GROWTH AND YIELD OF FRENCH BEAN AS INFLUENCED BY THREE VARIETIES AND NUTRIENTS

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JUNE, 2020

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BY

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REG. NO. 13-05507

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

MASTERS OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE 2020

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH AND YIELD OF FRENCH BEAN AS INFLUENCED BY THREE VARIETIES AND NUTRIENTS"** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* **MOUSUMI AKTER,** *Registration No.* ***13-05507*** *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.

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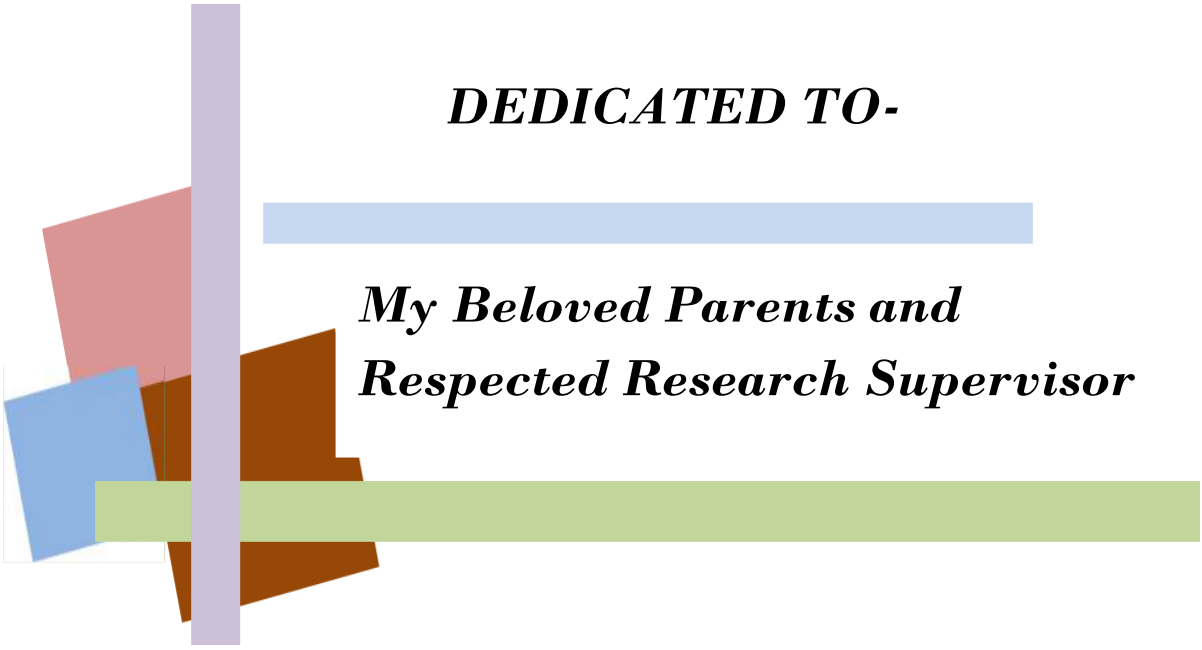

DEDICATED TO-

My Beloved Parents and
Respected Research Supervisor

ACKNOWLEDGEMENTS

*All praises and compliments are due to the Supreme Regulator and Ruler of the Universe, "**Almighty Allah**" for the blessing upon the successful accomplishment of education, to complete the research work and thesis leading to Master of Science (MS) in Horticulture.*

*The author likes to express her heartfelt respect, deep sense of gratitude and profound indebtedness to her reverend Supervisor **Prof**. **Dr. Tahmina Mostarin,** Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for her scholastic guidance, valuable advice, important suggestions, affection feelings, endless encouragement, and supervision throughout this research work and in preparing this thesis.*

*The author also extends her sincere appreciation, profound regards and cordial thanks to his Co-supervisor, **Prof. Dr. Abul Hasnat M. Solaiman,** Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for his kind help, constructive advise, fruitful criticism, creative suggestion, necessary correction and encouragement during the compilation of this thesis.*

*The author feels to express her heartfelt thanks to the honorable chairman of Horticulture **Prof. Dr. Md. Jahedur Rahman** along with all other teachers and staff members of the department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka. The author also grateful to Minister of Science and Technology, The Peoples Republic of Bangladesh for providing her a National Science and Technology (NST) fellowship to conduct her research properly.*

The author wishes to express her wholehearted thanks to her well-wishers, classmates Md. Abdus Samad, Sharmin Sultana Rima for their keen help as well as heartiest co-operation and encouragement.

June, 2020 ***The Author***

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted of two factors. Factor A: different varieties as V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3 and Factor B: different level of nutrients as N_1 = cowdung (5t/ha) + vermicompost (2t/ha), N_2 = cowdung(5t/ha) + N_{90} P_{30} K_{45} kg/ha, N_3 = cowdung (5t/ha) + vermicompost (2t/ha) + N_{90} P_{30} K_{45} kg/ha. The experiment was laid out in a Randomized Complete Block Design with three replications. In case of different varieties of French bean the maximum number of flower (27.83), the highest number of pod harvested per plant (22.14) and the highest yield (15.95 t/ha) were found from V_2 treatment, whereas the lowest from V_3 treatment. For different level of nutrients the highest number of flower (25.58), the maximum number of pod per plant (22.60) and the highest yield (14.10 t/ha) were recorded from N_2 treatment, while the minimum were from N_1 treatment. Due to combined effect, the maximum number of flower (32.02), the maximum number of pod harvested per plant (26.50), the highest yield (18.92 t/ha) were observed from V_2N_2 treatment combination, while the lowest were from V_2N_1 treatment combination. So, the V_2N_2 treatment combination appeared to be the best for achieving the higher growth and yield of French bean.

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LIST OF ABBREVIATIONS AND ACRONYMS

BARI	=	Bangladesh Agricultural Research Institute
AEZ	=	Agro-Ecological Zone
BCR	=	Benefit cost ratio
BBS	=	Bangladesh Bureau of Statistics
DAS	=	Days after sowing
M. S.	=	Master of Science
et al	=	and others (*at elli*)
SAU	=	Sher-e-Bangla Agricultural University
ml/l	=	Milliliter per liter
LSD	=	Least Significant Difference
CV%	=	Percent of coefficient of Variation
MoP	=	Muriate of Potash
PGR	=	Plant growth regulator
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate

CHAPTER I

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an herbaceous annual plant. It is a short durated high yielding legume crop and it can be utilized both as vegetable and pulse. It belongs to the family Leguminosae and subfamily Papiolionaceae (Swiader *et al.,* 1992*).* It is widely cultivated in the temperate, tropical, subtropical regions of the world (George, 1985). It is also grown in Europe, Africa, India, Peru, Mexico, Bangladesh etc. It has others name such as bush bean, kidney bean, snap bean, raj bean, common bean, basic bean, navy bean, haricot bean, pole bean, wax bean, string bean and bonchi (Salunkhe *et al*. 1987). In our country it is known as "Farashi Sheem" (Rashid, 1993). The green pods and mature seeds are used as cooked vegetable in our country. Seeds are also used as pulse in Sylhet, Moulvibazar, Sonamgonj, Habigonj, Brahmmanbaria, Feni, Coxs bazar, Chittagong etc. French bean including other related species of the genus *Phaseolus* occupied 32.08 million hectares of the world cropped area and the production of pods was about 23,139,004 t (FAO, 2013). The largest French bean producing country in the world is Brazil. In Bangladesh there is no statistics about the information of area and production of this crop. Although the crop is not extensively grown in Bangladesh, it has a great export potentiality.

Hortex foundation exported 330 metric tons of fresh French bean during the year 2012-2013 (Anonymous, 2013). Now days Hortex Foundations and BRAC are trying to extend the production area because French bean is now exportable vegetable among others. Immature green pods are also marketed as fresh, frozen or canned. The dry seeds have a good market price. The protein which is obtained from bean and seeds are easily transportable and absorbed in human body compare to animal protein. French bean may also provide hay, silage and green pod. It can be used as feed to cattle, sheep and horses etc. Bush bean is nutritionally rich in case of both pods and seeds. 100 g dry bean seed contains 336 calories for energy with 12% moisture, 21.7 g of protein, 1.5 g of lipid, 60 g CHO, 120 mg of Ca, 8.2 mg of Fe, 0.37 mg of Thiamin and 2.4 mg of Niacin (Schoonhoren and Rovset, 1993).

French bean production depends on so many factors such as variety, quality of seed, time of sowing, irrigation schedule, fertilizer and proper management practices etc. One of the most important factors that influence on the productivity and profitability of bush bean is variety. A few well adopted local varieties such as Sylhet local and Chittagong local are used to cultivate local farmers normally in limited areas of Bangladesh. There is no available recommanded variety of French bean. Bangladesh Agricultural Research Institute (BARI) has developed some varieties for the development of this crop. Only three varieties viz. BARI bush bean-1 (BARI Bush Bean-1), BARI bush bean-2 (BARI Bush Bean -2) and BARI bush bean-3 (BARI Bush Bean-3) have so far been released from BARI (BARI, 2017). Few works have been conducted regarding performance and characterization of bush bean varieties but we don't know which one give the best result under balanced nutrient system. Now more attention should be paid on these aspects to improve yield mainly seed yield. The performances of all varieties do not produce same quantity and quality of pod. So, it is an important task to identify specific variety which is more productive than others

Another factors of low productivity of French bean is due to inadequate fertilization. Different types of organic manures such as vermicompost is an eco-friendly, cost effective and ecologically sound bio-fertilizer. Use of vermicompost has a significant positive influence on seed germination and seedling vigor, plant growth, flowering, fruiting, tuberization, root development, color, shelf-life and quality of vegetables (Premsekhar & Rajashree, 2009). French bean responds considerably to major essential elements like N, P and K in respect to its growth and yield (Thompson and kelly, 1957). Shahana sultana (2014) found that the organic manure had significant effect on the plant height, number of branch, leaf size, number of flower, number of pod per plant and pod yield per hectare. Singh *et al*. (2011) reported that the increased amount of humus in soil through application of vermicompost and decomposition of organic mulch by earthworms would certainly help favourable change in physical, chemical and biological properties of soil and in enhancing the water holding capacity. Nitrogen management plays a significant role in maximizing production of French bean. Nitrogen is essential for its vegetative growth and development. French bean requires nitrogen in quite high amount in the first stage of development for the emergence of the nodules and builds up of the symbiotic nitrogen fixation.

The amount of nitrogen which symbiotically bound depends on the kind of plant; the efficiency of the bacteria inoculated and soil properties.

Phosphorus is one of the most significant determinants of plant growth (Wang *et al.*, 1998). For the general health and vigor of all plants, it is an essential plant nutrient. The growth and development of crops depend mostly on the development of root system. Robinson *et al.* (1981) reported the effect of phosphorus in stimulating root and plant growth. Phosphorus improves fertilization, quality of fruits, vegetable and grain crops and increases their resistance to diseases, drought and adverse environmental conditions. It is a major component of compounds whose functions relate to growth, root development, flowering, and ripening (Raboy, 2003). Potassium application influence vegetative growth, pod and seed yields and the quality of seeds, measured in terms of germinability (Sangakkara, 1996). Islam *et al.* (2016) found that due to application of potassium exerted a positive effect on plant growth characteristics and also on the yield of French beans. Potassium also has significant role on the productivity on French bean. It is essential for cell organization and structure of cell wall. It enhances plants ability to resist diseases, cold and other adverse condition such as poor flower development and poor pod setting.

Research on the growth and yield of French bean influenced by variety and nutrient management is very limited. The yield of French bean may be increased through judicious combination of cultivars and nutrient management application. Considering all above the factors, the present study was undertaken with the following objectives:

1. to find out varietal performance on growth and yield of French bean.
2. to identify optimum nutrients for growth and yield of French bean.
3. to identify suitable combination of varieties and nutrients on growth and yield of French bean.

CHAPTER II

REVIEW AND 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 varieties and combined nutrition of N, P, K, vermicompost, manures on the growth and yield of French bean. But in Bangladesh available research regarding effect of varieties and combined nutrition of N, P, K vermicompost and manures is insufficient. However, some of the literatures relevant to the effect of varieties and combined nutrition of N, P, K, vermicompost and manures on French bean production are reviewed in this chapter.

2.1 Effect of variety on productivity of French bean

Hossain, M. M. (2017) conveyed an experiment laid out at the Horticultural Farm, Sher-e-Bangla Agricultural University, Bangladesh during the period from November 2016 to April 2017 to study the application of phosphorus fertilizer interaction with different varieties for higher growth, seed yield and seed quality of bush bean. He found that at harvest, the tallest (63.92 cm) plant, the highest number of leaves (33.72) per plant, longest length of leaf (17.29 cm), maximum leaf breadth (10.88 cm) were produced from V_3 (BARI bush bean-3) treatment and the shortest (47.77 cm), the lowest number of leaves (19.87), the shortest length of leaf (15.40 cm) were found from V_1 (BARI bush bean-1) treatment. The longest (42.08 days) required for first flower initiation was identified from V_3 (BARI Bush Bean-1) treatment. The highest weight of 1000 bush bean seed (356.00 g) was obtained from V_3 (BARI Bush Bean -3) treatment and the lowest weight of 1000 bush bean seed (224.00 g) was found from V_2 treatment (BARI Bush Bean -2).

Kakon *et al.* (2015) dealed with an experiment into agronomy research field of Bangladesh Agricultural Research Institute (BARI), Joydebpur under Gazipur districts of Bangladesh during the period from November 2009-10 and 2010-11.The experiment site was located Chhiata Series under Agro-Ecological Zone-28 (AEZ-28) and found that effect of flowering pattern and floral abscission on the yield and yield attributed characters of French bean varieties. There nine varieties were treated- (1) BARI Jhar sheem-l (2) BARI Jhar sheem-2 (3) Sylhet local 1 (4) Sylhet local 2 (5)

Sylhet local 3 (6) Sylhet local 4 (7) Sylhet local 5(8) Sylhet local 6 and (9) Sylhet local 7. The duration of flowering was dependent on growing periods and varieties. All local varieties started flowering at 37-40 DAS and high yielding variety BARI Jhar sheem-1 and BARI Jhar sheem-2 were taken 5-6 days more than local variety. In both the years, the longest among the treatment the highest number of flower was recorded within 5 to 8 days in BARI Jhar sheem-2. Although, the maximum flower opened within *5* to 8 days and following ceased within 15 to 20 days after first flowering. The total number of flowers per plant varied between 19.36 to 45.06 and 22.0 to 47.20 in two consecutive years while percentage of pod abscission varied between 70.53 to 82.26 and 73.46 to 80.75 in two consecutive years. The flowering pattern and percent abscission as well greater number of pod were found to be the influential character for the highest yield of French bean.

Noor *et al.* (2014) directed an experiment that eleven genotypes variety of bush bean including BARI bush bean-1 and BARI bush bean-2 which were screened to select a suitable one which could provide optimum yield of fresh pod. BARI bush bean-1 required the minimum time of 88.33 days while BB-3 the maximum of 110.00 days to attain 90% pods maturity. No significant difference ($P<0.05$) in maximum protein content among the studied genotypes was observed, for example BB 15 (21.60%) and BARI bush bean-1 (21.57%). BARI bush bean-1 took minimum time for 90% flowering (34.67days), 90% pod setting (37.33 days), and 90% maturity of pods (88.33 days). Moreover, the maximum crude protein (21.57%) and crude fiber (5.53%) were obtained from BARI bush bean-1. Therefore, BARI bush bean-1 was selected as best for its quality and yields (fresh pod) among eleven genotypes of rench bean.

An experiment was carried out at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2012 to February, 2013 to study the effects of different organic manure on the growth and yield of different French bean cultivars by Shahana Sultana. Two cultivars of French bean viz, V_1: BARI French bean-1; V_2: BARI French bean-2 were used in this experiment. She found that at 15 DAS, 30 DAS and 45 DAS the highest plant height (16.18, 42.05 and 44.43) and maximum number of compound leaf (4.30, 10.00 and 18.08) were observed from V_2 (BARI French bean-2) whereas lowest plant height (13.26, 40.58 and 43.38) and

minimum number of compound leaf (3.90, 8.10 and 12.21) from V_1 (BARI French bean-1). The highest (28.08) number of branches per plant, maximum number of pods per plant (20.01), maximum length of pod (11.18), diameter of pod (1.87), maximum pod yield per plant (23.06 g) was showed by variety BARI French bean-2 (V_2) and the lowest number of branches per plant (25.83), minimum number of pod per plant (18.62), minimum length of pod (10.92), diameter of pod (0.96), pod yield per plant (12.85 g) was recorded in variety BARI French bean-1 (V_1).

Muthal *et al.* (2012) conveyed an experiment involving twelve varieties were laid out at the Research Block of Vegetable Section in Sector No.1, University of Horticultural Sciences, Bagalkot (Karnataka, India) during Rabi season of 2012. Among the varieties studied, Arka Anoop was better with respect to growth parameters like plant height and number of primary branches along with number of nodules on roots and dry matter content in pods as well as yield attributing characters like number of pods per clusters, number of pods per plant and weight of ten pods which is determined by pod length and number of seeds per pod reflecting in higher pod yield per plant and per hectare (24.58 t/ha).

Six green bean varieties were evaluated in a replicated small plot trial at the Gladstone Road Agricultural Centre during 2012. Results from this study indicated that there were significant differences among the six varieties with respect to the total number of pods per plant, weight of pods per plant and pod length (Richardson, 2012).

Roy *et al.* (2006) had been found the relationship between yield and its component characters of twenty seven bush bean (*Phaseolus vulgaris* L.) genotypes during November 2002 to February 2003. Ten characters were studied to identify suitable traits for yield improvement of this crop. The yield difference was attributed mainly due to variation in yield components such as days to 50% flowering, duration of flowering, plant height, pod length, pod breadth, pod per plant among genotypes (BB 1, BB 2, BB 3, BB 4, BB 5, BB 6, BB 7, BB 8, BB 9, BB 10, BB 11, BB 12, BB 13, BB 14, BB 15, BB 16, BB 17, BB 18, BB 19, BB 20, BB 21, BB 22, BB 23, BB 24, BB 25, BB 26 and BARI bush bean-1). Genotypes varied from 34.33 to 54.67 days to initiate 50% flowering. The number of pods per plant was the highest in BB 15 (22.64) followed by BB 3 (17.87) whereas BARI bush bean (7.97).

Hussain, M. M. (2005) directed an experiment in Bangabandhu Seikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur on yield and quality of improvement of bush bean as influenced by date of sowing and marked differences in diseased plants were observed in all eleven genotypes of French bean. The highest number of diseased plant was recorded in BB 5 (30.33%) and the lowest in BARI bush bean-1 (7.33%). It has been reported that percentages of disease plants were influenced by sowing time of bush bean and this percentage increased the yield of the French bean. Early sowing (15 November) was found better than late sowing (15 December) that is yield and quality decreased gradually with the delay of sowing. BARI bush bean-1 took the shortest time (86.67 days), while BB 3 the longest time (101.83 days) to maturity.

Roy, S. K. (2004) conveyed an experiment in Bangabandhu Seikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur on Characterization and yield variation in bush bean (*Phaseolus vulgaris* L.) genotypes and observed variation (15.00 to 21.67 days) among the genotypes in respect of days required to attain 4 leaves stage. BARI bush bean-1 took the shortest time to attain 4 leaves stage (17.33 days), whereas the genotype BB 3 took the longest (23.00 days). BB 4 (33.01) took minimum days to first flowering followed by BB 22 (35.31), BB 5 (36. 10) and BB 24 (36.77). The maximum day was required for the genotype BB 9 (53.80). Number of leaves at first flowering ranged between 7.00 (BARI bush bean-1) and 17.39 (BB 9). Regarding days to 50% flowering the genotype BB 9 (54.67) took maximum days closely followed by BB 14 (54.33). The longest pod (12.34 cm) was recorded in BB 18 followed by BB 10 (11 .92 cm), BB 22 (11 .82 cm) and BB 19 (11.41 cm), respectively while BARI bush bean-1 was recorded (8.94 cm).

Significant differences were confirmed by Dahiya *et al.* (2000) for 16 traits in 48 genotypes of French bean. Days to first flowering, days to 50% flowering, days to pod initiation, plant height, primary branches per plant and secondary branches per plant were characterized by high genetic advance combined of these characters and indicating the possibility of improving these traits through simple selection. The investigation revealed that among the genotypes, HUR-146 genotype was the highest yielder.

Salam *et al*. (1997) guided from their study with 13 cultivars of French bean that all the parameters like plant height, days to 50% flowering, seeds/pod, 100-seed weight, yield/plant (g) showed wide variability except pod length. Phenotypic and genotypic variances were maximum (26.55 and 15.42) in 100-seed weight and minimum (0.47 and 0.41) in pod length. They also observed that the Phenotypic Coefficients of Variation (PCV) had higher estimate than corresponding Genotypic Coefficients of Variation (GCV). Yield/plant and days to 50% flowering showed the highest and lowest PCV, respectively. The little difference between PCV and GCV were obtained for days to 50% flowering and pod length.

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Twenty-one genotypes of French bean including the check cultivar "Contender", were evaluated in a randomized block design at Solan during 1994 for plant height, days to 50% flowering, days to first picking, number of pods per cluster, number of pods per plant, pod length, girth, shape and color, yield per plant, harvest index, number of seeds per pod and 100-seed weight, Korla *et al*. (1997) analyzed that all the characters showed significant differences.

2.2 Effects of N, P, K, vermicompost and manures on the growth and yield of French bean:

El-Hassan *et al.* (2017) reported that treatments of compost and vermicompost individually or in combination with or without adding 50% of recommended dose of mineral fertilizers, were investigated on bean plants. The maximum height of 68.00 cm and 58.85 cm was obtained with 100% Mineral Fertilizer during 2016 and 2017 respectively, whereas it was 42 cm and 39.43 cm using 100% compost during 2016

and 2017 respectively and using 100% vermicompost it was 51.33 cm and 44.96 cm in 2016 and 2017 respectively.

Bipradas *et al*. (2016) carried out an experiment on yield response of tomato (*Lycopersicon esculentum* Mill.) under different combination of manures and fertilizers at Hogladanga village under the Batiaghata upazila of Khulna district during November, 2013 to March, 2014. The study revealed that vermicompost combined with NPK fertilizers increased the tomato growth and yield. Based on the findings of the experiment, treatment T_6 (50% Vermicompost + 50% recommended dose of NPK) was most profitable than rest of the treatment combinations.

An experiment in the greenhouse of the Institute of Biological Sciences, Faculty of Science, University of Malaya, Kualalumpur Malaysia during September, 2013 to February 2014 was carried out by Islam *et al*. (2016). They used vermicompost (20%), Traditional Compost (20%) and N:P:K fertilizer (farmer's practice) to determine the growth and yield attributes of bush bean (*Phaseolus vulgaris*), winged bean (*Psophocarpus tetragonolobus*) and yard long bean (*Vigna unguiculata*). For bush bean, total plant height was the highest 314.19 cm in VC (20%) treated plants and the lowest 160.24 cm in the FP. Bush bean grown with VC (20%) produced the highest number of pods 58.93 compared to 22.20 recorded in the FP treatment. For bush bean, regarding the length of the pod it was highest in VC (20%) treatment 10.76 cm followed by compost 9.87 cm and the shortest pod length were observed in FP treated plants with 7.89 cm. For bush bean, single pod weight was highest in the VC (20%) treatments compared to the FP treatment with the highest recorded values of 5.09 g and the lowest value observed were 3.76 g. Bush bean grown with VC (20%) had the highest pod yield of 2.98 t ha^{-1} followed by TC (20%) and FP (20%) which provided 1.45 t ha^{-1} and 0.83 t ha^{-1} of pods, respectively.

A research was carried out by Thriveni *et al*. (2015) they reported that 100 percent N:P:K + vermicompost had a beneficial effect on bitter gourd *viz*. maximum vine length (534 cm), number of branches per vine (18.0), maximum number of fruits per plant (40.0), fruit weight (86.4 g), fruit girth, fruit yield (4036 kg ha-1), ascorbic acid (111.1 mg/100 g), TSS (2.10°Brix) and protein content (1.76%).

Lad *et al.* (2014) conducted a 3- year field experiment during 2003-04, 2004-05 and 2005-06 with four levels of nitrogen (0, 50, 100 and150 kg/ha) and four levels of phosphorus (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) to study their impact on growth, yield attributes, yield and economics of French bean (*Phaseolus vulgaris* L.) grown under medium deep Vertisol soil in Marawada region. Higher dose of nitrogen (150 kg/ha) and phosphorus (75 kg/ha) resulted significantly highest grain & straw yield of French bean and show at par result with crop receiving 100 kg N & 50 kg P_2O_5 ha^{-1}which was found more profitable.

To investigate the effects of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chili an experiment was conducted randomized block design with three replications at Botanical Garden of Rajshahi University Campus, Bangladesh during August 2008 to February 2009 by Rahman *et al*., (2012). They suggested that inorganic fertilizers (NPK) with bio compost (3kg/pot) is suitable for better production of chili that may increase soil fertility and this integrated approach could be contributed to improve crop production.

Singh *et al.* (2011) investigated the effects of vermicompost, NPK fertilizer and organic mulch on crop growth, nodulation and pod yield of French bean. The shoot length, number of primary branches, shoot fresh weight and shoot dry weight, pod fresh weight and pod dry weight were increased by 28-63% through application of $N:P_2O_5:K_2O$ @ 8:13:10 kg ha^{-1} + vermicompost 3.75 t ha^{-1}. Application of vermicompost reduced nodule fresh weight and nodule dry weight by 44.9 and 44.5%, respectively. This study shows that application of $N:P_2O_5:K_2O$ fertilizer @ 8-15:13-25:10-20 kg ha^{-1}, vermicompost @ 2.50-3.75 t ha^{-1}, 4 cm thick mulch of dried crop residues and 50% irrigation is the most suitable and sustainable strategy to improve plant growth, pod formation, pod number, pod length, pod diameter and pod yield of French bean and soil health of mild-tropical climate during dry season.

A field experiment to evaluate the effect of different organic manures and bio-fertilizers on French bean conducted by Thakur *et al.* (2010). The study revealed that among all the treatments, combined application of vermicompost and biofertilizers increased the growth and yield of the crop in comparison to control.

An investigation at field research center of Department of Seed Science and Technology, H.N.B. Garhwal University, Srinagar (India), during Rabi season, 2007 by Singh *et al.* (2009) to explore the effect of organic sources of nutrients viz., vermicompost, FYM and along with inorganic fertilizers in French bean under irrigated condition with an objective to study growth and yield without degrading soil quality by using various nutrient compositions. In this investigation, vermicompost treatment (T_2) recorded the maximum height 30.13 cm of the French bean while minimum height growth of 21.09 cm was observed in N:P:K + Vermicompost (VC) + FYM (T_6). In this investigation, highest number of flowers per plant 36.4, pods per plant 25.2, pod length 10.8 cm and single pod weight 12 g were obtained from vermicompost treatment (T_2) while the least values were observed in control (T_7).

The application of organic manure yielded higher uptake of NPK than the control. The study also revealed that uptake of nutrient was higher with Composted Poultry Manure. The added organic manure not only acted as a source of nutrient might have influenced their availability (Amanullah *et al*., 2007).

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

With an field experiment Kumar *et al.* (2004) found that increment in NPK level (0:0:0 to 120:60:45 kg ha-^{1}) significantly increased plant height from 17 to 21.18 cm. He observed that number of pods per plant, pod length and pod diameter significantly increased due to application of fertilizers at the rate of 120:60:45 kg N: P_2O_5: K_2O ha^{-1} over control and 40:20:15 kg N: P_2O_5: K_2O ha-^{1}.

An experiment was conducted by Khan and Arvanitoyannis (2003) 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.

A research conducted Saxena *et al.* (2003) in Kanpur, Uttar Prades, India during the Rabi season of 2000-2002 where PDR-14 were supplied with 0, 60 and 120 kg N and K ha-^{1} and 0, 60 and 90 kg P ha-^{1} on French bean (*Phaseolus vulgaris*). Leaf area index, leaf area distribution and relative growth rate increased with growth stages and increasing rated of N, P and K. Crop yield increased with increasing rates N and P during both years.

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 cultivars (Holland 84 and PDR 14) to different application rates (0, 30, 60, 90 Kg/ha) of nitrogen. Holland 84 was 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 and yield attributes and yield increased with increasing rate of nitrogen up to 90 kg/ha.

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

An experiment was conducted by Chaudhuri *et al.* (2001) in Nagpur, Maharashtra, India, during the rabi season of 2000-01 to study the effect of nutrient management treatments on the growth and yield of French bean (*Phaseolus vulgaris*). They recommended dose of 90 kg N ha^{-1} and 60 P_2O_5 ha^{-1}.

An experiment was carried out by Dhanjal *et al.* (2001) reported that the plant height of French bean increased from 22.69 cm to 27.13 cm during 1996-97 and 21.69 cm to 26.45 cm during 1997-98, by increased nitrogen fertilization from 0-120 kg N ha^{-1}. He observed that linear increase in the number of branches per plant up to 120 kg N ha^{-1}, with HUR-87 variety of French bean on sandy loam soil and significantly higher number of pods per plant was recorded in the treatment receiving 120 kg N ha^{-1}.

An experiment was performed by Rana *et al.* (2001) opined that plant height of Rajmash cultivar Kailash increased significantly with increased fertility up to N_{40} P_{80} K_{20} kg ha^{-1}. He reported that all fertility levels tried (N_{20} P_{60} K_{00}, N_{20} P_{60} K_{20}, N_{20} P_{80}

K_{20}, N_{40} P_{60} K_{20} and N_{40} P_{80} K_{20}) increased number of pods per plant significantly over farmers practice (N_{15} P_{15} K_{15}).

A experiment accomplished by Rajesh *et al.* (2001) in India to study the effect of N (80, 160 and 240 Kg ha^{-1}) and S (0, 20, 40 and 60 Kg ha^{-1}) on the nutrient uptake and grain yield of French bean (*Phaseolus vulgaris cv.; Hur 137*). The highest seed yield was found at N level of 240 kg ha^{-1} (2091kg ha^{-1}) and S (6.58 kg ha^{-1}) and that of straw yields (3331 kg ha^{-1}) and highest to total N (90.70 kg ha^{-1}) and S (6.58 kg ha^{-1}) uptake. Sulphur at 40 kg ha^{-1} recorded the highest seed yield (1811 kg ha^{-1}) and highest total N (77.45 kg ha^{-1}) and S (6.06 kg ha^{-1}) uptake.

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

Tewari and Singh (2000) studied from a trial in India to identify the optimum and economical dose of nitrogen (0, 40, 80, 120 or 160 kg ha^{-1}) and phosphorus (0, 20, 40 or 60 kg ha^{-1}) for better growth and yield of French bean. They obtained highest yield of pods per plant, weight of seeds per plant and seed yield with the application of 120 kg N ha^{-1} whereas 160 kg N ha^{-1} significantly reduced seed yield.

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

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

A field experiment in Brazi conducted by Alves *et al.* (1999) to determine the effect of productivity evaluation and seed quality of French bean cultivated with organic matter. They considered of 4 organic amendments applied 5 levels (0, 5, 10, 15 and 20 ton ha-1 of earthworm or chicken manure and 0, 10, 20, 30 and 40 ton ha-1 of bovine or poultry manure). They found that the maximum production was obtained with 30 ton ha-1 poultry manure when applied.

Another field experiment was performed by Arya *et al.* (1999) 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 that 25 kg N ha^{-1}. 75 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} was the best combinations for yield per plant and yield per hectare.

An experiment in Egypt by Singer *et al.* (1999) to study the effects of delta mix and organic matter on growth and productivity of French bean plants. They applied different doses of delta mix and organic matter at 10 and 20 ton ha-1 and NPK fertilizers were applied at different doses. They found that plant height, number of leaves and number of shoots were significantly affected by the different rates of delta mix and different levels of organic matter and chemical fertilizers.

An field experiment carried out by Kanaujia *et al. (*1999) in Himachal Pradesh, India to observe the effect of P and K on growth, yield and quality French bean cv. contender. They applied 0,40, 80 and 120 kg P_2O_5/ha and 0,30,60 and 90 kg K_2O/ha and obtained the highest plant height, green pod yield and protein content among them potassium rates were obtained from 80 kg P_2O_5/ha. with the increasing level of potassium level upto 60 kg K_2O/ha increased the plant height, number of branches per plant, pod length, pod girth, number of pod per plant and protein content.

An experiment was performed by Rana and Singh (1998) they opined that seed yield is increased significantly with N rate in French bean. They used 0, 40, 80 and 120 kg N ha^{-1} and 0, 50 or 100kg P_2O_5 ha^{-1}. The mean increase in seed yield with 120 kg N ha^{-1} compared with 0, 40 and 80 kg N ha^{-1} was 66.6, 21.7 and 7.0% respectively.`

Gajendra and Singh (1998) performed an experiment at Lalchaoti with moisture regimes and fertility levels in soil on French bean. They stated that 120 kg N + 90 kg P_2O_5 and 45 kg K per ha gave higher fresh pod yield per plant and pod yield per ha and also grain yield in French bean.

A field experiment was conducted by Devender *et al.* (1998) in cold desert, dry-temperature region of Kinnaur, to study the effect of nitrogen and phosphorus on yield and uptake of nutrients in French bean or rajma (*Phaseolus vulgaris* L.). Plant height, pods/plant, seeds/pod and seed yield increased significantly up to 15 kg N and 60 kg P_2O_5 Kg/ha. The N and P uptake also showed similar trend during both the years. Nutrients-use efficiency however was significantly highest at their lower levels, i.e. 15 kg N and 30 kg P_2O_5 gave significantly highest N and P-use efficiency respectively.

An experiment was conducted by Parthiban and Thamburaj (1991) 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.

Adetunji (1990) have reported similar findings in beans cultivated with organic manures. Specific leaf weight showed decreasing pattern by increasing the amounts of vermicompost and application of organic mulch. The finding clearly shows that optimum dose of vermicompost and organic mulching play an important role towards partitioning of photo assimilates from vegetative source to reproductive sink (leaf to green pod) which will ultimately lead to development of yield attributes.

A field experiment was performed by Shrinivas and Naik (1988) with cv. Arka Komal of French bean to observe the response to nitrogen and phosphorus fertilization. Nitrogen was applied at 0, 40, 80, 120 and 160 kg ha^{-1} and P at 0, 17.5 or 34.9 kg ha^{-1}. Half of the total N and all P plus 33.2 kg ha^{-1}K were applied at sowing and the remaining N was top dressed 25 days later. Pod yields were increased with increasing fertilizer rate from 392 kg ha^{-1}at 0 kg N to 13617 kg ha^{-1} at 160 kg N ha^{-1}.

An experiment carried out by Ali and Tripathi (1988) 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.

A field experiment was performed by Abbound and Duque (1986) to find out the effects of application of organic matter and vermiculite in a French bean- maize production. They found that seed yield of the crop was increased by incorporation of organic matter.

Bhopal and Singh (1987) accomplished a field experiment in Himachal Pradesh to evaluate the response of French bean to nitrogen and phosphorus fertilization. Nitrogen was applied at 0-80 kg ha^{-1} and P_2O_5 at 2-120 kg ha^{-1}, and a basal dose of K_2O at 50 kg ha^{-1}. The optimum nitrogen phosphorus dose was 67.3: 79.7 kg ha^{-1}; it gave yields over 210 q ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November 2018 to January 2019 to compare growth and yield of French bean as influenced by three varieties and nutrients. This chapter includes a brief description of the experimental period, location, soil and climate condition of the experimental area and materials that were used for conducting the experiment i.e. treatment and design of the experiment, growing of crops, intercultural operations, data collection procedure and procedure of data analysis that were used for conducting the experiment.

3.1 Experimental Site

The research was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The experiment was carried out during rabi season. The location of the experimental site is situated at 90° 22 ' E longitude and 23° 41' N latitude. The altitude of 8.6 meters above the sea level. The experimental site is presented in Appendix I.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, Soil Research Development Institute Farmgate, Dhaka and the results showed that the soil composed of 27% sand, 43% silt and 30% clay. The soil was having a texture of sandy loam with pH and organic matter 5.47–5.63 and 0.83%, respectively. The details soil characteristics are presented in Appendix II.

3.3 Climatic condition of the experimental site

The experimental area was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). During the experimental period the maximum temperature (32.24^0 C),

highest relative humidity (78.82%) and highest rainfall (68.5 mm), highest rainfall (68.5 mm) was recorded in the month of September 2018, whereas the minimum temperature (13.6^0 C), minimum relative humidity (62.04%) and no rainfall was recorded for the month of January, 2019. The climatic conditions during the period of experiment were collected from the Bangladesh Meteorological Department, Agargaon, Dhaka and the data are presented in Appendix III.

3.4. Agro-ecological region

The experimental field belongs to the agro-ecological region of the Madhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces associated with either shallow or broad, deep valleys.

3.5. Experimental details

3.5.1 Planting materials

The seeds were collected from the Horticulture Research Center (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5.2 Experimental treatments: The experiment consists of two factors:

Factor A: Variety

V_1 = BARI French bean-1

V_2 = BARI French bean-2

V_3= BARI French bean-3

Factor B: Nutrients

N_1 = Cowdung (5t/ha) + vermicompost (2t/ha)

N_2 = Cowdung(5t/ha) + N_{90} P_{30} K_{45} kg/ha

N_3 = Cowdung (5t/ha) + vermicompost (2t/ha) + N_{90} P_{30} K_{45} kg/ha

There are 9 treatment combinations such as V_1N_1,V_1N_2,V_1N_3,V_2N_1,V_2N_2, V_2N_3, V_3N_1, V_3N_2, V_3N_3.

3.5.3 Design and layout of the experiment

The two factor experiment was laid out in the randomized complete block design (RCBD) with three replications. There were 9 treatment combinations. In total 27 plots for 3 replications. Each block consisted of 9 unit plots. The size of each unit plot was (1.2 m x 0.9 m) or 1.08 m^2. The distance maintained between two replications

and two plots were 1 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.6 Land preparation

The experimental area was first ploughed by a power tiller and the soil was exposed to sun for 5 days. Then the land was thoroughly prepared by ploughing and cross ploughing. The weeds and stubbles were removed from the field. Then the land was divided into 27 unit plots keeping plot and block to block spacing. During land preparation, carbofuran @ 16 kg/ha was mixed with the soil uniformly for controlling soil borne insects. Sevin 50WP @ 5 kg/ha was applied to soil for protecting the young plants from the attack of ants and cutworms.

3.7 Seed sowing

Two seeds were sown per hill at a depth of 3.0 cm on 8 November, 2018 in the row, plant to plant distance was 15 cm and row to row distance was 30 cm (Plate 1). The seeds were covered with pulverized soil just after sowing and gently pressed with hands. Surrounding of the experimental plots, French been seeds were also sown as border crop to reduce border effects.

3.8 Fertilizers and manure application

The fertilizer and manures for French bean was applied in the following way. Total amount of well composed cow dung (5 t/ha), vermicompost (2 t/ha), triple supper phosphate (TSP) (150 Kg/ha) and half of muriate of potash (MP) (as per treatment) were during final land preparation and rest of MP (as per treatment) was used after 35 DAS. Urea (196 kg/ha) was used as equal three splits. 1/3rd amount of urea was used during final land preparation and rest amount was applied in two installments at 15 and 30 days after sowing (as per treatment). The fertilizers which were applied mixed in appropriate portion with the plot soil.

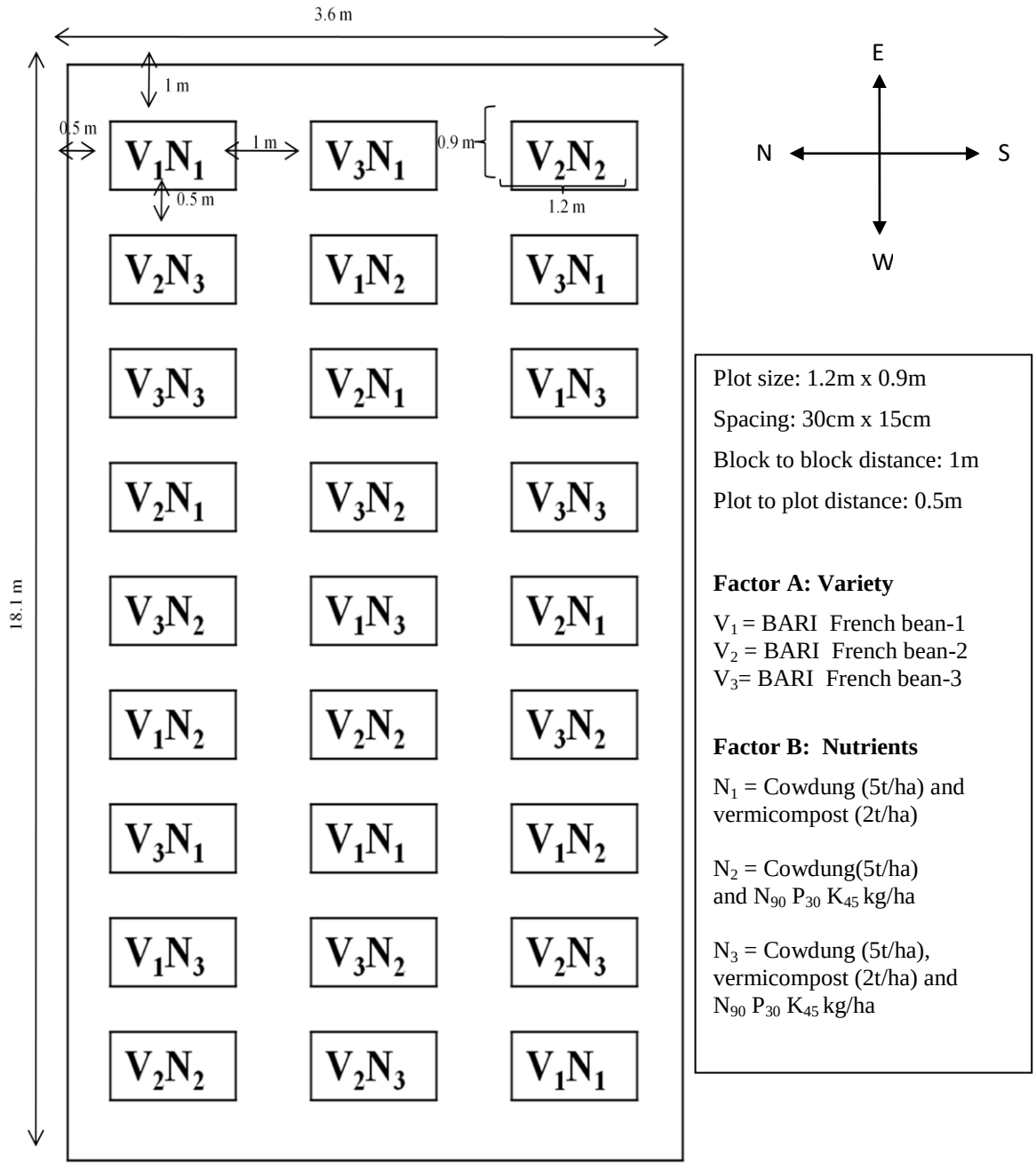

Fig. 1. Field layout of the experimental plot on French bean in the Randomized Complete Block Design.

3.9 Intercultural operations

Various intercultural operations, such as gap filling, weeding, mulching with water hyacinth, earthing up, irrigation, pest and disease control etc. were accomplished for better growth and development of the French bean seedlings. The crop was kept free from weeds by regular weeding and irrigated as and when required.

3.9.1 Gap filling

During seed sowing, few seeds were sown in the border of the plots. All gaps were filled up within one week after germination of seeds.

3.9.2 Thinning

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

3.9.3 Weeding

Weeding was done whenever it was necessary to keep the plots free from weeds and to pulverize the soil.

3.9.4 Earthing up

Earthing up was done three times at 15, 30 and 45 days after sowing.

3.9.5 Irrigation and drainage

Earlier on the seedling establishment stages light watering was given by a watering cane in every afternoon. After well establishment of the seedlings watering was given with irrigation channels. At the reproductive stage no water stress was encountered. Proper drainage facilities were made surrounding the experimental plots for drainage of excess water.

3.10 Plant protection

3.10.1 Insect pests

At the early stage of growth, some plants were attacked by insect's pests (mainly aphid) and Malathion 57 EC was sprayed twice at the rate of 2 ml /liter at an interval of 10 days.

3.10.2 Diseases

Some plants were attacked by Bean Common Mosaic Virus (BCMV) which is an important disease of French bean. These plants were removed from the plots and destroyed and also Admire 20 SL sprayed twice at the rate of 1ml liter^{-1} at 10 days interval to control vector. Seedlings were attacked by damping off and Dithane M-45 was sprayed twice at the rate of 2 ml litre^{-1} at an interval of 7 days.

3.11 Harvesting

At tender stage, immature green pods were harvested through hand picking and weighed to estimate the yield of fresh pod (Plate 1). At harvest, pods were nearby full size, with the seeds still small (about one quarter developed) with firm flesh (Swiader *et al*., 1992) and the pods were soft and smooth.

3.12 Collection of data

At the time of data collection five representative plants were selected at random from each of unit plot to avoid border effect and tagged in the field. Data were recorded periodically from the sample plants at 15 days interval. The details of data recording are given below:

3.12.1 Plant height (cm)

The plant height was recorded at 15, 30 and 45 days after sowing (DAS). Plant height was considered as the height from ground level to the tip of largest leaf of the plants (Plate 1). Plant height of five randomly sampled plants was recorded and mean was calculated in centimeter (cm).

3.12.2 Number of compound leaves per plant

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

3.12.3 Leaf length (cm)

Leaf lengths of full grown selected leaves were measured by using a measuring scale.

3.12.4 Leaf breadth (cm)

Leaf breadth of full grown selected leaves were measured by using a measuring scale

3.12.5 Number of branches per plant at harvest

The number of branches of five randomly selected plants from each plot at final harvest was recorded.

3.12.6 Days required to first flowering

The dates of first flowering for different treatments were recorded.

3.12.7 Number of flowers per plant

From five randomly selected plants per unit plot, the numbers of flowers were counted and their mean values were found out.

3.12.8 Number of pods per plant

Number of pods from five randomly selected plants was counted and their mean values were calculated.

3.12.9 Length of green pod (cm)

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

3.12.10 Diameter of green pod (cm)

Diameter of green pods from ten randomly selected green pods and measured in cm with the help of a slide calipers and the average was taken and expressed in cm.

3.12.11 Number of seeds per green pod

Numbers of seeds per green pod was recorded from ten randomly selected green pods and the mean value was calculated.

3.12.12 Dry matter content of plant (%)

Hundred g plants from each plot were taken, cut into some small pieces and was dried under direct sunshine for 3 days and then was dried in an oven at 70^0 for 72 hours before taking the dry weight till it was constant. The dry weight was recorded in gram (g) by using a beam balance.

3.12.13 Dry matter content of pod (%)

100 g pods from each plot were taken, cut into some small pieces and was dried under direct sunshine for 3 days and then was dried in an oven at 70^0 for 72 hours before taking the dry weight till it was constant. The dry weight was recorded in gram (g) by using a beam balance.

3.12.14 Pod yield per plant (g)

The green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different and the total pod weights were recorded in each plant and expressed in gram (g).

3.12.15 Pod yield per plot (g)

The green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different and the total pod weights were recorded in each unit plot and expressed in gram (g).

3.12.16 Pod yield per hectare (t)

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

3.13 Statistical analysis

The recorded data on different parameters were statistically analyzed using Statistic 10 software. The significance of the difference among the treatments means was estimated by least significant difference test (LSD) at 5% level of probability.

a b

c d

Plate 1. Pictorial presentation of different operations during field experiment. a. Sowing of seed ; b. Measurement of plant height at 15 DAS using meter scale in cm (centimeter); c. Harvesting of pod ; d. Harvested pod from different plot.

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was conducted to study growth and yield of French bean as influenced by three varieties and nutrients. Data on different growth and other parameter, yield attributes and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in appendix section (IV-XV). The effect of different varieties, cowdung, vermicompost, N, P, K and their interaction on growth yield and yield contributing characters have been presented and discussed in this chapter under the following heads.

4.1. Plant height (cm)

Different varieties showed significant variation on plant height of French bean at 15, 30, 45 days after sowing (DAS) (Fig. 2 and Appendix IV, X). At 15 DAS, the longest plant (31.57 cm) was found from V_3 (BARI French bean-3) and the shortest plant (22.89 cm) from V_1 (BARI French bean-1). At 30 DAS, the highest plant height (48.56 cm) was found from V_3 (BARI French bean-3), while the lowest (31.83 cm) was recorded from V_1 (BARI French bean-1). The longest plant (50.21 cm) was recorded from V_3 (BARI French bean-3) and the shortest plant (36.17 cm) was recorded from V_1 (BARI French bean-1) at 45 DAS. Optimum plant height can be achieved through proper management practices during growth and development stage. A study was conducted by Salam *et al*. (1997) with 13 cultivars of French bean. They reported that plant height showed wide variability except pod length. This result is in agreement with findings of Hossain M. M. (2017) that reported at the same days, the longest plant height for BARI French bean-3 and shortest BARI French bean-1.

Plant height of French bean was significantly influenced by different levels of nutrients at 15, 30, 45 (DAS) (Fig. 3 and Appendix IV, XI). Results revealed that the longest plant height (28.66 cm) was obatined from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the shortest plant height (24.43 cm) was obatined from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment at 15 DAS. At 30 DAS, the longest plant height (43.15 cm) was found from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the lowest plant height (35.27 cm) was recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha). The longest plant height (45.78 cm) was observed from N_3

(cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the shortest plant height (39.55 cm) was obatined from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment at 45 DAS. It revealed that cowdung, vermicompost and $N_{90}P_{30}K_{45}$ increased plant height, which might be due to the effect of nitrogen. Rahman *et al*. (2012), Thriveni *et al*. (2015) observed similar trend of results.

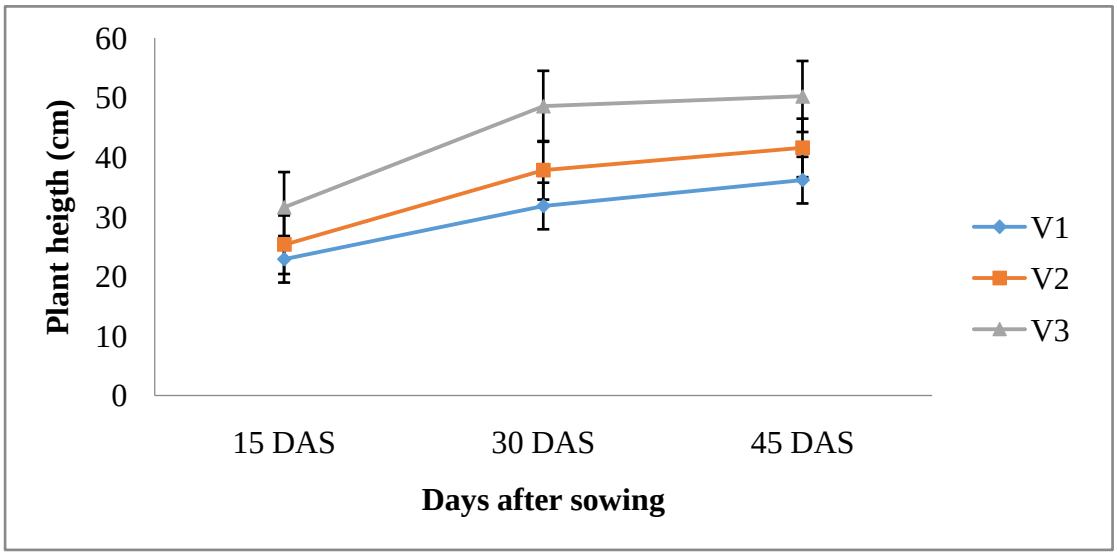

Fig. 2. Effect of different varieties on plant height of French bean at different days after sowing. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

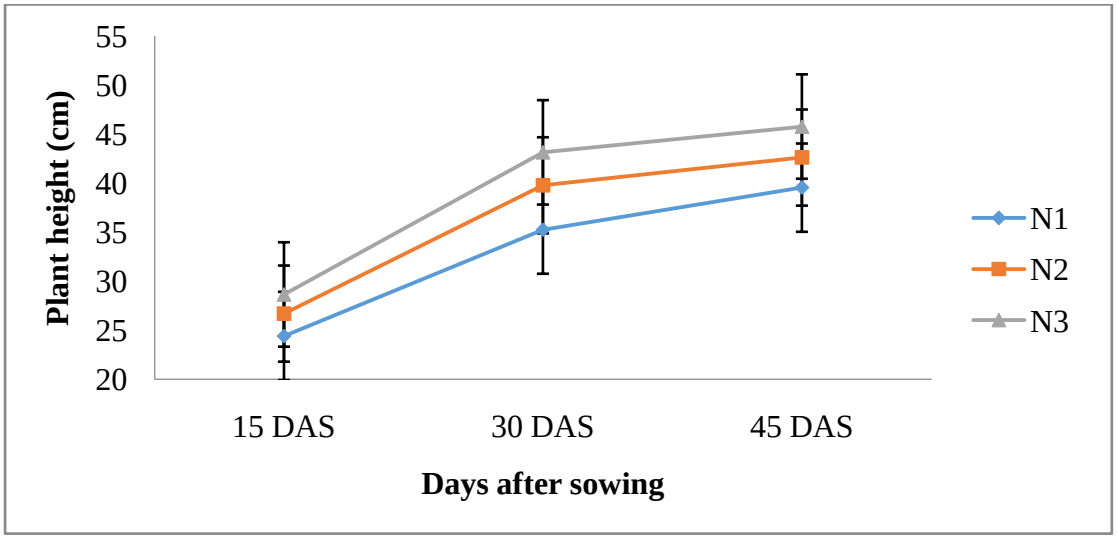

Fig. 3. Effect of different levels of nutrients on plant height of French bean at different days after sowing. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

Significant variation was observed due to the combined effect of different varieties and levels of nutrients in terms of plant height of French bean at 15, 30, 45 days after sowing (Table 1 and Appendix IV). At 15 DAS, the maximum plant height (33.45 cm) was recorded from treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), while the minimum plant height (20.55 cm) from V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha). At 30 DAS significant differences in terms of plant height was observed among the treatment combinations and the maximum plant height (50.60 cm) was recorded from the treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), whereas the minimum (28.07 cm) was noted from the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha). At 45 DAS, the maximum plant height (53.13 cm) was recorded from the treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), whereas the minimum (3.40) from V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

Table 1. Combined effect of different varieties and levels of nutrients on plant height at different days after sowing of French bean

Treatment Combinations	Plant height (cm)		
	15 DAS	30 DAS	45 DAS
V_1N_1	20.55 g	28.07 h	33.4 h
V_1N_2	23.16 f	31.69 g	35.69 g
V_1N_3	24.98 e	35.75 f	39.43 f
V_2N_1	23.15 f	31.2 g	37.93 f
V_2N_2	25.29 e	39.15 e	42.02 e
V_2N_3	27.55 d	43.1 d	44.78 d
V_3N_1	29.59 c	46.54 c	47.33 c
V_3N_2	31.69 b	48.53 b	50.16 b
V_3N_3	33.45 a	50.60 a	53.13 a
LSD(0.05)	1.5313	1.7781	1.9672
CV%	3.33	2.61	2.66

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

4.2 Number of leaves per plant

Number of leaves per plant is an important parameter of crop plant because of its physiological role in photosynthetic activities. The effect of different varieties on number of leaves of French bean was statistically significant (Fig. 4 and Appendix V, XII). The maximum (3.43) number of leaves per plant was recorded from V_3 (BARI French bean-3) and the minimum (2.64) number of leaves per plant was obtained from V_1 (BARI French bean-1) at 15 DAS. At 30 DAS, the maximum (21.54) number of leaves per plant was recorded from V_3 (BARI French bean-3) while the minimum (15.22) number of leaves per plant was found from V_1 (BARI French bean-1). The maximum (27.05) number of leaves per plant was obtained from V_3 (BARI French bean-3) while the minimum (18.39) number of leaves per plant was recorded from V_1 (BARI French bean-1) at 45 DAS. This variation might be due to the difference in genetic constituents as well as environmental effects. The result is similar with the findings of Hossain M. M. (2017), Sultana, S. (2014).

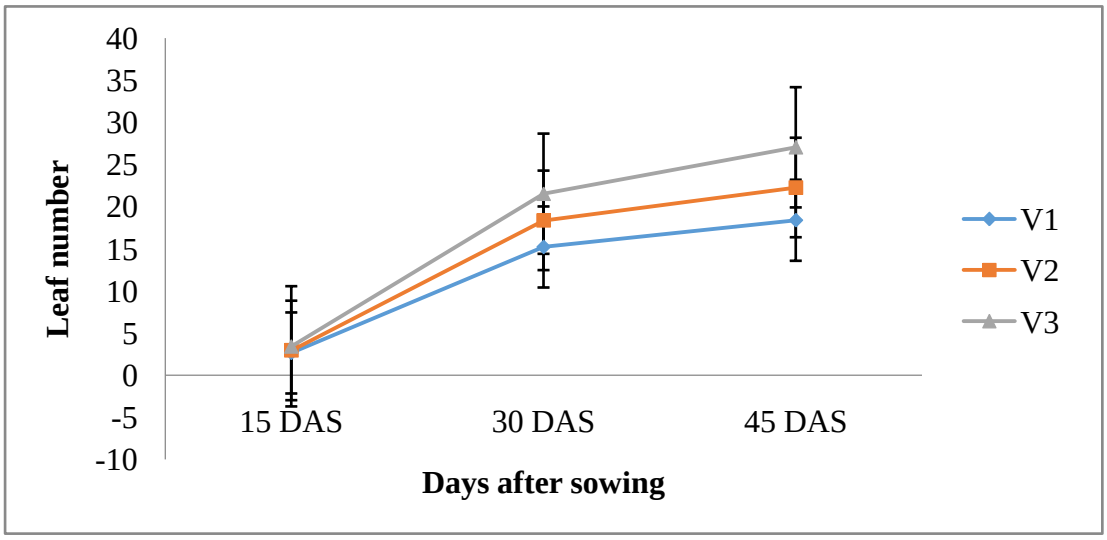

Fig. 4. Effect of different varieties on number of leaves per plant of French bean at different days after sowing. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Application of different levels of nutrients exhibited a significant influence on number of leaves of French bean plants at 15, 30, 45 (DAS) days after sowing (Fig. 5 and Appendix V, XIII). At 15 DAS, the maximum number of leaves (3.21) was found from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the minimum number of leaves (2.82) from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment which is statistically identical with N_2 (cowdung @

5t/ha + N_{90} P_{30} K_{45} kg/ha). At 30 DAS, the maximum number of leaves (19.73) was recorded from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment, while the minimum (16.95) was recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The maximum number of leaves (24.66) was recorded from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the minimum (20.72) was recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment, at 45 DAS. It was revealed that the number of leaves increased with the increased days after sowing (DAS) i.e., 15, 30, 45 DAS. Cowdung, vermicompost, $N_{90}P_{30}K_{45}$ kg/ha is rich in its nitrogen and nutrient content. This favorable condition creates better nutrient absorption for vegetative growth and consequently, the maximum number of leaves was found by cowdung, vermicompost, $N_{90}P_{30}K_{45}$. Rahman *et al*. (2012) reported similar trend of results.

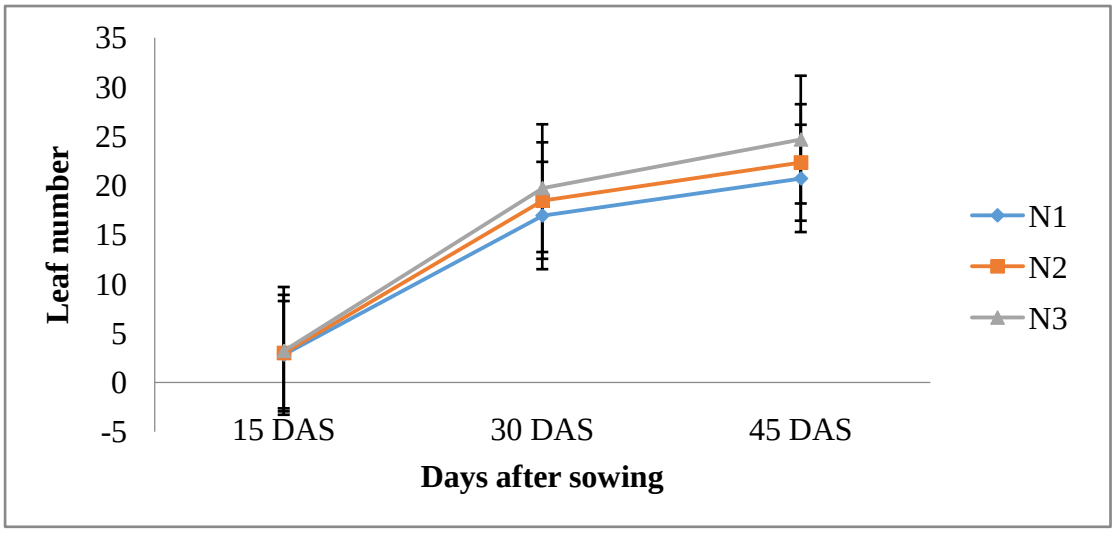

Fig. 5. Effect of different levels of nutrients on number of leaves per plant of French bean at different days after sowing. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

Combined beffect of different varieties and levels of nutrients showed significant differences for number of leaves per plant of French bean at different days after sowing (Table 2 and Appendix V). At 15 DAS the maximum (3.68) number of leaves per plant was recorded from treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), while the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) gave the minimum (2.48) number of leaves per plant which is statistically

similar with V_1N_2 and V_2N_1 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination. At 30 DAS significant differences in terms of number of leaves per plant was observed among the treatment combination and the maximum (22.90) number of leaves per plant was recorded from the treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) whereas the minimum (13.53) was recorded from the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha). At 45 DAS the maximum (28.63) number of leaves per plant was recorded from the treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), while the minimum (16.36) number of leaves per plant was recorded from the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

4.3 Leaf length (cm)

Variation on leaf length at harvest differed significantly among different varieties of French bean (Fig. 6 and Appendix V, XII). Results revealed that maximum leaf length (22.94 cm) was observed from V_3 (BARI French bean-3) treatment and minimum leaf length (16.97 cm) was found from V_1 (BARI French bean-1) treatment. The productivity of field crops depends mainly on the size of leaf, the photosynthesis system as well as on the length of time during, which it remains active (Carr and Wardlaw, 1965). The present observation is similar to the result of that found by Hossain M. M. (2017).

Leaf length of French bean varied apparently due to application of different levels of nutrients (Fig. 7 and Appendix V, XII). Results revealed that maximum leaf length (20.92 cm) was observed from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and minimum leaf length (18.84 cm) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment.

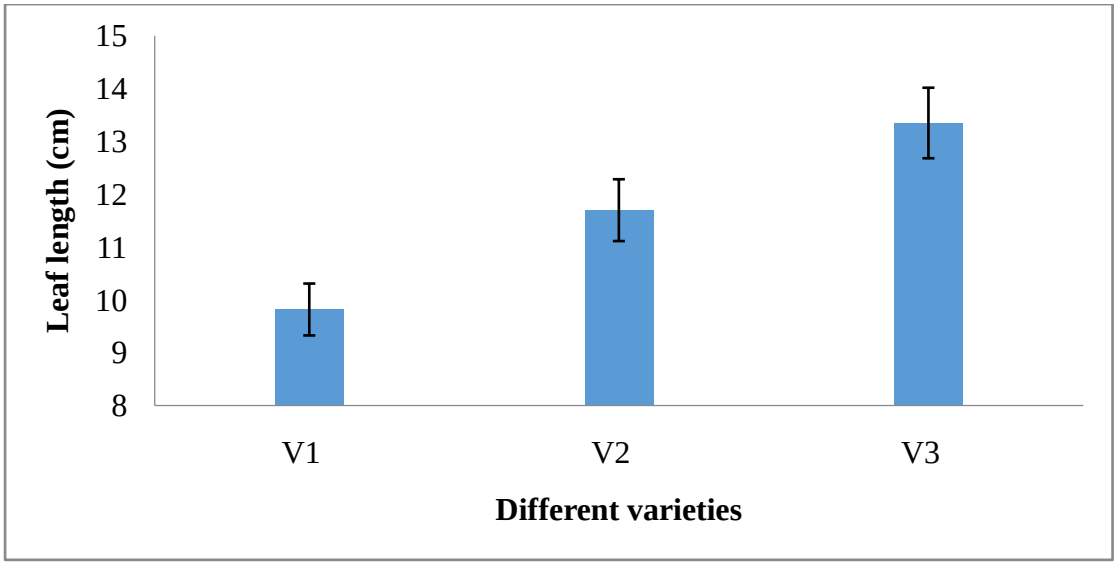

Fig. 6. Effect of different varieties on leaf length of French bean. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

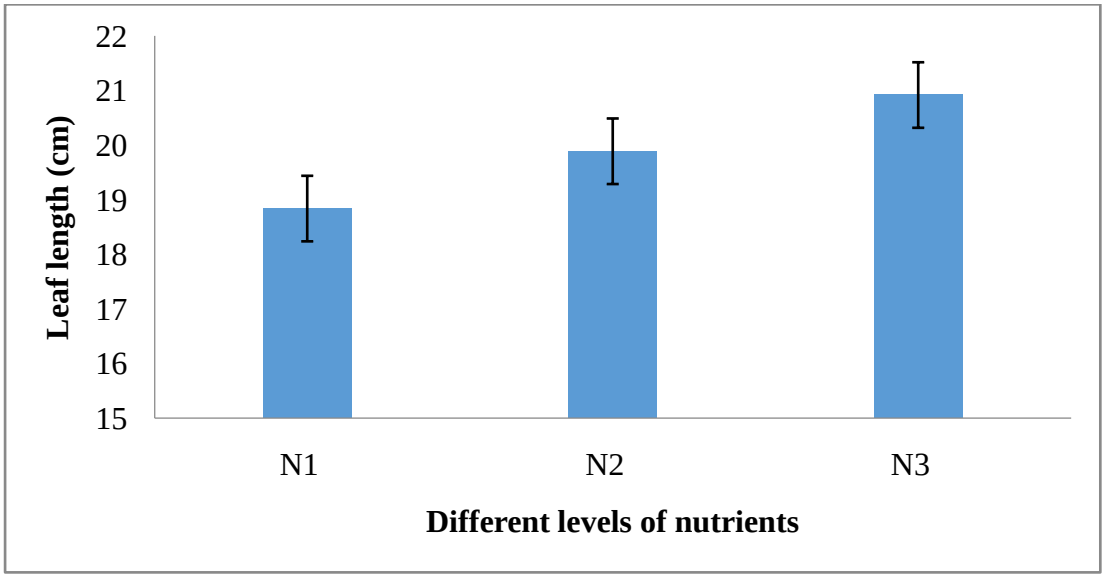

Fig. 7. Effect of different levels of nutrients on leaf length of French bean. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

Combined effect of different varisties and levels of nutrients showed statistically significant variation on leaf length of French bean at harvest (Table 2 and Appendix V). The result showed that maximum leaf length (23.97 cm) was recorded from treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) which is significantly different from other treatment combinations whereas the minimum leaf length (16.02 cm) was found from the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha +

vermicompost @ 2 t/ha). From the above result it revealed that application of cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha increases the leaf length.

4.4 Leaf breadth (cm)

At harvest leaf breadth varied significantly among different varieties of French bean (Fig. 8 and Appendix V, XII). The highest (13.35 cm) leaf breadth was recorded from V_3 (BARI French bean-3) and the lowest (9.82 cm) due to V_1 (BARI French bean-1) treatment. Leaf breadth is the protected means of trapping solar energy and converting it into food and other useful materials so that it can play a great role in the crop production.

Significant influence was noted on leaf breadth of French bean at harvest by different levels of nutrients (Fig. 9 and Appendix V, XIII). The highest (12.27 cm) leaf breadth was recorded from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and lowest (11.08 cm) leaf breadth was recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment.

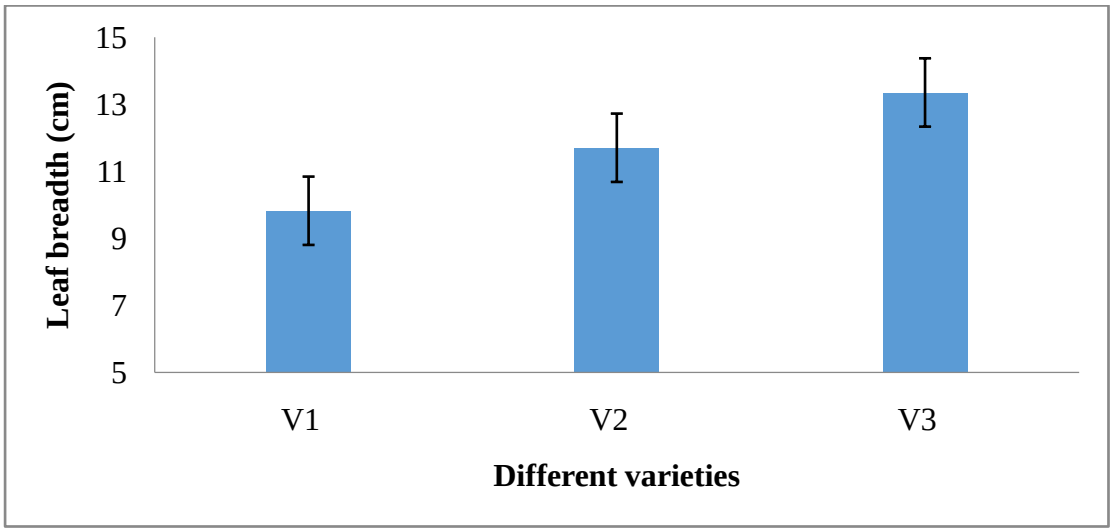

Fig. 8. Effect of different varieties on leaf breadth of French bean. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

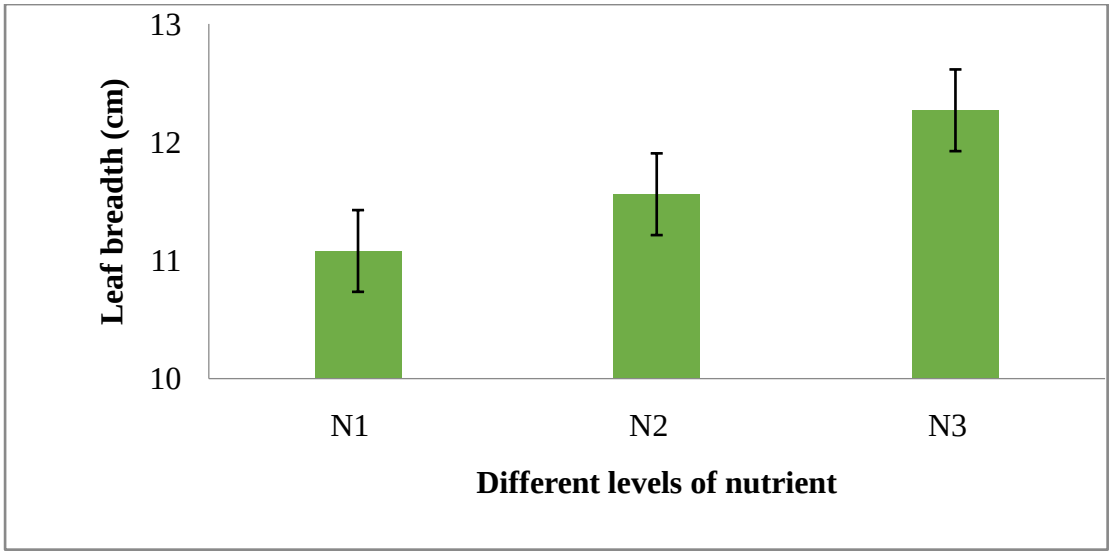

Fig. 9. Effect of different levels of nutrients on leaf breadth of French bean. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

Table 2. Combined effect of different varieties and levels of nutrients on leaf number, leaf length, leaf breadth of French bean

Treatment combinations	Leaf number			Leaf length (cm)	Leaf breadth (cm)
	15 DAS	30 DAS	45 DAS		
V_1N_1	2.48 f	13.53 g	16.36 g	16.02 h	9.06 g
V_1N_2	2.61 ef	14.97 f	18.01 f	17.03 g	9.85 f
V_1N_3	2.83 de	17.17 e	20.79 e	17.87 fg	10.55 e
V_2N_1	2.74 def	17.01 e	19.85 e	18.61 f	11.26 d
V_2N_2	2.98 cd	19.02 d	22.45 d	19.71 e	11.63 d
V_2N_3	3.12 bc	19.12 d	24.55 c	20.91 d	12.34 c
V_3N_1	3.25 bc	20.3 c	25.96 b	21.9 c	12.93 bc
V_3N_2	3.36 b	21.43 b	26.57 b	22.94 b	13.20 b
V_3N_3	3.68 a	22.9 a	28.63 a	23.97 a	13.9 a
LSD(0.05)	0.2890	0.9931	1.3416	0.9637	0.6110
CV%	5.55	3.12	3.43	2.80	3.03

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and N_{90} P_{30} K_{45} kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and N_{90} P_{30} K_{45} kg/ha.

Significant variation was remarked on leaf breadth of French bean at harvest influenced by combined effect of different varieties and levels of nutrients (Table 2 and Appendix V). The highest (13.90 cm) leaf breadth was obtained from the V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$

kg/ha) treatment combination. The lowest (9.06 cm) leaf breadth was obtained from V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

4.5 Number of branches per plant at harvest

The number of branches per plant showed significant difference due to different varieties of French bean (Fig. 10 and Appendix VI, XIV). At harvest the maximum number of branches (15.64) was found V_3 (BARI French bean-3) treatment while minimum number of branches (9.56) was counted from V_1 (BARI French bean-1) treatment. Dahiya *et al*. (2000) conducted a study with 48 genotypes of French bean. They observed that primary branches per plant and secondary branches per plant varied significantly due to characterized by genetic advanced.

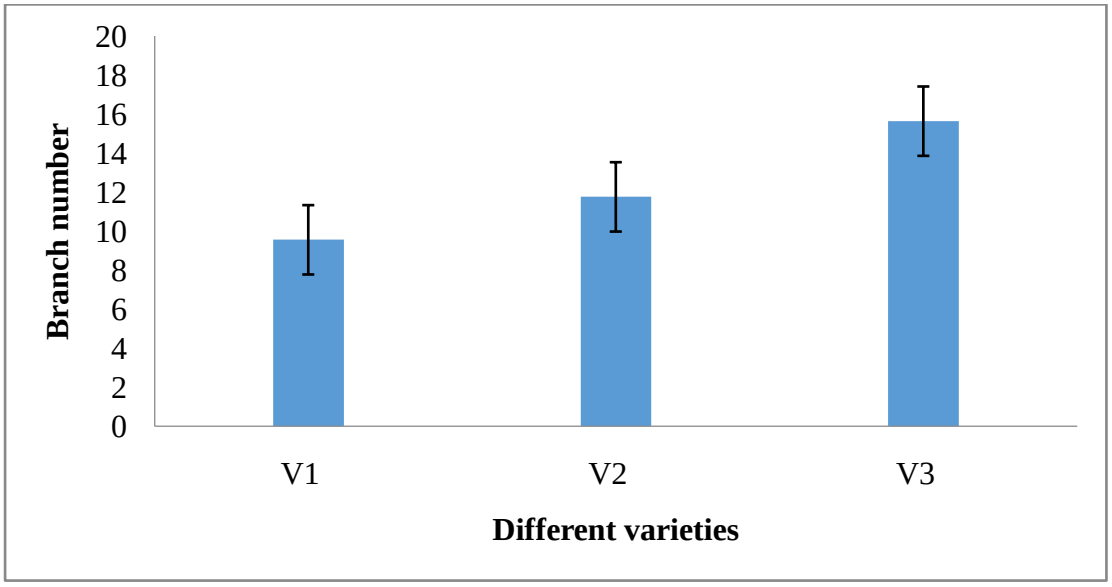

Fig. 10. Effect of different varieties on number of branches per plant of French bean. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Application of different levels of nutrients showed significant variations on number of branches per plant of French bean (Fig. 11 and Appendix VI, XV). At harvest the maximum number of branches (13.69) was found in N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the minimum number of branches (11.10) was recorded in N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. This result is in agreement with the findings of Rahman *et al*. (2012), Thriveni *et al*. (2015).

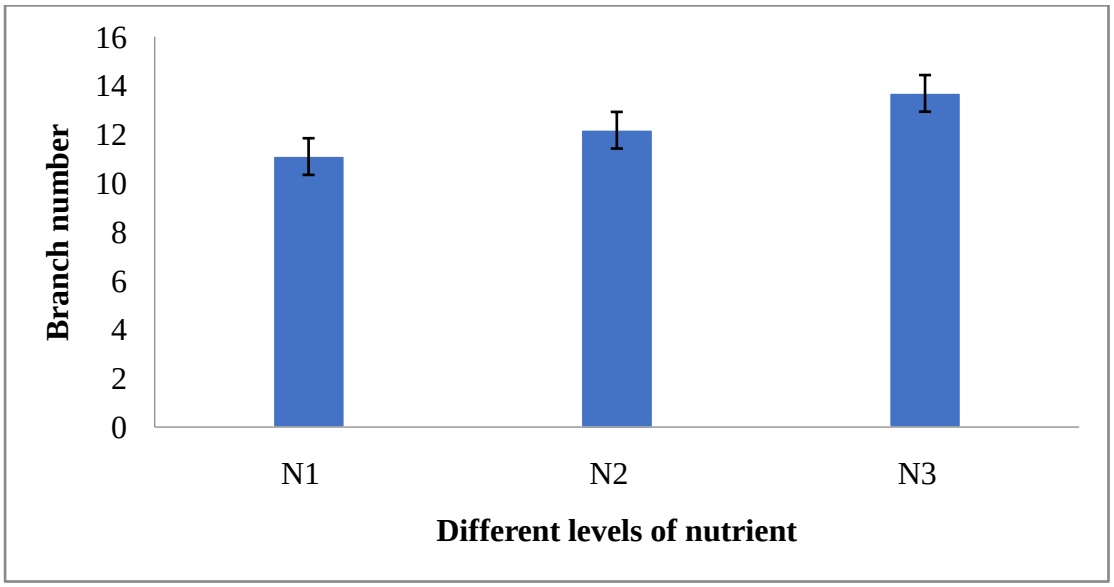

Fig. 11. Effect of different levels of nutrients on number of branches per plant of French bean. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

The combined effect of different varieties and levels of nutrients performed wide range of variations on number of branches per plant of French bean at harvest (Table 5 and Appendix VI). At harvest the highest number of branch (16.60) was counted from V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination while the minimum number of branches per plant (8.10) was found from V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

4.6 Days required to first flowering

Different varieties had significant influence on days required to first flowering of French bean (Table 3 and Appendix VI). It was observed that maximum days (37.63) to first flowering was required in V_2 (BARI French bean-2) treatment whereas minimum days to first flowering (26.81) was required in V_3 (BARI French bean-3) treatment. The flowering time is a very necessary part which plays an exigent role in the life of a plant. Korla *et al*. (1997) analyzed that days to required first flowering showed little differences among the various cultivars of French bean. The result is similar with the findings of Kakon *et al*. (2015).

The data on days required to first flowering was found to be significant in terms of different levels of nutrients on French bean (Table 4 and Appendix VI). Results exposed that maximum days (33.46) to first flowering was required in N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment whereas minimum days (30.44) to first flowering was required in N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Rahman *et al*. (2012), Thriveni *et al*. (2015), Bipradas *et al.* (2016) observed similar trend of results.

Table 3. Effect of different varieties on days to first flowering, number of flower of French bean

Treatment	Days to first flowering	Number of flower
V_1	31.89 b	23.88 b
V_2	37.63 a	27.83 a
V_3	26.81 c	15.47 c
LSD(0.05)	0.6562	0.7653
CV%	2.04	3.42

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Significant variation was remarked on days to first flowering influenced by combination of different varieties and levels of nutrients on French bean (Table 5 and Appendix VI). It was observed that maximum days (38.89) to first flowering was required in V_2N_3 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination whereas minimum days (25.67) to first flowering was required from V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

4.7 Number of flowers per plant

The number of flowers per plant of French bean was significantly influenced by the three different varieties (Table 3 and Appendix VI). The highest number of flowers per plant (27.83) was recorded for the V_2 (BARI French bean-2) treatment and the lowest number of flowers (15.47) was recorded for the V_3 (BARI French bean-3) treatment. Kakon et. al (2015) observed that BARI French bean-2 produced the highest number of flowers per plant while BARI French bean-1 produced the lowest number.

There was significant variation on number of flowers per plant for the effect of different levels of nutrients on French bean under the present study (Table 4 and Appendix VI). The maximum number of flowers per plant (25.58) was recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the minimum number of flowers per plant (18.33) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Rahman *et al*. (2012), Thriveni *et al*. (2015), Bipradas *et al.* (2016) observed similar trend of results.

Combined effect between different varieties and levels of nutrients showed a statistically significant variation in consideration to number of flower per plant of French bean (Table 5 and Appendix VI). The maximum number of flower per plant (32.02) was recorded from the treatment combination of V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the minimum number of flower per plant (13.33) was recorded from combination treatment of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

Table 4. Effect of different levels of nutrients on days to first flowering, number of flower per plant of French bean

Treatment	Days to first flowering	Number of flower per plant
N_1	30.44 c	18.33 c
N_2	32.42 b	25.58 a
N_3	33.46 a	23.26 b
LSD(0.05)	0.6562	0.7653
CV%	2.04	3.42

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and N_{90} P_{30} K_{45} kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and N_{90} P_{30} K_{45} kg/ha.

Table 5. Combined effect of different varieties and levels of nutrients on branch number, days to first flowering, number of flower per plant of French bean

Treatment combinations	Branch number	Days to first flowering	Number of flower per plant
V_1N_1	8.1 g	29.33 e	20.03 f
V_1N_2	9.5 f	32.67 d	27.17 c
V_1N_3	11.09 e	33.67 d	24.45 d
V_2N_1	9.86 f	36.33 c	21.63 e
V_2N_2	12.03 d	37.67 b	32.02 a
V_2N_3	13.38 c	38.89 a	29.83 b
V_3N_1	15.33 b	25.67 g	13.33 i
V_3N_2	15.01 b	26.93 f	17.57 g
V_3N_3	16.6 a	27.83 f	15.50 h
LSD(0.05)	0.9389	1.1365	1.3255
CV%	4.40	2.04	3.42

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and N_{90} P_{30} K_{45} kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and N_{90} P_{30} K_{45} kg/ha.

4.8 Number of pods per plant

Significant variation was observed on number of pods per plant of French bean among different varieties (Fig. 12 and Appendix VII, XIV). The maximum number of pods per plant (22.14) was recorded from V_2 (BARI French bean-2) treatment, while the minimum (11.22) was counted from V_3 (BARI French bean-3) treatment. Singh *et al.* (1993) found significant variation in number of pods per plant with an experiment of seven French bean genotypes.

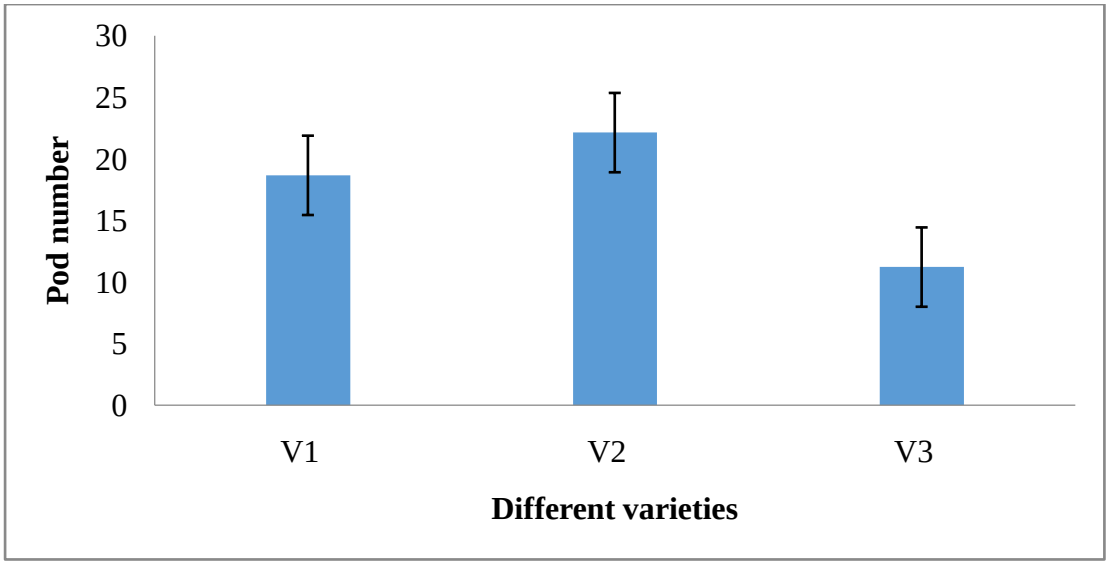

Fig. 12. Effect of different varieties on number of pods per plant of French bean. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Number of pods per plant differed significantly due to application of different levels of nutrients on French bean (Fig. 13 and Appendix VII, XV). The maximum number of pods per plant (20.60) was recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) and the minimum number of pod per plant (13.66) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. It was revealed that number of pods per plant increased by using cowdung and $N_{90}P_{30}K_{45}$ kg/ha. This might be caused that cowdung and $N_{90}P_{30}K_{45}$ contents high amount of nitrogen which increased the number of leaves, cell division and cell enlargement. Rahman *et al*. (2012), Thriveni *et al*. (2015) observed similar trend of results.

The variation was found due to combined effect of different varieties and levels of nutrients on number of pods per plant of French bean (Table 8 and Appendix VII).). The maximum number of pods per plant (26.50) was recorded from the treatment combination of V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the treatment combination of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) performed the minimum number of pods per plant (9.32).

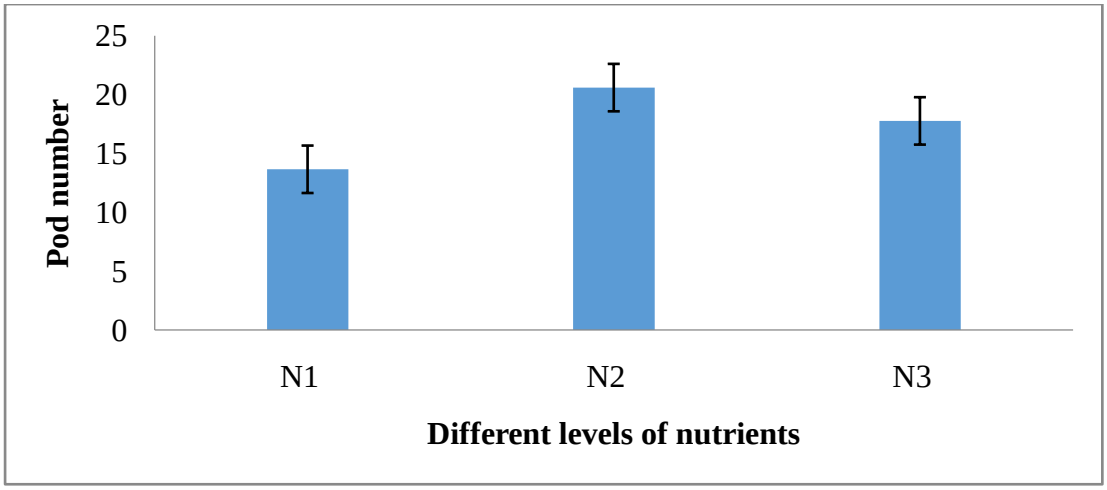

Fig. 13. Effect of different levels of nutrients on number of pods per plant of French bean. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

4.9 Length of green pod (cm)

Variation on pod length differed significantly among different varieties of French bean (Table 6, Plate 2 and Appendix VII). Results revealed that maximum pod length (13.70 cm) was observed from V_3 (BARI French bean-3) treatment and minimum pod length (12.09 cm) was found from V_1 (BARI French bean-1) treatment. It is similar with the result of Sultana, S. (2014).

Significant influence was observed in terms of pod length of French bean influenced by different level of nutrients (Table 7 and Appendix VII). Result signified that maximum pod length (13.13 cm) was observed from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment which is statistically similar with N_3 (cowdung @ 5t/ha and vermicompost @ 2t/ha and N_{90} P_{30} K_{45} kg/ha) treatment and minimum pod length (12.57 cm) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. From the above result it revealed that application of cowdung and $N_{90}P_{30}K_{45}$ kg/ha increases the pod length. Rahman *et al*. (2012) observed similar trend of results.

Combined effect of different varieties and levels of nutrients showed statistically significant variation on pod length of French bean (Table 8 and Appendix VII). The result showed that maximum pod length (14.22 cm) was recorded from treatment combination V_3N_2 (BARI French bean-3 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha)

which is statistically similar with V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination and the minimum pod length (11.58 cm) was found from the treatment combination of V_1N_1 which is statistically similar with V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) and V_1N_3 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination.

4.10. Diameter of green pod (cm)

There was significant variation on diameter of green pod for the effect of different varieties of French bean (Table 6, Plate 2 and Appendix VII). The maximum diameter of pod (0.76 cm) was recorded from V_3 (BARI French bean-3) treatment, while the minimum (0.65 cm) was counted from V_2 (BARI French bean-2) treatment.

Remarkable variation was identified on pod diameter due to the application of different levels of nutrients on French bean (Table 7 and Appendix VII). The highest pod diameter (0.72 cm) was achieved from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment which is statistically identical with N_3 (cowdung @ 5t/ha and vermicompost @ 2t/ha and N_{90} P_{30} K_{45} kg/ha) treatment where the lowest pod diameter (0.67 cm) was achieved from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment.

Significant variation was remarked on pod diameter of French bean influenced by combined effect of different varieties and levels of nutrients (Table 8 and Appendix VII). Results exposed that the highest pod diameter (0.78 cm) was obtained from the treatment combination of V_3N_2 (BARI French bean-3 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) which is statistically similar with V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination. The lowest pod diameter (0.63 cm) was obtained from treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) which is statistically similar with V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination.

4.11. Number of seeds per green pod

There was significant variation on number of seeds per green pod for the effect of different varieties of French bean (Table 6 and Appendix VII). The maximum number of seeds per green pod (6.28) was recorded from V_1 (BARI French bean-1), while the minimum (4.82) was counted from V_3 (BARI French bean-3) treatment. It is similar with the result of Kakon *et al.* (2015).

Significant variation was recorded on number of seeds per green pod for the effect of different levels of nutrients on French bean (Table 7 and Appendix VII). The maximum number of seeds per green pod (5.82) was recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) and the minimum number of seeds per green pod (5.42) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment.

The variation was found due to combined effect of different varieties and levels of nutrients on number of seeds per green pod of French bean (Table 8 and Appendix VII). The maximum number of seeds per green pod (6.47) was recorded from the treatment combination of V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the treatment combination of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) performed the minimum number of seeds per green pod (4.60).

Plate 2. A photograph showing the harvested French bean from different treatments which are different in length and diameter.

Table 6. Effect of different varieties on pod length, pod diameter, no. of seeds per pod of French bean

Treatment	Pod length (cm)	Pod diameter (cm)	No of seeds per pod
V_1	12.09 c	0.65 c	6.28 a
V_2	12.69 b	0.70 b	5.71 b
V_3	13.70 a	0.76 a	4.82 c
LSD(0.05)	0.4745	0.0173	0.0939
CV%	3.70	2.47	1.68

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Table 7. Effect of different levels of nutrients on pod length, pod diameter, no. of seeds per pod of French bean

Treatment	Pod length (cm)	Pod diameter (cm)	No of seeds per pod
N_1	12.57 b	0.67 b	5.42 c
N_2	13.13 a	0.72 a	5.82 a
N_3	12.78 ab	0.71 a	5.57 b
LSD(0.05)	0.4745	0.0173	0.0939
CV%	3.70	3.43	1.68

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

4.12 Dry matter content of plant (%)

Different varieties had significant influence on the percentage of dry matter content of plant of French bean (Table 9 and Appendix VIII). The highest (24.12%) dry matter content of plant was observed from the V_3 (BARI French bean-3) and lowest (21.09%) dry matter content was observed from treatment V_2 (BARI French bean-2).

The data on the percentage of dry matter content of plant was found to be significant in terms of different levels of nutrients on French bean (Table 10 and Appendix VIII). Results indicated that the highest (23.62%) dry matter content of plant was observed from the N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the lowest was (21.56%) recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment

Table 8. Combined effect of different varieties and levels of nutrients on pod number, pod length, pod diameter, no. of seeds per pod of French bean

Treatment combinations	Pod number	Pod length (cm)	Pod diameter (cm)	No of seeds per pod
V_1N_1	15.79 e	11.58 d	0.63 g	6.13 b
V_1N_2	22.2 c	12.38 cd	0.65 fg	6.47 a
V_1N_3	18.01 d	12.32 cd	0.66 f	6.23 b
V_2N_1	15.87 e	12.79 bc	0.67 ef	5.51 e
V_2N_2	26.5 a	12.80 bc	0.74 bc	5.93 c
V_2N_3	24.06 b	12.47 c	0.70 de	5.69 d
V_3N_1	9.32 h	13.34 b	0.72 cd	4.6 h
V_3N_2	13.09 f	14.22 a	0.78 a	5.06 f
V_3N_3	11.25 g	13.55 ab	0.77 ab	4.8 g
LSD(0.05)	1.7145	0.8219	0.03	0.1626
CV%	5.71	3.70	2.47	1.68

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha..

Combined effect of different varieties and levels of nutrients showed statistically significant variation on percentage of dry matter content of plant of French bean (Table 11 and Appendix VIII). The result showed that the highest (25.60%) dry matter content of plant was observed from the V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment which is significantly different from other treatment combinations while the lowest (20.26%) dry matter content of plant was observed from V_2N_1 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

4.13 Dry matter content of pod (%)

Variation on pod length differed significantly among different varieties of French bean (Table 9 and Appendix VIII). The highest (11.03%) dry matter content of pod was observed from the V_3 (BARI French bean-3) and lowest (6.42%) dry matter content was observed from treatment V_2 (BARI French bean-2).

Table 9. Effect of different varieties on dry matter content of plant, dry matter content of pod of French bean

Treatment	Dry matter content of plant (%)	Dry matter content of pod (%)
V_1	22.89 b	8.61 b
V_2	21.09 c	6.42 c
V_3	24.12 a	11.03 a
LSD(0.05)	0.4098	0.4496
CV%	1.81	5.18

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Table 10. Effect of different levels of nutrients on dry matter content of plant, dry matter content of pod of French bean

Treatment	Dry matter content of plant (%)	Dry matter content of pod (%)
N_1	21.56 c	7.91 c
N_2	22.92 b	8.71 b
N_3	23.62 a	9.44 a
LSD(0.05)	0.4098	0.4496
CV%	1.81	5.18

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

Significant variation was observed on percentage of dry matter content of pod of French bean influenced by different levels of nutrients (Table 10 and Appendix VIII). Results indicated that the highest (9.44%) dry matter content of pod was observed from the N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the minimum (7.91%) dry matter content of pod was recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment.

Combined effect of different varieties and levels of nutrients showed statistically significant variation on percentage of dry matter content of pod of French bean (Table 11 and Appendix VIII). The result showed that the highest (11.93%) dry matter content of pod was observed from the V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment which is significantly different from other treatment combinations while the lowest (5.67%) dry matter content of pod was observed from V_2N_1 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment.

Table 11. Combined effect of different varieties and levels of nutrients on dry matter content of plant, dry matter content of pod of French bean

Treatment combinations	Dry matter content of plant (%)	Dry matter content of pod (%)
V_1N_1	22.33 de	7.91 e
V_1N_2	22.89 cd	8.61 de
V_1N_3	23.47 c	9.30 d
V_2N_1	20.26 g	5.67 g
V_2N_2	21.21 f	6.51 f
V_2N_3	21.79 ef	7.08 f
V_3N_1	22.07 e	10.14 c
V_3N_2	24.67 b	11.01 b
V_3N_3	25.60 a	11.93 a
LSD(0.05)	0.7098	0.7788
CV%	1.81	5.18

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

4.14 Pod yield per plant (g)

Significant variation was observed on the yield per plant among different varieties of French bean (Table 12 and Appendix IX). The highest (71.78 g) yield was recorded from V_2 (BARI French bean-2) and the lowest (27.51 g) yield was obtained from V_3 (BARI French bean-3) treatment. Similar observations were recorded by Sultana, S. (2014).

Yield per plant of French bean was significantly varied due to different levels of nutrients (Table 13 and Appendix IX). It was examined that the highest yield per plant (63.46 g) was observed from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the lowest yield per plant (41.78 g) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Rahman *et al*. (2012), Thriveni *et al*. (2015), Bipradas *et al.* (2016), Taheri *et al.* (2017) observed similar trend of results.

Combined effect between different varieties and levels of nutrients showed a statistically significant variation for yield per plant of French bean (Table 14 and Appendix IX). The result indicated that the highest yield per plant (85.13 g) was

observed from V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination while the lowest yield per plant (18.68 g) was found from V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

4.15. Pod yield per plot (g)

Significant influence was noted on pod yield per plot of French bean affected by different varieties of French bean (Table 12 and Appendix IX). The highest pod yield per plot (1722.70 g) was found from the V_2 (BARI French bean-2) treatment where the lowest pod yield per plot (660.20 g) was found from the treatment V_3 (BARI French bean-3).

Pod yield per plot of French bean varied significantly due to different levels of nutrients (Table 13 and Appendix IX). The highest pod yield per plot (1523.00 g) was achieved from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment where the lowest pod yield per plot (1002.60 g) was achieved from the treatment of N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

Table 12. Effect of different varieties on yield/plant, yield/plot of French bean

Treatment	Yield/plant (g)	Yield/plot (g)
V_1	61.16 b	1467.7 b
V_2	71.78 a	1722.7 a
V_3	27.51 c	660.2 c
LSD(0.05)	3.4525	82.861
CV%	6.46	6.46

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3.

Significant variation was remarked on pod yield per plot of French bean as influenced by combined effect of different varieties and levels of nutrients (Table 14 and Appendix IX). The highest pod yield per plot (2043.00 g) was recorded from the treatment combination of V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) which was significantly different from all other treatment combinations. The lowest pod yield per plot (448.20 g) was recorded from the treatment combination of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha +

vermicompost @ 2 t/ha) which was significantly different from other treatment combinations.

Table 13. Effect of different levels of nutrients on yield/plant, yield/plot of French bean

Treatment	Yield/plant (g)	Yield/plot (g)
N_1	41.78 c	1002.6 c
N_2	63.46 a	1523 a
N_3	55.21 b	1325 b
LSD(0.05)	3.4525	82.861
CV%	6.46	6.46

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

4.16. Pod yield per hectare (t)

Variation on pod yield per ha of French bean was noted as significant influenced by different irrigation levels (Fig. 14 and Appendix IX, XIV). The highest pod yield per ha (15.95 t) was achieved from V_2 (BARI French bean-2) treatment whereas the lowest pod yield per ha (6.11 t) was achieved from the treatment of V_3 (BARI French bean-3).

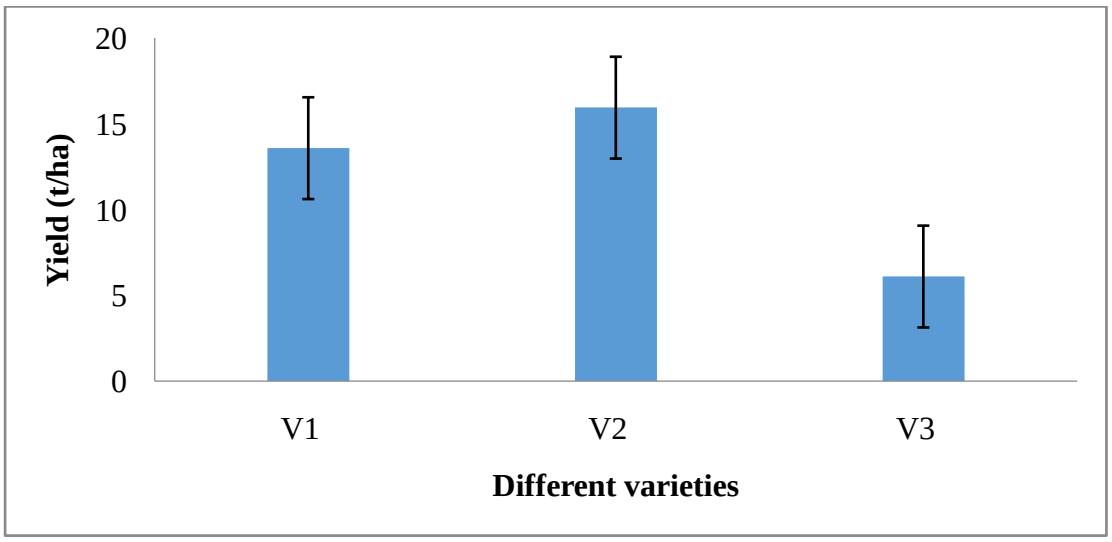

Fig. 14. Effect of different varieties on yield per hectare of French bean. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3

The recorded data on pod yield per ha of French bean was significant due to the effect of different levels of nutrients (Fig. 15 and Appendix IX, XV). The highest pod yield per ha (14.10 t) was achieved from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment whereas the lowest pod yield per ha (9.28 t) was achieved from the treatment of N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

Combined effect between different varieties and levels of nutrients showed a statistically significant variation for pod yield per hectare of French bean (Table 14 and Appendix IX). The result indicated that the highest pod yield per hectare (18.92 t) was observed from V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination while the lowest pod yield per hectare (4.15 t) was found from V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

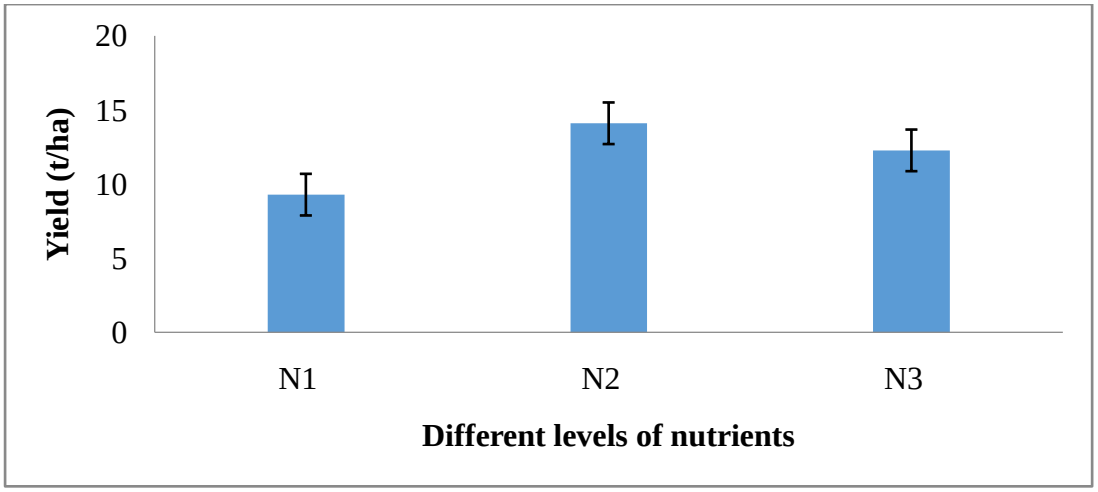

Fig. 15. Effect of different levels of nutrients on yield per hectare of French bean.
Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

Table 14. Combined effect of different varieties and levels of nutrients on yield/plant, yield/plot yield/ha of French bean

Treatment combinations	Yield/plant (g)	Yield/plot (g)	Yield (t/ha)
V_1N_1	52.56 e	1261.4 e	11.68 e
V_1N_2	69.48 c	1667.5 c	15.44 c
V_1N_3	61.43 d	1474.2 d	13.65 d
V_2N_1	54.09 e	1298.2 e	12.02 e
V_2N_2	85.13 a	2043 a	18.92 a
V_2N_3	76.13 b	1827 b	16.92 b
V_3N_1	18.68 h	448.2 h	4.15 h
V_3N_2	35.78 f	858.6 f	7.95 f
V_3N_3	28.08 g	673.9 g	6.24 g
LSD(0.05)	5.9800	143.52	1.3289
CV%	6.46	6.46	6.46

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3. Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha.

CHAPTER V
SUMMARY AND CONCLUSION

The research was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh, the period from November 2018 to January 2019 to compare growth and yield of French bean as influenced by three varieties and nutrients. Factor A: different varieties as V_1= BARI French bean-1, V_2 = BARI French bean-2, V_3= BARI French bean-3 and Factor B: different level of nutrients as N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha. Levels of these two factors made 9 treatment combinations and the numbers of plots were twenty seven. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on the following parameters-plant height, number of leaves per plant, leaf length, leaf breadth, number of branches per plant, days to first flowering, number of flower, pod number, pod length, pod diameter, no. of seeds per pod, dry matter content of plant (%), dry matter content of pod (%), yield per plant, yield per plot, yield per hectare. The recorded data on different parameters were statistically analyzed using Statistic 10 software.

At 45 days, the longest plant (50.21 cm) height and the maximum (27.05) number of leaves per plant were recorded from V_3 (BARI French bean-3) treatment while the shortest plant (36.17 cm) height and the minimum (18.39) number of leaves per plant were recorded from V_1 (BARI French bean-1) treatment. At harvest, the highest leaf length (22.94 cm), the highest leaf breadth (13.35 cm) and the highest (15.64) number of branches per plant found from V_3 (BARI French bean-3) treatment where the lowest (16.97cm) leaf length, the lowest leaf breadth (9.82cm) and the lowest number of branches (9.56) per plant were recorded from V_1 (BARI French bean-1) treatment. It was observed that maximum days (37.63) to first flowering, the highest number of flowers per plant (27.83) and the maximum number of pods per plant (22.14) were recorded from V_2 (BARI French bean-2) treatment, whereas minimum days to first flowering (26.81), the lowest number of flowers (15.47) per plant and the minimum (11.22) number of pods per plant were counted from V_3 (BARI French bean-3)

treatment. Results revealed that maximum pod length (14.00 cm) was observed from V_3 (BARI French bean-3) treatment and minimum pod length (12.09 cm) was found from V_1 (BARI French bean-1) treatment. The maximum diameter of pod (0.75 cm) was recorded from V_3 (BARI French bean-3) treatment, while the minimum (0.64 cm) was counted from V_2 (BARI French bean-2) treatment. The maximum number of seeds per green pod (6.28) was recorded from V_1 (BARI French bean-1) treatment, while the minimum (4.82) was counted from V_3 (BARI French bean-3) treatment. The highest (24.12%) dry matter content of plant and the highest (11.03%) dry matter content of pod were obtained from V_3 (BARI French bean-3) treatment while the lowest (21.09%) dry matter content of plant and the lowest (6.42%) dry matter content of pod were observed from V_2 (BARI French bean-2) treatment. The highest (71.78 g) pod yield per plant, the highest pod yield per plot (1722.70 g) and the highest pod yield per ha (15.95 t) was achieved from V_2 (BARI French bean-2) treatment whereas the lowest (27.51 g) pod yield per plant, the lowest pod yield per plot (660.20 g) and the lowest pod yield per ha (6.11 t) were achieved from V_3 (BARI French bean-3) treatment.

At 45 days, the longest plant height (45.78 cm) and the maximum number of leaves (24.66) were recorded from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment where the shortest plant height (39.55 cm) and the minimum (20.72) number of leaves per plant were recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. At harvest, maximum leaf length (20.92 cm), the highest (12.27 cm) leaf breadth and the maximum number of branches (13.69) per plant were found in N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the minimum leaf length (18.84 cm), the lowest (11.08 cm) leaf breadth and the minimum number of branches (11.10) were recorded in N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Results exposed that maximum days (33.46) to first flowering was required in N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment whereas minimum days (30.44) to first flowering was required in N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The maximum number of flowers per plant (25.58) and the maximum number of pods per plant (20.60) were recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment whereas the minimum number of flowers per plant (18.33) and the minimum number of pods per plant (13.66) was found from N_1 (cowdung @ 5

t/ha + vermicompost @ 2 t/ha) treatment. Result signified that the maximum pod length (13.13 cm), the highest pod diameter (0.72 cm) and the maximum number of seeds per green pod (5.82) were achieved from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}$ K_{45}kg/ha) treatment where the minimum pod length (12.57 cm), the lowest pod diameter (0.67 cm) and the minimum number of seeds per green pod (5.42) were achieved from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The highest (23.62%) dry matter content of plant and the highest (9.44%) dry matter content of pod were observed from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the minimum dry matter content of plant (21.56%) and the minimum dry matter content of pod (7.91%) were recorded from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The highest yield per plant (63.46 g), the highest pod yield per plot (1523.00 g) and the highest pod yield per ha (14.10 t) were achieved from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the lowest yield per plant (41.78 g) ,the lowest pod yield per plot (1002.60 g) and the lowest pod yield per ha (9.28 t) were achieved from the treatment of N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

At 45 DAS, the maximum plant height (52.53 cm) and the maximum (28.63) number of leaves per plant were recorded from the treatment combination of V_3N_3(BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), whereas the minimum (39.87cm) plant height and the minimum (16.36) number of leaves per plant were recorded from the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha). At harvest, the maximum leaf length (23.97 cm), the highest (13.90 cm) leaf breadth and the highest number of branch (16.60) were counted from V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination while the minimum leaf length (16.02 cm), the lowest (9.06 cm) leaf breadth and the minimum number of branches per plant (8.10) were found from V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination. It was observed that maximum days (38.89) to first flowering was required in V_2N_3 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination whereas minimum days (25.67) to first flowering was required from V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination. The maximum number of flower per plant (32.02) and the

maximum number of pods per plant (26.50) were recorded from the treatment combination of V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), while the minimum number of flower per plant (15.50) and the minimum number of pods per plant (9.32) were recorded from V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination. The result showed that maximum pod length (14.22 cm) and the highest pod diameter (0.78 cm) were obtained from the treatment combination of V_3N_2 (BARI French bean-3 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), where the minimum pod length (11.58 cm) and the lowest pod diameter (0.63 cm) were obtained from treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha). The maximum number of seeds per green pod (6.47) was recorded from the treatment combination of V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the treatment combination of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) performed the minimum number of seeds per green pod (4.60). The highest (25.60%) dry matter content of plant and the highest (11.93%) dry matter content of pod were observed from the V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination. The lowest (20.26%) dry matter content of plant and the lowest (5.67%) dry matter content of pod were observed from V_2N_1 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The result indicated that the highest yield per plant (85.13 g), the highest pod yield per plot (1043.00 g) and the highest pod yield per hectare (18.92 t) were observed from V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination. The lowest yield per plant (18.68 g), the lowest pod yield per plot (448.20 g) and the lowest pod yield per hectare (4.15 t) were found from V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

Conclusion: Considering the above result of this experiment, the following conclusion and recommendations can be drawn:

1. In the experiment, treatment V_2 (BARI French bean-2) was superior to the others.
2. In respect of all, the N_2 (cowdung @ 5 t/ha and $N_{90}P_{30}K_{45}$ kg/ha) showed better performance than others.
3. The treatment combination of V_2N_2 (BARI French bean-2 with cowdung @ 5t/ha and $N_{90}P_{30}K_{45}$ kg/ha) showed the best potentiality of 18.92 t/ha.

Recommendations:
Considering the situation of the present experiment, further study might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances. The experiment was however, conducted in one season only and hence the results should be considered as a tentative. It is imperative that similar experiment should be carried out with more variables to reconfirm the recommendation.

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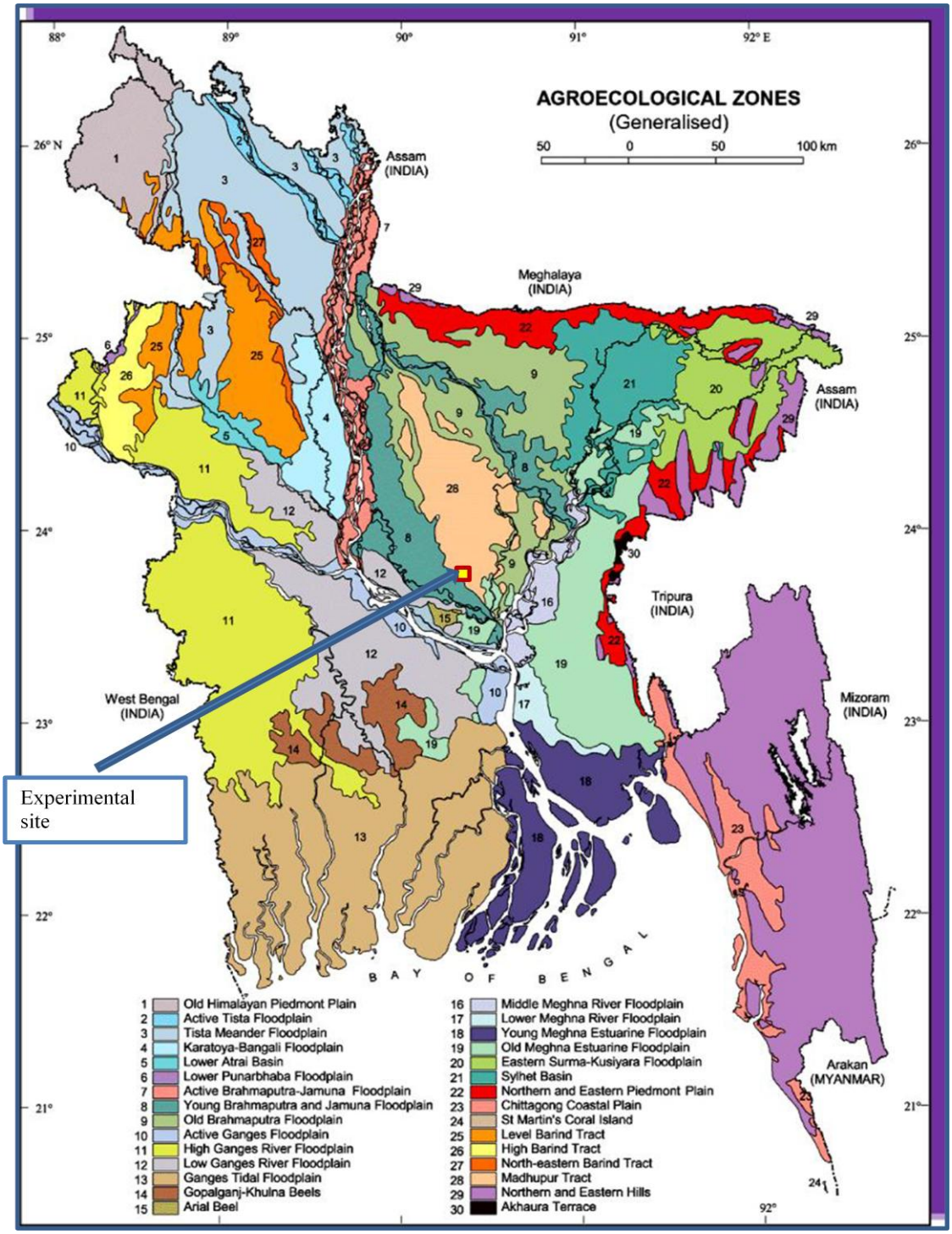
APPENDICES

Appendix I. Map showing the experimental site



Appendix II: Characteristics of Sher-e-Bangla Agricultural University soil is analysed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural
AEZ	Madhupur Tract (28)
General soil type	Shallow Red Brown Terrace Soil
Land Type	High land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-Tomato

B. Physical and chemical properties of initial soil

CHARACTERISTICS	VALUE
Partial Size Analysis	
% Sand	27
% Silt	43
% Clay	30
Textural Class	
PH	5.47 – 5.63
Organic carbon (%)	0.46
Organic matter (%)	0.83
Total N (%)	0.05
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.12
Available S (ppm)	46

Source: Soil Resources Development Institute (SRDI)

Appendix III: Monthly record of annual temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from September 2018 to March 2019 (Site-Dhaka).

Year	Month	Air temperature			Relative humidity (%)	Rainfall (mm)	Sunhine
		Max.	Mini.	Avg.			
2018	September	31.35	25.15	28.25	71.02	26	20.33
	October	30.60	24.2	27.40	75.87	04	206.9
	November	29.85	18.50	24.17	70.12	00	235.2
	December	26.76	16.72	21.74	70.63	00	190.5
2019	January	24.05	13.82	18.93	62.04	00	197.6
	February	28.90	18.03	23.46	68.79	09	220.5
	March	32.24	22.10	27.17	78.82	68.5	208.2

Source: Bangladesh Meteorological Department (Climatic Division), Agargaon, Dhaka-1212.

Appendix IV: Analysis of variance of the data on plant height at different days after sowing (DAS) of french bean as influenced by different varieties and levels of nutrients.

Source of variation	Degree of freedom	Mean square		
		Plant height (cm) at different days after sowing		
		15 DAS	30 DAS	45 DAS
Replication	2	1.215	0.152	1.747
Different varieties (A)	2	180.389**	646.334**	450.987**
Different level of nutrients (B)	2	40.365**	140.800**	87.273**
Interaction (AxB)	4	0.127**	13.058**	0.711**
Error	16	0.783	1.055**	1.292**

** **:** Significant at 0.01 level of probability

Appendix V: Analysis of variance of the data on no. of leaf at different days after sowing, leaf length, leaf breadth of french bean as influenced by different varieties and levels of nutrients.

Source of variation	Degree of freedom	Mean square				
		No. of leaf at different days after sowing				
		15 DAS	30 DAS	45 DAS	Leaf length	Leaf breadth
Replication	2	0.02194	0.1298	2.858	0.0609	0.0439
Different varieties (A)	2	1.42943**	89.8388**	169.614**	80.1488**	28.0449**
Different level of nutrients (B)	2	0.34043**	17.5122**	35.212**	9.6725**	3.1810**
Interaction (AxB)	4	0.00653**	0.9679**	1.184**	0.0428**	0.0774**
Error	16	0.02049	0.3292	0.601	0.3100	0.1246

** **:** Significant at 0.01 level of probability

Appendix VI: Analysis of variance of the data on branch number, days to first flowering, number of flower of french bean as influenced by different varieties and levels of nutrients.

Source of variation	Degree of freedom	Mean square		
		Branch number	Days to first flowering	Number of flower
Replication	2	0.1250	1.215	9.438
Different varieties (A)	2	85.4303**	263.801**	358.779**
Different level of nutrients (B)	2	15.2809**	21.197**	123.349**
Interaction (AxB)	4	1.5174**	1.373**	9.443**
Error	16	0.2943	0.431	0.586

** **:** Significant at 0.01 level of probability

Appendix VII: Analysis of variance of the data on pod length, pod diameter, no. of seeds per pod, pod number of french bean as influenced by different varieties and levels of nutrients.

Source of variation	Degree of freedom	Mean square			
		Pod number	Pod length	Pod diameter	No. of seeds per pod
Replication	2	2.723	0.00927	0.00005	0.00303
Different varieties (A)	2	280.276**	9.64151**	0.02965**	4.85263**
Different level of nutrients (B)	2	109.549**	4.57509*	0.00780*	0.37210**
Interaction (AxB)	4	12.971**	0.18897**	0.00048**	0.00358**
Error	16	0.981	0.06752	0.00020	0.00882

** **:** Significant at 0.01 level of probability and * **:** Significant at 0.05 level of probability

Appendix VIII: Analysis of variance of the data on dry matter content of plant, dry matter content of pod of french bean as influenced by different varieties and levels of nutrients.

Source of variation	Degree of freedom	Mean square	
		Dry matter content of plant (%)	Dry matter content of pod (%)
Replication	2	0.2699	0.2429
Different varieties (A)	2	20.9281**	47.7663**
Different level of nutrients (B)	2	9.9066**	5.2709**
Interaction (AxB)	4	1.4349**	0.0439**
Error	16	0.1682	0.2024

** **:** Significant at 0.01 level of probability

Appendix IX: Analysis of variance of the data on yield/plant, yield/plot, yield/ha of french bean as influenced by different varieties and levels of nutrients.

Source of variation	Degree of freedom	Mean square		
		Yield/plant	Yield/plot	Yield/ha
Replication	2	21.06	12131	1.040
Different varieties (A)	2	4807.06**	2768869**	237.386**
Different level of nutrients (B)	2	1078.20**	621044**	53.245**
Interaction (AxB)	4	60.79**	35013**	3.002**
Error	16	11.94	6875	0.589

** **:** Significant at 0.01 level of probability

Appendix X: Effect of different varieties on plant height of french bean.

Treatment	Plant height (cm)		
	15 DAS	30 DAS	45 DAS
V_1	22.89 c	31.83 c	36.17 c
V_2	25.33 b	37.82 b	41.58 b
V_3	31.57 a	48.56 a	50.21 a
LSD(0.05)	0.8841	1.0266	1.1357
CV%	3.33	2.61	2.66

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI french bean-1, V_2 = BARI french bean-2, V_3= BARI french bean-3.

Appendix XI: Effect of different levels of nutrients on plant height of french bean.

Treatment	Plant height (cm)		
	15 DAS	30 DAS	45 DAS
N_1	24.43 c	35.27 c	39.55 c
N_2	26.71 b	39.79 b	42.62 b
N_3	28.66 a	43.15 a	45.78 a
LSD(0.05)	0.8841	1.0266	1.1357
CV%	3.33	2.61	2.66

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = Cowdung (5t/ha) and vermicompost (2t/ha), N_2 = Cowdung (5t/ha) and N_{90} P_{30} K_{45}kg/ha, N_3 = Cowdung (5t/ha) and vermicompost (2t/ha) and N_{90} P_{30} K_{45} kg/ha.

Appendix XII: Effect of different varieties on leaf number, leaf length, leaf breadth of french bean.

Treatment	Leaf number			Leaf length (cm)	Leaf breadth (cm)
	15 DAS	30 DAS	45 DAS		
V_1	2.64 c	15.22 c	18.39 c	16.97 c	9.82 c
V_2	2.95 b	18.38 b	22.28 b	19.74 b	11.7 b
V_3	3.43 a	21.54 a	27.05 a	22.94 a	13.35 a
LSD(0.05)	0.1668	0.5734	0.7746	0.5564	0.3528
CV%	5.55	3.12	3.43	2.80	3.03

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI french bean-1, V_2 = BARI french bean-2, V_3= BARI french bean-3.

Appendix XIII: Effect of different levels of nutrients on leaf number, leaf length, leaf breadth of french bean.

Treatment	Leaf number			Leaf length (cm)	Leaf breadth (cm)
	15 DAS	30 DAS	45 DAS		
N_1	2.82 b	16.95 c	20.72 c	18.84 c	11.08 c
N_2	2.98 b	18.47 b	22.34 b	19.89 b	11.56 b
N_3	3.21 a	19.73 a	24.66 a	20.92 a	12.27 a
LSD(0.05)	0.1668	0.5734	0.7746	0.5564	0.3528
CV%	5.55	3.12	3.43	2.80	3.03

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = Cowdung (5t/ha) and vermicompost (2t/ha), N_2 = Cowdung (5t/ha) and N_{90} P_{30} K_{45}kg/ha, N_3 = Cowdung (5t/ha) and vermicompost (2t/ha) and N_{90} P_{30} K_{45} kg/ha.

Appendix XIV: Effect of different varieties on branch number, pod number, yield/ha of french bean.

Treatment	Branch number	Pod number	Yield/ha
V_1	9.56 c	18.67 b	13.59 b
V_2	11.76 b	22.14 a	15.95 a
V_3	15.64 a	11.22 c	6.11 c
LSD(0.05)	0.5421	0.9898	0.7672
CV%	4.40	5.71	6.46

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V_1 = BARI french bean-1, V_2 = BARI french bean-2, V_3= BARI french bean-3.

Appendix XV: Effect of different levels of nutrients on branch number, pod number, yield/ha of french bean.

Treatment	Branch number	Pod number	Yield/ha
N_1	11.10 c	13.66 c	9.28 c
N_2	12.18 b	20.60 a	14.1 a
N_3	13.69 a	17.77 b	12.27 b
LSD(0.05)	0.5421	0.9898	0.7672
CV%	4.40	5.71	6.46

In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, N_1 = Cowdung (5t/ha) and vermicompost (2t/ha), N_2 = Cowdung (5t/ha) and N_{90} P_{30} K_{45}kg/ha, N_3 = Cowdung (5t/ha) and vermicompost (2t/ha) and N_{90} P_{30} K_{45} kg/ha.