetables in Bangladesh. A lots of work has been done in the world to study the effect of growth regulators and nutrients Nitrogen, Phosphorus and potassium. But in bangladesh available literature regarding effects of growth regulators, nitrogen , phosphorus and potassium is insuffucient and sometimes conflicting. However, soma of relevent literatures are presented below to know the effect of growth regulator auxin and nutrient management of nitrogen, potassium, phosphorus on yard long bean growth and yield.

2.1 Review in relation to growth regulator Auxin (Indole 3 Acetic Acid)

Emonger (2007) carried out an experiment with plant growth regulators Auxin on Cowpea exogenously 7 days after emergence at 30, 60 and 90 mgl^{-1} significantly increased plant height, first node length, leaf area, leaf number, nodulation, pod number/plant, pod length, seed number/pod, plant dry matter accumulation, 100 seed weight.

Reshmi and Gopalakrishna (2004) carried out an experiment on Yardlong bean to study the effect of 4 growth regulators in Kerala. 4 plant growth regulators namely NAA (15, 30, 45 ppm), 2,4-D (2, 4 and 6 ppm), IAA (20, 40 and 60 ppm) and CCC (300, 400, 500 ppm) were sprayed on yard long bean at different growth stages to evaluate its impact on flowering and fruit set. Foliar spray of NAA of 15 ppm give the highest yield followed by IAA at 40 ppm and CCC at 300 ppm. 2,4-D had a strong depressing effect on growth and yield of yard long bean.

Mishriky (1990) conduct an experiment on pea and found that protein content increased when 50 ppm GA_3 was applied at 30 DAS . The forgoing 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 in yard long bean.

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.

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, IAA or ascrobic acid applied at 40 days after sowing, the higher concentration being determental to yield.

Biswas and Mandal (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.

2.2. Review in relation to Nutrient management

Mbeke *et al*. (2014) carried out an experiment to study the effect of nitrogen on *Phaseolus vulgaries* L.. and found higher yield obtained with 22 kg N/ha.

Yin *et al.* (2018) performed an experiment on mung bean from 2013-2016 at the Baichang Academy of Agricultural Sciences, Baichang, China to study the combined effect of N, P, K and maximum yield was found by the ration N:P:K = 1:0.5:1.59.

Dwivedi *et al*. (1994) studied the efect of plant densities and N level 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.

Farhad *et al.* (2017) was conducted a field experiment on soya bean (*Glycine max*) at char jangalia under MLT site, Laxmipur to evaluate the effect on growth and yield performance of soya bean .Best result was found by the combination of nutrient managemnent 50% N:P:K (15:12.5:27.5 kg/ha) + biofertilizer.

Aray *et al*. (1999) performed an experiment to study the combined effect of N, P, K on french bean. Best combination was found by using 25 kg N/ha, 75 kg P_2O_5/ha, 50 kg K_2O/ha.

Begum *et al.* (2003) conduct an experiment on yard long bean and found highest yield by the treatment of N, P, K is followed by 90, 50, 120. The pod length is highest (55.7cm) in this treatment.

Landa *et al*. (2002) showed that application of N, P, K significantly influenced the growth and advanced the harvesting date off green beans.

Tiwari and Singh (2000) conducted a field experiment to find the optimum and economical dose of nitrogen (0, 40, 80 or 160 kg ha^{-1}) and phosphorus (0, 20, 40 or 60 kg/ha) for higher growth and seed yield of french bean. They reprted that plant growth of height, number of branch, pod length incease with the succesive increse of the dose of nitroogen and phosphorus.

Landa *et al*. (2002) reported that application of N, P, K significantly influenced the growth, vigor and advanced the harvesting date of yard long beans.

Thirumalai *et al.* (1993) reported that the best yield of Yard long bean was obtained by applying 62.5 kg N + 100 kg P_2O_5 + 75 kg K_2O/ha.

Sushant *et al*. (1999) conducted an experiment in india to investigate the effect of N(O, 50 or 100 kg N ha^{-1}) and P (O,30 or 60 kg P $ha^{-1)}$ on the yield and water used efficiency of french bean.Yield increased with increasing irrigation and N and P rates. The highest yield was obtained at 100 kg N ha^{-1} and 60 kg P_2O_5.Water use efficiency increased with increasing N and P rates. Interaction of irrigation and N. and N and P were significant for pods $plant^{-1}$ and seed yield.

Gajendra and Singh (1998) conducted a field experiment at lalchaoti in india.They reported that 120 Kg N + 90 kg P_2O_5 and 45 kg K_2O ha^{-1} gave higher grain yield of French bean.

Sexena and Varma (1995) studied the effect of nitrogen, phosphorus and potassium on the growth and yield of French bean (*Phaseolus vulgaris*). They observed that nitrogen affected all the growth attributes, viz, plant height, leaf

number, leaf area, fresh weight, dry weight, branches, at harvest and yield significantly up to 120 kg N ha^{-1} . Interaction effect of nitrogen and phosphorus was noticed in leaves $plant^{-1}$. All the growth attributes were positive and significantly correlated with the grain yield.

Srinivas and Khan (1990) conducted field trails to study the nitrogen uptake of French bean as influenced by nitrogen and phosphorus fertilization.They applied N at 0, 40,80 and 120 kg / ha and P_2O_5 at 0, 40 and 80 kg ha^{-1}. Half of N all the P and basal K_2O at 40 kg ha^{-1} were applied at planting and the remaining n was applied 25 days later. They found that both N and p application increased plant growth, plant height, nutrient uptake and yield green pods.

Srinivas and Naik (1988) reported that pod yield increased with increasing fertilizer rate from 3927 kg ha^{-1} at zero N to 13167 kg ha^{-1} at 160 kg N $ha^{-1.}$.

Rana and Singh (1988) stated that seed and straw yield were increased significantly with the increse of N rate in Yard long bean. They used 0, 40, 80 or 120 kg N ha^{-1} and 0, 50 or 100 kg P_2O_5 ha^{-1}. The mean increses in seed yield with 120 kg N ha^{-1} compared with 0, 40 and 80 kg N ha^{-1} were 66.66, 21.7 , 7.096 respectively.

Bhopal and Singh (1987) studied the respose of french ban to nitrogen and phosphorus fertilization. They applied nitrogen at 0-90 kg/ha and at 0-120 kg P_2O_5/ha and 50 kg K_2O / ha. They found that the optimum dose of N, P was 67.3, 79.7 kg/ha.

Popescu *et al*. (1992) experimented on Yard long bean and found that N, P, K significantly increased the seed yield , Pand the highest yield was found at 75 kg N, 80 kg P_2O_5 and 120 kg K_2O/ ha.

Srinivas and Rao (1984) performed an experiment in Bangalore. India dfield experiment on French bean with phosphorus at 0, 60, 120 and 160 kg/ha and Potassium at 0, 60 and 120 kg/ha. Nitrogen was applied at 100 kg/ha. The growth rate of shoot and yield was increased with the increased rate of P and K and found highest yield at the combination of 160 kg P + 120 kg K /ha.

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

A field experiment was conducted by Farkade and Pawar (2002) to determine the effect of N:P fertilizer at 60:45, 90:75 and 120:75 kg ha^{-1} on *Phaseolus vulgaris* cultivativars, The yield and growth characters increased with increasing N:P fertilzer level and the highest value was obseved at 120:75 kg ha^{-1}.

Kakon *et al*. (2016) conducted an experiment at BARI, Joydebpur , Gazipur to study the effect of N and P on growth , dry matther production on French bean and observed that seed yield significantly increased with the increase of nitrogen and phosphorus level upto 150 kg N and 44 kg P / ha respectively.

Morais *et al.* (1995) conducted a field experiment on French bean with Phosphorus at 0, 60, 120 and 160 kg/ha and Potassium at 0, 60 and 120 kg/ha. Nitrogen was applied at 100 kg/ha. The growth rate of shoot and yield was increased with the increased rate of P and K and found highest yield at the combination of 160 kg P + 120 kg K /ha.

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 and Singh (1988) 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.

Parthiban and Thamburaj (1991) carried a field 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 (1989) carried a field 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.

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.

Kamal (2007) carried a field experiment at research field of Sher-e-Bangla Agricultural University. Dhaka in the Modhupur Tract (AEZ 28), during the rabi season from December 2006 to February 2007 to study the effect of nitrogen and molybdenum on the growth and yield of bush bean (*Phaseolus vulgaris* L.) cv. BARI Jhar Sheem-l. He found that there was a positive impact of each nutrient and their interaction on number of effective branches plant^{-1}, population m $^{-1}$, number of green pod plant^{-1}, pod length, diameter of pod, number of seed pod^{-1}, pod yield plot^{-1} seed yield plot^{-1} and 1000 seed weight, green pod yield, seed yield and straw yield with increasing the rate of' nitrogen and molybdenum. All these parameters increased upto N_{120} and $Mo_{0\cdot5.}$ Highest green pod yield (18.00 t ha^{-1}) and seed yield (3.10 t ha^{-1}) was obtained from $N_{120.}$

Shamima (2010) carried a field experiment at the research field of Sher-e-Bangla Agricultural University, Dhaka in Modhupur Tract (AEZ 28), during the rabi season from December 2004 to February 2005 to study the effect of nitrogen and phosphorus on the growth and yield of bush bean (*Phaseolus vulgaris* L.) cv. BARI bush bean-I. The highest green pod yield (15.35 t ha^{-1}) and seed yield (2.58 ha^{-1}) were obtained from P_{75}.

A field experiment was conducted by Roy and Parthasarathy (1999) to investigate the phosphorus requirement of French bean varieties. They used 0-120 kg P/ ha and observed that pod yield was highest (07.69 t/ ha) with 120 kg P/ ha.

Prabhakar *et al.* (1987) reported that green pod yield of French bean increased with phosphorus fertilization up to 75 kg ha^{-1}. Addition of phosphorus and zinc up to certain level increased the yield of green grain (Patial and Somawanshi, 1982)

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

Devender *et al.* (1988) carried out an experiment to study the effect of nitrogen and phosphorus on the yield of French bean and stated that application of nitrogen upto 150 kg and 60 kg P_2O_5 / ha significantly increased seed per pod and seed yield.

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

Parmer and Singh (1999) reported that French bean was treated with three levels of nitrogen (0, 15 and 30 kg/ha) and four levels of Phosphorus (0, 30, 60 and 90 kg P_2O_5/ha) in a field experiment conducted in Himachal Pradesh, India during summer season. Plant height, number of pods per plant and seed/pod were increased with increasing rate of N

Sadhu and Roy (1991) reported that application of phosphorus, nitrogen and potassium significantly increased the growth and yield of kidney bean. They got highest plant height (48 cm) and highest yield (12.5 ton/ha) with the combination of 120 kg N + 75 kg P_2O_5+ 60 kg K_2O/ha.

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

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.

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 Nagi (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

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 growth and yield performance of Yard long bean influenced by nutrient management and auxin during the period from 15th March, 2019 to 20th July 2019. The methods and materials which was used in conducting the experiment have been presented in this chapter under following subtitles.

3.1. Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.2. Characteristics of soil

The soil of this experiment was collected from the Horticultural farm. The soil of the experiment area belongs to 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). The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix III.

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 rainfall associated with moderate temperature during robi season i.e. October to March .

3.4. Planting materials

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

3.5 Experimental details

3.5.1 Treatment of the Experiment

The experiment involved two factors. Factor A and Factor B

Factor A: Nutrient management – 4 levels

1. N_0 : Control ($N_0P_0K_0$)
2. N_1 : ($N_{12}P_{18}K_{22}$) Kg/ha
3. N_2 : ($N_{18}P_{27}K_{33}$) Kg/ha
4. N_3 : ($N_{24}P_{36}K_{44}$) Kg/ha

Factor B: IAA (Indole acetic acid) – 3 levels

1. I_0 : control (0 ppm)
2. I_1 : 20 ppm
3. I_2 : 40 ppm

Treatment combinations - 12 treatment combinations

(I_0N_0, I_0N_1, I_0N_2, I_0N_3, I_1N_0, I_1N_1, I_1N_2, I_1N_3, I_2N_0, I_2N_1, I_2N_2 and I_2N_3) Kg/ha

3.5.2 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 layout of the experiment was prepared for distributing the different combination of nutrient management and IAA levels. The 12 treatment combinations of the experiment

were assigned at random into 36 plots. The size of each unit plot 1.5 m × 1.2 m. All together there were 36 unit plot and required 149.25 m^2 . Layout of this experiment is showed

3.6 Land preparation

Firstly, the land was ploughed with a power tiller at 15th March, 2019. Then the land was kept to dry sunlight. Doing ploughing and cross ploughing the experiment plot wae 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.

3.7 Fertilizers and manures application

The following manure and fertilizers were applied

In the treatment of N_1 : Urea , TSP and MoP were applied 27 kg/ha, 86 kg/ha and 31 kg/ha, respectively. And per block 43 g urea , 61 g TSP and 60 g MOP was given. Per split 1.56 g urea was given.

In the treatment of N_2 : Urea , TSP, MoP were applied 39.130 kg/ha, 56.25 kg/ha, 55kg/ha, respectively. 59 g Urea, 91 g TSP and 89 g MoP were given per block. Per split 2.34 g Urea was given.

In the treatment of N_3 : 52.2 kg/ha Urea, 75 kg/ha TSP and 73.3 kg/ha MoP were given. 85 g Urea, 121 g TSP and 118.8 g MoP were given per block. Per split 3.13 gm Urea was given.

Total amount of well composed cow dung, triple super phosphate (TSP) and murate 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 1/3rd amount of urea was applied and rest amount was applied in two instalments at 15th and 30th days after sowing. The fertilizers which were applied mixed in appropriate portion with the plot soil

3.8 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 brone diseases. The seeds were coverd with pulverized soil just after sowingand gently pressed with hands. The seed sowing was done on 15th March, 2019 in rows and at spacing of 60 cm×30 cm . The seeds were covered with loose soil. French bean was sown as border crops to reduce border effects.

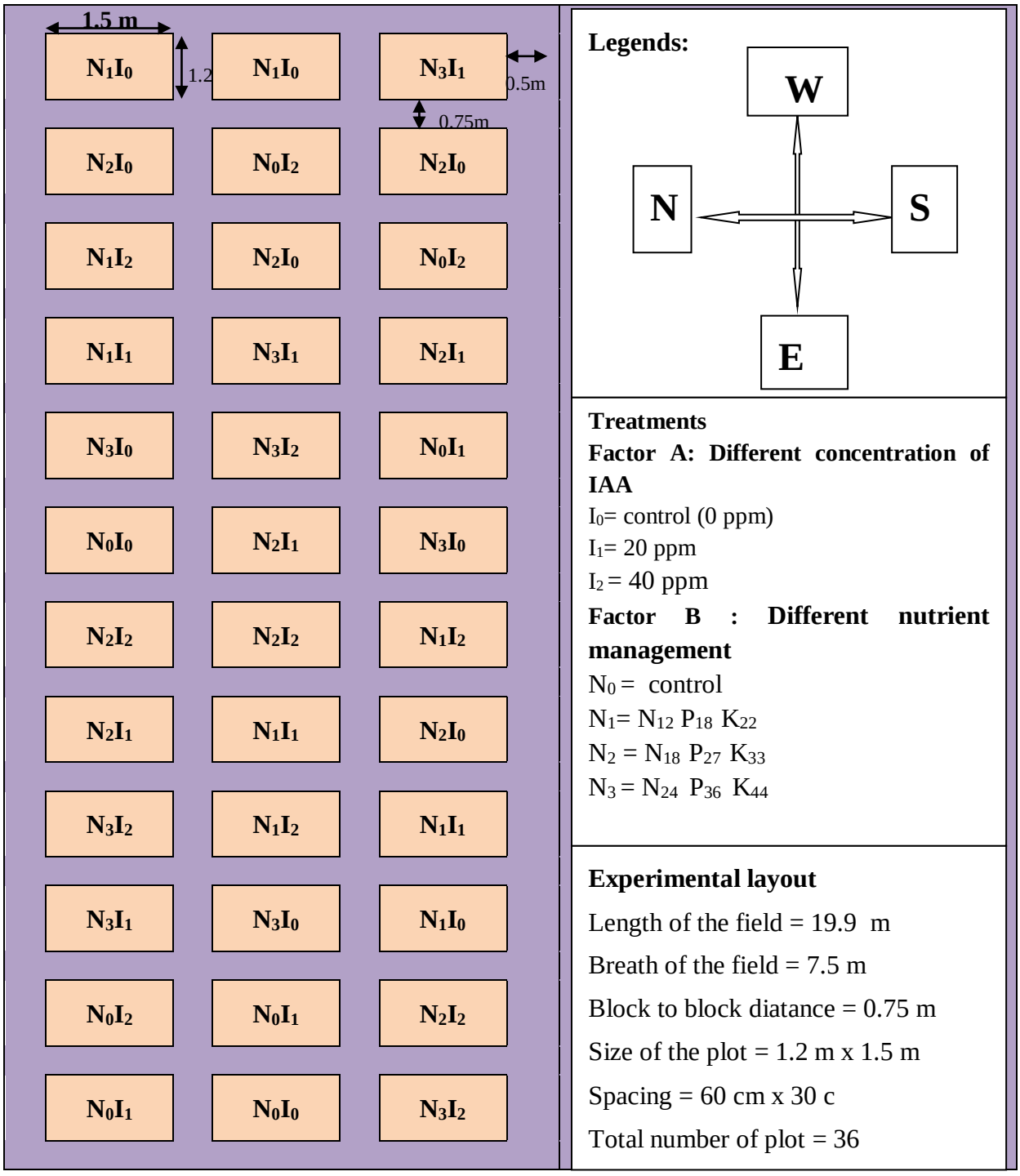

Fig. 1. Layout of the experimental plot

3.9 INTERCULTURAL OPERATION

3.9.1 Gap filling

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

3.9.2 Thinning

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

3.9.3. Irrigation

Irrigation was given as per requirement with the help of watering cane into young plant. Irrigation was done after 4 days interval.

3.9.4 Weeding

The plots were kept free from weeds by three weeding. First weeding was done at 30 days after planting (DAP), second at 55 DAP and third weeding at 80 DAP. The weeds were eradicated with roots carefully so that the transplanted so that yard long bean plant did not affect during weeding.

3.10 Plant protections

3.10.1 Insect pests

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

3.10.2. Diseases

Some seedlings were attacked by damping off diseases. To protect seedlings Dithane M-45 was sprayed @ 2 ml/L of water at an interval of 15 days. Bean

common mosaic virus also found in few plants which was removed immediately and destroyed.

3.11 Harvesting

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

3.12 Collection of Data

Four representative plants were selected at random from each of unit plot to avoid border effect and tagged in the field. Data ere recorded periodilaccly from the sample plants at 30 days interval. The details of data recordings are given below.

3.12.1 Number of leaves per plant

The number of leaves of four randomly selected plants was counted from each unit plot at 15 days interval from 15 to 30 DAS and means were calculated.

3.12.2 Number of branches per plant

The number of branches of 4 randomly selected plants from each plot till final harvest was recorded

3.12.3 Number of flowers per plant

The number of flowers were counted from randomly selected 4 plants from each plot. Their mean value were calculated.

3.12.4 Number of pods per plant

From four randomly selected plant from each plot flowers were counted and their mean value were calculated.

3.12.5. Weight of green pod

Ten sample pods from each plant was randomly selected and their avarage weight was taken in gram.

3.12.6. Pod yield per hectare

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

3.13. Statistical analysis

The recorded data on different parameters were statistically analyzed using MSTAT computer package programme. The analysis of variance for the characters under study were performed by "F" variance test. The differences between the pairs of treatment means was compared using least significant difference (LSD) test (Gomez and Gomez, 1984).

3.14 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of spacing and macro nutrient management in cost and return were done in details according to the procedure of Alam*et al*. (1989).

3.14.1 Analysis of total cost of production

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production

3.14.2 Gross income

Gross income was calculated on the basis of grain and pod sale. The price was assumed on the basis of local market value.

3.14.3 Net return

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

3.14.4 Benefit cost ratio (BCR)

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

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

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises of the presentation and discussion of the results obtained from the present study. The results have been presented, discussed and possible interpretations were given in tabular and graphical forms. The results obtained from the experiment have been presented under separate headings and sub-headings as follows:

4.1 Growth parameters

4.1.1 Number of branches plant^{-1}

Significant influence was found on number of branches plant^{-1} of long yard bean at all growth stages affected by different levels of nutrient management (Fig.2 and Appendix IV). Results revealed that the highest number of branches plant^{-1} (1.83, 4.43, 8.21 and 12.20 at 30, 60, 90 and 120 DAS, respectively) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) kg/ha which was statistically identical with N_3 (N_{24} P_{36} K_{44})kg/ha at whole crop duration whereas the lowest number of branches plant^{-1} (0.87, 2.67, 6.37 and 8.09 at 30, 60, 90 and 120 DAS, respectively) was recorded from the control treatment N_0 (N_0 P_0 K_0).

Mishriky (1990) observed that growth regulators such as GA3 and IAA could increase the branches, grain yield as well as protin content of pea.

The influence of IAA on number of branches plant^{-1} was found significant throughout the life period of yard long bean (Fig.3 and Appendix IV). It was observed that the highest number of branches plant^{-1} (1.61, 4.01, 7.87 and 11.16 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) at all growth stages whereas the lowest number of branches plant^{-1} (1.19, 3.16, 6.84 and 9.46 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment control treatment I_0 (0 ppm IAA)

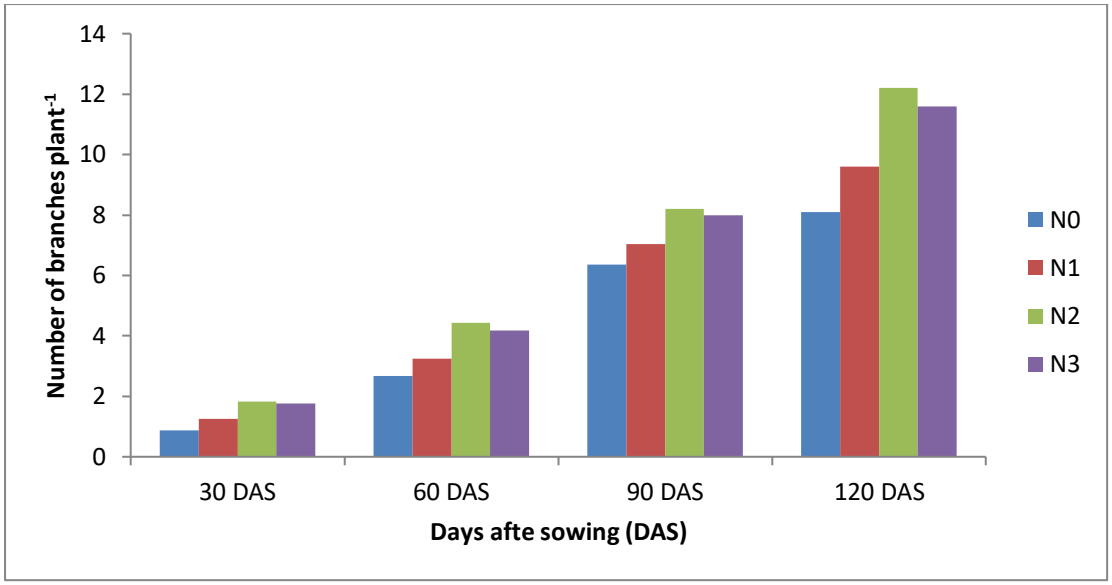

Fig. 2. Number of branches plant^{-1} of yard long bean as influenced by nutrient management

N_0 = control (N_0 P_0 K_0) kg/ha, N_1 = (N_{12} P_{18} K_{22}) kg/ha, N_2 = (N_{18} P_{27} K_{33}) kg/ha, N_3= (N_{24} P_{36} K_{44}) kg/ha

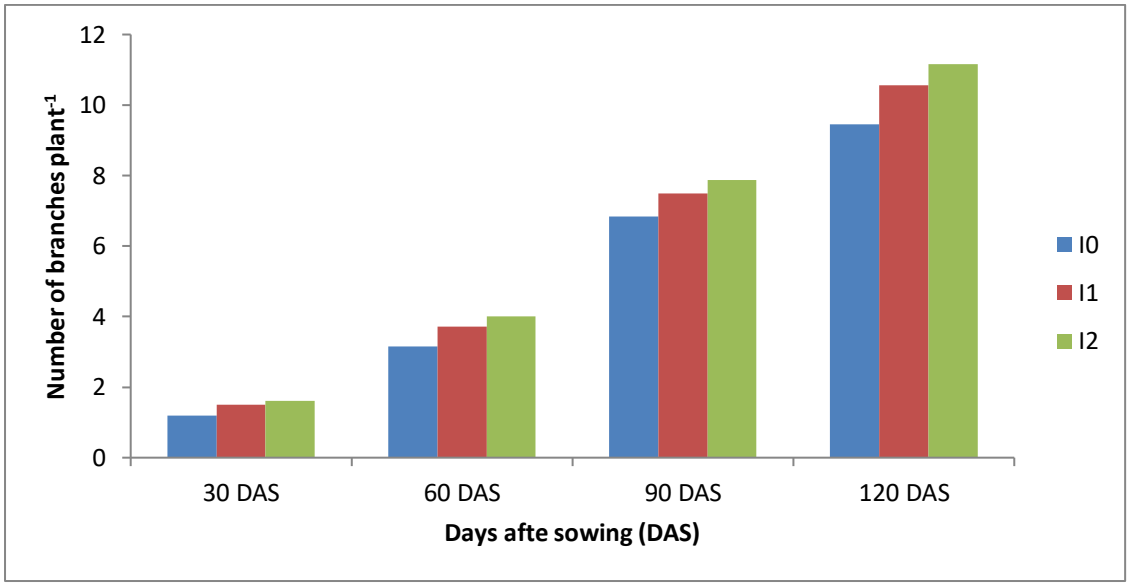

Fig. 3. Number of branches plant^{-1} of yard long bean as influenced by auxin (IAA)

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Combined effect of nutrient management and IAA showed significant role among the treatment combinations at all growth stages in terms of number of branches plant^{-1} (Table 1 and Appendix IV). Results showed that the highest number of branches plant^{-1} (2.11, 5.22, 9.16 and 13.28 at 30, 60, 90 and 120 DAS, respectively) was achieved from the treatment combination of N_2I_2 which was statistically similar with the treatment combination of N_3I_1. The lowest number of branches plant^{-1} (0.73, 2.52, 6.03 and 7.72 at 30, 60, 90 and 120 DAS, respectively) was observed from the treatment combination of N_0I_0. At 120 DAS, N_0I_0 was statistically identical with the treatment combination of N_0I_1.

Table 1. Number of branches plant^{-1} of yard long bean as influenced by nutrient management and auxin (IAA)

Treatments	Number of branches plant^{-1}			
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**
N_0I_0	0.73 g	2.52 h	6.03 g	7.72 i
N_0I_1	0.93 f	2.71 gh	6.49 f	8.10 hi
N_0I_2	0.96 f	2.78 gh	6.59 ef	8.44 gh
N_1I_0	1.04 f	3.00 fg	6.70 ef	9.00 fg
N_1I_1	1.25 e	3.18 f	6.94 e	9.40 ef
N_1I_2	1.48 cd	3.57 de	7.44 cd	10.44 d
N_2I_0	1.36 de	3.24 ef	7.03 de	9.780 e
N_2I_1	1.81 b	4.07 c	7.82 c	11.80 c
N_2I_2	2.11 a	5.22 a	9.16 a	13.28 a
N_3I_0	1.61 c	3.88 cd	7.61 c	11.32 c
N_3I_1	1.99 ab	4.92 a	8.73 ab	12.92 ab
N_3I_2	1.88 b	4.48 b	8.29 b	12.48 b
$LSD_{0.05}$	0.186	0.382	0.448	0.589
CV(%)	6.82	8.02	7.71	6.81

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

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$)kg/ha

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

4.1.2 Number of leaves plant^{-1}

Significant variation was observed on number of leaves plant^{-1} at different growth stages affected by different levels of nutrient management (Fig. 4 and Appendix V). The highest number of leaves plant^{-1} (14.31, 67.80, 87.35 and 105.60 at 30, 60, 90 and 120 DAS, respectively) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was significantly different from all other treatments. The lowest number of leaves plant^{-1} (10.42, 46.57, 60.82 and 78.62 at 30, 60, 90 and 120 DAS, respectively) was recorded from the control treatment N_0 ($N_0P_0K_0$).

Number of leaves plant^{-1} was significantly influenced by different levels of IAA at different growth stages of yard long bean (Fig. 5 and Appendix V). The highest number of leaves plant^{-1} (13.39, 62.72, 81.40 and 98.53 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) which was significantly different from all other treatments whereas the lowest number of leaves plant^{-1} (11.98, 55.23, 71.81 and 89.12 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment I_0 (0 ppm IAA).

Significant effect was recorded on number of leaves plant^{-1} affected by different treatment combination of nutrient management and IAA (Table 2 and Appendix V). The highest number of leaves plant^{-1} (15.25, 72.62, 94.39 and 112.50 at 30, 60, 90 and 120 DAS, respectively) was achieved from the treatment combination of N_2I_2. At 60 and 120 DAT, N_2I_2 was statistically identical with N_3I_1. The lowest number of leaves plant^{-1} (10.18, 45.15, 59.22 and 76.97 at 30, 60, 90 and 120 DAS, respectively) was observed from the treatment combination of N_0I_0 which was statistically identical with N_0I_1 and N_0I_2 at all growth stages.

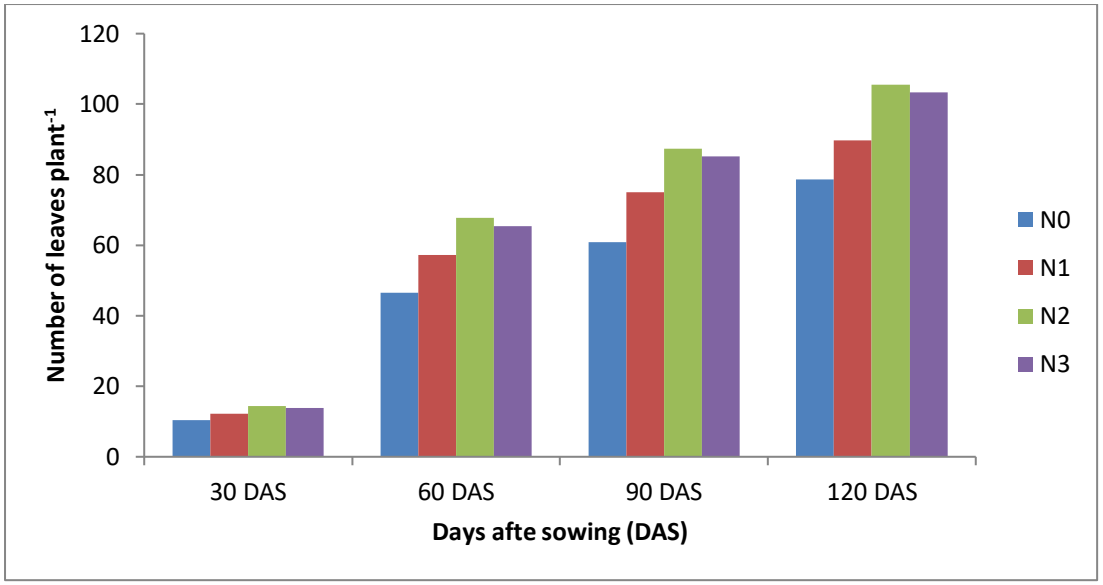

Fig. 4. Number of leaves plant^{-1} of yard long bean as influenced by nutrient management

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$) kg/ha

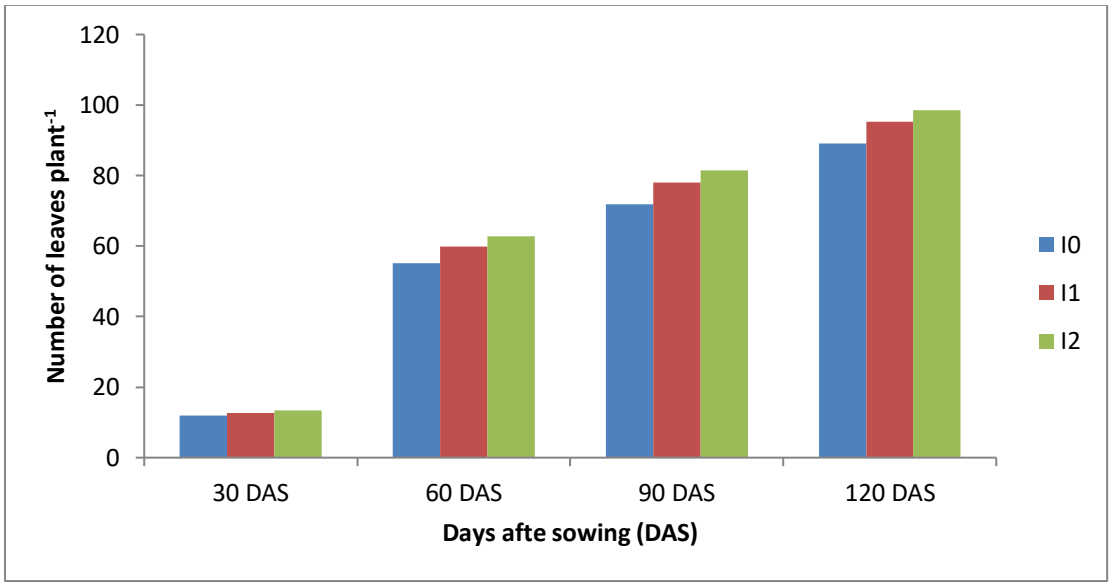

Fig. 5. Number of leaves plant^{-1} of yard long bean as influenced by auxin (IAA)

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Table 2. Number of leaves plant^{-1} of yard long bean as influenced by nutrient management and auxin (IAA)

Treatments	Number of leaves plant^{-1}			
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**
N_0I_0	10.18 g	45.15 g	59.22 g	76.97 g
N_0I_1	10.43 g	46.39 g	60.88 g	78.47 g
N_0I_2	10.65 g	48.17 g	62.37 g	80.43 fg
N_1I_0	11.51 f	54.95 f	70.55 f	85.31 ef
N_1I_1	11.83 f	55.93 f	73.97 f	88.35 e
N_1I_2	13.20 de	60.93 de	80.36 de	95.70 cd
N_2I_0	12.68 e	57.50 ef	75.46 ef	93.53 d
N_2I_1	13.81 c	65.93 bc	85.74 cd	103.7 b
N_2I_2	15.25 a	72.62 a	94.39 a	112.5 a
N_3I_0	13.56 cd	63.33 cd	81.99 d	100.7 bc
N_3I_1	14.91 ab	70.89 a	91.57 ab	110.7 a
N_3I_2	14.45 b	69.17 ab	88.50 bc	105.5 b
$LSD_{0.05}$	0.5408	3.787	5.617	5.094
CV(%)	5.37	9.09	8.09	10.23

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

N_0 = control ($N_0P_0K_0$), N_1 = ($N_{12}P_{18}K_{22}$) kg/ha, N_2 = ($N_{18}P_{27}K_{33}$) kg/ha, N_3= ($N_{24}P_{36}K_{44}$) kg/ha

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

4.2 Yield contributing parameters

4.2.1 Number of flowers plant^{-1}

Significant influence was found on number of flowers plant^{-1} of long yard bean affected by different levels of nutrient management (Table 4 and Appendix VI). Results indicated that the highest number of flowers plant^{-1} (157.10) was recorded from N_2 (N_{18} P_{27} K_{33}) treatment which was statistically identical (155.30) with N_3 (N_{24} P_{36} K_{44}) treatment whereas the lowest number of flowers plant^{-1} (123.50) was recorded from the control treatment N_0 (N_0 P_0 K_0).

The influence of IAA on number of flowers plant^{-1} was found significant among the treatments (Table 4 and Appendix VI). Results revealed that the highest number of flowers plant^{-1} (148.60) was found from the treatment I_2 (40 ppm IAA) which was statistically identical (146.50) with I_1 (20 ppm IAA) treatment whereas the lowest number of flowers plant^{-1} (136.40) was obtained from the control treatment control treatment I_0 (0 ppm IAA).

Combined effect of nutrient management and IAA showed significant difference among the treatment combinations in terms of number of flowers plant^{-1} (Table 2 and Appendix V). The highest number of flowers plant^{-1} (164.20) was achieved from the treatment combination of N_2I_2 which was statistically identical with the treatment combination of N_3I_1 and statistically similar with N_2I_1. The lowest number of flowers plant^{-1} (116.80) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations.

4.2.2 Number of pods plant^{-1}

Number of pods plant^{-1} showed significant difference among the treatments regarding different levels of nutrient management (Table 3 and Appendix VI). The highest number of pods plant^{-1} (48.18) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was statistically identical (47.49) with N_3 ($N_{24}P_{36}K_{44}$)

whereas the lowest number of pods plant^{-1} (37.77) was recorded from the control treatment N_0 ($N_0P_0K_0$).

Significant effect on number of pods plant^{-1} among the treatments was found affected by different levels of IAA (Table 4 and Appendix VI). The highest number of pods plant^{-1} (45.84) was found from the treatment I_2 (40 ppm IAA) which was statistically identical (45.74) with treatment I_1 (20 ppm IAA) whereas the lowest number of pods plant^{-1} (41.29) was obtained from the control treatment control treatment I_0 (0 ppm IAA).

Number of fruits plant^{-1} was significantly affected by combined effect of nutrient management and IAA (Table 5 and Appendix VI). The highest number of pods plant^{-1} (51.16) was achieved from the treatment combination of N_2I_2 which was statistically identical (50.34) with the treatment combination of N_3I_1. The lowest number of pods plant^{-1} (32.51) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations.

4.2.3 Days to first harvest

Significant influence was found on days to first harvest of yard long bean affected by different levels of nutrient management (Table 3 and Appendix VI).

The lowest days to first harvest (61.22 days) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was statistically identical with N_3 ($N_{24}P_{36}K_{44}$) whereas the highest days to first harvest (70.78 days) was recorded from the control treatment N_0 ($N_0P_0K_0$).

Landa *et al*. (2002) showed that application of N, P, K significantly influenced the growth and advanced the harvesting date off green beans.

The influence of IAA on days to first harvest was found significant among the treatments (Table 4 and Appendix VI).

The lowest days to first harvest (63.92 days) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) whereas the highest days to first harvest (67.67 days) was obtained from the control treatment control treatment I_0 (0 ppm IAA

Combined effect of nutrient management and IAA showed significant difference among the treatment combinations in terms of days to first harvest (Table 5 and Appendix VI). The lowest days to first harvest (58.00 days) was achieved from the treatment combination of N_2I_2 which was statistically similar with the treatment combination of N_3I_1. The highest days to first harvest (71.67 days) was observed from the treatment combination of N_0I_0 which was statistically similar with the treatment combination of N_0I_1.

4.2.4 Pods length (cm)

Fruit length showed significant difference among the treatments regarding different levels of nutrient management (Table 3 and Appendix VI). Results revealed that the highest pod length (55.50 cm) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was statistically identical with N_3 ($N_{24}P_{36}K_{44}$) whereas the lowest pod length (43.73 cm) was recorded from the control treatment N_0 ($N_0P_0K_0$).

The finding from the experiment is more or less similar with the following reaesrch work of Begum *et al.* (2003) . They conduct an experiment on yard long bean and found highest yield by the treatment of N, P, K is followed by 90, 50, 120. The pod length is highest (55.7cm) in this treatment.

Significant effect on pod length was found among the treatments affected by different levels of IAA (Table 4 and Appendix VI). Results indicated that the the highest pod length (53.10 cm) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) whereas the lowest pod length (46.49 cm) was obtained from the control treatment control treatment I_0 (0 ppm IAA).

Fruit length was significantly affected by combined effect of nutrient management and IAA (Table 6 and Appendix VI). Results showed that the highest pod length (62.44 cm) was achieved from the treatment combination of N_2I_2 which was statistically identical (60.48 cm) with N_3I_1. The lowest pod length (41.30 cm) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations.

4.2.5 Individual pod weight (g)

Significant influence was found on individual pod weight of yard long bean affected by different levels of nutrient management (Table 3 and Appendix VI). The highest individual pod weight (52.51 g) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was statistically identical with N_3 ($N_{24}P_{36}K_{44}$) whereas the lowest individual pod weight (36.44 g) was recorded from the control treatment N_0 ($N_0P_0K_0$).

The role of IAA on individual pod weight was found significant among the treatments (Table 4 and Appendix VI). The highest individual pod weight (48.88 g) was found from the treatment I_2 (40 ppm IAA) which was significantly different from all other treatments followed by I_1 (20 ppm IAA) whereas the lowest individual pod weight (42.34 g) was obtained from the control treatment control treatment I_0 (0 ppm IAA). Singh and Upadhaya (1967) found large size of tomato with the application of IAA.

Combined effect of nutrient management and IAA showed significant difference among the treatment combinations in terms of individual pod weight (Table 6 and Appendix VI). The highest individual pod weight (58.64 g) was achieved from the treatment combination of N_2I_2 which was statistically identical with N_3I_1 whereas the lowest individual pod weight (35.24 g) was observed from the treatment combination of N_0I_0 which was statistically identical with N_0I_1 and similar with N_0I_2.

Table 3. Yield contributing parameters of yard long bean as influenced by nutrient management

Treatments	Yield contributing parameters				
	Number of flowers plant^{-1}	**Number of pods plant^{-1}**	**Days to first harvest**	**Pod length (cm)**	**Individual pod weight (g)**
N_0	123.50 c	37.77 c	70.78a	43.73 c	36.44 c
N_1	139.40 b	43.71 b	67.44 b	47.71 b	43.11 b
N_2	157.10 a	48.18 a	61.22c	55.50 a	52.51 a
N_3	155.30 a	47.49 a	61.56 c	55.19 a	52.22 a
$LSD_{0.05}$	3.013	2.102	1.206	1.083	1.929
CV(%)	12.54	8.63	8.11	6.19	7.28

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

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$)kg/ha

Tiwari and Singh (2000) observed that optimum and economical dose of N and P is responsible for higher growth and seed yield of french bean. Kanaujia *et al. (*1999) observed that the highest plant height, green pod yield and protein content among them potassium rates were obtained from 80 kg P_2O /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.

Table 4. Yield contributing parameters of yard long bean as influenced by Auxin (IAA)

Treatments	Yield contributing parameters				
	Number of flowers plant^{-1}	**Number of pods plant^{-1}**	**Days to first harvest**	**Pod length (cm)**	**Individual pod weight (g)**
I_0	136.40 b	41.29 b	67.67 a	46.49 b	42.34 c
I_1	146.50 a	45.74 a	64.17 b	52.01 a	47.00 b
I_2	148.60 a	45.84 a	63.92 b	53.10 a	48.88 a
$LSD_{0.05}$	2.459	1.079	1.045	1.263	1.605
CV(%)	12.54	8.63	8.11	6.19	7.28

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

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Table 5. Yield contributing parameters (Number of flowers plant $^{-1}$, Number of pods plant^{-1} , Days to first harvest) of yard long bean as influenced by combined effect of nutrient management and auxin (IAA)

Treatments	Yield contributing parameters		
	Number of flowers plant^{-1}	Number of pods plant^{-1}	Days to first harvest
N_0I_0	116.80 h	32.51 f	71.67 a
N_0I_1	125.40 g	39.40 e	70.67 ab
N_0I_2	128.50 g	41.41 de	70.00 bc
N_1I_0	135.70 f	43.00 cde	69.33 c
N_1I_1	136.90 ef	43.80 cd	67.67 d
N_1I_2	145.70 d	44.33 cd	65.33 e
N_2I_0	141.80 de	43.95 cd	66.00 e
N_2I_1	160.00 ab	49.43 ab	59.67 h
N_2I_2	164.20 a	51.16 a	58.00 i
N_3I_0	151.50 c	45.69 c	63.67 f
N_3I_1	163.80 a	50.34 a	58.67 hi
N_3I_2	155.90 bc	46.46 bc	62.33 g
$LSD_{0.05}$	5.201	3.641	1.225
CV(%)	12.54	8.63	8.11

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

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$)kg/ha

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Table 6. Yield contributing parameters (Pod length and Individual pod weight) of yard long bean as influenced by combined effect of nutrient management and auxin (IAA)

Treatments	Yield contributing parameters	
	Pod length (cm)	Individual pod weight (g)
N_0I_0	41.30 g	35.24 g
N_0I_1	44.76 f	36.72 g
N_0I_2	45.12 ef	37.36 fg
N_1I_0	45.40 ef	40.38 ef
N_1I_1	47.00 ef	41.60 e
N_1I_2	50.72 d	47.36 cd
N_2I_0	47.36 e	45.14 d
N_2I_1	55.78 b	52.88 b
N_2I_2	62.44 a	58.64 a
N_3I_0	51.88 cd	48.60 c
N_3I_1	60.48 a	56.80 a
N_3I_2	54.14 bc	52.14 b
$LSD_{0.05}$	2.527	3.341
CV(%)	6.19	7.28

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

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$)kg/ha

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

4.3 Yield parameters

4.3.1 Yield plot^{-1}

Yield plot^{-1} showed significant difference among the treatments regarding different levels of nutrient management (Table 7 and Appendix VII). The

highest yield plot^{-1} (2.53 kg) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) which was statistically identical with N_3 (N_{24} P_{36} K_{44}) whereas the lowest yield plot^{-1} (1.38 kg) was recorded from the control treatment N_0 (N_0 P_0 K_0).

Significant effect on yield plot^{-1} was found among the treatments affected by different levels of IAA (Table 8 and Appendix VII). The highest yield plot^{-1} (2.26 kg) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) whereas the lowest yield plot^{-1} (1.77 kg) was obtained from the control treatment control treatment I_0 (0 ppm IAA). Emonger (2007) observed that appplication of Auxin on Cowpea exogenously 7 days after emergence at 30, 60 and 90 mgl^{-1} significantly increased plant height, first node length, leaf area, leaf number, nodulation, pod number/plant, pod length, seed number/pod, plant dry matter accumulation, 100 seed weight.

Yield plot^{-1} was significantly affected by combined effect of nutrient management and IAA (Table 9 and Appendix VII). The highest yield plot^{-1} (3.00 kg) was achieved from the treatment combination of N_2I_2 which was statistically identical with N_3I_1 whereas the lowest yield plot^{-1} (1.14 kg) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations.

4.3.2 Yield ha^{-1}

Under the present study, yield ha^{-1} of yard long bean was affected significantly by different levels of nutrient management (Table 7 and Appendix VII). The highest yield ha^{-1} (14.05 t) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) which was statistically identical with N_3 (N_{24} P_{36} K_{44}) whereas the lowest yield ha^{-1} (7.65 t) was recorded from the control treatment N_0 (N_0 P_0 K_0).

According to the tratment of N_2 N, P, K was applied 39.130 kg/ha , 56.25 kg/ha, 55 kg/ha respectively. The finding from the experiment was more or less similar with following research work

Aray *et al.* (1999) performed an experiment to study the combined effect of N, P, K on french bean. Best combination was found by using 25 kg N/ha, 75 kg P_2O_5/ha, 50 kg K_2O/ha. Mbeke *et al*. (2014) carried out an experiment to study the effect of nitrogen on *Phaseolus vulgaries* L.. and found higher yield obtained with 22 kg N/ha.

Table 7. Yield parameters of yard long bean as influenced by nutrient management

Treatments	Yield parameters	
	Yield plot^{-1} (kg)	Yield ha^{-1} (t)
N_0	1.38 c	7.65 c
N_1	1.88 b	10.46 b
N_2	2.53 a	14.05 a
N_3	2.50 a	13.87 a
$LSD_{0.05}$	0.142	1.001
CV(%)	6.97	6.99

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

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$)kg/ha

Table 8. Yield parameters of yard long bean as influenced by Auxin (IAA)

Treatments	Yield parameters	
	Yield plot^{-1} (kg)	Yield ha^{-1} (t)
I_0	1.77 b	9.83 b
I_1	2.18 a	12.12 a
I_2	2.26 a	12.57 a
$LSD_{0.05}$	0.295	0.682
CV(%)	6.97	6.99

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

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Table 9. Yield parameters of yard long bean as influenced by nutrient management and auxin (IAA)

Treatments	Yield parameters	
	Yield plot^{-1} (g)	Yield ha^{-1} (t)
N_0I_0	1.14 i	6.36 h
N_0I_1	1.44 h	8.01 g
N_0I_2	1.54 gh	8.57 g
N_1I_0	1.73 fg	9.62 f
N_1I_1	1.82 ef	10.12 f
N_1I_2	2.10 d	11.64 de
N_2I_0	1.99 de	11.03 e
N_2I_1	2.61 b	14.48 b
N_2I_2	3.00 a	16.64 a
N_3I_0	2.22 cd	12.32 d
N_3I_1	2.86 a	15.88 a
N_3I_2	2.42 bc	13.42 c
$LSD_{0.05}$	0.245	0.8433
CV(%)	6.97	6.99

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

N_0 = control ($N_0P_0K_0$), N_1 = ($N_{12}P_{18}K_{22}$) kg/ha, N_2 = ($N_{18}P_{27}K_{33}$)kg/ha , N_3= ($N_{24}P_{36}K_{44}$) kg/ha

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Significant effect on yield ha^{-1} was found among the treatments affected by different levels of IAA (Table 8 and Appendix VII). The highest yield ha^{-1} (12.57 t) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) whereas the lowest yield ha^{-1} (9.83 t) was obtained from the control treatment control treatment I_0 (0 ppm IAA).

Reshmi and Gopalakrishna (2004) carried out an experiment on Yardlong bean to study the effect of 4 growth regulators in Kerala. 4 plant growth regulators namely NAA (15, 30, 45 ppm), 2,4-D (2, 4 and 6 ppm), IAA (20, 40 and 60 ppm) and CCC (300, 400, 500 ppm) were sprayed on yard long bean at different growth stages to evaluate its impact on flowering and fruit set. Foliar spray of NAA of 15 ppm give the highest yield followed by IAA at 40 ppm and CCC at 300 ppm. 2,4-D had a strong depressing effect on growth and yield of yard long bean

Yield ha^{-1} was affected significantly by combined effect of nutrient management and IAA (Table 9 and Appendix VII). The highest yield ha^{-1} (16.64 t) was achieved from the treatment combination of N_2I_2 which was statistically identical with N_3I_1 followed by N_2I_1. The lowest yield ha^{-1} (6.36 t) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations.

4.4 Economic analysis

Different material cost and non-material input cost like land preparation, seed cost, seed sowing cost, organic manure, irrigation and manpower required for all the operations, interest on fixed capital of land (Leased land by ban loan basis) and miscellaneous cost were considered for calculating the total cost of production in per hectare basis (Table 10 and Appendix VIII). Price of yard long bean pod in terms were considered at market rate. The economic analysis is presented under the following headlines:

4.4.1 Gross income

The combination of different nutrient management and IAA levels showed different gross return (Table 10 and Appendix VIII). Gross income was calculated on the basis of sale of yard long bean pod. The highest gross return (Tk. 499200) obtained from N_2I_2 ($N_{18}P_{27}K_{33}$ with 40 ppm IAA) treatment combination and lowest gross return (Tk. 190800) obtained from the treatment combination of N_0I_0 ($N_0P_0K_0$ with 0 ppm IAA).

4.4.2 Net return

Treatment combinations of different nutrient management and IAA levels showed net returns variation (Table and Appendix VIII). The highest net return (Tk. 318263) obtained from the treatment combination of ($N_{18}P_{27}K_{33}$ with 40 ppm IAA) and lowest net return (Tk. 19814) obtained from the treatment combination of N_0I_0 ($N_0P_0K_0$ with 0 ppm IAA).

Table10. Economic analysis of yard long bean affected by nutrient management and IAA in terms of BCR

Treatments	Yield (ha^{-1} t)	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
N_0I_0	6.36	170986	190800	19814	1.12
N_0I_1	8.01	173222	240300	67078	1.39
N_0I_2	8.57	175459	257100	81641	1.47
N_1I_0	9.62	174637	288600	113963	1.65
N_1I_1	10.12	176873	303600	126727	1.72
N_1I_2	11.64	179110	349200	170090	1.95
N_2I_0	11.03	176464	330900	154436	1.88
N_2I_1	14.48	178701	434400	255699	2.43
N_2I_2	16.64	180937	499200	318263	2.76
N_3I_0	12.32	178291	369600	191309	2.07
N_3I_1	15.88	180528	476400	295872	2.64
N_3I_2	13.42	182764	402600	219836	2.20

N_0 = control ($N_0 P_0 K_0$) kg/ha, N_1 = ($N_{12} P_{18} K_{22}$) kg/ha, N_2 = ($N_{18} P_{27} K_{33}$) kg/ha,

N_3= ($N_{24} P_{36} K_{44}$)kg/ha

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm IAA

4.4.3 Benefit cost ratio (BCR)

Among different treatment combinations of nutrient management and IAA, difference on benefit cost ration (BCR) was observed among the treatment combinations (Table 5). The highest BCR (2.76) was obtained from the treatment combination of N_2I_2 ($N_{18}P_{27}K_{33}$ with 40 ppm IAA) and lowest BCR (1.12) was obtained from N_0I_0 ($N_0P_0K_0$ with 0 ppm IAA) treatment combination. From economic point of view, it was noticeable from the above results, the treatment combination of N_2I_2 ($N_{18}P_{27}K_{33}$ with 40 ppm IAA) was more profitable than rest of the treatment combinations.

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 nutrient management and Auxin on the growth and yield of Yard long bean during the period of 15th March, 2019 to 20th July 2019. 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: four levels of nutrient management; i) N_0: control (N_0, P_0, K_0); ii) N_1: N_{12} P_{18} K_{22}; iii)N_2: N_{18} P_{27} K_{33}; iv) N_3: N_{24} P_{36} K_{44} . Factor B: three levels of Auxin (Indole acetic acid); i)I_0 : control (0 ppm); ii)I_1: 20 ppm iii) I_2: 40 ppm. The variety of Yard long bean was taken BARI borboti-1. The layout of the experiment was at Randomized complete block Design (RCBD) and the size of the each plot was 1.5m x1.2m. The total number of treatment was12 and total number of plot was 36. The Yard long bean seed was collected from Bangladesh Agricultural Research Institute, joydebpur, Gazipur. Data on different growth and yield contributing characters and yield at different days after sowing (DAS) were recorded.

Nutrient management was considered as significant under present study. Significant influence was found on growth and yield contributing and yield parameters by different levels of nutrient management treatments. In terms of growth parameters, the highest number of branches plant^{-1} (1.83, 4.43, 8.21 and 12.20 at 30, 60, 90 and 120 DAS, respectively) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) and lowest number of branches plant^{-1} (0.87, 2.67, 6.37 and 8.09 at 30, 60, 90 and 120 DAS, respectively) was recorded from the control treatment N_0 ($N_0P_0K_0$). Similarly, the highest number of leaves plant^{-1} (13.39, 62.72, 81.40 and 98.53 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) and the lowest number of leaves

plant^{-1} (11.98, 55.23, 71.81 and 89.12 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment control treatment I_0 (0 ppm IAA). In terms of yield contributing parameters, highest number of flowers plant^{-1} (157.10) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was statistically identical with N_3 ($N_{24}P_{36}K_{44}$) whereas the lowest number of flowers plant^{-1} (123.50) was recorded from the control treatment N_0 (N_0 P_0 K_0) . The lowest days to first harvest (61.22 days) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) and the highest days to first harvest (70.78 days) was recorded from the control treatment N_0 ($N_0P_0K_0$).The highest number of pods plant^{-1} (47.49) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) , whereas the lowest number of pods plant^{-1} (37.77) was recorded from the control treatment N_0 (N_0 P_0 K_0). The highest individual pod weight (52.51 g) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) whereas the lowest individual pod weight (36.44 g) was recorded from the control treatment N_0 ($N_0P_0K_0$). Highest pod length (55.50 cm) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) and the lowest pod length (43.72 cm) was recorded from the control treatment N_0 ($N_0P_0K_0$).). And in yield parameters, the highest yield plot^{-1} (2.53 kg) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) and the lowest yield plot^{-1} (1.38 kg) was recorded from the control treatment N_0 (N_0 P_0 K_0).

Considering Auxin application, all parameters among the treatment was significant. the highest number of branches plant^{-1} (1.61, 4.01, 7.87 and 11.16 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) whereas the lowest number of branches plant^{-1} (1.19, 3.16, 6.84 and 9.46 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment control treatment I_0 (0 ppm IAA). The highest number of leaves plant^{-1} (13.39, 62.72, 81.40 and 98.53 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) whereas the lowest number of leaves plant^{-1} (11.98, 55.23, 71.81 and 89.12 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment I_0 (0 ppm IAA). Highest number of flowers plant^{-1} (148.60) was found from the treatment I_2 (40 ppm

IAA) and the lowest number of flowers plant^{-1} (136.40) was obtained from the control treatment control treatment I_0 (0 ppm IAA). The highest number of pods plant^{-1} (45.84) was found from the treatment I_2 (40 ppm IAA) whereas the lowest number of pods plant^{-1} (41.29) was obtained from the control treatment control treatment I_0 (0 ppm IAA). The lowest days to first harvest (63.92 days) was found from the treatment I_2 (40 ppm IAA) ,the highest days to first harvest (67.67 days) was obtained from the control treatment control treatment I_0 (0 ppm IAA). The highest individual pod weight (48.88 g) was found from the treatment I_2 (40 ppm IAA) and the lowest individual pod weight (42.34 g) was obtained from the control treatment control treatment I_0 (0 ppm IAA). Highest yield plot^{-1} (2.26 kg) was found from the treatment I_2 (40 ppm IAA) and the lowest yield plot^{-1} (1.77 kg) was obtained from the control treatment control treatment I_0 (0 ppm IAA).

In terms of combined effect of plant nutrient management and Auxin, regarding growth parameters, the highest number of branches plant^{-1} (2.11, 5.22, 9.16 and 13.28 at 30, 60, 90 and 120 DAS, respectively) was achieved from the treatment combination of N_2I_2 . The lowest number of branches plant^{-1} (0.73, 2.52, 6.03 and 7.72 at 30, 60, 90 and 120 DAS, respectively) was observed from the treatment combination of N_0I_0. The highest number of leaves plant^{-1} (15.25, 72.62, 94.39 and 112.50 at 30, 60, 90 and 120 DAS, respectively) was achieved from the treatment combination of N_2I_2. The lowest number of leaves plant^{-1} (10.18, 45.15, 59.22 and 76.97 at 30, 60, 90 and 120 DAS, respectively) was observed from the treatment combination of N_0I_0. In terms of yield contributing and yield parameters, The highest number of flowers plant^{-1} (164.20) was achieved from the treatment combination of N_2I_2 which was statistically identical with the treatment combination of N_3I_1 and statistically similar with N_2I_1. The lowest number of flowers plant^{-1} (116.80) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations. The highest number of pods plant^{-1} (51.16) was achieved from the treatment combination of N_2I_2, The lowest number of

pods plant^{-1} (32.51) was observed from the treatment combination of N_0I_0. The highest pod length (62.44 cm) was achieved from the treatment combination of N_2I_2 and the lowest pod length (41.30 cm) was observed from the treatment combination of N_0I_0. The highest individual pod weight (58.64 g) was achieved from the treatment combination of N_2I_2 whereas the lowest individual pod weight (35.24 g) was observed from the treatment combination of N_0I_0. The highest yield plot^{-1} (3.00 kg) was achieved from the treatment combination of N_2I_2 whereas the lowest yield plot^{-1} (1.14 kg) was observed from the treatment combination of N_0I_0. The highest yield ha^{-1} (16.64 t) was achieved from the treatment combination of N_2I_2 . The lowest yield ha^{-1} (6.36 t) was observed from the treatment combination of N_0I_0 .

From above result it may be concluded that the tratment combination N_2I_2 (nutrient management N_2: N_{18} P_{27} K_{33} with Auxin I_2: 40 ppm) can be considered as the best treatment combinations compared to other treatment combinations in respect of the yield. So, from the above all findings, it might be concluded that application of 18 kg N/ha, 27 kg P/ha and 33 kg K/ha with 40ppm Auxin ensure the higher yield and growth of Yard long 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

Arya, P. S., Sagarand, V. and Singh, S. R. (1999). Effect of N, P and K on seed yield of French bean (*Phaseolus vulgaris* L.), *Haryana J. Hort. Sci*., **16**(8): 146-147.

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

BBS. (2018). Yearbook of Agricultural Statistics-2017. Bangladesh Beuro of Statistics. P. 268

Begum, A . , Ahad, A . , kaisar, M . O., Islam, M. M. and M. K. (2003). Effect of sowing dates and fertilizer treatments on the reproductive variability of Yard long bean (*Vigna unguiculata*), *Pak. J. Biol. Sci.*, **6**(22): 1897-1901.

Bhagavati, P. P., Kiran, T. S. K. K., Prasad, N. V. and Reddy, M. L. N. (2019). Correlation for growth, quality, yield and yield components in Yardlong bean (*Vigna unguiculata* (L.) walp. ssp. *Sesquipedalis* verdc.), *Int. J. Curr. Microbiol. App. Sci.* **8**(1) : 410-414

Bhopal and Singh, S. B. (1987). Response of French bean to nitrogen and phosphorus fertilization , *Indian J. Agron*., **32**(3): 223-225.

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.

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

Dash, J. N. and Dash, D.K. (1947). Response of French bean to phosphorus and spacing. *Indian J. of Hort*., **42** (2) : 385-386.

Devender, K. P., Sharma, T. R. and Saini, J. P. and Sharma, V. (1988). Response of French bean to nitrogen and phosphorus in cold desert area of Himachal Pradesh. *Indian J. Agron.*, **44**(4): 787-790.

Dwivedi, D. K., Singh, H. and 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

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

Emonger, V. (2007). Influence on vegetative growth, nodulation and yield of Cowpea (*Vigna unguiculata* L.) walp, *J. Agron.*, **6**(4) : 509-517

Farhad, I. S. M., Rahman, M. A., Jahan, E., Azam, M. G. and Khan, N.R. (2017). Integrated nutrient management on Soyabean in a coastal char land of Bangladesh. *J. Bangladesh Agron.,* **20** (1) : 77-83

FAO. (1988). Production Year Book. Food and Agricultural Organization of the United Nations, Rome, Italy. **42**:190-193.

Farkade, B. K. and Pawar, W. S. (2002). Growth performance and yield of French bean varieties as influenced by different fertilizer levels, *Indian J. Agric. Sci.*, **12**(l): 142-144.

Gajendra, S. and Singh, T. P. (1998). Effect of moisture regimes and fertility levels on growth and yield and water use of French bean (*Phaseolus vulgaris* L.), *Indian J. Agron*., **44**(2): 389-391.

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

Heiser, C. B. (1990). *Seed to civilization: The story of food.* US: Harvard University press. Pp. 228.

Kakon, S. S., Bhuiya, M. S. U., Hossain, S. M. A.and Naher, Q. (2016). Effect of nitrogen and phosphorus on growth and seed yield of bush bean, *Bangladesh J. Agril. Res.*, **41**(4): 759-772.

Kamal, H. (2007). Effect of N and Mo on the growth and yield of French bean-I. An M. S. thesis Dept. of Soil Science. Sher-E-Bangla Agricultural University, Dhaka, Bangladesh. p 24.

Kanaujia, S. P., Narayan, R. and Narayan, S. (1999). Effect of potassium and phosphorus on growth, quantity and yield of Yard long bean, *J. Veg. Sci.*, **26**(1): 91-92.

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.

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

Kikuti. H., Andrade, M. J. B., and Carvaiho, J. G. (2005). Nitrogen and phosphorus in the cultivated variety bean BRS MG Talisma .*J. Indian Soc. Soil Sci*., **21**: 115-119.

Landa, R., Rayas, A., Gonzalez, D. L. and Craz, J. A. (2002). Effect of N, P, K on the Yard long bean, *Current Res. Univ. Agril. Sci., Bangalore*, **22** (3-5): 67-69

Leikam, D., Whitney, D. A. and Hickma, J. S. (2007). *Uses ligumes in crop rotations*. SA : Markein. kansas State University press. P. 220.

Mbeke, A. M., Kirui, S. C., Kibet, N. C., and Nguta, C. M. (2014). Effects of nitrogen application on snap beans production in koibatek district, *J. Development and Sustainability*, **3**(5) : 1013-1015.

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

Nemesskeri, R. D. and Nagi, A. A. (1996). Effect of row spacing, plant density and N - level on the yield and quality of French bean. *P K V Res. J.,* **20**(2) 174-175

Parmer, N. S., and Singh, R.(1999). Effect of nitrogen and phosphorous on growth and yield of French bean. *South Indian Hort*., **39** (3): 137-138

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

Popescu, C., Sirbu, M. and Ailinci, P. (1992). Influence on fertilizers N, P, K on yield of Yard long bean, *Cerceteri. Agron. Moldova,* **25** (47):67-71.

Rana, N. S. and Singh, R. (1988). Effect of nitrogen and phosphorus in growth and yield of Yard long bean (*Vigna unguiculata*), *Indian J. Agron*., **43**(2): 367-370.

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

Resmi, R. and Gopalakrishnan, T. R. (2004). Effect of plant growth regulators on the performance of Yard long bean (*Vigna unguiculata* var. *sesquipedalis* (L.) verdcourt, *J. Tro. Agri.,* **42**(1-2) : 55-57.

Roy, N. R. and Parthasarathy, V. A. (1999). Note on phosphorus requirement of French bean (*Phaseolus vulgaris*) varieties planted at different dates. *Indian J. Hort.,* **56**(4): 3 17-320.

Rubatzky, V. E. and Yamaguchi, M. (1997). *World vegetables : principles, production and nutritive values.* New Yourk, NY: Chapman and Hall . pp. 360.

Salisbury, F. B. and Ross, C.W. (1992). *Plant physiology*. Belmont, CA : Wadsworth. pp. 357-548.

Saxena, K. K. and Varma, V. S. (1995). Effect of nitrogen, phosphorus and potassium on growth and yield of green bean, *Centro Agricola*, **29**(3) :26-29.

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

Shamima, A. (2010) Effect of N and P on the growth and yield of Bushbean-1., SAU, Dhaka, Bangladesh.

Singh, D. N., Mehar, R. C. and Singhans, M. (1981). Response of French bean (*Phasiolus vulgaris)* to irrigation and nitrogen application, *Haryana J. Agron.,* **6** (1) : 94-95.

Singh, J., Kalloo, G. and Singh, K. P. (2001). *Vegetable Crops: Nutritional Security*. Indian Institute of vegetable research, Varanasi. pp. 56.

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

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

Srinivas, K. and Khan, B. (1990). Response of French bean (*Phaseolus vulgaris)* to irrigation and nitrogen, phosphorus fertilization., *Indian J. Agril. Sci.* , **79** (9): 520-523

Srinivas, K. and Rao, J.V. (1984). Response of French bean to nitrogen and phosphorus. *Indian J. Agron*., **29**(2): 146-149.

Sushant, R. S., Dixit and Singh, G. R. (1999). Effect of irrigation, nitrogen and growth and yield of Yard long bean (*Vigna unguiculata). Indian J. Agron.*, **44**(2): 382-388.

Susila, A. D., Kartika, J. G., Prasetiyo, T. and Palada, M. C. (2010). Fertilizer recommendation: correlation and calibration study of Soil P test for Yard long bean (*Vigna unguiculata* L.) on Ultisols in Nanggung Bogor, *J. Agron.,* **38**(3) : 225-231.

Tewari, J. K. and Singh, S. S. (2000). Effect of nitrogen and phosphorus on growth and the growth and yield of French bean, *Indian J. Agron*., **40**(2):249-252.

Thirumalai, M., Khalak, A. and Ahad, A. (1993). Fertilizer application economics in yield of French bean (*Phaseolus vulgaris*), *Veg. sell*., **27**(2): 172-175.

Ullah, M. Z., Hassan, M. J., Rahman, A. H. M. A. and Saki, A. I. (2011). Genetic variability, character association and path analysis in Yard long bean, *SAARC J. Agric*., **9**(2): 9-16.

UNDP. (1988). Land Resource Apprisal of Bangladesh For Agricultural Development Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome, Italy. p. 577.

Varennes, K. J., Yildrim, E. and Guvenc, I. (2002). Effect of nitrogen and potassium on the growth and yield of Yard long bean, *European J. Agron*., **22** (1):11-18.

Yin, Z., Wenyun, G., Wang, Q. and Liang, J. (2018). Nitrogen, phosphorus and potassium fertilization to achieve expect yield of yard long bean, *J. Agril. Research*, **10**(13): 525-526

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

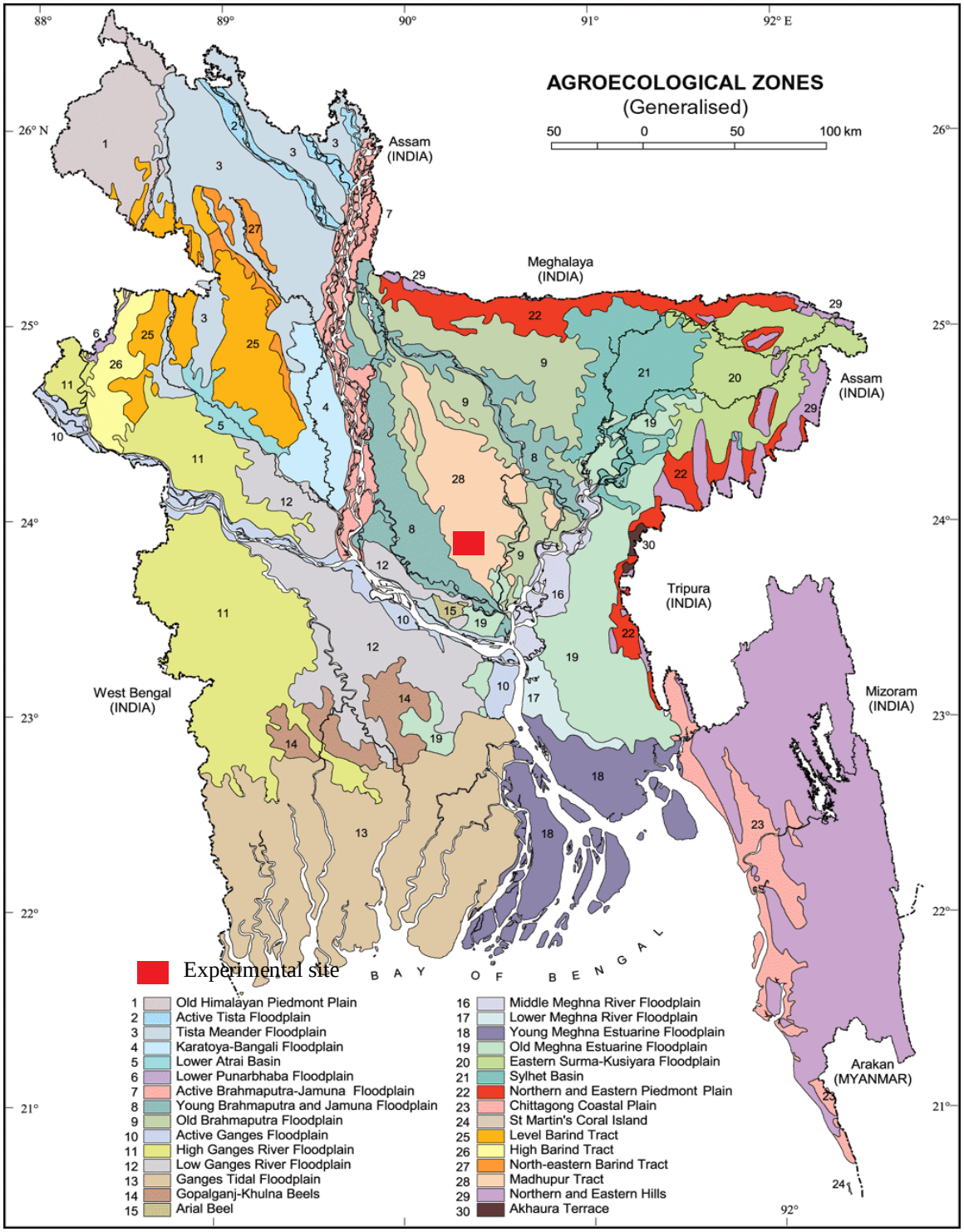

Fig. 6. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2018 to January 2019.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2018	November	28.60	8.52	18.56	56.75	14.40
2018	December	25.50	6.70	16.10	54.80	0.0
2019	January	23.80	11.70	17.75	46.20	0.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur 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
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Mean square of number of branches per plant of yard long bean

Treatments	Degrees of freedom	Mean square of number of branches plant^{-1}			
		30 DAS	60 DAS	90 DAS	120 DAS
Replication	2	0.022	0.002	3.969	0.155
Factor A	3	1.821*	5.999*	6.655*	32.532*
Factor B	2	0.580**	2.252*	3.231*	8.966*
AB	6	0.052**	0.614**	0.625**	1.464*
Error	22	0.002	0.021	0.040	0.501

*** = Significant at 5% level** **** = Significant at 1% level**

Appendix V. Mean square of number of leavess per plant of yard long bean

Treatments	Degrees of freedom	Mean square of number of leaves plant^{-1}			
		30 DAS	60 DAS	90 DAS	120 DAS
Replication	2	2.119	14.062	23.187	24.141
Factor A	3	28.62*	824.537*	1320.66*	1423.39*
Factor B	2	5.930*	171.042*	284.621*	274.708*
AB	6	1.009**	28.718*	46.080*	55.51*
Error	22	0.002	0.003	0.005	0.049

* = Significant at 5% level ** = Significant at 1% level

Appendix VI. Mean square of Yield contributing parameters of yard long bean

sources	df	Mean square of yield contributing parameters				
		Number of flowers plant^{-1}	Number of fruits plant^{-1}	Days to first harvest	Pod length (cm)	Individual pod weight (g)
Replication	2	79.146*	15.562*	11.676**	38.549*	32.592**
Factor A	3	30.433	14.623	0.523	1.227	3.112
Factor B	2	2207.277	25.912	0.250	22.075	3.112
AB	6	2214.73*	204.69*	195.731*	302.11*	542.45*
Error	22	505.775*	81.210*	52.750*	151.01*	135.87*

* = Significant at 5% level ** = Significant at 1% level

Appendix VII. Mean square of yield parameters

Treatments	Degrees of freedom	Mean square of yield parameters	
		Yield plot^{-1}(g)	Yield ha^{-1} (t)
Replication	2	0.021	0.631
Factor A	3	2.737	84.194
Factor B	2	0.837	25.845
AB	6	0.167	5.141
Error	22	0.021	0.648

* = Significant at 5% level ** = Significant at 1% level

Appendix VIII: Cost of production of yard long bean per hectare

A. Input cost (Tk. ha-1)

Treatments	Labor cost	Ploughing cost	Seed cost	Sowing cost	Irrigation	Cowdung				Cost of IAA	Subtotal (A)
							Urea	TSP	MoP		
N_0I_0	12000	8000	7000	10000	4000	50000	0	0	0	0	91000
N_0I_1	12000	8000	7000	10000	4000	50000	0	0	0	2000	93000
N_0I_2	12000	8000	7000	10000	4000	50000	0	0	0	4000	95000
N_1I_0	12000	8000	7000	10000	4000	50000	417	2143	705	0	94265
N_1I_1	12000	8000	7000	10000	4000	50000	417	2143	705	2000	96265
N_1I_2	12000	8000	7000	10000	4000	50000	417	2143	705	4000	98265
N_2I_0	12000	8000	7000	10000	4000	50000	626	3215	1058	0	95899
N_2I_1	12000	8000	7000	10000	4000	50000	626	3215	1058	2000	97899
N_2I_2	12000	8000	7000	10000	4000	50000	626	3215	1058	4000	99899
N_3I_0	12000	8000	7000	10000	4000	50000	835	4287	1411	0	97533
N_3I_1	12000	8000	7000	10000	4000	50000	835	4287	1411	2000	99533
N_3I_2	12000	8000	7000	10000	4000	50000	835	4287	1411	4000	101533

N_0 = control ($N_0P_0K_0$), $N_1 = N_{12}P_{18}K_{22}$, $N_2 = N_{18}P_{27}K_{33}$, $N_3 = N_{24}P_{36}K_{44}$ I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

B. Overhead cost (Tk. ha-1), Cost of production (Tk. ha-1), Gross return (Tk. ha-1), Net return (Tk. ha-1) and BCR

Treatments	Overhead cost (Tk. ha^{-1})				Subtotal (A)	Total cost of production (A+B)	Yeard long bean yield ha^{-1} (t)	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
	Cost of leased land for 6 months (13% of value of land Tk. 10,00,000/-	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (13% of cost $year^{-1}$)	Subtotal (B)						
N_0I_0	65000	4550	10436	79985.75	91000	170986	6.36	190800	19814	1.12
N_0I_1	65000	4650	10572	80222.25	93000	173222	8.01	240300	67078	1.39
N_0I_2	65000	4750	10709	80458.75	95000	175459	8.57	257100	81641	1.47
N_1I_0	65000	4713.25	10659	80371.8363	94265	174637	9.62	288600	113963	1.65
N_1I_1	65000	4813.25	10795	80608.3363	96265	176873	10.12	303600	126727	1.72
N_1I_2	65000	4913.25	10932	80844.8363	98265	179110	11.64	349200	170090	1.95
N_2I_0	65000	4794.95	10770	80565.0568	95899	176464	11.03	330900	154436	1.88
N_2I_1	65000	4894.95	10907	80801.5568	97899	178701	14.48	434400	255699	2.43
N_2I_2	65000	4994.95	11043	81038.0568	99899	180937	16.64	499200	318263	2.76
N_3I_0	65000	4876.65	10882	80758.2773	97533	178291	12.32	369600	191309	2.07
N_3I_1	65000	4976.65	11018	80994.7773	99533	180528	15.88	476400	295872	2.64
N_3I_2	65000	5076.65	11155	81231.2773	101533	182764	13.42	402600	219836	2.20

Selling cost of yard long bean = Tk.18/kg. N_0 = control ($N_0P_0K_0$), N_1 = $N_{12}P_{18}K_{22}$, N_2 = $N_{18}P_{27}K_{33}$, N_3= $N_{24}P_{36}K_{44}$, I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm