GROWTH, YIELD AND SEED VIABILITY OF FRENCH BEAN VARIETIES AS INFLUENCED BY VERMICOMPOST

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DHAKA-1207

DECEMBER, 2017

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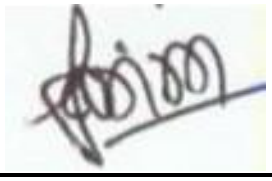
A Thesis
Submitted to the Institute of Seed Technology,
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
SEED TECHNOLOGY

SEMESTER: JULY - DECEMBER, 2017

APPROVED BY:



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CERTIFICATE

*This is to certify that the thesis entitled "***GROWTH, YIELD AND SEED VIABILITY OF FRENCH BEAN VARIETIES AS INFLUENCED BY VERMICOMPOST***" submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in SEED TECHNOLOGY, embodies the results of a piece of bona fide research work carried out by* SHIFAT ZAMAN KOLY ***Registration. No. 16-07584 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.***

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

Dated:

Dhaka, Bangladesh

(Dr. Jasim Uddain)
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ACKNOWLEDGEMENTS

At first the author expresses her gratefulness to the Almighty Allah who has helped her in pursuit of her education in Agriculture and for giving the strength to complete this research work.

The author is highly grateful and obliged to her Supervisor, ***Dr. Jasim Uddain****, Associate Professor, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his continuous encouragement, innovative suggestions and affectionate inspiration throughout the study period.*

With deepest emotion the author wishes to express her heartfelt gratitude, indebtedness, regards and sincere appreciation to her benevolent research Co-Supervisor ***Dr. Tuhin Suvra Roy****, Professor, Department of Agronomy, SAU, Dhaka, Bangladesh for his intellectual guidance, intense supervision, affectionate feelings and continuous encouragement during the entire period of research work and for providing valuable suggestions for the improvement of thesis writing.*

Cordial thanks are extended to all the respected teachers of the Institute of Seed Technology, SAU, Dhaka, Bangladesh and the entire staff member of the Institute of Seed Technology, SAU.

The author would like to thank to her younger brothers and sisters of this university for their valuable and sincere help in carrying out research work at the Farm of SAU, Dhaka.

Finally, the author expresses her heartfelt indebtedness to her beloved mother, brother, sisters and husband for their sacrifice, encouragement and blessing which pavek the way to her higher study which can never be forgotten.

Growth, yield and seed viability of french bean varieties as influenced by vermicompost

ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2017 to February 2018 to study the growth, yield and seed viability of french bean varieties as influenced by vermicompost. Two factors *viz.* three french bean varieties; V_1 (BARI jhar seem-1), V_2 (BARI jhar seem-2) and V_3 (BARI jhar seem-3) and four levels of vermicompost; Vc_0 (0 t ha^{-1}), Vc_1 (6 t ha^{-1}), Vc_2 (8 t ha^{-1}) and Vc_3 (10 t ha^{-1}) were considered for the experiment. The experiment consisting of 12 treatment combinations laid out in Randomized Complete Block Design (RCBD) with three replications. It was noted that the maximum plant height (47.92 cm) was found from the variety, V_3 (BARI jhar seem-3). But the the variety V_1 (BARI jhar seem-1) showed the highest flowers $plant^{-1}$ (41.09), pods $plant^{-1}$ (32.09), fresh weight of pods $plant^{-1}$ (267.19 g), dry weight of pods $plant^{-1}$ (45.91 g) and fresh pod yield ha^{-1} (7.13 t). The treatment Vc_3 (10 t ha^{-1}) showed the highest plant height (43.31 cm), branches $plant^{-1}$ (15.20), flowers $plant^{-1}$ (50.92), number of pods $plant^{-1}$ (40.82), pod length (11.11 cm), fresh weight of pods $plant^{-1}$ (342.25 g), dry weight of pods $plant^{-1}$ (57.56 g), number of seeds pod^{-1} (6.53) and fresh pod yield ha^{-1} (9.13 t). Treatment combination of V_1Vc_3(BARI jhar seem -1with 10 t ha^{-1}) gave the highest flowers $plant^{-1}$ (52.62), pods $plant^{-1}$ (42.56), pod length (11.37), fresh weight of pods $plant^{-1}$ (367.50g), dry weight of pods $plant^{-1}$ (61.50 g) and fresh pod yield ha^{-1} (9.80 t) whereas V_2Vc_0 (BARI jhar seem-2 with 0 t ha^{-1}) had lowest value for all the parameters. Incase of seed viability test seed germination (96.67%), root length (20.02 cm), shoot length (24.08 cm), and seed vigor index (2348.00) were recorded as maximum with V_1Vc_3 (BARI jhar seem-1 with 10 t ha^{-1} vermicompost) where the lowest was obtained from V_2Vc_0 .

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ABBREVIATIONS AND ACRONYMS

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

CHAPTER I

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is commonly known as bush bean, kidney bean, snap bean, forashi sheem or jhar sheem in Bengali and also commonly known as rajmash in India (Roy *et al*. 2006), belongs to the family Fabaceae is an annual, diploid (2n=2x=22) species (Galvan *et al*. 2003). Generally it is grown during rabi season which is a native of central and South America. It is a dual purpose crop grown as pulse and also consumed as immature tender fruits. In Bangladesh, it is grown for tender vegetables, shelled green beans and dry beans. It is an important legume, grown in the areas of Jessore, Rangpur, Comilla, Chittagong and Sylhet in Bangladesh. French bean is becoming popular for its tender pods and shelled beans. Besides, it maintains soil fertility through biological nitrogen fixation in association with symbiotic *Rhizobium* prevalent in their root nodules. As per the FAO estimates, it is grown in the world in an area of 28 million hectares with annual production of 20 million tons and productivity 729 Kg/ha (Prakash and Ram, 2014).

French bean is grown extensively because of its short duration and for nutritive values. It is a good source of protein, calcium, phosphorus, iron, carotene, thiamine, riboflavin and vitamin C. Its dry seed contains 69.9 percent carbohydrates, 1.7 percent fat, 381 mg calcium, 425 mg phosphorous and 12.4 mg iron per 100 g of edible part (Ali and Kushwaha, 1987). It is also reported that common bean is an important source of protein and calories in human diets and both its pods and seeds are nutritionally rich having 22-25% protein in its dry seeds and 1-2.4% in green pods (Smithson *et al*. 1993).

Different factors are responsible for higher crop production. The suitable variety is important factor for higher crop production (Dhanjal *et al*. 2001; Shivakumar *et al*. 1996). Genotype is the most important factor in any crop production program and

is the basic material to which all other technologies are applied (Goutam *et al*. 2001). Therefore, unless a good genotype of high potential is used; other technologies will also not work. These genotypes are also greatly varied in their performance under different agro-climatic conditions of the country which often creates confusions among the farmers about their choice of variety. So, selection of particular variety for pod and/or seed production is also prime important for higher pod and/or seed yield. Hence, it is essential to look forward for the production of quality seed in the country itself to uplift quality production of french bean. Variety is one of the most important factors that influence on the productivity and profitability of bush bean. A few research have been conducted in Bangladesh Agricultural Research Institute (BARI) on the development of this crop, only three varieties *viz*. BARI jhar seem-1, BARI jhar seem-2 and BARI Jharsheem-3 have so far been released from BARI. All the varieties do not produce same quantity and quality of pod. So it is essential to identify specific variety which is more productive than others.

One of the factors of low productivity of french bean is due to inadequate fertilization. Indiscriminate use of chemical fertilizers reduce nutritive value, whereas use of organic manure like vermicompost, biofertilizer etc. or integration of organic and bio-fertilizers with chemical fertilizer improve the soil health and plant nutrient availability resulting in higher crop yields besides being environmentally safe. The long-term use of inorganic fertilizer without organic manure causes environmental pollution. Organic manures act not only as a source of nutrients and but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients turnover and many other related physical, chemical, and biological parameters of the soil (Albiach *et al*. 2000 and Manivannan *et al*. 2009). Many farmers are forced to switch over to the organic means of cultivation to produce safe, tasty and nutritious foodstuff and to get higher premium price from the market.

Organic fertilizer like vermicompost can be a good substitute for chemical fertilizers to overcome their adverse effects. It is necessary to minimize the use of chemical fertilizers by adding organic ones for rendering sustainability to the agricultural productivity.

Different factors like variety, soil nutrients, organic and inorganic fertilizer and environmental factors etc. are responsible for quality seed production. Viability of seed is an important character for quality seed. Higher production of crops depends largely on the ability to integrate better crop management (high yielding variety, proper fertilization, harvesting time and suitable environment) into the cultivation systems. To boost yield, quality seed is essential both for vegetables and seed production. Seed maturity, viability and storability are correlated with each other. Early harvested seeds are immature and poorly developed compared to seeds harvested at physiological maturity (Shaheb *et al*. 2015).

The present experiment was undertaken to study the performance of growth, yield and seed viability of french bean varieties as influenced by vermicompost with the following objectives.

1. To identify the suitable variety on growth, yield and seed viability of french bean.
2. To optimize the vermicompost level on growth, yield and seed viability of frence bean .
3. To determine the combined effect of variety and vermicompost on growth, yield and seed viability of French bean .

CHAPTER II

REVIEW OF LITERATURE

French bean (*Phaseolus vulgaris* L.) is a popular vegetable crop of the world. The relevant literatures available on various aspects of French bean cultivation with respect to growth, yield and seed viability of different varieties as influenced by vermicompost as were reviewed as under following heads :

2.1 Effect of variety

Rahman *et al*. (2018) conducted an experiment in the field of Lamonirhat, Bangladesh to assess the effect of phosphorus levels on the growth, yield attributes and yield of french bean varieties. The experiment was consisting three French bean varieties, *viz*. V_1 - BARI Jhar Sheem-1, V_2 - BARI Jhar Sheem-2 and V_3 - Nick and four levels of phosphorus *viz*. P_0, P_{20}, P_{40} and P_{60} kg phosphorus ha^{-1}. Varieties showed significant results on growth and yield attributes except number of branches $plant^{-1}$. Highest pod yield (22.70 t ha^{-1}) was obtained from BARI Jhar Sheem-2 while lowest (16.64 t ha^{-1}) from BARI jhar Seem-1.

Nazrul and Shaheb *(2016)* conducted an experiment at farming system research and development (FSRD) site, Jalalpur and multi location testing (MLT) sites, Zokigonj and Moulvibazar during 2013-2015 to evaluate the suitable varieties (genotypes) of french bean for maximize the seed yield of the farmers. Eight bush bean genotypes were tested of which 3 were developed by BARI (var. BARI jhar seem-1, BARI jhar seem-2, BARI jhar seem-3), five local accessions: Local-I (black), Local-2 (white colour with chocolate spot at hylum), Local-3 (coffee colour), Local-4 (coffee colour with few chocolate spots) and Local-5 (black with chocolate colour spots). The seed yields were varied significantly among the genotypes. All the local French bean lines performed better and produced higher seed yields compared to BARI developed varieties. The maximum seed yields

2.66, 3.48 and 2.05 t ha^{-1} was produced by Local-4 and Local-5 at Jalalpur, Zakigonj and Moulvibazer, respectively.

Yadav (2015) conducted an experiment to investigate the performance of french bean as influenced by varieties and sowing time during *rabi* season of 2013-14 in India. The experimental results revealed that among the four varieties (Aparna, Arka Anoop, Arka Sarath and Arka Subidha) Arka Sharath recorded higher plant height (30.42 cm at 30 DAS and 43.69 cm at harvest), higher number of primary branches per plant (3.32 at 30 DAS and 6.32 at harvest), maximum pod length (15.33 cm) and maximum number of pods per plant (24.09). Higher pod width (1.01 cm) and lowest number of pods per plant was recordrd in Arka Anoop (21.70). Aparna recorded minimum pod length (12.59 cm) and pod width (0.78 cm). Aparna recorded lower plant height (25.38 cm at 30 DAS and 36.38 cm at harvest) and lowest number of primary branches per plant (3.05 at 30 DAS and 5.87 at harvest). Arka Sharath recorded maximum green pod yield per plant (156.27 g) and minimum green pod yield per plant (119.28 g) was recorded in Aparna. Arka Sharath recorded higher green pod yield (87.37 q/ha) which was on par with Arka Anoop (82.23 q/ ha) and lower pod yield was recorded by Aparna (66.22 q/ ha).

Kakon *et al.* (2015) conducted an experiment at BARI, Joydebpur, Gazipur, Bangladesh during Rabi season (November 2009-10 and 2010-11) to study the 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 Jharsheem-l (2) BARI Jharsheem-2 (3) Sylhet local 1 (4) Sylhet local 2 (5) Sylhet local 3 (6) Sylhet local 4 (7) Syihet local 5 (8) Sylhet local 6 and (9) Sylhet local 7. The duration of flowering and number was dependent on growing periods and varieties. In both the years, the highest number of flower was recorded within 5 to 8 days in BARI Jharsheem-2. Although, the maximum flower opened within 5 to 8 days and following ceased within 15 to 20 days after first flowering. 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.

Santhi *et al.* (2015) carried out an experiment of ten bush type French bean accessions at Nanjanad Farm, HRS, Ooty. The result of pooled means of four years from 2010 to 2013, among the bush bean types revealed that accession number FBB-7 (Aruvath Avarai) recorded the maximum plant height (67.21 cm), maximum number of branches (6.80). The maximum number of pods (34.15), pod length (18.48 cm), pod diameter (3.35cm), pod weight (15.80g) and the highest pod yield of 712.73 g/plant also found from accession number FBB-7 (Aruvath Avarai).

Noor *et al.* (2014) reported that eleven genotypes of French bean *(Phaseolus vulgaris* L.) 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. The maximum fresh pod yield (14.25 t/ha) was found for BARI bush bean-1 followed by BARI bush bean-2 (13.23t/ha). Among all the genotypes, BARI bush bean-1 showed highest pod yield and superior quality of French bean that was recorded in BARI bush bean-1 (64.13 g and 14.25 t/ha) followed by BARI bush bean-2 (59.53 g and 13.23 t/ha) ($P< 0.05$) which are more suitable for human consumption. BARI bush bean-1 took minimum time for 90% flowering (34.67 days), 90% pod setting (37.33 days), and 90% maturity of pods (88.33 days). Moreover, the maximum plant height (48 cm) and number of compound leaves per plant (16.52) were obtained from BARI bush bean-1 compared to BARI bush bean-2.

Das *et al* .(2014) conducted an experimental study during 2011-2012 and 2012-2013 at Nadia, West Bengal, India, to evaluate the performance of fourteen different bush type French bean genotypes for seed yield and to study varietal characterization. The fourteen genotypes under evaluation were Abhay, Shillong

Local-3, Arjun, Selection-9, Arka Anoop, Arka Komal, Badshah, Anupam, Arka Suvidha, Falguni, Sonali, Local, Victoria and Vaishnavi-264. The highest plant height was obtained in case of the genotype Badsah (47.53 cm) and lowest for the genotype Abhay (25.67 cm). The highest number of branches per plant was obtained from the variety Anupam (3.73) and lowest was in case of Selection-9 (2.03). The highest mature pod yield was obtained from the variety Arka Suvidha (43.83 g/plant) followed by Falguni (42.57 g/plant). The lowest mature pod yield was obtained from Shillong Local-3 (11.49g/plant). Among the genotypes under study, Arka Suvidha was the best one as it produced the highest seed yield (2180.92 kg/ha) and relatively good plant vigour and fairly high seed vigour index (2944.38). Falguni and Mohanpur Local also can be considered promising once for seed production point of view.

Khafa (2013) studied the performance of bush type French bean varieties under organic production system. French bean variety China 804 produced the computed marketable yield per plot with a mean of 6.17 kg/ $5m^2$ followed by 'Sablan' (5.16 kg/ 5 m^2), 'Contender' (4.73 kg/ 5 m^2), 'Bokod' (3.87 kg/ $5m^2$) and the lowest is the 'French bean' (3.63 kg/ 5 m^2).

Pandey *et al* .(2012) conducted an experiment to investigate the response of 18 exotic and indigenous French bean genotypes during the summer season of 2010 with the objectives to assess the variability of the genotypes and their potential for utilization in improvement programmes at the Agriculture Research Station, Pokhara, Nepal. The genotypes under the evaluation include Samjhana, Madhav, Chinese Long (Run Long), Four Season, Trishuli, Syangja, LB-39, Tarbare, LB-31, Myagdi and Makwanpur among the pole type and Mandir, Arka Komal, S-9, LB-27, Pant Anupma, Mallika , Arka Suvidha among the bush type. The highest plant height was obtained from Makwanpur (271.7 cm) and lowest plant height was produced by the plants of Trishuli (256.2 cm) in pole type French bean. The highest number of branches was produced by Myagdi (8.93) and the lowest by

LB- 39 (3.5) among the pole types. Among the bush types, the highest number of branches was obtained from the genotype S-9 (7.93) and the lowest from the variety Mandir (5.2). Pod length was highest in (18.34 cm) and lowest in Makwanpur (15.07 cm). Pod width was highest in Trishuli (9.04 mm) and lowest in Makwanpur (7.10 mm). The highest fresh pod yield was produced by Four season (25.08 t/ha) followed by Makwanpur (23.11t/ha) and the lowest by Trishuli (19.97 t/ha).

Moniruzzaman *et al.* (2009) reported that French bean comprising two varieties i.e. BARI jhar seem-1 and BARI jhar seem-2 by application of 120 kg N/ha coupled with the highest plant density such as the lowest plant spacing gave the maximum pod yield of 34.3 t/ha and 30.2 t/ha in BARI bush bean-1 and BARI bush bean-2 respectively. There was no significant difference in two varieties with respect to branches per plant, pod length, and number of green pods per plant. However, the plant heights, pod width, green pod weight per plant and pod yield were significantly higher in BARI bush bean-1 as compared to BARI bush bean-2. The pod yield varied due to effect of variety of bush bean are 23.3 and 21.4 t/ha respectively.

Maske *et al*. (2009) carried out a field experiment during rabi season of 2005-06 at Parbhani, India to investigate the performance of French bean genotypes under different fertility levels. The experiment consisted of twelve treatment combinations of four varieties ***i.e.*** Contender, Waghya, HPR-35, Varun and three fertility levels 90:45:45 NPK kg ha^{-1}, 120:60:60 NPK kg ha^{-1}, 150:75:75 NPK kg ha^{-1}. Variety HPR 35 recorded significantly higher plant height, branches, total dry matter, seed and straw yield over rest of the varieties. Application of 120:60:60 NPK kg.ha^{-1} was at par with 150:75:75 NPK kg ha^{-1} and recorded significantly higher number of pods per plant, 100 seed weight and seed yield over application of 90:45:45 NPK kg ha^{-1}.

Singh *et al*. (2011) conducted a field experiment with the objective to investigate the effects of vermicompost, NPK fertilizer and organic mulch on crop growth, nodulation and pod yield of french bean with an ultimate aim of optimizing water and nutrient requirement in mild-tropical climate during dry season. The shoot growth traits, namely shoot length, number of primary branches, shoot fresh weight and shoot 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 tha^{-1} and by 5-50% in organic mulching treatments. Application of vermicompost reduced nodule fresh weight and nodule dry weight by 44.9 and 44.5%, respectively. Poor nodulations might be due to reduced oxygenation of the soils under vermicompost and organic mulch which is ultimately impeding the nitrogenase activity and biological nitrogen fixation. Present 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 tha^{-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 and pod yield of French bean, and soil health of mild-tropical climate during dry season.

Moniruzzaman *et al.* (2007) carried out an experiment on French bean having three varieties (BARI jhar seem-1, BARI jhar seem-2 and Local) and six sowing dates at 10 days interval from November 01 to December 20) to find out the suitable variety and optimum sowing date for getting higher pod yield. Varieties showed significant variation in plant height, number of branches per plant and dry weight per plant. Variety BARI Jhar sheem-2 produced significantly smallest plant, whereas the plant height was highest in local variety though at par with BARI Jhar sheem-1. However, branches/plant and dry weight/plant was significantly lowest in local variety compared to BARI Jhar sheem-2 and BARI Jhar sheem-1. BARI Jhar sheem-1 significantly produced maximum number of branches/plant closely followed by BARI Jhar seem-2 and highest dry weight/plant. Varieties had significant effect on the yield attributes (pod length,

pod width, pods/plant and weight of 10 pods) and yield of French bean. The variety BARI Jhar sheem-2 significantly produced longer pods having lowest diameter.

Pawar *et al.* (2007) studied the effect of plant density on vegetative growth and yield Performance of different varieties of French bean under irrigated condition**.** The experiment was conducted at Parbhani (Maharashtra) during *rabi* season of 2003-2004. The four varieties namely HPR -35, PDR- 14, HUR -15 and VL- 63 with three spacing (plant densities) i.e. 30 x 10 cm (3.33 lakh plants/ha), 45 x 10 cm (2.22 lakh plants/ha) and 45 x 15 cm (1.48 lakh plants/ha) were allotted. The plant height (33.54 cm) under the variety V_1 (PDR-14) was recorded significantly superior over the rest of the treatments. The highest number of branches per plant (6.63), number of pods per plant and green pod yield per ha was recorded under the variety V_2 (PDR-14) over the other treatments.

Anjanappa *et al* .(2000) studied the performance of four French bean varieties (Local, Burfi Stringless, Arka Komal, Selection-11) during *kharif* season of 1997 and *rabi* season of 1998 at Main Research Station, Hebbal of Karnataka. In pooled data the highest plant height (53.57 cm) was observed in Arka Komal, whereas lowest plant height (44.94 cm) was observed in Local. Significantly higher number of primary branches was obtained from Arka Komal (5.22), whereas, it was lowest in in Burfi Stringless. The higher pod yield (21.90t/ha) was obtained from Arka Komal followed by Selection-11 (19.38t/ha). Significantly lower yield was recorded in Local (11.76 t/ha) and was on par with Burfi Stringless (13.10t/ha).

2.2 Effect of organic manure and/or vermicompost

Yadav *et al.* (2017) carried out a field experiment at Shillong, Meghalaya, to evaluate the effect of organic manure and biofertilizers on system productivity and profitability of french bean . The experiment consisting of 10 treatments. The

maximum height (46.7 cm) and highest yield 6.2t/ha were found in Recommended Dose of Fertilizer. The maximum number of pods per plant (13.7) was found with 30t FYM + Azotobacter + PSB. lowest plant height (24cm), lowest number of pods per plant (7.7) and lowest yield of 0.9t/ha were found in control.

El-Hassan *et al.* (2017) investigated the possibility of using compost and vermicompost as substitutes partial or fully for mineral fertilizers used in the production of green beans. The bean seeds (cv. Paulista) were sown during 2016 and 2017. 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 pods 12.33 and 11.26 per plant were obtained with 100% Mineral Fertilizer during 2016 and 2017 respectively, whereas it was 8.33 and 8.38 pods using 100% compost during 2016 and 2017 respectively and using 100% vermicompost it was 10.33 and 9.62 pods in 2016 and 2017 respectively. Again, the maximum weight of the pod 4.71g and 4.37g were obtained with 100% Mineral Fertilizer during 2016 and 2017 respectively, whereas it was 3.36g and 3.38g using 100% compost during 2016 and 2017 respectively and using 100% vermicompost it was 3.96 g and 3.58 g in 2016 and 2017 respectively.

Santosa *et al.* (2017) conducted an experiment to study the influence of organic and inorganic fertilizers on growth and yield of green bean in Batu, East Java, for dry season (from May to July 2013) and rainy season (from January to March 2014). For dry season, treatment of 100 kg N/ha, 300 kg P_2O_5/ha and 100 kg K_2O/ha resulted in the highest weight of the pod 7.24 g while it was 6.26g in 5t/ha FYM and 6.85 in 10t/ha FYM. In a similar way during rainy season highest weight of the pod was obtained in 100 kg N/ha, 300 kg P_2O_5 /ha and 100 kg K_2O/ha. For dry season, treatment of 100 kg N/ha, 300 kg P_2O_5/ha and 100 kg K_2O/ha resulted in the highest number of pods per plant 13.68 while it was 8.62

and 11.41 in 5t/ha and 10t/ha cow manure treatment respectively during dry season, the similar results were obtained in the rainy season as well.

Islam *et al.* (2016) carried out an experiment in the greenhouse of the Institute of Biological Sciences, Malaysia during September, 2013 to February 2014. 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%) also produced the highest number of flowers (66.50), pods (58.93), length of the pod (10.76 cm), single pod weight (5.09 g) and highest pod yield (2.98 t/ha) where the minimum number of flowers (37.20), pods (22.20), shortest pod (7.89 cm), single pod weight (3.76 g) and lowest pod yield (0.83 t/ha) were also recorded in the FP treatment.

Kamble *et al.* (2016) revealed that organic and inorganic fertilizers combinations significantly increase the growth and green pod yield of french bean. The highest green pod yield/plant 55.81 g was recorded in treatment T_3- 100% NPK + poultry manure @ 5 t/ ha and it was at par with T_1- 100% NPK + vermicompost @ 5 t/ha, T_5- 100% NPK + FYM @ 25 t/ha, T_4- 100% NPK + poultry manure @ 2.5 t/ha, T_2- 100% NPK + vermicompost @ 2.5 t/ ha and T_6- 100% NPK + FYM @ 12.5 t/ha while The lowest yield per plant 31.24 g was recorded in treatment T_{16} -FYM @ 25 t/ha.

Zahida *et al.* (2016) conducted a field experiment at SKUAST-Kashmir during *Kharif,* 2012 to study the effect of integrated nutrient management on morphology, yield and soil quality of French bean under temperate conditions. The experiment consisted of twelve treatment combinations. The results revealed that T_4 (125% RDF) recorded highest plant height (35.98 cm), highest number of

primary branches (5.20) and highest yield (7.12 t/ha) while the lowest plant height (26.05 cm), lowest number of primary branches (3.07) and lowest yield (3.20 t/ha) were achieved in T_1 (Control).

Sarma *et al.* (2014) studied the effect of different combinations of organic sources of nutrients *viz*., vermicompost, FYM, rock phosphate along with bio-fertilizer on different growth parameters, yield and profitability of French bean cultivar Arka Anoop. In this investigation, the results revealed that in treatment T_2 (vermicompost + FYM + *Rhizobium* + rock phosphate) provided the maximum plant height (37.50 cm), maximum number of branches per plant (6.48), maximum compound leaves per plant (17.30), maximum green pod (20 per plant), maximum length of pods (12.16 cm), maximum seeds per pod (7.12), maximum yield per plant (300.05g) and maximum yield (14 t/ha) while T_1 (control) treatment provided minimum plant height (19.50cm), least number of branches per plant (4.34), least number of pods per plant (15.00) and pod length (10.36 cm), minimum yield per plant (221.12 g) and yield/ha (7.00 t/ha).

Datt *et al.* (2013) reported that in organic treatment T_1 (10 t FYM/ha + nitrogen fixer- A, phosphate solubilizer and chopped crop residues of same plot) the yield of French bean obtained was 7.12 t/ha, in treatment T_2 (10 t FYM/ha + nitrogen fixer-B, Phosphate solubilizers and chopped crop residues of same plot) the yield was 7.10 t/ha while the lowest yield of 4.63 t/ha was obtained in control.

Prabhakar *et al.* (2011) conducted a field experiment during 2007-2010 to study the effect of levels of organic manures and conventional practices on growth and yield of French bean grown organically. The trial included four levels of organic manure nutrient supply treatments. The treatment which received 100% recommended dose of N (RND) through organics produced the maximum height of 45.5 cm, maximum length of pods 14.7cm and highest pod yield 17.77 t/ha

followed by treatment which received 75% RDN through organics and conventional practices (17.45 and 15.93 t/ha).

Thakur *et al.* (2010) evaluated the effect of different organic manures and biofertilisers on the French bean in the mid-hills of Himachal Pradesh during kharif season 2008. There were nine treatments *viz.* FYM, Vermicompost, Biofertilizers (Azotobactor, PSB and *Rhizobium),* FYM + Biofertlizers, Vermicompost + Biofertilizers, Organophos, Fertimine, Conventional and Untreated Control. The study revealed that amon all the treatments, highest number of pods per plant (17.65), maximum length of pods (21.21 cm) were recorded with conventional treatment (Ts -NPK @ 50:100:50 kg/ha). However this treatment (T_5) was at par with organic treatment (T_5- Vermicompost+Rhizobium) where the number of pods recorded to be (17.29). When plants were treated with only (T_1-FYM @ 20 t/ha), (T_2- Vermicompost @ 5 t/ha) the length of pods were recorded to be (17.24cm) and (17.12cm) respectively. The highest yield 8.34 t/ha was recorded with conventional treatment (T_8 -NPK @ 50:100:50 kg/ha). However, this treatment (T_8) was *at par* with organic treatment (T_5- Vermicompost + *Rhizobium)* where the yield was 8.12 t/ha.

Santos *et al*. (2000) conducted an experiment to evaluate the effect of levels and sources of organic matter on French bean in Brazil. Treatments comprised 4 sources of organic matter, such as, poultry manure or 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}.

Alves *et al.* (1999) conducted a field experiment in Brazil 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.

From the above mentioned literature, it can be concluded that effect of cultivars and organic manure have significant effect on growth and yield of French bean. It is observed that pod yield increases with the use of organic manures.

CHAPTER III

MATERIALS AND METHODS

In this chapter a short description of the location of the experimental plot, climatic condition of the area where the plot was situated, materials used for experimental treatments, design of the experiment, method of cultivation, method of data collection, statistical analysis have been presented.

3.1 Experimental site

The research work was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207 to study the effect of organic manure and variety on the yield contributing characters and yield of french bean during the period from December 2017 to February 2018. Experimental field was located at 90°22/ E longitude and 23°41/ N latitude and altitude of 8.2 m above the sea level. The experimental site is presented in Appendix I.

3.2 Climate

Experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high temperature and relatively long day period during "Kharif-1" season (April-September) and scarce rainfall, low humidity, low temperature and short day period during "Rabi" season (October-March). This climate is also characterized by distinct season, *viz*. the monsoon extending from May to October, the winter or dry season from November to February and per-monsoon period or hot season from March to April (Edris *et al.* 1979). The meteorological data in respect of temperature, total rainfall, relative humidity, average sunshine and soil temperature for the entire experimental period have been shown in Appendix II.

3.3 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract in Agroecological Zone (AEZ)-28 (UNDP, 1988). It was medium high land and the soil series was Tejgaon (FAO, 1988). The soil was having a texture of sandy loam with pH and CEC were 5.6 and 2.64 meq/100 g soil, respectively. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix III.

3.4 Planting materials

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

3.5 Treatments of the experiment

Factor A – Variety (3)

1. V_1 = BARI jhar seem-1
2. V_2 = BARI jhar seem-2
3. V_3 = BARI jhar seem-3

Factor B – Vermicompost (4)

1. Vc_0 = 0 t ha^{-1} (Control)
2. Vc_1 = 6 t ha^{-1}
3. Vc_2 = 8 t ha^{-1}
4. Vc_3 = 10 t ha^{-1}

There were 12 (3×4) treatment combinations given below:

V_1Vc_0, V_1Vc_1, V_1Vc_2, V_1Vc_3, V_2Vc_0, V_2Vc_1, V_2Vc_2, V_2Vc_3, V_3Vc_0, V_3Vc_1, V_3Vc_2, V_3Vc_3

3.6 Design and layout of the experiment

The two factor experiment was laid out in the Randomized Complete Block Design RCBD (factorial) with three replication. Each block consisted of 12 unit plots. The size of each unit plot was (1 m × 1.2 m) or 1.2 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.

3.7 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 24 unit plots keeping plot and block to block spacing. During land preparation, carbofuran @ 16 kg ha^{-1} was mixed with the soil uniformly for controlling soil borne insects.

3.8 Vermicompost application

All the rate of vermicompost was incorporated into the soil during final land preparation as per treatment. No chemical fertilizers were used .

3.9 Sowing of seeds

Two seeds were sown per hill at a depth of 3.0 cm on 2nd December, 2017 in the row. Row to Row and Plant to Plant distance were maintained 25cm × 15cm respectively. 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.

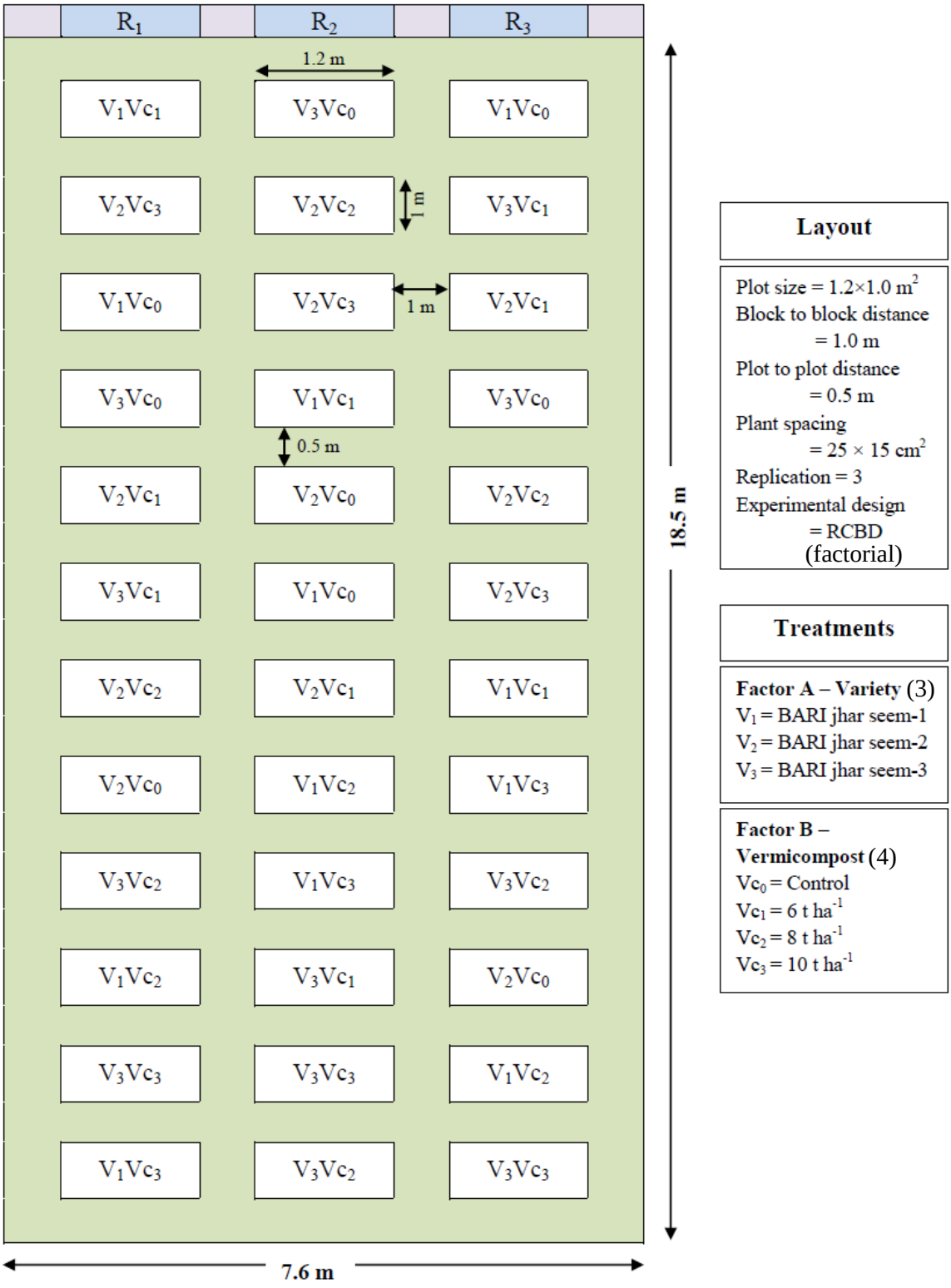

Fig 1. Layout of the experiment field

3.10 Intercultural operation

3.10.1 Gap filling

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

3.10.2 Thinning

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

3.10.3 Weeding and mulching

Weeding and mulching were done whenever it was necessary to keep the plots pulverized free from weeds.

3.10.4 Plant protection

3.10.4.1 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.

3.10.4.2 Diseases

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. 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.

3.11 Harvesting

Immature green pods were harvested at tender stage through hand picking and weighed to estimate the yield of fresh pod. At harvest, pods were 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

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

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

3.12.2 Branches plant^{-1}

The number of branches of five randomly selected plants from each plot at different days after sowing. Number of branches plant^{-1} was recorded at 35, 45 and 55 days after sowing (DAS).

3.12.3 compound leaves plant^{-1}

The number of leaves of five randomly selected plants was counted from each unit plot at 10 days interval from 25 to 45 DAS and means were calculated.

3.12.4 Flowers plant^{-1}

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

3.12.5 Pods plant^{-1}

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

3.12.6 Pod length (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.

3.12.7 Fresh weight of pods plant^{-1} (g)

Fresh pods of ten sample plants were weighed and their average was taken in gram (g).

3.12.8 Dry weight of pod plant^{-1} (g)

Fresh pods from five plants were collected randomly from each plot at harvest. Samples from each plot were placed in oven maintained at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the sample was taken and recorded in gram.

3.12.9 Seeds pod^{-1}

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

3.12.10 Fresh pod yield ha^{-1}

Green pods were harvested from each unit plot at seven days interval and their weight was recorded. Harvesting was done at three times and their total weight was recorded in each unit plot and expressed in gram (g). The green pod yield per plot was finally converted to yield per hectare and expressed in ton (t).

3.12.11 Seed viability test

For seed viability test, harvested seeds of different variety were used.

3.12.11.1 Percent (%) seed germination

The number of sprouted and germinated seeds was counted daily commencing. Germination was recorded at 24 hrs interval and continued up to 10^{th}. More than 2 mm long plumule and radicle was considered as germinated seed.

The germination rate was calculated using the following formula:

$$\text{Rate of germination (\%)} = \frac{Total\ Number\ of\ germinated\ seeds}{Total\ seed\ placed\ for\ germination} \times 100$$

3.12.11.2 Root length (cm)

The root length of five seedlings from each sample was recorded finally at 10 DAS. Measurement was done using a meter scale and unit was expressed in centimeter (cm).

3.12.11.3 Shoot length (cm)

The shoot length of five seedlings from each sample was measured finally at 10 DAS. Measurement was done using the unit centimeter (cm) by a meter scale.

3.12.11.4 Fresh weight $plant^{-1}$ (g)

Five plants were collected randomly from each sample at 10 days old seedlings.

The average fresh weight of the sample was taken and recorded in gram (g).

3.12.11.5 Dry weight plant^{-1} (mg)

Five plants were collected randomly from each sample at 10 days old seedlings. Fresh plant samples from each plot were put into envelop and placed in oven maintained at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the sample was taken and recorded in milligram (mg).

3.12.11.6 Seed vigor index

The vigor index (VI) of the seedlings can be estimated as suggested by Abdul-Baki and Anderson (1973):

$$VI = RL+SL\times GP$$

Where

RL = Root length (cm)

SL = Shoot length (cm) and

GP = Germination percentage.

3.13 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to see growth, yield and seed viability of French bean varieties influenced by vermicompost as a safe agriculture. A summary of the analysis of variances of all the characters studied together with their sources of variation and corresponding degrees of freedom have been shown in Appendix IV-IX. The effect of different cultivars, vermicompost and their interaction on growth yield contributing characters and yield and also seed viability have been presented and discussed in this chapter under the following heads.

4.1 Growth parameters

4.1.1 Plant height

Effect of variety

Plant height is an important character, which is very essential parameter for plant growth and development. Plant height was significantly influenced by variety (Fig. 2 and Appendix IV). Plant height was found to be statistically significant at 25 DAS, 35 DAS and 45 DAS. The maximum plant height (35.24, 41.19 and 47.92 cm at 25, 35 and 45 DAS, respectively) was found from V_3 (BARI jhar seem-3) and the minimum (22.45, 29.34 and 40.41cm at 25, 35 and 45 DAS, respectively) was observed from V_2 (BARI jhar seem-2). Probably the genetic makeup of varieties was responsible for the variation in plant height. This result is in agreement with findings of Yadav (2015), Santhi *et al.* (2015) and Moniruzzaman *et al*. (2009). They reported variety had significant influence on plant height.

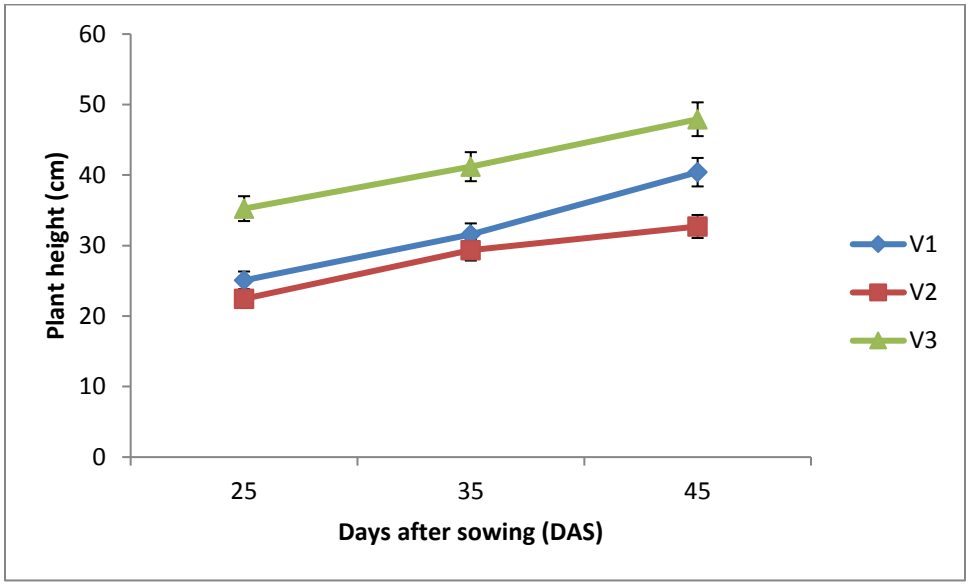

Fig. 2. Effects of variety on plant height of french bean at different days after sowing ($LSD_{0.05}$ = 2.536, 3.114, 3.267 at 25, 35, 45 DAS, respectively)

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3

Effect of vermicompost

Application of organic manures exhibited a significant influence on plant height of french bean plants at 25, 35, 45 days after sowing (Fig. 3 and Appendix IV). At all growth stages, the rate of vermicompost Vc_3 (10 t ha^{-1}) showed highest plant height and control treatment Vc_0 represented smallest plant. Result revealed that the highest plant height (30.30, 38.58 and 43.31 cm at 25, 35 and 45 DAS, respectively) was attained from Vc_3 (10 t ha^{-1}) which was statistically different from other treatments. Conversely, the lowest plant height (23.51, 28.20 and 40.41 cm at 25, 35 and 45 DAS, respectively) was achieved from Vc_0 (Control).This findings from the present study was similar with the findings of Yadav *et al.* (2017) and Islam *et al.* (2016).

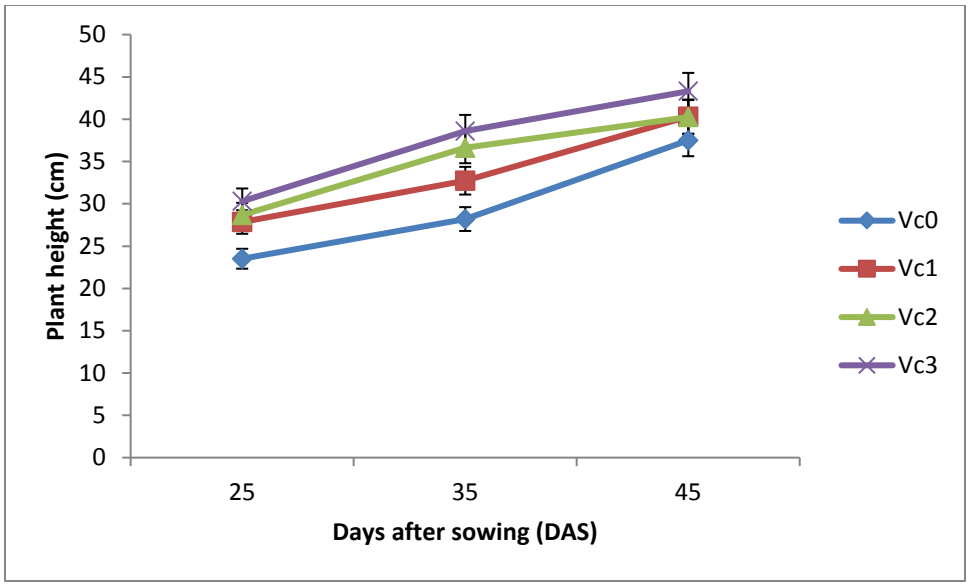

Fig. 3. Effects of vermicompost on plant height of french bean at different days after sowing ($LSD_{0.05}$ = 1.588, 1.876, 2.014 at 25, 35, 45 DAS, respectively)

Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

Combined effect of variety and vermicompost

The significant variation was found due to combined effect of variety and vermicompost for plant height at different days after sowing (Table 1 and Appendix IV). The maximum plant height (36.65, 44.39 and 50.55 cm at 25, 35 and 45 DAS, respectively) was recorded from treatment combination of V_3Vc_3, which was statistically similar with the treatment combination of V_3Vc_1 and V_3Vc_2 at 45 DAS. The minimum plant height (18.30, 22.28 and 29.95 cm at 25, 35 and 45 DAS, respectively) was found from the treatment combination, V_2Vc_0 which was statistically similar with the treatment combination of $V_2Vc_1$and V_2Vc_2 at 45 DAS.

Table 1.Combined effects of variety and vermicompost on plant height of French bean at different days after sowing

Treatment	Plant height (cm)		
	25 DAS	35 DAS	45 DAS
V_1Vc_0	20.73 fg	26.54 g	37.19 fg
V_1Vc_1	23.56 ef	28.01 g	39.35 ef
V_1Vc_2	26.90 cd	33.75 e	41.09 de
V_1Vc_3	29.09 bc	37.97 cd	43.99 cd
V_2Vc_0	18.30 g	22.28 h	29.95 i
V_2Vc_1	23.61 ef	29.59 fg	33.19 hi
V_2Vc_2	22.71 ef	32.12 ef	32.29 hi
V_2Vc_3	25.16 de	33.38 e	35.40 gh
V_3Vc_0	31.49 b	35.78 de	45.37 bc
V_3Vc_1	36.37 a	40.58 bc	48.39 ab
V_3Vc_2	36.43 a	44.01 ab	47.38 ab
V_3Vc_3	36.65 a	44.39 a	50.55 a
$LSD_{0.05}$	3.021	3.510	3.096
CV(%)	8.541	10.207	9.686

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3
Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

4.1.2 Branches plant^{-1}

Effect of variety

Different variety of French bean revealed a significant influence on number of branches plant^{-1} at 45 and 55 DAS but at 35 DAS non-significant influence was observed (Fig. 4 and Appendix V). The highest number of branches plant^{-1} (11.04 and 13.15 at 45 and 55 DAS, respectively)was enlisted from the variety V_1 (BARI jhar seem-1) followed by variety V_2 (BARI jhar seem-2) while the lowest number of branches plant^{-1} (10.18 and 12.19 at 45 and 55 DAS, respectively) was recorded from the variety V_3 (BARI jhar seem-3).Yadav (2015), Santhi *et al.* (2015), Das *et al.* (2014) and Pandey *et al.* (2012) also found similar results which supported the present study.

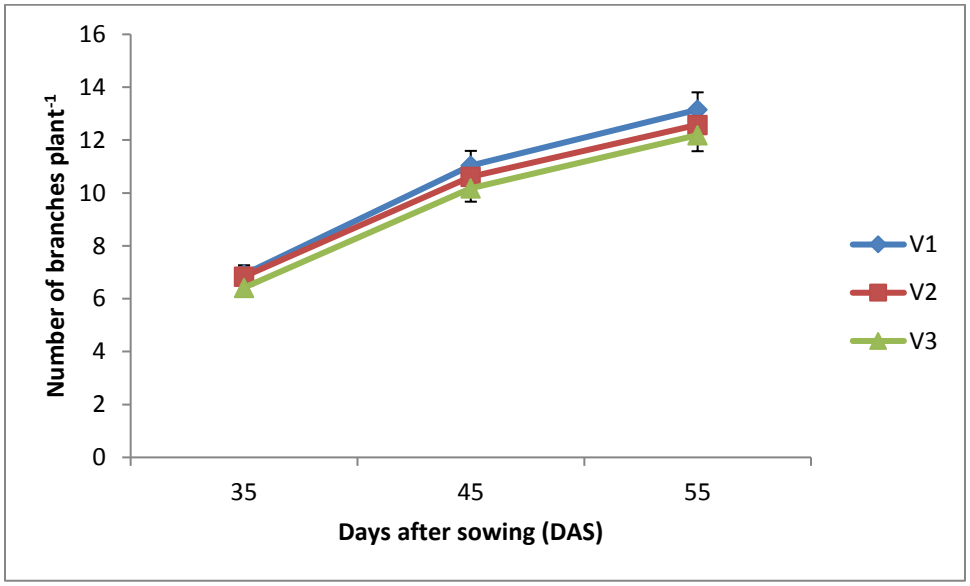

Fig. 4. Effects of variety on number of branches plant^{-1}of french bean at different days after sowing ($LSD_{0.05}$= NS, 0.216, 0.238 at 25, 35, 45 DAS, respectively)

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3

Effect of vermicompost

Application of vermicompost showed a significant influence at all growth stages (35 -55 DAS) on number of branches plant^{-1}(Fig. 5 and Appendix V). The highest number of branches plant^{-1} (8.33, 12.76 and 15.20 at 35, 45 and 55 DAS, respectively) was recorded from the treatment Vc_3 (10 t ha^{-1}) whereas the lowest number of branches plant^{-1} (5.00, 8.02 and 13.15 at 35, 45 and 55 DAS, respectively) was found with control treatment (Vc_0). It was also observed that all the treatments on vermicompost application regarding number of branches plant^{-1} was significantly different with each other at all growth stages and it was might be due to cause of nutrient availability to plants. Similar result was also achieved by Sarma *et al.* (2014).

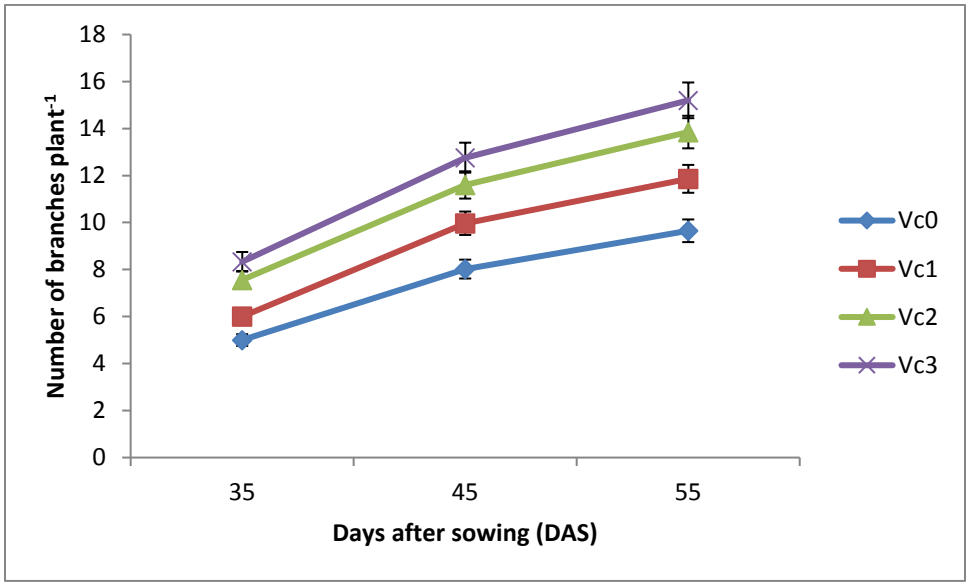

Fig. 5. Effects of vermicompost on number of branches plant^{-1} of French bean at different days after sowing ($LSD_{0.05}$ = 0.375, 0.452, 0.614 at 25, 35, 45 DAS, respectively)

Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

Combined effect of variety and vermicompost

Combined effect of variety and vermicompost demonstrated significant variation for number of branches plant^{-1} at different days after sowing (Table 2 and Appendix V). The maximum number of branches plant^{-1} (8.67, 13.20 and 14.33 at 35, 45 and 55 DAS, respectively) was recorded from treatment combination of V_1Vc_3.The treatment combination of V_3Vc_0 gave the minimum number of branches plant^{-1} (4.67, 7.50 and 9.00 at 35, 45 and 55 DAS, respectively) which was statistically identical with the treatment combination of V_2Vc_0 at 55 DAS.

Table 2.Combined effects of variety and vermicompost on number of branches plant^{-1}of French bean at different days after sowing

Treatment	Number of branches plant^{-1}		
	35 DAS	45 DAS	55 DAS
V_1Vc_0	5.33 g	8.80 g	10.70 h
V_1Vc_1	6.00 f	9.90 f	11.75 g
V_1Vc_2	7.67 cd	12.0 bc	14.33 cd
V_1Vc_3	8.67 a	13.2 a	15.80 a
V_2Vc_0	5.00 gh	7.75 h	9.25 i
V_2Vc_1	6.67 e	10.7 e	12.50 f
V_2Vc_2	7.67 cd	11.60 cd	13.90 de
V_2Vc_3	8.00 bc	12.33 bc	14.67 bc
V_3Vc_0	4.67 h	7.50 h	9.00 i
V_3Vc_1	5.33 g	9.25 fg	11.33 gh
V_3Vc_2	7.33 d	11.20 de	13.32 e
V_3Vc_3	8.33 ab	12.75 ab	15.12 b
$LSD_{0.05}$	0.5247	0.742	0.6426
CV(%)	6.356	8.214	6.873

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3
Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

4.1.3 Compound leaves plant^{-1}

Effect of variety

Number of compound leaves plant^{-1} is a crucial parameter and an important part of crop plant because of its physiological role in photosynthetic activities. Number of leaves is directly related to the yield of bush bean. Effect of variety on number of compound leaves was found to be statistically non- significant at 25and 35 DAS but at45 DAS it was found to be statistically significant (Fig. 6 and Appendix VI). At 45 DAS, highest number of compound leaves plant^{-1} (15.77) was recorded from V_1 (BARI jhar seem-1) while lowest number of compound leaves plant^{-1} (14.44) was found from V_3 (BARI jhar seem-3) which was statistically identical with V_2 (BARI jhar seem-2). Noor *et al*. (2014) also found highest number of compound leaves per plant in BARI bush bean-1 compared to BARI bush bean-2.

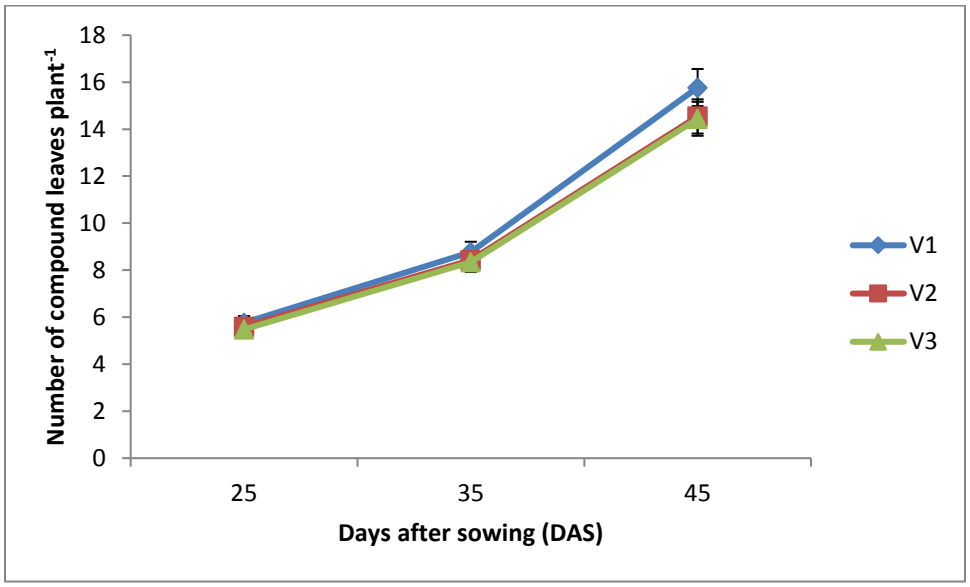

Fig. 6. Effects of variety on number of compound leaves plant^{-1}of french bean at different days after sowing ($LSD_{0.05}$ = 0.325^{NS,} 0.438^{NS,} 0.346 at 25, 35, 45 DAS, respectively)

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3

Effect of vermicompost

Effect of vermicompost on number of compound leaves plant^{-1} was observed statistically significant at all growth stages (Fig. 7 and Appendix VI). At 25, 35 and 45 DAS, the highest number of compound leaves plant^{-1} was recorded (6.61, 10.27 and 16.26, respectively) from Vc_3 (10 t ha^{-1}) treatment, which is statistically different with others while the lowest number of compound leaves plant^{-1}(4.71, 6.45 and 12.59, respectively) was counted from Vc_0 (Control) treatment, which was also statistically different from other treatments. The result obtained from the present study was in agreement with the findings of Sarma *et al.* (2014).

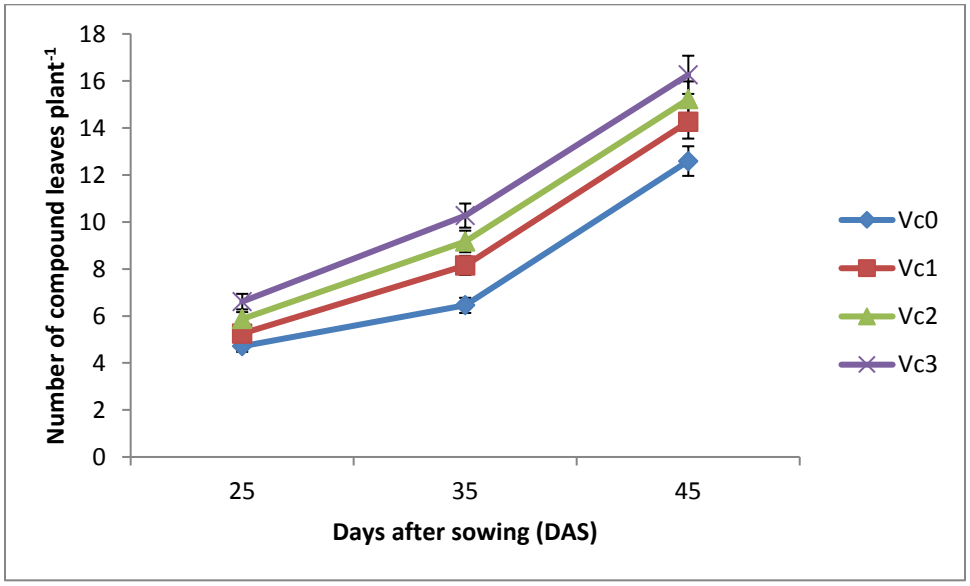

Fig. 7. Effects of vermicompost on number of compound leaves plant^{-1}of french bean at different days after sowing ($LSD_{0.05}$ = 3.852, 5.386, 5.289 at 25, 35, 45 DAS, respectively)

Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

Combined effect of variety and vermicompost

Combined effect of variety and vermicompost application had significant differences on number of compound leaves plant^{-1} at different growth stages (Table 3 and Appendix VI). It was observed that the number of compound leaves plant^{-1} was gradually increased with time up 25 to 45 DAS. At 25, 35 and 45 DAS, the highest number of compound leaves plant^{-1} (6.80, 10.80 and 16.66, respectively) was recorded from V_1Vc_3 treatment combination which was statistically similar with V_2Vc_3 and V_3Vc_3 at 45 DAS. The lowest number of compound leaves plant^{-1} (4.60, 6.44 and 12.60, respectively) was recorded from V_3Vc_0 treatment combination which was statistically identical with V_1Vc_0 and 12.42 at 45 DAS.

Table 3.Combined effects of variety and vermicompost on number of compound leaves plant^{-1}of French bean at different days after sowing

Treatment	Number of compound leaves plant^{-1}		
	25 DAS	35 DAS	45 DAS
V_1Vc_0	4.80 ef	6.60 h	12.75 e
V_1Vc_1	5.24 d	8.16 fg	14.18 d
V_1Vc_2	6.20 bc	9.48 c	15.48 bc
V_1Vc_3	6.80 a	10.80 a	16.66 a
V_2Vc_0	4.72 ef	6.30 h	12.42 e
V_2Vc_1	5.42 d	8.52 ef	14.50 cd
V_2Vc_2	5.92 c	9.24 cd	15.45 bc
V_2Vc_3	6.44 ab	9.66 c	15.80 ab
V_3Vc_0	4.60 f	6.44 h	12.60 e
V_3Vc_1	5.10 de	7.78 g	14.10 d
V_3Vc_2	5.50 d	8.80 de	14.72 cd
V_3Vc_3	6.58 ab	10.30 b	16.33 ab
$LSD_{0.05}$	0.3935	0.4908	0.9367
CV(%)	3.852	5.386	5.289

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3
Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

4.2 Yield contributing parameters and yield of French bean

4.2.1 Flowers plant^{-1}

Effect of variety

Number of flowers plant^{-1} was significantly varied due varietal performance of French bean under the present study (Table 4 and Appendix VII). Results indicated that the maximum number of flowers plant^{-1} (41.09) was recorded from V_1 (BARI jhar seem-1) followed by V_2 (BARI jhar seem-2) whereas and the minimum number of flowers plant^{-1} (37.81) was found from V_3 (BARI jhar seem-3). Kakon *et al.* (2015) also observed that the duration of flowering and number was dependent on growing periods and varieties.

Effect of vermicompost

Significant variation was found in terms of number of flowers plant^{-1} affected by application of four different vermicompost rate(Table 4 and Appendix VII). Results revealed that the highest number of flowers plant^{-1}(50.92) was recorded for the treatment Vc_3 (10 t ha^{-1}) followed by Vc_2 (8 t ha^{-1}) and the lowest number of flowers plant^{-1} (25.63) was recorded for the control treatment (Vc_0). Increased levels of phosphorus contained in higher rate of vermicompost might have increased the branching and increased the activity of florigen. Vc_1 (6 t ha^{-1}) and Vc_2 (8 t ha^{-1}) also give significant effect on flower number that is 36.67 and 44.22, respectively. Islam *et al.* (2016) also showed similar result on number of flowers plant^{-1} which supports the present study.

Combined effect of variety and vermicompost

The variation was observed due to combined effect of varieties and vermicompost on number of flowers plant^{-1}(Table 4 and Appendix VII). The maximum number of flowers plant^{-1}(52.62) was recorded from the treatment combination of V_1Vc_3 which was statistically similar with the treatment combination of V_2Vc_3 and

V_3Vc_3.The treatment combination of V_3Vc_0 performed the minimum number of flowers plant^{-1} (24.30) which was statistically similar with the treatment combination of V_2Vc_0.

4.2.2 Pods plant^{-1}

Effect of variety

Significantly influence was remarked on number of pods plant^{-1} due varietal difference of French bean under the present study (Table 4 and Appendix VII). Results pointed out that the maximum number of pods plant^{-1} (32.09) was recorded from V_1 (BARI jhar seem-1) whereas and the minimum number of pods plant^{-1} (29.26) was found from V_3 (BARI jhar seem-3) which was statistically identical with the variety V_2 (BARI jhar seem-2). Similar result was also observed by Santhi *et al.* (2015), Kakon *et al.* (2015), Yadav (2015) and Moniruzzaman *et al.* (2009) and they found that pod number per plant varied due to varietal difference.

Effect of vermicompost

Considerable variation was achieved in terms of number of pods plant^{-1} affected by different levels of vermicompost application (Table 4 and Appendix VII). Results indicated that the highest number of pods plant^{-1} (40.82) was recorded from the treatment Vc_3 (10 t ha^{-1}) followed by Vc_2 (8 t ha^{-1}) and the lowest number of pods plant^{-1} (16.21) was recorded from the control treatment (Vc_0). The present observation is similar to the result of the findings achieved by Islam *et al.* (2016) and Kamble *et al.* (2016).

Combined effect of variety and vermicompost

The variation was recorded due to combined effect of varieties and vermicompost on number of pods plant^{-1} (Table 4 and Appendix VII). It was found that the highest number of pods plant^{-1} (42.56) was recorded from the treatment

combination of V_1Vc_3 which was statistically similar with the treatment combination of V_2Vc_3 and V_3Vc_3. The treatment combination, V_3Vc_0 gave the lowest number of pods plant^{-1} (16.72) which was statistically identical with the treatment combination of V_2Vc_0.

4.2.3 Pod length

Effect of variety

The effect of variety on pod length of was not significant (Table 4 and Appendix VII). But it was found that the maximum length of pod (9.89 cm) was recorded from V_3 (BARI jhar seem-3) and the minimum pod length (9.28 cm) was found from V_2 (BARI jhar seem-2). Similar results was also found by Pandey *et al.* (2012) and Moniruzzaman *et al.* (2007).

Effect of vermicompost

Pods length of French bean differed significantly due to application of different rates of vermicompost (Table 4 and Appendix VII). The maximum pod length (11.11 cm) was recorded from Vc_3 (10 t ha^{-1}), while the minimum pod length (8.30 cm) was counted from Vc_0 (Control). It was revealed that the pod length was increased by using higher rate of vermicompost. This might be caused that higher rate of vermicompost contents high amount of nitrogen which increased the number of leaves, cell division and cell enlargement. The present observation is similar to the findings of Sarma *et al.* (2014), Kamble *et al.* (2016) and Islam *et al.* (2016).

Combined effect of variety and vermicompost

The significant variation was found due to combined effect of varieties and vermicompost on pod length of French bean (Table 4 and Appendix VII). The maximum pod length (11.37 cm) was recorded from the treatment combination of V_1Vc_3 which was statistically same with the treatment combination of V_3Vc_3.

Reversely, the minimum pod length (7.80 cm) was obtained from the treatment combination of V_2Vc_0 followed by V_3Vc_0 and V_1Vc_0.

4.2.4 Fresh weight of pods plant^{-1}

Effect of variety

Significantly influence was observed on fresh weight of pods plant^{-1} due varietal difference of French bean under the present study (Table 4 and Appendix VII). It was recorded that the highest fresh weight of pods plant^{-1} (267.19 g) was achieved from the variety V_1 (BARI jhar seem-1) whereas the minimum fresh weight of pods plant^{-1} (240.19 g) was found from V_2 (BARI jhar seem-2) which was statistically identical with the variety V_3 (BARI jhar seem-3).The result on fresh weight of pods plant^{-1} from the present study was similar with the findings of Noor *et al.* (2014) and Moniruzzaman *et al.* (2009).

Effect of vermicompost

Considerable variation was found in terms of fresh weight of pods plant^{-1}affected by different levels of vermicompost application (Table 4 and Appendix VII). Results indicated that the highest fresh weight of pods plant^{-1} (342.25 g) was recorded from the treatment Vc_3 (10 t ha^{-1}) followed by Vc_2 (8 t ha^{-1}) and the lowest fresh weight of pods plant^{-1} (155.00 g) was recorded from the control treatment (Vc_0). The present finding is similar to the findings of Santosa *et al.* (2017), Sarma *et al.* (2014) and Islam *et al.* (2016).

Combined effect of variety and vermicompost

The variation was recorded due to combined effect of varieties and vermicompost on fresh weight of pods plant^{-1} (Table 4 and Appendix VII). It was found that the highest fresh weight of pods plant^{-1} (367.50 g) was recorded from the treatment combination of V_1Vc_3 followed by the treatment combination of V_3Vc_3. The

treatment combination, V_2Vc_0 gave the lowest fresh weight of pods plant^{-1} (131.30 g) which was closer to the treatment combination of V_3Vc_0.

4.2.5 Dry weight of pod plant^{-1}

Effect of variety

Dry weight of pods plant^{-1} was significantly influenced by varietal performance of French bean under the present study (Table 4 and Appendix VII). It was recorded that the highest dry weight of pods plant^{-1} (45.91 g) was achieved from the variety V_1 (BARI jhar seem-1) whereas and the minimum dry weight of pods plant^{-1} (41.92 g) was found from V_2 (BARI jhar seem-2) which was statistically identical with the variety V_3 (BARI jhar seem-3). Maske *et al*. (2009) and Moniruzzaman *et al.* (2007) also found similar results with the present study.

Effect of vermicompost

There was significant variation ondry weight of pods plant^{-1}was recorded influenced by different levels of vermicompost application (Table 4 and Appendix VII). Results revealed that the highest dry weight of pods plant^{-1} (57.56 g) was recorded from the treatment Vc_3 (10 t ha^{-1}) followed by Vc_2 (8 t ha^{-1}) and the lowest dry weight of pods plant^{-1} (28.80 g) was recorded from the control treatment (Vc_0).

Combined effect of variety and vermicompost

Combined effect of varieties and vermicompost gave significant variation on dry weight of pods plant^{-1} (Table 4 and Appendix VII). It was recorded that the highest dry weight of pods plant^{-1} (61.50 g) was found from the treatment combination of V_1Vc_3 which was statistically identical with the treatment combination of treatment combination of V_3Vc_3. The treatment combination, V_2Vc_0 gave the lowest dry weight of pods plant^{-1} (24.25 g) which was closer to the treatment combination of V_1Vc_0 and V_3Vc_0.

4.2.6 Seeds pod^{-1}

Effect of variety

Non-significantly effect was observed on number of seeds pod^{-1} due varietal difference of French (Table 4 and Appendix VII). But it was observed that the highest number of seeds pod^{-1} (5.90) was achieved from the variety V_3 (BARI jhar seem-3) whereas and the minimum number of seeds pod^{-1} (5.73) was found from V_2 (BARI jhar seem-2).

Effect of vermicompost

Considerable variation was found in terms of number of seeds pod^{-1} affected by different levels of vermicompost application (Table 4 and Appendix VII). Results indicated that the highest number of seeds pod^{-1} (6.53) was recorded from the treatment Vc_3 (10 t ha^{-1}) which was statistically identical with the treatment of Vc_2 (8 t ha^{-1}) and the lowest number of seeds pod^{-1} (4.38) was recorded from the control treatment (Vc_0). The present finding is similar to the findings of Sarma *et al.* (2014).

Combined effect of variety and vermicompost

Significant variation was recorded due to combined effect of varieties and vermicompost on number of seeds pod^{-1}(Table 4 and Appendix VII). It was found that the highest number of seeds pod^{-1}(6.60) was recorded from the treatment combination of V_3Vc_3 which was statistically same with the treatment combination of V_1Vc_2, V_1Vc_3, V_2Vc_2, V_2Vc_3 and V_3Vc_2. The treatment combination, V_2Vc_0 gave the lowest number of seeds pod^{-1}(4.25) which was statistically identical with the treatment combination of V_1Vc_0 and V_3Vc_0.

4.2.7 Fresh pod yield ha^{-1}

Effect of variety

Significantly influence was observed on fresh pod yieldha^{-1} due varietal difference of French bean under the present study (Table 4 and Appendix VII). It was recorded that the highest fresh pod yield ha^{-1} (7.13 t) was achieved from the variety V_1 (BARI jhar seem-1) whereas the minimum fresh pod yield ha^{-1} (6.41 t) was found from V_2 (BARI jhar seem-2) which was statistically identical with the variety V_3 (BARI jhar seem-3). The result obtained from the present study was conformity with the findings of Rahman *et al*. (2018), Yadav (2015) and Noor *et al.* (2014).

Effect of vermicompost

Considerable variation was found in terms of fresh pod yield ha^{-1} affected by different levels of vermicompost application (Table 4 and Appendix VII). Results indicated that the highest fresh pod yield ha^{-1}(9.13 t) was recorded from the treatment Vc_3 (10 t ha^{-1}) followed by Vc_2 (8 t ha^{-1}) and the lowest fresh pod yield ha^{-1}(4.13 t) was recorded from the control treatment (Vc_0). The present finding is similar to the findings of El-Hassan *et al.* (2017), Santosa *et al.* (2017), Sarma *et al.* (2014), Kamble *et al.* (2016) and Islam *et al.* (2016).

Combined effect of variety and vermicompost

The variation was recorded due to combined effect of varieties and vermicompost on fresh pod yield ha^{-1}(Table 4 and Appendix VII). It was found that the highest fresh pod yield ha^{-1}(9.80 t) was recorded from the treatment combination of V_1Vc_3 which was statistically similar with the treatment combination of V_3Vc_3. The treatment combination, V_2Vc_0 gave the lowest fresh pod yield ha^{-1}(3.50 t) which was statistically similar with the treatment combination of V_3Vc_0.

Table 4. Effects of variety and vermicompost on yield contributing parameters and yield of French bean

Treatment	Yield contributing parameters and yield of French bean						
	Number of flowers plant^{-1}	Number of pods plant^{-1}	Pod length (cm)	Fresh weight of pods plant^{-1}(g)	Dry weight of pod plant^{-1} (g)	Number of seeds pod^{-1}	Fresh pod yield ha^{-1} (t)
Effect of variety							
V_1	41.09 a	32.09 a	9.78	267.19 a	45.91 a	5.78	7.13 a
V_2	39.18 b	29.54 b	9.28	240.19 b	41.22 b	5.73	6.41 b
V_3	37.81 c	29.26 b	9.89	242.16 b	42.69 b	5.90	6.46 b
$LSD_{0.05}$	1.211	1.052	0.343^{NS}	8.576	1.073	0.27 ^{NS}	0.448
Effect of vermicompost							
Vc_0	25.63 d	16.21 d	8.30 d	155.00 d	28.80 d	4.38 c	4.13 d
Vc_1	36.67 c	28.95 c	9.22 c	229.25 c	39.95 c	5.83 b	6.11 c
Vc_2	44.22 b	35.19 b	9.97 b	272.88 b	46.79 b	6.47 a	7.28 b
Vc_3	50.92 a	40.82 a	11.11 a	342.25 a	57.56 a	6.53 a	9.13 a
$LSD_{0.05}$	2.052	2.849	0.547	10.402	3.217	0.486	0.564
Combined effect of variety and vermicompost							
V_1Vc_0	27.40 e	18.40 g	8.61 ef	179.30 i	32.70 f	4.40 c	4.78 g
V_1Vc_1	35.60 d	29.60 ef	9.11 cd	226.50 h	38.96 de	5.80 b	6.04 f
V_1Vc_2	48.75 b	37.80 b	10.02 b	295.50 d	50.48 b	6.42 a	7.88 cd
V_1Vc_3	52.62 a	42.56 a	11.37 a	367.50 a	61.50 a	6.50 a	9.80 a
V_2Vc_0	25.20 ef	13.50 h	7.80 g	131.30 k	24.25 g	4.25 c	3.50 h
V_2Vc_1	40.25 c	30.48 de	9.54 c	243.00 g	42.71 cd	5.78 b	6.48 ef
V_2Vc_2	42.50 c	34.50 c	9.44 cd	270.00 e	45.72 c	6.40 a	7.20 de
V_2Vc_3	49.66 ab	39.66 ab	10.35 b	316.50 c	52.21 b	6.48 a	8.44 bc
V_3Vc_0	24.30 f	16.72 g	8.50 f	154.50 j	29.44 f	4.50 c	4.12 gh
V_3Vc_1	34.16 d	26.78 f	9.00 de	218.30 h	38.18 e	5.90 b	5.82 f
V_3Vc_2	41.40 c	33.28 cd	10.46 b	253.10 f	44.16 c	6.58 a	6.75 ef
V_3Vc_3	50.48 ab	40.25 ab	11.60 a	342.80 b	58.96 a	6.60 a	9.14 ab
$LSD_{0.05}$	2.949	3.218	0.4544	9.466	4.165	0.3076	0.9458
CV(%)	5.367	8.355	4.867	11.644	7.522	5.365	6.081

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3
Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level

4.3 Seed viability test

4.3.1 Percent (%) seed germination

Effect of variety

Different variety produced seed had the most influence on seed germination of French bean (Table 5 and Appendix VIII). It was found that the highest percent (%) seed germination (70.00) was achieved from the V_1 (BARI jhar seem-1) variety produced seeds whereas the minimum percent (%) seed germination (54.00) was found from V_2 (BARI jhar seem-2) which was statistically identical with the variety V_3 (BARI jhar seem-3).

Effect of vermicompost

Cultivation practice of French bean with different rate of vermicompost showed significant influence on percent (%) seed germination (Table 5 and Appendix VIII). Results indicated that the highest percent (%) seed germination (94.44) was recorded from the Vc_3 (10 t ha^{-1}) treated seeds followed by Vc_1 (6 t ha^{-1}) whereas the lowest percent (%) seed germination (39.78) was recorded from the seeds of control treatment (Vc_0).

Combined effect of variety and vermicompost

Significant variation was recorded on percent (%) seed germination affected by combined effect of varieties and vermicompost (Table 5 and Appendix VIII). It was found that the highest percent (%) seed germination (96.67) was recorded from seeds which were produced from the treatment combination of V_1Vc_3 which was statistically same with V_2Vc_3 and V_3Vc_3. The lowest percent (%) seed germination (20.00) was found from the seeds achieved from the treatment combination, V_2Vc_0 followed by V_1Vc_0 and V_3Vc_0.

4.3.2 Root length

Effect of variety

Root length was significantly affected by the different variety of French bean (Table 5 and Appendix VIII). Root length (16.36 cm) was highest from the V_1 (BARI jhar seem-1) variety produced seeds which was statistically identical with V_3 (BARI jhar seem-3) whereas the minimum root length (14.84 cm) was found from V_2 (BARI jhar seem-2) variety produced seeds.

Effect of vermicompost

Root length of French bean differed significantly due to vermicompost application (Table 5 and Appendix VIII). The maximum root length (18.14 cm) was recorded from the seeds achieved by Vc_3 (10 t ha^{-1}) vermicompost application, while the minimum root length (12.47 cm) was counted from the seeds of Vc_0 (Control) treatment.

Combined effect of variety and vermicompost

The significant variation was found due to combined effect of varieties and vermicompost on root length of French bean (Table 5 and Appendix VIII). The maximum root length (20.02 cm) was recorded from the seeds achieved from the treatment combination of V_1Vc_3 followed by V_3Vc_3. Reversely; the minimum root length (10.27 cm) was found from seeds that were obtained from the treatment combination of V_2Vc_0 followed by V_1Vc_0.

4.3.3 Shoot length

Effect of variety

The effect of variety had significant effect on shoot length of French bean (Table 5 and Appendix VIII). The maximum shoot length (19.60 cm) was recorded from V_1

(BARI jhar seem-1) variety produced seeds where the minimum shoot length (17.76 cm) was found from the seeds produced by V_2 (BARI jhar seem-2).

Effect of vermicompost

Shoot length of French bean varied significantly due to application of different rates of vermicompost (Table 5 and Appendix VIII). The maximum shoot length (22.34 cm) was recorded from the seeds achieved from Vc_3 (10 t ha^{-1}) rate of vermicompost, while the minimum shoot length (14.45 cm) was counted from the seeds of Vc_0 (Control) treatment.

Combined effect of variety and vermicompost

The significant variation was found due to combined effect of varieties and vermicompost on shoot length of French bean (Table 5 and Appendix VIII). The maximum shoot length (24.08 cm) was recorded from seeds achieved by the treatment combination of V_1Vc_3 which was statistically same with V_3Vc_3. Reversely, the minimum shoot length (12.79 cm) was obtained from the seeds achieved by the treatment combination of V_2Vc_0 followed by V_3Vc_0 and V_1Vc_0.

4.3.4 Fresh weight $plant^{-1}$

Effect of variety

Fresh weight $plant^{-1}$ from different variety produced seeds was significant (Table 5 and Appendix VIII). The maximum fresh weight $plant^{-1}$(1.42 g) was recorded from V_1 (BARI jhar seem-1) variety produced seeds where the minimum fresh weight $plant^{-1}$(1.30 g) was found from the seeds produced by V_2 (BARI jhar seem-2) which was statistically identical with V_3 (BARI jhar seem-3).

Effect of vermicompost

Fresh weight $plant^{-1}$of French bean from the seeds produced by the different rates of vermicompost application was significant (Table 5 and Appendix VIII). The

maximum fresh weight plant^{-1} (1.87 g) was recorded from the seeds achieved from Vc_3 (10 t ha^{-1}) rate of vermicompost, while the minimum fresh weight plant^{-1}(0.84 g) was counted from the seeds of Vc_0 (Control) treatment.

Combined effect of variety and vermicompost

Fresh weight plant^{-1} from the seeds produced from different treatment combination of varieties and vermicompost was significant (Table 5 and Appendix VIII). The maximum fresh weight plant^{-1}(2.07 g) was recorded from seeds achieved by the treatment combination of V_1Vc_3 whereas the minimum fresh weight plant^{-1}(0.78 g) was obtained from the seeds achieved by the treatment combination of V_2Vc_0 followed by V_3Vc_0 and V_1Vc_0.

4.3.5 Dry weight plant^{-1}

Effect of variety

Dry weight plant^{-1} from different variety produced seeds was significant (Table 5 and Appendix VIII). The maximum dry weight plant^{-1} (25.58mg) was recorded from V_1 (BARI jhar seem-1) variety produced seeds where the minimum dry weight plant^{-1} (22.74mg) was found from the seeds produced by V_2 (BARI jhar seem-2).

Effect of vermicompost

Dry weight plant^{-1} of French bean from the seeds produced by the different rates of vermicompost application was significant (Table 5 and Appendix VIII). The maximum dry weight plant^{-1} (31.19 mg) was recorded from the seeds achieved from Vc_3 (10 t ha^{-1}) rate of vermicompost, while the minimum dry weight plant^{-1} (13.19mg) was counted from the seeds of Vc_0 (Control) treatment.

Combined effect of variety and vermicompost

The seeds achieved from the different treatment combination of varieties and vermicompost showed significant variation on dry weight plant^{-1} of French bean (Table 5 and Appendix VIII). The maximum dry weight plant^{-1} (32.80mg) was recorded from seeds achieved by the treatment combination of V_1Vc_3 which was statistically similar with V_2Vc_3 and V_3Vcwhereas the minimum dry weight plant^{-1} (12.28mg) was obtained from the seeds achieved by the treatment combination of V_2Vc_0 which was statistically identical with V_3Vc_0 and V_1Vc_0.

4.3.6 Seed vigor index

Effect of variety

Seed vigor index is an important factor for successful crop production. Under the present study, seed vigor index influenced by different variety was significant (Table 5 and Appendix VIII). The maximum seed vigor index (1441.13) was recorded from V_1 (BARI jhar seem-1) variety produced seeds where the minimum seed vigor index (1016.25) was found from the seeds produced by V_2 (BARI jhar seem-2).

Effect of vermicompost

Seed vigor index of French bean affected by the different rates of vermicompost application was significant (Table 5 and Appendix VIII). The maximum seed vigor index (2129.94) was recorded from the seeds achieved from Vc_3 (10 t ha^{-1}) rate of vermicompost, while the minimum seed vigor index (595.02) was counted from the seeds of Vc_0 (Control) treatment.

Combined effect of variety and vermicompost

The seeds achieved from the different treatment combination of varieties and vermicompost showed significant variation on seed vigor index (Table 5 and

Appendix VIII). The maximum seed vigor index (2348.00) was recorded from seeds achieved by the treatment combination of V_1Vc_3 followed by V_3Vc_3 and whereas the minimum seed vigor index (395.80) was obtained from the seeds achieved by the treatment combination of V_2Vc_0 followed by V_1Vc_0.

Table 5. Effects of variety and vermicompost on different parameters of seed viability test of french bean

Treatment	Seed viability test					
	Percent (%) seed germination	Root length (cm)	Shoot length (cm)	Fresh weight plant^{-1} (g)	Dry weight plant^{-1} (mg)	Seed vigor index
Effect of variety						
V_1	70.00 a	16.36 a	19.60 a	1.42 a	25.58 a	1441.13 a
V_2	54.00 b	14.84 b	17.76 c	1.33 b	22.74 c	1016.25 c
V_3	57.50 b	16.00 a	18.11 b	1.30 b	23.75 b	1117.86 b
Effect of vermicompost						
Vc_0	39.78 d	12.47 c	14.45 c	0.84 d	13.19 d	595.02 d
Vc_1	56.67 b	16.12 b	18.02 b	1.21 c	24.09 c	1041.76 b
Vc_2	51.11 c	16.18 b	19.14 b	1.47 b	27.62 b	1000.25 c
Vc_3	94.44 a	18.14 a	22.34 a	1.87 a	31.19 a	2129.94 a
$LSD_{0.05}$	3.211	1.104	1.207	0.076	1.117	11.344
Combined effect of variety and vermicompost						
V_1Vc_0	36.00 f	13.01 e	16.62 f	0.89 g	14.20 e	788.70 i
V_1Vc_1	53.33 d	16.14 c	18.17 de	1.21 ef	25.22 cd	985.20 f
V_1Vc_2	83.33 b	16.25 c	19.52 cd	1.52 c	30.10 ab	1643.00 d
V_1Vc_3	96.67 a	20.02 a	24.08 a	2.07 a	32.80 a	2348.00 a
V_2Vc_0	20.00 g	10.27 f	12.79 g	0.78 g	12.28 e	470.70 k
V_2Vc_1	66.67 c	16.15 c	18.77 d	1.31 de	25.06 cd	1268.00 e
V_2Vc_2	46.67 e	16.16 c	18.98 d	1.51 c	27.40 bc	395.80 l
V_2Vc_3	93.33 a	16.77 bc	20.51 c	1.70 b	30.24 ab	1931.00 c
V_3Vc_0	36.67 f	14.14 d	13.95 g	0.85 g	13.08 e	525.70 j
V_3Vc_1	50.00 de	16.08 c	17.13 ef	1.12 f	22.00 d	872.60 h
V_3Vc_2	50.00 de	16.14 c	18.92 d	1.39 cd	25.36 cd	962.10 g
V_3Vc_3	93.33 a	17.64 b	22.43 b	1.85 b	30.52 ab	2111.00 b
$LSD_{0.05}$	5.284	0.9458	1.237	0.161	4.302	10.38
CV(%)	9.852	6.543	8.361	4.116	5.614	10.524

V_1 = BARI jhar seem-1, V_2 = BARI jhar seem-2, V_3 = BARI jhar seem-3
Vc_0 = Control, Vc_1 = 6 t ha^{-1}, Vc_2 = 8 t ha^{-1}, Vc_3 = 10 t ha^{-1}

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level.

CHAPTER V

SUMMERY AND CONCLUSION

5.1 Summary

A field experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2017 to February 2018 to determine the growth, yield and seed viability of French bean varieties influenced by vermicompost as a safe agriculture. The experiment consisted of two factors *viz*. three French bean varieties and different rate of vermicompost application. Three varieties namely V_1 (BARI jhar seem-1), V_2 (BARI jhar seem-2) and V_3 (BARI jhar seem-3) and four levels of vermicompost as Vc_0 (Control), Vc_1 (6 t ha^{-1}), Vc_2 (8 t ha^{-1}) and Vc_3 (10 t ha^{-1}) were used under the present study. The experiment consisting of 12 treatment combinations that were laid out in Randomized complete Block Design RCBD (factorial) with three replications. The size of each unit plot was 1.2 m^2 (1 m × 1.2 m). The plants were randomly selected from each plot to record data on the growth parameters, yield components and yield of plants. Seed viability test was also done from achieved seeds through different treatments. The collected data were statistically analyzed and the results of this experiment have been summarized. In most cases variety of French bean, different rates of vermicompost application and their combination showed significant influence on growth, yield contributing parameters, yield and seed viability parameters.

In case of varietal performance, most of the parameters was influenced significantly except pod length (cm) and number of seeds pod^{-1}. It was noted that the maximum plant height (35.24, 41.19 and 47.92 cm at 25, 35 and 45 DAS, respectively) was found from the variety, V_3 (BARI jhar seem-3). The maximum pod length (9.89 cm) and highest number of seeds pod^{-1} (5.90) were also obtained from the variety V_3 (BARI jhar seem-3) which was significantly same with other

variety. But the highest number of branches plant^{-1} (11.04 and 13.15 at 45 and 55 DAS, respectively) was achieved from the variety V_1 (BARI jhar seem-1) which was also showed the highest number of compound leaves plant^{-1} (15.77), maximum number of flowers plant^{-1} (41.09), maximum number of pods plant^{-1} (32.09), highest fresh weight of pods plant^{-1} (267.19 g), highest dry weight of pods plant^{-1} (45.91 g) and highest fresh pod yield ha^{-1} (7.13 t). Likewise, the smallest plant (22.45, 29.34 and 40.41cm at 25, 35 and 45 DAS, respectively) was observed from V_2 (BARI jhar seem-2). The lowest pod length (9.28), minimum fresh weight of pods plant^{-1} (240.19 g), lowest dry weight of pods plant^{-1} (41.92 g), minimum number of seeds pod^{-1} (5.73) and minimum fresh pod yield ha^{-1} (6.41 t) were also found from V_2 (BARI jhar seem-2). But the lowest number of branches plant^{-1} (10.18 and 12.19 at 45 and 55 DAS, respectively) was recorded from the variety V_3 (BARI jhar seem-3) and this variety also showed lowest number of compound leaves plant^{-1} (14.44), lowest number of flowers plant^{-1} (37.81) and lowest number of pods plant^{-1} (29.26).

Different vermicompost treatment showed significant variation among the treatments regarding all the studied parameters. Results revealed that the tallest plant (30.30, 38.58 and 43.31 cm at 25, 35 and 45 DAS, respectively), highest number of branches plant^{-1} (8.33, 12.76 and 15.20 at 35, 45 and 55 DAS, respectively) and highest number of compound leaves plant^{-1} was recorded (6.61, 10.27 and 16.26, respectively) were attained from Vc_3 (10 t ha^{-1}) treatment. The highest number of flowers plant^{-1} (50.92), highest number of pods plant^{-1} (40.82), maximum pod length (11.11 cm), highest fresh weight of pods plant^{-1} (342.25 g), highest dry weight of pods plant^{-1} (57.56 g), highest number of seeds pod^{-1} (6.53) and highest fresh pod yield ha^{-1} (9.13 t) was also recorded from the treatment Vc_3 (10 t ha^{-1}). Similarly, the lowest plant height (23.51, 28.20 and 40.41 cm at 25, 35 and 45 DAS, respectively), lowest number of branches plant^{-1} (5.00, 8.02 and 13.15 at 35, 45 and 55 DAS, respectively) and lowest number of compound leaves

plant^{-1} (4.71, 6.45 and 12.59, respectively) were received from Vc_0 (Control) treatment. The lowest number of flowers plant^{-1} (25.63), lowest number of pods plant^{-1} (16.21), pod length (8.30), lowest fresh weight of pods plant^{-1} (155.00 g), lowest dry weight of pods plant^{-1} (28.80 g), lowest number of seeds pod^{-1} (4.38) and lowest fresh pod yield ha^{-1}(4.13 t) were also recorded from the control treatment (Vc_0).

Combined effect of variety and vermicompost showed significant influence on different parameters studied under the present study. The tallest plant (36.65, 44.39 and 50.55 cm at 25, 35 and 45 DAS, respectively) was recorded from treatment combination of V_3Vc_3 where the maximum number of branches plant^{-1} (8.67, 13.20 and 14.33 at 35, 45 and 55 DAS, respectively) and highest number of compound leaves plant^{-1} (6.80, 10.80 and 16.66, respectively) was recorded from V_1Vc_3. Again, the highest number of seeds pod^{-1} (6.60) was recorded from the treatment combination of V_3Vc_3 but the maximum number of flowers plant^{-1} (52.62), highest number of pods plant^{-1} (42.56), maximum pod length (11.37), highest fresh weight of pods plant^{-1} (367.50 g), highest dry weight of pods plant^{-1} (61.50 g) and highest fresh pod yield ha^{-1} (9.80 t) were recorded from the treatment combination of V_1Vc_3. The lowest number of branches plant^{-1} (4.67, 7.50 and 9.00 at 35, 45 and 55 DAS, respectively) and lowest number of compound leaves plant^{-1} (4.60, 6.44 and 12.60, respectively) were recorded from the treatment combination of V_3Vc_0. The minimum number of flowers plant^{-1} (24.30) and minimum number of pods plant^{-1} (16.72) were also obtained from the treatment combination of V_3Vc_0. But the smallest plant (18.30, 22.28 and 29.95 cm at 25, 35 and 45 DAS, respectively) was found from the treatment combination, V_2Vc_0. The lowest pod length (7.80), lowest fresh weight of pods plant^{-1} (131.30 g), lowest dry weight of pods plant^{-1} (24.25 g), lowest number of seeds pod^{-1}(4.25) and lowest fresh pod yield ha^{-1}(3.50 t) were also obtained from the treatment combination of V_2Vc_0.

Seed yield obtained from different treatments had significant effects on different contributing parameters of seed viability. In terms of varietal performance, the highest percent (%) seed germination (70.00%), highest root length (16.36 cm), highest shoot length (19.60 cm), highest fresh weight plant^{-1} (1.42 g), highest dry weight plant^{-1} (25.58 mg) and maximum seed vigor index (1441.13) was recorded from V_1 (BARI jhar seem-1) variety produced seeds where the lowest percent (%) seed germination (54.00%), lowest root length (14.84 cm), lowest shoot length (17.76 cm), lowest fresh weight plant^{-1} (1.30 g), lowest dry weight plant^{-1} (22.74 mg) and minimum seed vigor index (1016.25) was found from the seeds produced by the variety V_2 (BARI jhar seem-2). Considering vermicompost treatment, seeds obtained from the treatment of Vc_3 (10 t ha^{-1}) showed the highest percent (%) seed germination (94.44%), highest root length (18.14 cm), highest shoot length (22.34 cm), highest fresh weight plant^{-1} (1.87 g), highest dry weight plant^{-1} (31.19 mg) and maximum seed vigor index (2129.94) where seeds produced from control treatment (Vc_0) showed lowest percent (%) seed germination (39.78), lowest root length (12.47 cm), lowest shoot length (14.45 cm), lowest fresh weight plant^{-1} (0.84 g), lowest dry weight plant^{-1} (13.19 mg) and minimum seed vigor index (595.02). In case of seeds produced from different combined treatments of variety and vermicompost, the highest percent (%) seed germination (96.67), highest root length (20.02 cm), highest shoot length (24.08 cm), highest fresh weight plant^{-1} (2.07 g), highest dry weight plant^{-1} (32.80 mg) and highest seed vigor index (2348.00) were recorded from seeds produced by the treatment combination of V_1Vc_3 where the lowest percent (%) seed germination (20.00), lowest root length (10.27 cm), lowest shoot length (12.79 cm), lowest fresh weight plant^{-1} (0.78 g), lowest dry weight plant^{-1} (12.28 mg) and lowest seed vigor index (395.80) were obtained from the seeds achieved by the treatment combination of V_2Vc_0.

5.2 Conclusion

From the above findings the following conclusion could be made :

1. V_1 (BARI jhar seem-1) showed the best performance in respect of growth, yield contributing parameters, yield and seed viability.
2. Vermicompost application at the rate10 t ha^{-1} gave best results regarding growth, yield contributing parameters, yield and seed viability.
3. BARI jhar seem-1 along with Vermicompost at 10 t ha^{-1} shown best results considering growth, yield contributing parameters, yield and seed viability.

5.3 Recommendations

The following recommendation could be made from the results of the present experiment:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance
2. Another doses of vermicompost may be included in the future program
3. Other cultivars may be included in the further program.

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APPENDICES

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

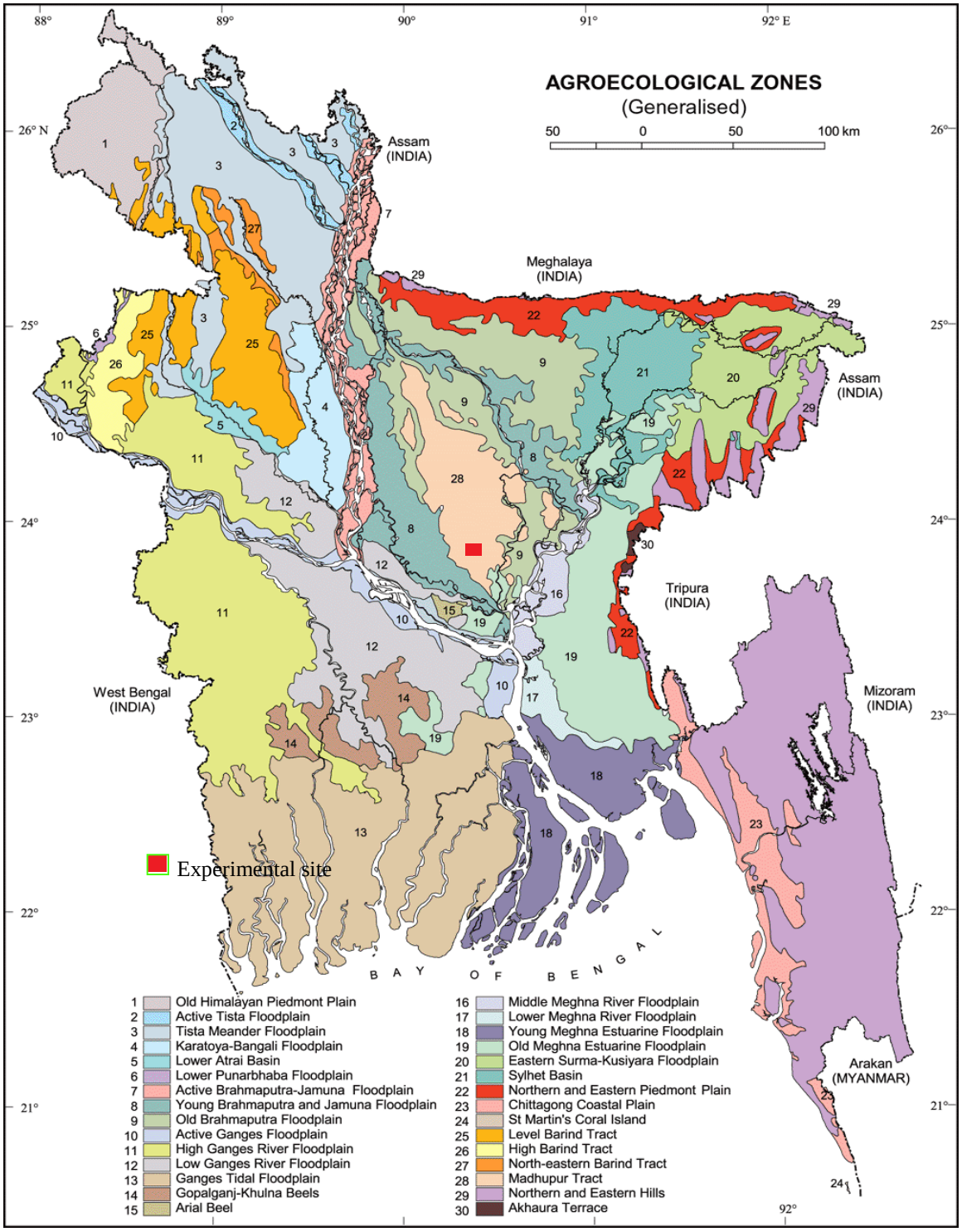

Fig. 9. Experimental site

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from December 2017 to February, 2018

Month and year	RH (%)	Air temperature (C)			Total Rainfall (mm)	Sunshine (Hours)
		Max.	*Min.*	*Mean*		
December, 2017	72.70	25.40	17.30	21.35	Trace	196.00
January, 2018	70.50	30.20	20.40	25.30	Trace	223.00
February, 2018	66.40	32.60	21.80	27.20	2.00	220.00

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

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

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

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

Source: Soil Resource Development Institute (SRDI)

Appendix IV. ANOVA for effects of variety and vermicompost on plant height of French bean at different days after sowing

Source of variation	Degrees of freedom	Mean square of plant height (cm)		
		25 DAS	35 DAS	45 DAS
Replication	2	0.352	1.067	2.104
Factor A	2	7.325*	12.78*	16.87*
Factor B	3	12.11*	18.68*	42.48*
AB	6	10.74**	24.79*	26.690*
Error	22	0.617	1.528	2.012

Appendix V. Effects of variety and vermicompost on number of branches plant^{-1}of French bean at different days after sowing

Source of variation	Degrees of freedom	Mean square of number of branches plant^{-1}		
		35 DAS	45 DAS	55 DAS
Replication	2	0.114	0.548	0.631
Factor A	2	3.021^{NS}	5.481**	8.296*
Factor B	3	7.778*	10.02*	14.083*
AB	6	5.363*	8.954**	12.269*
Error	22	0.240	0.416	0.514

Appendix VI. Effects of variety and vermicompost on number of compound leaves plant^{-1}of French bean at different days after sowing

Source of variation	Degrees of freedom	Mean square of number of compound leaves plant^{-1}		
		25 DAS	35 DAS	45 DAS
Replication	2	0.361	0.756	1.022
Factor A	2	1.66^{NS}	13.75^{NS}	11.77**
Factor B	3	5.55**	22.68**	28.37*
AB	6	3.832*	12.623*	18.55*
Error	22	0.627	1.038	1.213

Appendix VII. Effects of variety and vermicompost on yield contributing parameters and yield of French bean

Source of variation	Degrees of freedom	Mean square of yield contributing parameters and yield of French bean						
		Number of flowers plant^{-1}	Number of pods plant^{-1}	Pod length (cm)	Fresh weight of pods plant^{-1} (g)	Dry weight of pod plant^{-1} (g)	Number of seeds pod^{-1}	Fresh pod yield ha^{-1} (t)
Replication	2	1.461	1.016	0.361	0.136	0.614	0.082	0.713
Factor A	2	18.22*	14.18*	2.58^{NS}	1.301*	7.07**	2.39^{NS}	4.90*
Factor B	3	44.25*	26.52*	18.46*	7.437*	16.14*	9.79*	9.19*
AB	6	22.58*	10.31*	8.91*	5.516**	8.149**	7.48*	3.08*
Error	22	1.644	2.939	0.379	0.324	0.114	0.412	1.91

Appendix VIII. Effects of variety and vermicompost on different parameters of seed viability test of French bean

Source of variation	Degrees of freedom	Mean square of seed viability contributing characters					
		Percent (%) seed germination	Root length (cm)	Shoot length (cm)	Fresh weight plant^{-1} (g)	Dry weight plant^{-1} (mg)	Seed vigor index
Replication	2	2.104	0.116	0.263	0.411	0.062	3.142
Factor A	2	14.36*	5.115*	7.57*	5.316*	2.014**	136.22*
Factor B	3	21.27**	9.508*	10.32*	8.422*	5.167*	247.25**
AB	6	12.518*	4.521*	6.725*	4.506**	2.135**	104.58*
Error	22	3.247	0.338	0.471	0.324	0.204	8.635