EFFECT OF ORGANIC AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF BUSH BEAN (BARI JHAR SHEEM-1)

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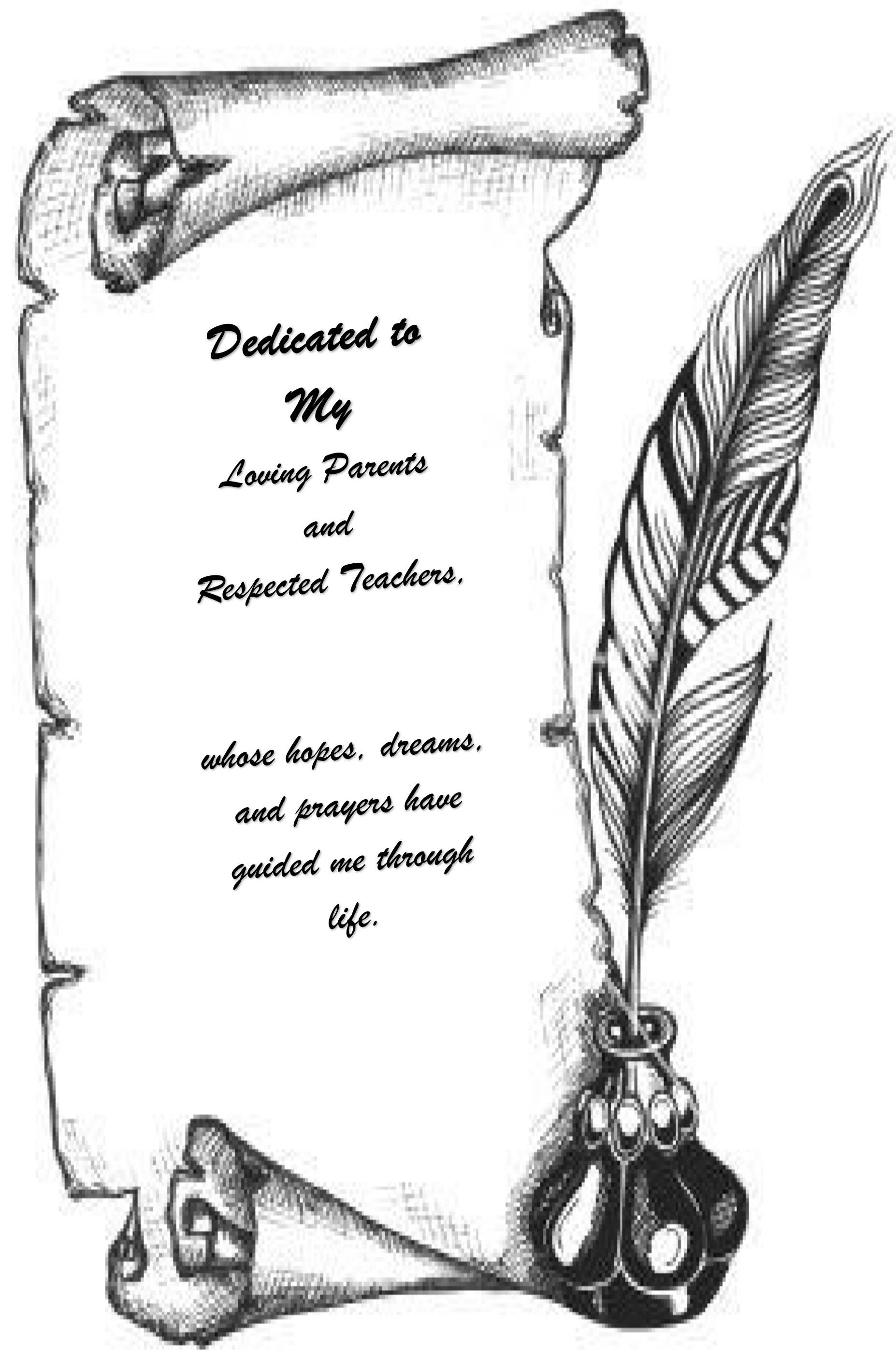

Dedicated to

My

Loving Parents

and

Respected Teachers,

whose hopes, dreams,
and prayers have
guided me through
life.

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CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF ORGANIC AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF BUSH BEAN (BARI JHAR SHEEM-1)"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***SOIL SCIENCE****, embodies the result of a piece of bona fide research work carried out by* ***HUMYRA HAQUE****, Registration number:* ***15-06455*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: September 7, 2023
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-Author

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University during the period from November 2021 to February 2022 under AEZ 28 (Madhupur tract) for assessing the effect of different organic and inorganic fertilizers doses on the growth and yield of Bush bean. The experiment comprised a single factor comprising seven treatments viz. T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}. This experiment was laid out in a randomized complete block design (RCBD) with three (3) replications. Data were collected on different aspects of growth, yield attributes, and yield of bush bean including soil properties and nutrient contents. The results revealed that treatment T_4 [T_4 = 75% RCF + 6 t VC ha^{-1}] exhibited its superiority compared to other inorganic fertilizers with different doses of vermicompost treatments in terms of yield of bush bean. Treatment T_4 [75% RCF + 6 t VC ha^{-1}] also showed the tallest plant (42.65 cm), the maximum number of branches $plant^{-1}$ (14.29), highest number of flower $plant^{-1}$ (13.79), the highest number of pod $plant^{-1}$ (24.33), maximum pod length (16.20 cm), maximum weight of pods $plant^{-1}$ (147.23 g), maximum pod yield (6239.8 g), highest pod yield (13.14 t ha^{-1}), maximum stover yield (5.43 t ha^{-1}) than other treatments in this experiment. On the other hand, treatment T_5 [50% RCF + 2 t VC ha^{-1}] returned with 7.37% lower yield than treatment T_6 which was significantly the lowest compared with other treatments under this study. In the case of soil properties, the highest soil organic carbon (0.85%) and the maximum soil pH (6.17) were recorded from treatment T_4 in post-harvest soil. Additionally, the highest available P content in soil (23.0 ppm) and the maximum potassium content in soil (0.13 meq. /100 g soil) was recorded from the treatment T_4 containing chemical fertilizer and vermicompost. Vermicompost (6 t ha^{-1} VC) + (75% RCF) application seemed promising for producing higher pod yield of bush bean and maintaining soil productivity.

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ABBREVIATIONS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-bangla Agricultural University
BBS	Bangladesh Bureau of Statistics
Co	Cobalt
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
Max	Maximum
mg	Milligram
Min	Minimum
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
UPOV	Union for the Protection of Plant Varieties
Wt.	Weight

CHAPTER I

INTRODUCTION

Bush bean (*Phaseolus vulgaris* L.), also known as Forashi sheem or Jhar sheem in Bengali (Roy *et al.,* 2006), is an annual, diploid (2n=2x=22) plant in the family Fabaceae (Galvan *et al.,* 2003). This plant is cultivated as a pulse and is consumed as immature, fragile fruits. It is cultivated in the Bangladeshi regions of Jessore, Rangpur, Comilla, Chittagong, and Sylhet. Its dried seed has 21,1% protein, 69.9% carbs, 1.7% fat, 381 mg calcium, 425 mg phosphorus, and 12.4 mg iron per 100 g of edible component (Thapa *et al.,* 2022). According to reports, the common bean is also a significant source of human protein and calories (Celmeli *et al.,* 2018). The French bean is gaining popularity due to its soft pods and shelled beans. In addition, it preserves soil fertility through biological nitrogen fixation in conjunction with the prevalent symbiotic Rhizobium in their root nodules. The correct variety and acceptable soil are the two most significant elements for increased crop yield (Blair 2013; Dhanjal *et al.,* 2001; Shivakumar *et al.,* 1996; Singh *et al.,* 1996). Farmers in the Sylhet region typically cultivate local French bean cultivars that vary in color, size, form, and flavor. Several of these have a high yield and are resistant to disease and drought. Bangladesh Agricultural Research Institute (BARI) has created three varieties of Bush bean.

The appropriate amounts of nutrients are required to grow and develop these tropical legume vegetables. Otherwise, physiological deficit symptoms may develop (Brown *et al.,* 2022). Over the years, inorganic fertilizers have been widely employed to support and maximize the growth of these vegetables throughout the world. In the last few decades, however, the usage of organic fertilizer has gained prominence globally due to conservation initiatives in agriculture. Organic fertilizers have been demonstrated to protect natural resources and reduce ecosystem deterioration (Rehman *et al.,* 2022; Mäder *et al.,* 2002; Francis and Daniel, 2004).

The rate of nutrient release is the primary functional difference between organic and inorganic fertilizers. The immediate discharge of many inorganic fertilizers is frequently detrimental. Ammonia could be lost to the atmosphere from surface-applied fertilizers (Freney and Simpson, 1983), excessive nitrates are easily leached, particularly in the tropics after heavy rains, and a significant fraction of the applied inorganic phosphorus is fixed. Within one month, more than half of the superphosphate-applied P in an Italian volcanic soil was fixed by AI and Fe compounds. Cattle manure additions caused a rapid and significant rise in soluble P (Felleca *et al.,* 1983). The net release of nutrients from organic matter is determined by the decomposition rates of the various organic matter fractions and the intake of nutrients by the increasing biomass (Avnimelech, 1986). Floyd *et al.* (1988) observed a better efficiency of nutrient utilization for P and K administered in organic manure than in inorganic manure in Papua New Guinea's volcanic soil. This result can be due to the direct delivery of nutrients to the plant, hence avoiding P fixation. Takana (1977), attributed the fundamental usefulness of compost to the ability of organic matter to mix with active AI, hence decreasing P fixation, and increasing the cation-exchange capacity.

Consequently, organic agriculture has evolved into an alternative technology that promotes using natural organic materials such as plant leftovers, manure, mulch, and compost (Shannon *et al.,* 2002). Application of these natural organic compounds has been shown to improve the nutritional state of the soil, as well as influence other soil properties, such as aeration, water holding capacity, and particle aggregation (Pagliai *et al.,* 2004), all of which contribute to improved crop production, with or without the use of fertilizer. Due to their rapid and simple availability to plants, inorganic fertilizers are favored by most vegetable growers (Thy and Buntha, 2005). However, continued use of synthetic fertilizers can eventually degrade the soil's chemical, physical, and biological qualities (Albiach *et al.*, 2000). On the other hand, organic fertilizers have favorable effects on the soil and boost nutrient availability, which helps preserve crop quality and output at a lower cost than inorganic fertilizers (Thy and Buntha, 2005). Organic fertilizers are the source of organic matter and nutrients and improve the soil's microbial population and physical, biological, and chemical qualities (Albiach *et al.,* 2000). Compost and vermicompost are well-known sources of plant nutrients among organic fertilizers (Sheata and El-Helaly, 2010 and Manivannan *et al.,* 2009). Compost and vermicompost are soil conditioners that add nutrients and organic matter to the soil and improve its water-retention capacity, stiffness, and structure (Vogtmann *et al.,* 1993). They can improve the physical, chemical, and biological aspects of degraded or low-fertility soil and provide plants with nitrogen, phosphorus, and potassium (Baziramakenga and Simard, 2001).

Vermicompost is a nutritive "organic fertilizer" rich in NKP (nitrogen 2-3%, potassium 1.85-2.25%, and phosphorus 1.55-2.25%), micronutrients, and beneficial soil microbes such as "nitrogen-fixing bacteria" and "mycorrhizal fungi," which are scientifically proving to be "miracle growth promoters and protectors" (Sinha *et al*., 2009). The vermicast of earthworms contains as much as 7.37 percent nitrogen (N) and 19.58 percent phosphorus as P_2O_5. Suhane (2008), demonstrated that vermicompost's exchangeable potassium (K) content was almost 95% more. In addition, there are substantial quantities of calcium (Ca), magnesium (Mg), zinc (Zn), and manganese (Mn). In addition, vermicompost contains enzymes such as amylase, lipase, cellulase, and chitinase, which continue to degrade organic materials in the soil (to release nutrients and make them accessible to plant roots) even after they have been expelled (Chaoui *et al.,* 2003). A yearly application of a sufficient quantity of vermicompost led to a large rise in the soil enzyme activity 'urease,' 'phosphomonoesterase', 'phosphodiesterase,' and 'arylsulphase'. The vermicompost-treated soil exhibits dramatically increased electrical conductivity (EC) and a near-neutral pH. (Chaoui *et al.*, 2003). Vermicompost possesses exceptionally high 'porosity,' 'aeration,' 'drainage,' and 'water-holding capacity.' They have a large surface area, which increases their ability to absorb and retain nutrients. They appear to store more nutrients for a longer duration. A study revealed that soil treated with vermicompost had a considerably higher soil bulk density,' making it significantly more porous, lighter, and resistant to compaction. Increased number of pores in the 30-50 m and 50-500 m size ranges and decreased number of pores higher than 500 m have been related to an increase in porosity (Ebrahimiazar *et al.,* 2022). Multiple claims have been that worm-worked waste and worm excrement (vermicast) can stimulate exceptional plant growth (Makkar *et al.,* 2023). It has been found to affect all yield parameters, including seed germination, seedling growth rate, flowering, and fruiting of major crops such as wheat, paddy, corn, sugarcane, tomato, potato, brinjal, okra, spinach, grape, and strawberry, as well as flowering plants such as petunias, marigolds, sunflowers, chrysanthemums, poinsettias, and bush bean. In all growth studies, the strongest growth responses were observed when vermicompost comprised a small percentage (10%-20%) of the total volume of the container medium. Interestingly, increasing the vermicompost quantity in the plant development medium has not always enhanced plant growth (Arancon and Solarte, 2019). Suhane *et al.* (2008) claim that vermicompost is at least four times more nutritious than cow dung compost. In Argentina, farmers that use vermicompost perceive it to be seven (7) times more nutrient- and growth-promoting than standard composts (Kavitha, 2022). Suhane *et al.* (2008) observed that the exclusive use of vermicompost at a rate of 25 quintals per hectare (qt/ha) on agricultural wheat crops supported yield more effectively than chemical fertilizers. Vermicompost use had further agronomic benefits. It decreased the demand for irrigation by 30-40% across the Americas and Europe. According to test results, the availability of key micronutrients and beneficial microorganisms was found to be greater in vermicompost-applied soils. With crops treated with vermicompost, the incidence of insect and disease assaults was dramatically reduced. Yatoo *et al.* (2021) and Raza *et al.* (2022) also observed exceptionally healthy development of potted corn and wheat crops on vermicompost compared to conventional composts and chemical fertilizers. Comparable to chemical fertilizers, Mishra *et al.* (2022) showed that successive applications of the same quantity of vermicompost boosted the yields of wheat crops cultivated on vermicompost.

Therefore, in order to improve the current condition of Bush bean production in Bangladesh, it is necessary to promote improved varieties to Bangladeshi growers. Current study was conducted to increase the growth, yield, and chemical content of Bush bean treated with mixed fertilizers with vermicompost at different rates.

1. To study the effect of organic and inorganic fertilizers on the growth and yield of bush bean plant.

2. To find out the optimum dose of organic and inorganic fertilizer for bush bean plant.

CHAPTER II

REVIEW OF LITERATURE

Bush bean (*Phaseolus vulgaris* L.) is a popular and important vegetable crop in the world. Much research work has been done in different parts of the world to study the effect of organic and inorganic fertilizers on the growth and yield of bush bean. But in Bangladesh, available literature regarding the effect of organic and inorganic fertilizer on bush bean is insufficient and sometimes conflicting. However, some of the literature relevant to the effect of organic and inorganic fertilizers on bush bean production are reviewed in this chapter.

1.1. Review in relation to inorganic fertilizers

Teferi *et al*. (2022) determined that the pod yield of snap beans was 12.9, 13.9, 15.0 and 15.8 tons per hectare (ha) with 0, 50, 100, and 150 kg of nitrogen per hectare (ha).

El-Beltagi *et al.* (2022) showed that the administration of varied N fertilizer doses considerably altered the pod number per plant. According to Parbhin (2021), adding N fertilizer boosted French bean pod production.

Usha *et al.* (2019) conducted a field experiment in Bihar, India to determine the influence of different N rates (0, 40, 80, 120, and 160 kg/ha) and application times on the growth and production of French bean. They discovered that nitrogen application at a rate of 160 kg ha^{-1} greatly increased the number of pods per plant, pod weight per plant, grain production, and straw output.

By enhanced nitrogen delivery, Nadeem *et al.* (2019), observed that French bean seed yield, pod number per plant, number of seeds per pod, and harvest index rose significantly.

Gupta and Pandey (2019) conducted an experiment in India to determine the impact of nitrogen on French bean development and production. In their experiment, the plant was given 0, 40, 80, or 120 kg/ha of nitrogen. At 120 kg N/ha, the green pod production was greatest (124.3-132.3 q/ha).

According to Akther *et al.* (2016), increasing nitrogen levels from 75 to 150 kilogram per hectare improved yield characteristics and seed yield (520 kg ha^{-1}) over 125, 100, and 75 kg N ha^{-1}, respectively.

In India, Kamble *et al.* (2016) conducted a two-year field experiment to determine the influence of nitrogen (0, 40, 80, and 120 kg N ha^{-1}) on French bean dry matter yield and nitrogen uptake. The production of dry matter increased dramatically to 120 kg N ha^{-1}. Up to 120 kg N ha^{-1}, there was significant uptake of nitrogen.

Kakon *et al.* (2016) observed that as N levels increased up to 150 kg ha^{-1}, French bean pod production increased.

Chauhan and Bagyaraj (2015) conducted an experiment in Bangalore, India, to determine the effect of nitrogen on the growth, yield, and nitrogen uptake of vegetable French bean. The nitrogen application rates were 0, 40, 80, 120, and 160 kg/ha. They observed that nitrogen application boosted plant growth, nutrient uptake, and pod yield.

According to Bedada *et al.* (2014), the highest yield of French bean (957 kg ha^{-1}) was attained with 150 kg N ha^{-1}.

Datt *et al.* (2013) conducted an experiment on French bean (*Phaseolus vulgaris* L.) cultivars with varying levels of N, P, K, and S for growth, yield, and economics. They discovered that fertilizer amounts (100:80:80:50 kg ha^{-1} NPKS) led to the highest growth metrics, yield parameters, and pod yield.

Yadav *et al.* (2013) conducted an experiment on the nitrogen response of French bean in Uttar Pradesh, India. The number of branches and seed output rose with the addition of nitrogen, and this increase was greatest at 120 kg N ha^{-1}.

Datt *et al.* (2013) conducted an experiment on French bean (*Phaseolus vulgaris* L.) cultivars with varying levels of N, P, K, and S for growth, yield, and economics. They discovered that fertilizer amounts (100:80:80:50 kg ha^{-1} NPKS) led to the highest growth metrics, yield parameters, and pod yield.

Sheravat *et al.* (2012) conducted an experiment in Uttar Pradesh, India, to determine the effect of nitrogen levels (0-60 kg N/ha) on French bean. They discovered that the number of pods per plant, 100-seed weight, seed yield, and seed protein content all rose with increasing nitrogen rate. Thakur *et al.* (2018) also reported that the rate of nitrogen increased plant growth in French bean.

Yadav (2010) conducted a field experiment at Vanarash, Uttar Pradesh, India, to determine the response of French bean (*Phaseolus vulgaris*) to different levels of Phosphorus (0.50 and 100 kg P_20_5 ha^{-1}) and variable spacing in sandy loam soil. The majority of growth and yield characteristics of French bean were shown to be impacted by phosphorus. They reported that 100 kg P_20_5 ha^{-1} resulted in a yield of 15 tons per hectare.

Nagesh Babu and Devaraj (2008) conducted an experiment in Bangalore, India, to examine the effect of nitrogen on the French bean vegetable. The nitrogen application rates were 0, 40, 80, 120, and 160 kg/ha. They reported that pod yields improved as fertilizer rates increased, from 3927 kg/ha at 0 kg N/ha to 13169 kg/ha at 160 kg N/ha.

Rondon *et al.* (2007) reported that the addition of 30 mg of nitrogen per kilogram of soil stimulated plant growth.

Rahman *et al.* (2007) conducted an experiment with French bean in India and discovered that greater yields were obtained by applying up to 120 kg ha^{-1} of nitrogen and 60 kg ha^{-1} of phosphorus.

Fageria *et al.* (2007) showed that P treatments had a considerable effect on the growth and production of common bean cultivars, but the response was varied. The optimal seed yield was achieved with 125 to 150 mg P.

Kamal (2007) conducted a field experiment at the research field of Sher-e-Bangla Agricultural University. Dhaka in the Modhupur Tract (AEZ 28) from December 2006 to February 2007 to determine the effect of nitrogen and molybdenum on the growth and yield of bush bean (*Phaseolus vulgaris* L. cv. BARI JharSheem-l). He discovered a positive effect of each nutrient and their interaction on the number of effective branches $plant^{-1}$, population m^{-2}, number of green pods $plant^{-1}$, pod length, pod diameter, number of seeds pod^{-1}, pod yield $plot^{-1}$, seed yield $plot^{-1}$, and 1000-seed weight, green pod yield, seed yield, and straw yield as the nitrogen and molybdenum rates increased. All of these characteristics grew until N120 and Mo0•5. N120 produced the greatest green pod yield (18.00 t ha^{-1}) and seed yield (3.10 t ha^{-1}).

Bildirici *et al.* (2005) conducted an experiment between 2001 and 2002 to assess the effects of bacterial (*Rhizobium phaseoli*) inoculation and nitrogen fertilizers (0, 20, 40, and 60 kg N/ha) on field bean. Nitrogen fertilizer had a large and beneficial influence on pod number, grain yield, and raw protein proportion, but had no effect on pod^{-1} seed weight or 1000-seed weight. Yet, bacterial inoculation had a considerable and beneficial influence on pod number per plant and grain output.

Shamima (2005) conducted a field experiment in the research field of Sher-e-Bangla Agricultural University, Dhaka, in Modhupur Tract (AEZ 28) from December 2004 to February 2005 to determine the effect of nitrogen and phosphorus on the growth and production of *Phaseolus vulgaris* L. cv. BARI bush bean-I. P75 produced the maximum green pod yield (15.35 t ha^{-1}) and seed yield (2.58 t ha^{-1}).

Prajapati *et al.* (2004) conducted an experiment in Sardar Krushinagar, Gujarat, India, to examine the effects of weed management methods and nitrogen levels on the nutrient intake and yield of French bean (0. 40, 80 and 120 kg ha^{-1}). They reported that the maximum yield was 120 kg per hectare.

Ram-Gopal *et al.* (2003) examined the impacts of irrigation (0.5, 0.7, and 0.9 W/CPE) and nitrogen rates (50, 100, and 150 kg ha^{-1}) with or without 5 FYM/ha. The water use and yield of French bean (*Phaseolus vulgaris*) in an experiment done in Faizabad, Uttar Pradesh, India. Plant height, number of branches $plant^{-1}$, dry matter $plant^{-1}$, grain production, consumptive use of water, and water usage efficiency improved with increased irrigation, N, and FYM rates.

Dhanjal *et al.* (2003) did a field study in the Indian state of Uttar Pradesh. The treatments included three French bean (*P. vulgaris*) cultivars (IIUR 87, PDR 14, and VL 63), three planting densities (250x103, 333x103, and 500x103 plants ha^{-1}) and three N concentrations (0, 60 and 120 kg ha^{-1}). The maximum leaf area index and crop growth rate were seen at 500 x 103 plants per hectare. Adding 120 kg of nitrogen per hectare boosted crop dry weight, leaf area index, crop growth rate, and relative crop growth rate.

Akhtar *et al.* (2003) tested French bean treated with Phosphorus at 0, 40, 80, or 120 kg P_20_5 ha^{-1} and K at 0, 30, 60, or 90 kg K_2O. The P rate of 80 kg ha^{-1} produced the greatest plant height, number of branches per plant, pod length and girth, number of pods per plant, and green pod yield.

Chaudhari *et al.* (2001) undertook an experiment to evaluate the nutrient management of French bean in Nagpur, India. They found that nitrogen injection greatly enhanced French bean plant height, pod quantity, and grain production per $plant^{-1}$. They suggested an N fertilizer dose of 90 kg ha^{-1}.

In India, Rajesh *et al.* (2001) conducted a field experiment to determine the impact of nitrogen (80, 160, and 240 kg/ha) and sulphur (0, 20, 40, and 60 kg/ha) on the nutrient uptake and grain yield of French bean (*Phaseolus vulgaris* cv. HUR 137). The maximum grain yield (2091 kg/ha) and straw yield (3331 kg/ha) were recorded at N levels of 240 kg/ha. At 40 kg/ha, sulphur (S) produced the maximum grain yield (1811 kg/ha).

Daba and Haile (2000) conducted a field experiment in Ethiopia on Red Wolaita, Rico-2, A-176, and A-250 French bean varieties. They found that Rhizobium inoculation and nitrogen greatly boosted French bean grain yield, nodule number, and dry matter production.

Singh and Singh (2000) conducted a field experiment in India to determine the effects of different nitrogen levels (0, 40, 80, or 120 kg N ha^{-1}) on the yield and yield components of French bean. Seed output and 100-seed weight were found to increase with increasing N rate.

Tewari and Singh (2000) conducted an experiment on French bean in India to identify the optimal and economical nitrogen dose (0, 40, 80, 120 and 160 kg ha^{-1}) for improved growth and seed yield (0, 40, 80, 120 and 160 kg ha^{-1}). Application of 120 kg N ha^{-1} considerably increased the number of pods per plant, weight of pods per plant, number of seeds per pod, and seed production, but the application of 160 kg N ha^{-1} significantly decreased seed output.

Singh (2000) investigated the nitrogen response of French bean in India. They reported that the number of pods per plant and the weight of 100 seeds increased when the N rate increased.

Rahman (2001) conducted an experiment at the Horticulture Farm of the Bangladesh Agricultural University in Mymensingh to determine the impact of nitrogen and plant spacing on French bean. Using four levels of nitrogen, namely 0 kg N ha^{-1}, 30 kg N ha^{-1}, 60 kg N ha^{-1}, and 90 kg N ha^{-1}, he determined that plant height, the number of branches per plant, the length of the green pods, and the number of individuals The higher nitrogen dose had a major impact on pod weight, pods $plant^{-1}$, and green pod yield per hectare.

Teixeira *et al.* (2000) conducted a field experiment to determine the influence of sowing density (6, 10, 14, and 18 seeds m^{-2}) and nitrogen (N) levels (0, 50, 100, and 150 kg N ha^{-1}). on *P. vulgaris* cv. By increasing N rates, grain output rose, leading to a rise in pods $plant^{-1}$, seeds pod^{-1}, and 100-seed weight. However, this effect was affected by seasons and planting densities. Increased sowing density decreased the number of pods per plant and enhanced grain production in the absence of nitrogen fertilizers. Increasing planting density decreased weed infestation throughout harvest.

Singh and Singh (2000) conducted a field experiment in Uttar Pradesh, India. The French bean (*Phaseolus vulgaris*) was administered 0, 60, or 120 kg of phosphorus per hectare. They found that yield and yield component were typically greatest with 60 kg P.

In an experiment done in India, Parthiban and Thamburaj (1991) found that nitrogen fertilizer of up to 50 kg ha^{-1} boosted grain output in French bean. With nitrogen fertilizer, the number of pods and grain output per plant increased considerably compared to the control.

In India, Hedge and Srinivas (1990) studied plant water relations and nutrient uptake in French bean. They found that nitrogen treatment boosted green pod output, nutrient uptake, and water usage efficiency.

The effect of nitrogen levels (0. 30, 60, 90, and 120 kg ha^{-1}) on the growth, yield characteristics, yield, and economics of French bean (*Phaseolus vulgaris* cv. PDR 14) under late-sown conditions in eastern Uttar Pradesh, India, was investigated over a two-year period (1995-1997). (Singh and Verma 2002). The highest nitrogen rates (120 kg ha^{-1}) led to the greatest plant height, number of branches per plant, number of pods per plant, weight of 100 seeds per pod, grain yield (21.19 q ha^{-1} with 120 kg N ha^{-1}) and straw yields (29.76 q ha^{-1} with 120 kg N ha^{-1}).

Roy and Parthasarathy (1999) conducted a field experiment to determine the phosphorus requirements of French bean types. They employed 0-120 kg P ha^{-1} and found that the highest pod yield (7.69 t ha^{-1}) occurred with 120 kg P ha^{-1}.

Sexena *et al.* (1995) administered P_2O_5 and K_2O at rates of 0.30 and 60 kg ha^{-1} and 0.20 and 40 kg ha^{-1}, respectively. The maximum seed output was reported with 60 kg P_20_5. Also, they found a positive correlation between seed yield and leaf area, dry matter plant, the relative moisture content in leaves, number of branches, number of pods, seed yield per plant, 1000 seed weight, and harvest index. The maximum seed yield (0.95 t ha^{-1}) was produced by 60 kg of P_20_5.

Tomar *et al.* (1991) obtained the highest seed yield with the treatment of 30 kg P_20_5 ha^{-1}; rates above this point did not result in a substantial yield improvement. However, applying P raised the number of nodules per plant from 26 to 51, the number of seeds and pods per plant, and the weight of 1000 seeds.

Ahlawat (1996) conducted a field experiment in New Delhi, India, to examine the comparative performance of French bean varieties and their response to phosphorus fertilizer. He reported that the application of phosphorus significantly increased yield attributes (pods $plant^{-1}$ and seeds pod^{-1}), seed yield, and N and P uptake. Up to 40 kg P ha^{-1}, the response of p was linear.

Arya and Kalra (1988) reported that the application of phosphorus had no effect on the vegetative growth of plants but had a significant effect on reproductive growth and the number of pods $plant^{-1}$, the weight of pods $plant^{-1}$, the number of grains $plant^{-1}$, the weight of grains $plant^{-1}$, the number of grains $plant^{-1}$, the grain yield $plant^{-1}$, and the harvest index. In addition, they found that phosphorus promoted early flowering and maturity.

The green pod yield of French bean rose with phosphorus fertilizer up to 75 kg ha^{-1}, according to Prabhakar et al. Phosphorus and zinc additions up to a specific amount boosted green grain production (Patial and Somawanshi, 1982).

Robinson and Jones (1972) observed that phosphorus and sulfur interacted with the growth of a variety of legumes cultivated on poor soils for both nutrients. Brar (1987) conducted an experiment in Haryana, India, and discovered that the application of phosphorus to mung bean increased the quantity and size of nodules.

Alt *et al.* (1998) conducted an experiment to determine the influence of various P fertilizer rates (0, 19, 34, and 58 kg ha^{-1}) on the production of selected vegetable crops. They discovered that *Phaseolus vulgaris* responded strongly to P and K.

In Indonesia, Subhan (1989) investigated the influence of plant distance and phosphate fertilizer on the growth and yield of (*Phaseolus vulgaris* L.). He noticed that the best yields occurred at 250 kg P_2O_5 ha^{-1}.

Parmar *et al.* (1999) conducted an experiment to determine the influence of nitrogen and phosphorus on the yield of French bean. They found that treatment of up to 150 kg of nitrogen and 60 kg of phosphorus per hectare considerably enhanced seed per pod and seed output.

1.2. Review in relation to organic fertilizer

Ndengu *et al.* (2022), concluded that the bean genotypes performed consistently across two dissimilar AEZs and among trial locations managed differently by mother trial community groups. Several cropping techniques and soil fertility management strategies influence the production of bush bean varieties, the findings indicate. Under intercrop, yields were lower than with bean lone crop. The application of manure, inorganic fertilizers, and their combination considerably increased SER45 crop yields. Only when both manure and fertilizer were applied did SER83 have a beneficial result. The application of inorganic fertilizer resulted in greater yields of maize. LER for both SER45 and SER83 were greater than 1.0, indicating that the maize-bush bean intercrop utilized land more efficiently. Hence, the promotion of better, drought-tolerant bean cultivars in conjunction with suitable soil fertility management and cropping system options can increase bean yield in Malawi.

Hitinayake (2021), conducted a field study to demonstrate conclusively that compost and liquid fertilizers are essential for maximizing Kangkong yields. Kangkong produced the highest yields when fertilized with cattle manure, compost, and inorganic fertilizers. The differences between the fresh and dry stem weights of Compost, Algifol, and Cow slurry treatments were not statistically significant (P=0.05). The control yielded the lowest yield. Findings also indicate that liquid fertilizers are more significant than compost for achieving a high yield in Kangkong.

Priyadarshini and Madhanakumari (2021), conducted a field experiment was undertaken in Poothurai village, Tamil Nadu, during the 2019 kharif season to determine the effects of biostimulants on the yield of bush bean cv. Co (Gb). Seaweed extract, panchagavya, chitosan, and an efficient microbe were used as bio stimulants in two quantities sprayed as foliar sprays 30, 45, and 60 days after sowing. Length of the raceme (51.2 cm), number of racemes plant^{-1} (8.5), number of flowers raceme^{-1} (26.4), number of flowers (221.5), days to 50% flowering (36.6 days), number of pods plant^{-1} (41.6), pod length (10.6 cm), pod width (3.2 cm), single pod weight (4.6 g), number of seeds (5.2), total pod yield (12.6 t ha^{-1}), net income (Rs. 1,71,628 ha^{-1}), and B: C ratio (3.14) The RDF + 3% panchagavya was the second-best therapy for these criteria. Seaweed outperformed all other biostimulants in terms of blooming and yield characteristics. The minimum values of each of these characters were meticulously noted.

Rahayu *et al.* (2021), concluded that LOF with standard NPK dosage can increase vitamin C and fiber content in bush beans. Higher LOF dose usage can reduce the change rate in bush beans’ quality. LOF from brown algae can reduce chemical fertilizers used in the soil. Thus, it will help create environmentally friendly vegetable production.

Islam *et al.* (2019), concluded that the Amaranth after yard-long bean rotation in vermicompost exhibited better performance with regard to yield and leaf number. Notably, protein, Fe, Ca, and Mg content were higher in VC+YLB treatment in amaranth. In water spinach, grown in vermicompost after winged bean, an improvement in yield, and leaf number was recorded. Protein, Fe, Ca, and Mg content in water spinach also recorded higher values when grown in vermicompost after winged bean rotation. The biomass of the beans enhanced and showed a positive linear relationship with the growth and yield of amaranth and water spinach.

Adewale *et al.* (2016), concluded that the successful reduction of GHG emissions and, consequently, global climate change by agriculture involves the identification of large CF and GHG sources or "hotspots" within agricultural production systems. Fuel consumption, organic fertilizer, soil emissions, and irrigation were identified as the primary hotspots in the CF by our analysis of a small organic vegetable farm. In this test example, cauliflower, potato, and pepper crops had the highest CF per hectare. The use of biodiesel instead of gasoline and diesel, along with the use of solar-powered irrigation systems instead of grid-powered irrigation systems, might lower the farm's CF emissions by 34%. Specialist plastic materials with a high CF (e.g., hoop house for peppers and row cover for cauliflower) might be replaced or their lifespan could be prolonged to reduce annual CF. This study also determined that the absolute values of the CF computed for different crops may vary based on the materials and activities included within the specified system limits. Estimating CF will be important for pinpointing materials and activities with the greatest potential for CF reduction.

Islam *et al.* (2016), conducted a field experiment to determine that the growth and yield characteristics of bush bean (*Phaseolus vulgaris*), winged bean (*Pseudotetragonolobus tetragonolobus*), and yard long bean was determined using VC (20%), TC (20%), and N:P:K fertilizer (farmer practice) (*Vigna unguiculata*). The highest fresh biomass yields for bush bean (527.55 g m^{-2}), winged bean (1168.61 g m^{-2}) and yard long bean were generated by plants cultivated with 20% VC (409.84 g m^{-2}). The VC (20%) treatment produced the highest pod weight, pod number, pod dry weight, and pod length among all examined legumes. At the pod formation stage, photosynthetic rates peaked in all three legumes, with the highest rate observed in winged bean (56.17 mol $m^{-2}s^{-1}$) grown with 20% VC. The VC (20%) treatment produced the highest yields of bush bean (2.98 tons ha^{-1}), winged bean (7.28 tons ha^{-1}) and yard long bean (2 tons ha^{-1}). Under VC (20%) treatment, bush bean had the highest protein content (26.50 g/100g), followed by yard long bean

(24.74 g/100g) and winged bean (22.04 g/100g). It can be inferred that the highest yield and yield qualities were achieved by legumes cultivated with 20% VC.

CHAPTER III
MATERIALS AND METHODS

The present investigation entitled "**Effect of Organic and Inorganic Fertilizer on Growth and Yield of Bush Bean (Bari Jhar Sheem-1)"** was carried out during the period from November 2021 to February 2022 under AEZ 28 (Madhupur tract), Sher-e-Bangla Nagar, Dhaka-1207. The details of materials used, experimental procedures followed, and techniques adopted during the investigation are described in this chapter. Climatic and edaphic conditions prevailing during crop season, selection of site, cropping history of the field, and other experimental details are also presented.

1.1. Characteristics of soil

The land was Agro- ecological zone of Modhupur tract (AEZ no. 28). It was deep red brown terrace soil and belongs to "Noadda" cultivated series. The altitude of the location was 8 m above sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207. The amount of organic carbon, total N, available P and K were 1.25%, 0.08%, 20 ppm and 0.20 mg/l00g soil, respectively. The physical and chemical characteristics of the soil have been presented in Appendix II.

1.2. Climate

The experimental area belongs to the subtropical climatic zone which is characterized by heavy rainfall, high humidity, high temperature, and a relatively long day period during "kharif" season (April-August) and scarce rainfall, low humidity, low temperature, and short day period during "Rabi" season (October-March). This climate is also characterized by distinct seasons viz., the monsoon or rainy season extending from May to October, the winter or dry season from November to February, and the pre-monsoon period or hot season from March to April (Di Nunno *et al.,* 2022). The meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and soil temperature for the entire experimental period have been shown in Appendix- 1

1.3. Experimental details

1.3.1. Planting materials

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

1.3.2. Collection and preparation of initial soil sample

Before initiation of the experiment, initial soil samples at 0-15 cm depth were collected from different plots of the experimental field. The composite soil sample was air dried, ground to pass through a 2 mm sieve, and used for the analysis of the physical and chemical properties of soil.

1.3.3. Experimental design

The single-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

1.3.3.1. Treatment of the experiment

The experiment consisted of a single factor:

T_1 = 100% RCF + 0 t ha^{-1} Vermicompost

T_2 = 75% RCF + 2 t ha^{-1} Vermicompost

T_3 = 75% RCF + 4 t ha^{-1} Vermicompost

T_4 = 75% RCF + 6 t ha^{-1} Vermicompost

T_5 = 50% RCF + 2 t ha^{-1} Vermicompost

T_6 = 50% RCF + 4 t ha^{-1} Vermicompost

T_7 = 50% RCF + 6 t ha^{-1} Vermicompost

1.3.3.2. Design and layout of the experiment

The single-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

1.3.3.3. Experimental layout

An area of 200 m^2 was divided into three blocks. The experimental area was divided into three blocks, each representing a replication. The size of each unit plot was 2.00 m × 3.00

m (6.00 m^2). The space was kept at .75 m between the blocks and 0.75 m between the plots. The distance between row to row and plant to plant was 60 cm and 40 cm, respectively.

1.3.4. Land preparation

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

1.3.5. Sowing of seeds

Two treated seeds were sown on each hill at a depth of 3.0 cm. Seeds were treated with Bavistin to protect them from seed-borne diseases. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 25 November 2021 in rows and at the spacing of 30 cm x 15 cm. The seeds were covered with loose soil. Bush bean was sown as border crops to reduce border effects.

1.3.6. Manuring and fertilization

The full amount of TSP (250 kg ha^{-1}), and MoP (180 kg ha^{-1}) and half amount of Urea (125 kg ha^{-1}) were applied as basal dose and incorporated during the final land preparation. The rest of the Urea was applied in two installments - one third at 15 days after sowing, another one third at 30 days after sowing. Vermicompost was applied as per treatment in specified plots as basal dose.

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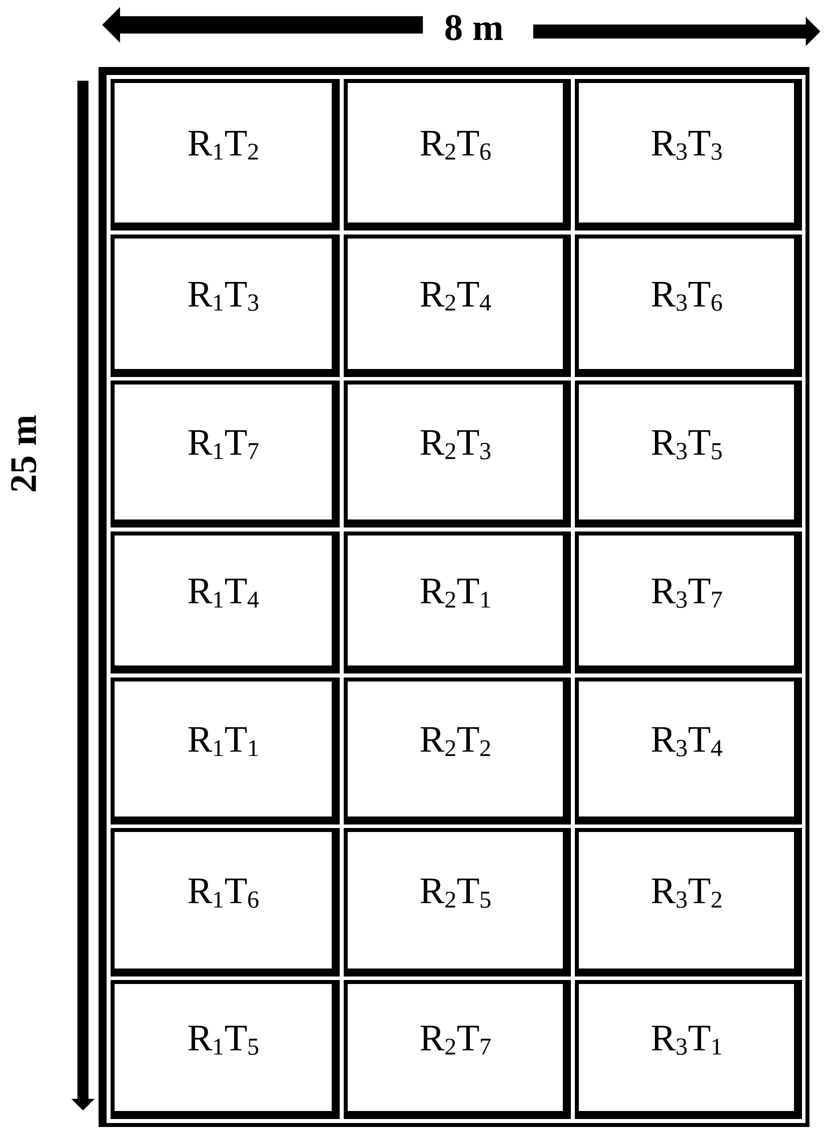

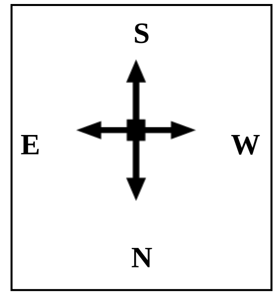

Figure 1. Compass

1.1.1. Layout of the experimental plots

Total number of plots: 21

Individual plot size (2m×3m): 6 m^2

Space between block: 0.75 m

Block to border (row) : 0.50 m

Block to border (column): 0.50 m

Replication: 3

Drainage size: 0.5 m

Figure 2. Field layout of the experimental plot

1.3.7. Intercultural operations

1.3.7.1. Gap filling

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

1.3.7.2. Thinning

One seedling was kept in each hill and remaining was uprooted after 15 days of emergence.

1.3.7.3. Weeding

Where necessary, the experimental plots were kept weed-free by hand weeding. The soil was aerated to maintain the plots free of weeds, which ultimately led to improved growth and development. After the complete emergence of the seedlings, the newly-emerging weeds were eradicated with care wherever necessary. Three cycles of weeding and mulching were performed at 20, 30, and 40 DAS.

1.3.7.4. Irrigation

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

1.3.8. Plant protection

a. Insect pests

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

b. Diseases

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

1.3.9. Harvesting

Harvesting of green pods were done at tender stage after attaining good size, suitable for use as vegetable. At the time of harvest, the pods were with small seeds and firm flesh. The pods were handpicked with care and weighed to estimate pod yield.

1.3.10. Collection of data

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

1.3.10.1. Plant height

The plant height was taken from ground level to the tip of the largest leaf of the plants. Plant heights were recorded from 5 randomly sampled plants, and the mean was calculated in centimeters (cm).

1.3.10.2. Number of branches per plant

The average number of branches per plant was found from 5 randomly selected plants from each unit plot after sowing (DAS) and mean was recorded.

1.3.10.3. Number of flowers per plant

From 5 randomly selected plants from each unit plot number of flowers were counted, and their mean values were founded.

1.3.10.4. Number of pods per plant

From 5 randomly selected plants from each unit plot numbers of pods were counted, and their mean values were calculated.

1.3.10.5. Weight of pods plant^{-1}

To determine the weight of pods plant^{-1} of bush bean (*Phaseolus vulgaris*) the methodology developed includes the following steps: selecting a healthy bush bean plant labeled as Plant -1, preparing a clean container or tray to hold the harvested pods, observing the plant to identify mature pods ready for harvest, gently removing mature pods from plant^{-1} without causing damage, placing each pod on a calibrated weighing scale and recording its weight, repeating this process for additional mature pods from plant^{-1}, optionally harvesting and weighing multiple pods to calculate an average weight, summing up the weights of all measured pods and dividing by the number of pods to obtain the average weight, recording this value for future reference or analysis, and emphasizing the importance of careful handling to prevent any harm or loss. This methodology provides a reliable means of determining the weight of pods from a specific plant and can be replicated for other plants if necessary.

$$\text{Average weight of pods} = \frac{\text{Total weight of pods}}{\text{Number of pods}}$$

1.3.10.6. Pod yield plot^{-1}

In this research, a study to determine the pod yield per plot of bush bean (*Phaseolus vulgaris*) has been conducted. The methodology involved dividing the planting area into distinct plots and randomly selecting representative plots for measurement. Throughout the growing season, the bush bean plants within each selected plot were closely monitored, noting the development and maturity of the pods. Once the pods reached maturity, they were carefully harvested from each plot, ensuring minimal damage to the plants and other pods. The harvested pods were collected, properly labeled, and counted for each plot. Additionally, a representative sample of the pods from each plot was weighed to calculate the average weight per pod. Using this data, the pod yield for each plot was calculated by multiplying the total number of pods by the average weight per pod for that plot. The resulting values represent the pod yield per plot of bush bean. This methodology allows for plot-specific evaluation of productivity and can be used to inform future planting decisions and optimize overall pod yield in bush bean cultivation.

$$\text{Pod yield per plot} = \text{Total number of pods in the plot} \times \text{Average weight per pod for the plot}$$

1.3.10.7. Pod yield (t/ha)

Harvesting was done at different intervals, and total pods were recorded in each unit plot and expressed in kilogram (kg). Finally pod yield per plot was converted to pod yield per hectare and expressed in ton.

1.3.11. Collection of Samples

1.3.11.1. Soil Sample collection

The initial soil samples were collected randomly from different spots of the field selected for the experiment at 0–15 cm depth before the land preparation and mixed thoroughly to make a composite sample for analysis. Post-harvest soil samples were collected from each plot at 0–15 cm depth on 24th February, 2022. The samples were air-dried, grounded, and sieved through a 2 mm sieve and preserved for analysis.

1.3.11.2. Soil Sample Analysis

The initial and postharvest soil sample were analyzed for both physical and chemical properties in the laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka. The properties studied included soil pH, organic matter, total N, available P, and exchangeable K. The properties studied included soil pH and organic matter, total N, available P, and exchangeable K. The following standard methods analyzed the soil:

1.3.11.3. Soil pH

Soil pH was determined by glass electrode pH meter in soil-water suspension having soil: water ratio of 1:2.5 as outlined by Cherie (2022).

1.3.11.4. Organic Carbon

The soil's organic carbon was determined by the wet oxidation method described by Walkley and Black (1934) and Page Jr *et al.* (1982). To obtain organic matter content, the amount of organic carbon was multiplied by the van Bemmelen factor of 1.73 (Chaikaew and Chavanich, 2017). The result was expressed in percentage.

1.3.11.5. Available Phosphorous

Available phosphorous was extracted from the soil by shaking with 0.5 M $NaCO_3$ solution of pH 8.5. The phosphorous in the extract was then determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 mm wavelength by spectrophotometer, and available P was calculated with the help of a standard curve.

1.3.11.6. Exchangeable Potassium

Exchangeable Potassium in the soil sample was extracted with 1 N neutral ammonium acetate (NH_4OAc) (pH 7.0), and the potassium content was determined by flame photometer (Ullah *et al.*, 2022).

1.3.12. Statistical analysis

All the data were statistically analyzed by using statistix 10 computer package programs for different characters to find out the significance of the difference between the different doses of inorganic and organic fertilizer on yield and yield contributing characteristics of bush bean. The mean values of all the treatments were calculated, and analyses of variance for all the characters were performed by the F-test (variance ratio). The significance of the difference among the treatment combinations of means was estimated by least significance difference (LSD) at a 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The objective of the experiment was to investigate the effect of organic and inorganic fertilizers on the growth and yield of Bush bean. In this chapter, the study's results are presented, examined, and compared utilizing table(s) and/or figure(s) (s). The study of data variance for all parameters is presented in the appendices. The data have been presented and discussed using the following tables, graphs, and possible interpretations. These are the headers used to present the analytical results:

1.1. Effect of organic and inorganic fertilizer on the plant height of Bush bean

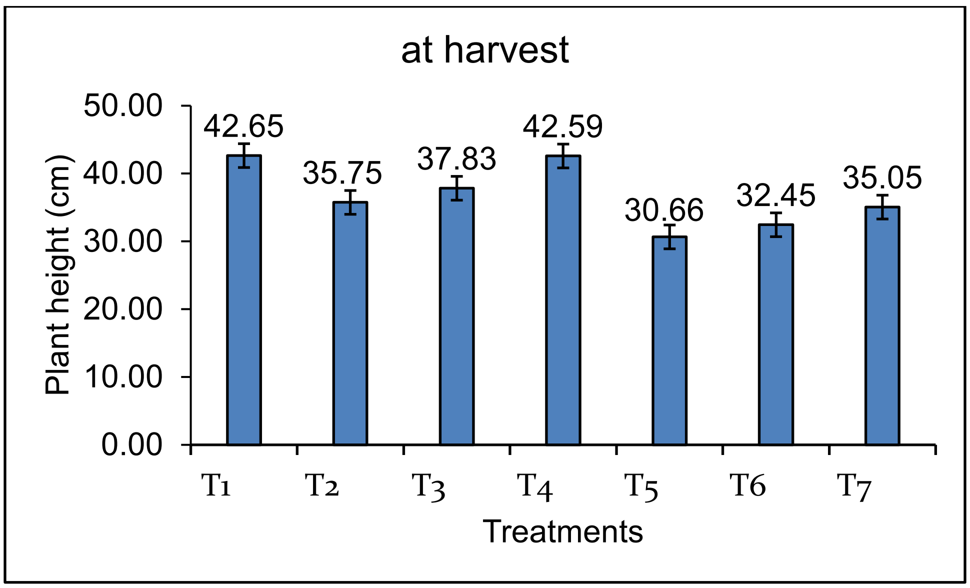

Figure 3. Effects of different organic and inorganic fertilizers doses on plant height; Here, T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}; Values in a column are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications.

Plant height is one of the important parameters, which is positively correlated with the yield of Bush bean. The application of organic and inorganic fertilizer exhibited a significant influence on the height of Bush bean plants at the final harvest (Figure 3). Plant height ranged from 30.66 cm to 42.65 cm among the different organic and inorganic fertilizer applications. At the final harvest, the tallest plant (42.65 cm) was recorded from the T_1 (100% RCF + 0 t ha^{-1} Vermicompost) treatment which is statistically similar (42.59 cm) to the treatment of T_4 (75% RCF + 6 t ha^{-1} Vermicompost) whereas the shortest (30.66 cm) was from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment which is statistically similar (32.45 cm) to the treatment of T_6 (50% RCF + 4 t ha^{-1} Vermicompost). Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF) performed best in recording plant height compared to other treatment(s) combinations. The lowest plant height was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop. The abundant nitrogen and nutrient content in vermicompost creates better nutrient absorption and favors vegetative growth. It is found that applied vermicompost, especially at 20% level had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher plant height. Low doses of vermicompost (10%) produced shorter plants. (Joshi *et al.,* 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on plant height. Sharma *et al.* (2018); Tasung *et al.,* (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest plant height over other treatments.

1.2. Effect of organic and inorganic fertilizer on the branches plant^{-1} of Bush bean

Different organic and inorganic fertilizer combinations showed a significant influence on the formation of branches plant^{-1} (Figure 4). At harvesting time, the highest number of branches plant^{-1} (14.29) was recorded from T_4 (75% RCF + 6 t ha^{-1} VC ha^{-1}) treatment which is statistically similar to (14.22) the treatment of T_1 (100% RCF + 0 t VC ha^{-1}). On the other hand, the lowest number of branches plant^{-1} (6.37) was recorded from T_5 (50% RCF + 2 t VC ha^{-1}) and T_6 (50% RCF + 4 t VC ha^{-1}) treatment (7.14), respectively. These results indicate that the highest number of branches plant^{-1} found from Vermicompost (6 t VC ha^{-1}) with inorganic fertilizer (75% RCF) whereas the lowest number of branches plant^{-1} was produced from 50% recommended dose of chemical fertilizer with 2 t VC ha^{-1} application.

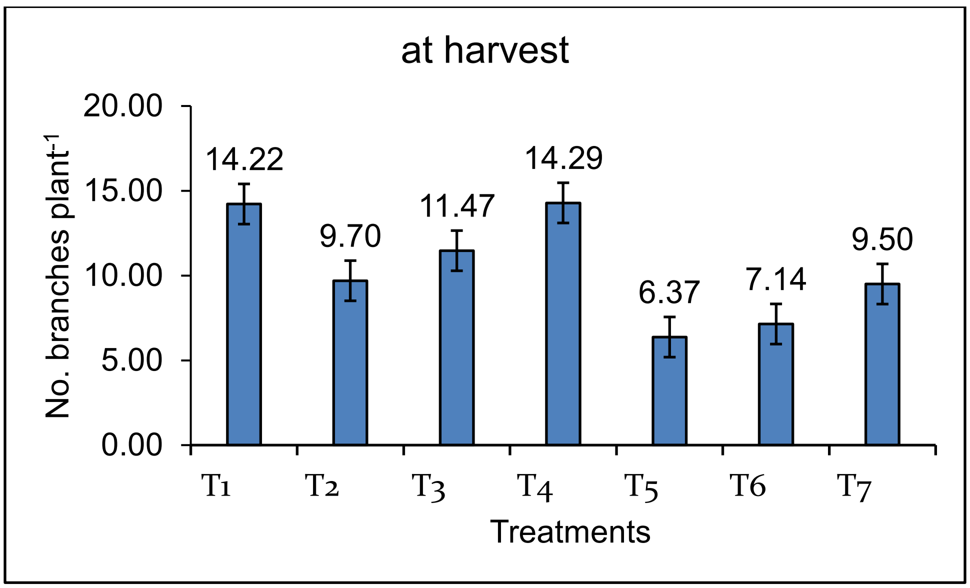

Figure 4. Effects of different organic and inorganic fertilizers doses on number of branches plant^{-1}; Here, T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}; Values in a column are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications.

Joshi *et al.* (2015), and Sharma *et al.* (2018), observed that vermicompost supplemented with NPK treated plots displayed better results regarding number of branches from other fertilizers treated plants. Sharma *et al.* (2018); Tasung *et al.*, (2022), recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest branches plant^{-1} over other treatments.

1.3. Effect of organic and inorganic fertilizer on the no. of flower plant^{-1} of bush bean

The number of flower plant^{-1} is one of the important parameters, which is positively correlated with the yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the number of flower plant^{-1} (Figure 5). Number of flower plant^{-1} ranged from 5.10 to 13.79 among the different organic and inorganic fertilizer applications.

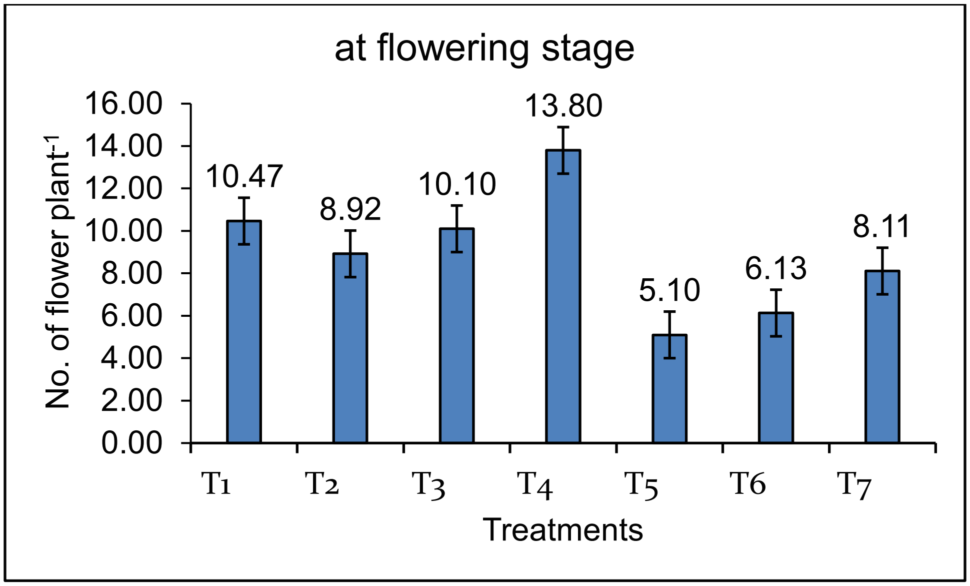

Figure 5. Effects of different organic and inorganic fertilizers doses on number of flower plant^{-1}; Here, T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}; Values in a column are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications.

At the flowering stage, the maximum number of flower plant^{-1} (13.79) was recorded from the T_1 (100% RCF + 0 t ha^{-1} Vermicompost) treatment which is statistically similar (13.31) to the treatment of T_4 (75% RCF + 6 t ha^{-1} Vermicompost) whereas the shortest (5.10) was from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment. Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the number of flower plant^{-1} compared to other treatment(s) combinations. The lowest number of flower plant^{-1} was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1}

vermicompost throughout the entire growth period of the crop. Vermicompost provides micronutrient along with NPK and improves nutrient availability and absorption which facilitates plant growth. It is found that applied vermicompost, especially at 20% level had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher number of flower plant^{-1}. Low doses of vermicompost (10%) produced lower number of flower plant^{-1}. (Joshi *et al.*, 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on number of flower plant^{-1}. Sharma *et al.* (2018); Tasung *et al.,* (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest number of flower plant^{-1} over other treatments.

1.4. Effect of organic and inorganic fertilizer on the number of pods plant^{-1} of bush bean

The number of pod plant^{-1} is one of the important parameters, which is positively correlated with the yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the pod plant^{-1} of Bush bean plants at the final harvest (Figure 6). Number of pod plant^{-1} ranged from 9.33 to 24.33 among the different organic and inorganic fertilizer applications. At the final harvest, the maximum number of pod plant^{-1} (24.33) in the treatment of T_4 (75% RCF + 6 t ha^{-1} Vermicompost), whereas the shortest (9.33) was from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment. Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the number of pod plant^{-1} compared to other treatment(s) combinations. The lowest number of pod plant^{-1} was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop.

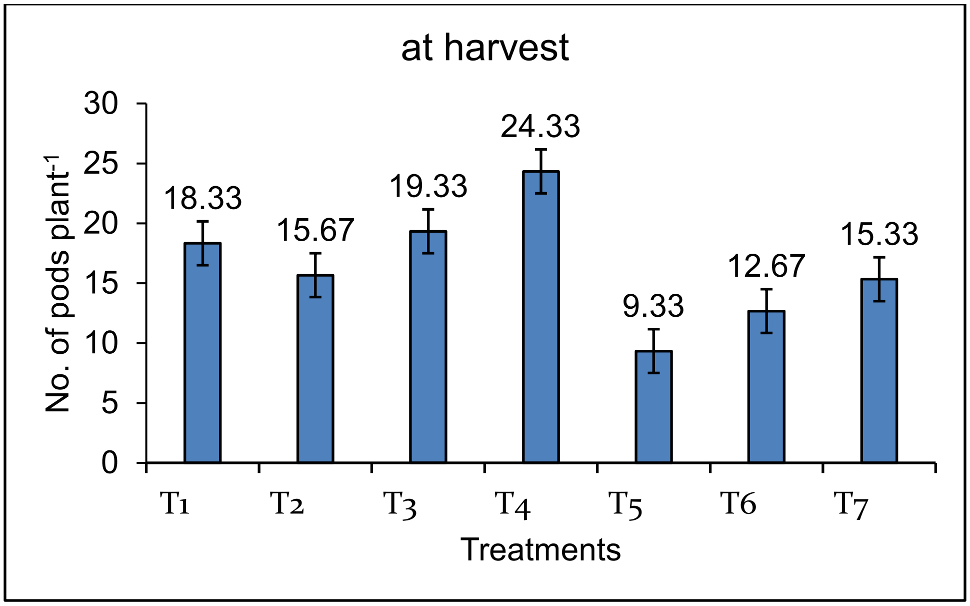

Figure 6. Effects of different organic and inorganic fertilizers doses on number of pods plant^{-1}; Here, T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}; Values in a column are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications.

Vermicompost facilitates better nutrient absorption and favors vegetative growth. It is found that applied vermicompost, especially at 20% level had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher number of pods plant^{-1}. Low doses of vermicompost (10%) produced lower number of pods plant^{-1}. (Joshi *et al.*, 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on number of pod plant^{-1}. Sharma *et al.* (2018); Tasung *et al.*, (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest number of pods plant^{-1} over other treatments. Islam *et al.*, (2016) concluded that the vermicompost (20%) treatment along with N:P:K fertilizers (farmer practice) produced the highest number of pods plant^{-1}.

1.5. Effect of organic and inorganic fertilizer on the pod length of bush bean

The pod length is one of the important parameters, which is positively correlated with the yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the pod length of Bush bean plants at the final harvest (Figure 7). The pod length ranged from (8.95 cm) to (16.20 cm) among the different organic and inorganic fertilizer applications.

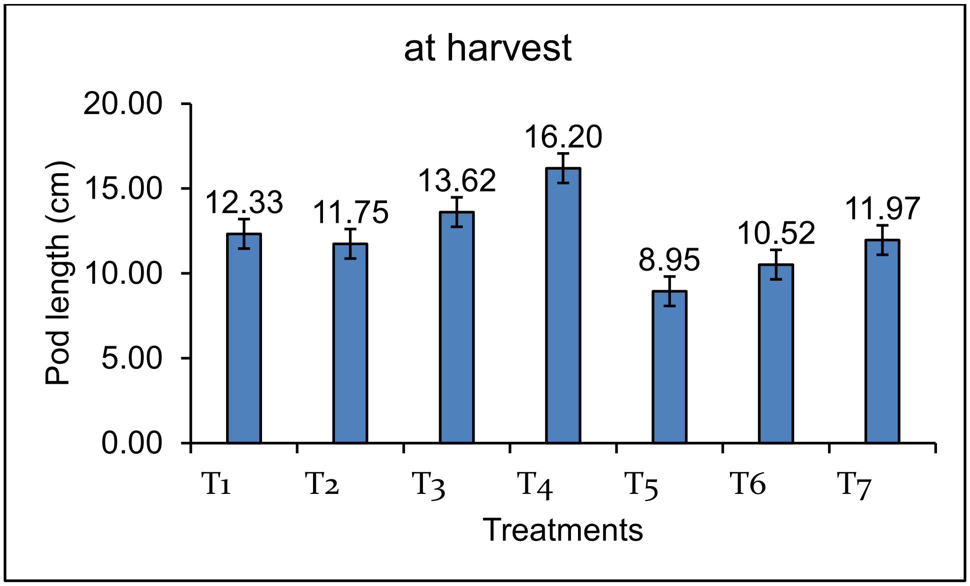

Figure 7. Effects of different organic and inorganic fertilizers doses on pod length of bush bean; Here, T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}; Values in a column are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications.

At the final harvest, the maximum pod length (16.20 cm) was recorded from the T_4 (75% RCF + 6 t ha^{-1} Vermicompost) treatment whereas the shortest (8.95 cm) was from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment. Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the pod length compared to other treatment(s) combinations. The lowest pod length was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop. Vermicompost is rich in nitrogen and nutrient content. This favorable condition creates better nutrient absorption and favors vegetative growth. It is found that applied vermicompost, especially at 20% level, had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher pod length. Low doses of vermicompost (10%) produced lower pod length. (Joshi *et al.,* 2015).

Islam *et al.,* (2016) recorded that the vermicompost (20%) treatment along with N:P:K fertilizers (farmer practice) produced the highest pod length. Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on pod length. Sharma *et al.* (2018); Tasung *et al.*, (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest pod length over other treatments.

1.6. Effect of organic and inorganic fertilizer on the weight of pods plant^{-1} of bush bean

The weight of pods $plant^{-1}$ is one of the important parameters, which is positively correlated with the yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the weight of pods $plant^{-1}$ of Bush bean plants at the final harvest (Table 1). The weight of pods $plant^{-1}$ ranged from 116.0 to 145.79 among the different organic and inorganic fertilizer applications. At the final harvest, the maximum weight of pods $plant^{-1}$ (147.23 g) was recorded from the T_4 (75% RCF + 6 t ha^{-1} Vermicompost) treatment whereas the minimum weight of pods $plant^{-1}$ was found in (116.0 g) the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment and (117.97) in the treatment T_6 (50% RCF + 4 t ha^{-1} Vermicompost) respectively. Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the weight of pods $plant^{-1}$ compared to other treatment(s) combinations. The lowest weight of pods $plant^{-1}$ was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop. Vermicompost nourishes soil and improves soil fertility. This favorable condition creates better nutrient absorption and favors vegetative growth. It is found that applied vermicompost, especially at 20% level, had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher weight of pods $plant^{-1}$. Low doses of vermicompost (10%) produced lower weight of pods $plant^{-1}$. (Joshi *et al.,* 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on the weight of pods $plant^{-1}$.

Table 1. Effect of different doses of organic and inorganic fertilizers on the weight of pods plant^{-1}, pod yield, yield, and stover yield

Treatment	Weight of pods plant^{-1} (g)	Pod yield plot^{-1} (g plot^{-1})	Pod yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	132.08 bc	5874.3 bc	9.847 c	3.50 bcd
T_2	125.16 bcd	5707.2 c	9.73 c	4.07 bc
T_3	135.89 ab	5905.0 b	11.35 b	4.17 b
T_4	147.23 a	6239.8 a	13.14 a	5.43 a
T_5	116.00 d	5205.7 e	6.86 e	2.82 d
T_6	117.97 cd	5393.6 d	8.24 d	2.94 d
T_7	123.53 bcd	5646.3 c	9.38 c	3.73 c
$LSD_{(0.05)}$	1.74	41.165	0.3248	0.1194
CV(%)	6.08	143.89	1.1354	0.4173

Here, dissimilar letter differs significantly at 0.05 percent level of probability. T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1};

Sharma *et al.* (2018); Tasung *et al.*, (2022) reported that the treatment with a vermicompost dose of 2.5 t ha^{-1} with the full recommended dose of chemical fertilizers produced the highest weight of pods plant^{-1} over other treatments. Islam *et al.*, (2016) recorded that the vermicompost (20%) treatment produced the highest weight of pods plant^{-1}.

1.7. Effect of organic and inorganic fertilizer on pod yield of bush bean

The pod yield is one of the important parameters, which is positively correlated with the yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the pod yield of Bush bean plants at the final harvest (Table 1). The pod yield ranged from 5205.7 to 6239.8 among the different organic and inorganic fertilizer applications. At the final harvest, the maximum pod yield (6239.8 g $plot^{-1}$) was recorded from the T_4 (75% RCF + 6 t ha^{-1} Vermicompost) treatment, whereas the lowest (5205.7 g $plot^{-1}$) was from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment. Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the pod yield compared to other treatment(s) combinations. The lowest pod yield was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop. Vermicompost improves the nutritional state of soil which contributes to improved crop production. It is found that applied vermicompost, especially at 20% level, had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher pod yield. Low doses of vermicompost (10%) produced lower pod yields of the Bush bean plants. Generally, the addition of vermicompost led to improve the pod yield of Bush bean cultivars as compared to the control. (Joshi *et al.*, 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on pod yield. Sharma *et al.* (2018); Tasung *et al.*, (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest pod yield over other treatments.

1.8. Effect of organic and inorganic fertilizer on pod yield of bush bean

The pod yield is one of the important parameters, which is positively correlated with the growth and pod yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the pod yield of Bush bean plants at the final harvest (Table 1). The pod yield ranged from 6.86 t ha^{-1} to 13.14 t ha^{-1} among the different organic and inorganic fertilizer applications. At the final harvest, the maximum pod yield (13.14) was recorded from the T_4 (75% RCF + 6 t ha^{-1} Vermicompost) treatment, whereas the lowest (6.86) was from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment. Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the pod yield compared to other treatment(s) combinations. The lowest pod yield was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop. Vermicompost improves soil condition along with increasing nutrient availability thus contributing to increased plant growth and pod yield. It is found that applied vermicompost, especially at 20% level, had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher pod yields. Low doses of vermicompost (10%) produced lower pod yields of the Bush bean plants. Generally, the addition of vermicompost led to improve the pod yield of Bush bean cultivars as compared to the control. (Joshi *et al.,* 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on pod yield. Sharma *et al.* (2018); Tasung *et al.,* (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest pod yield over other treatments.

1.9. Effect of organic and inorganic fertilizer on stover yield of bush bean

The stover yield is one of the important parameters, which is positively correlated with the growth and yield of Bush bean. The application of organic and inorganic fertilizers exhibited a significant influence on the stover yield of Bush bean plants at the final harvest (Table 1). The yield ranged from (2.82 to 5.43) t ha^{-1} among the different organic and inorganic fertilizer applications. At the final harvest, the maximum stover yield (5.43 t ha^{-1}) was recorded from the T_4 (75% RCF + 6 t ha^{-1} Vermicompost) treatment whereas the minimum stover yield (2.82 t ha^{-1}) was found from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment which is statistically (2.94 t ha^{-1}) similar to the treatment of T_6 (50% RCF + 4 t ha^{-1} Vermicompost). Vermicompost (6 t ha^{-1} Vermicompost), along with inorganic fertilizer (75% RCF), performed best in recording the stover yield compared to other treatment(s) combinations. The lowest stover yield was noted from the T_5 (50% RCF + 2 t ha^{-1} Vermicompost) treatment having 50% recommended dose of inorganic fertilizer along with 2 t ha^{-1} vermicompost throughout the entire growth period of the crop. Vermicompost provides nitrogen and other nutrient and creates favorable condition for better nutrient absorption and improved vegetative growth. It is found that applied vermicompost, especially at 20% level, had significantly improving effects on better growth and development of bush bean as vermicompost-treated bush bean had higher stover yield. Low doses of vermicompost (10%) produced lower stover yields of the Bush bean plants. Generally, the addition of vermicompost led to improve the stover yield of Bush bean cultivars as compared to the control. (Joshi *et al.*, 2015). Chala and Gurmu (2016) found that 85% of recommended chemical fertilizers with 4.8 t ha^{-1} vermicompost fertilizer gave the best result on stover yield. Sharma *et al.* (2018); Tasung *et al.*, (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with full recommended dose of chemical fertilizers produced the highest stover yield over other treatments.

1.10. Chemical properties of the collected soil after harvesting

After collecting soil, the Chemical Properties of soil, a composite soil test from 30 cm profundity was collected applying estimates from four diverse focuses of the test range and a few of its chemical properties sometime recently and after collect was decided as displayed in Table 2.

Table 2. Effects of different organic and inorganic fertilizers doses on soil characteristics after harvest

Treatment	Organic carbon (%)	Soil pH	Phosphorus content in soil (ppm)	Potassium content in soil (meq. /100 g soil)
T_1	0.60 e	6.06	13.56 d	0.11
T_2	0.71 c	6.01	14.50 b	0.12
T_3	0.78 b	6.13	12.00 c	0.12
T_4	0.85 a	6.17	23.00 a	0.13
T_5	0.60 e	6.00	10.00 e	0.11
T_6	0.64 d	6.03	23.00 a	0.12
T_7	0.71 c	6.08	15.00 b	0.12
$LSD_{0.05}$	**0.03**	**NS**	**1.75**	**NS**
CV (%)	**5.45**	**0.25**	**7.54**	**7.42**

Here, dissimilar letter differs significantly at 0.05 percent level of probability. NS= Non-significant; T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1};

4.10.1 Soil organic carbon

There was a significant residual effect of vermicompost and chemical fertilizer (Table 2). The highest organic carbon (0.85%) was noted in treatment T_4. This might be due to higher amounts of vermicompost along with chemical fertilizer applied, resulting in increased organic matter in soil due to organic manure treated plots than only chemical fertilizer and full dose vermicompost treatments. The lowest organic carbon (0.60 %) was noted in T1 which is statistically similar to the T_5 treatment of the crop.

1.10.1. Soil pH

Soil pH was not significantly influenced by the residual effect of vermicompost along with chemical fertilizer on the crop (Table 2). The maximum soil pH (6.17) was recorded in T_4 treatment. On the other hand, minimum soil pH (6.00) was noted in T_5 treatment. The vermicompost-treated soil exhibits a near-neutral pH which facilitates nutrient availability. (Chaoui *et al.,* 2003).

1.10.2. Available P (ppm)

Post-harvest soils were influenced due to the application of vermicompost along with chemical fertilizer (Table 2). Available P of the postharvest soils ranged from 10.0 to 23.0 ppm against the P content of 11.0 ppm in the initial soil. Available P of the post-harvest soils increased in all cases compared to the initial soils except for the control. The highest available P content in soil (23.0 ppm) was recorded in the T_4 treatment. Soil treated with organic manures along with chemical fertilizer gave higher values of available P compared to other treatments. The release of available P from the decomposition of vermicompost might be cause of higher available P in soils treated with vermicompost. The lowest available phosphorus (10.0 ppm) was noted in full dose vermicompost treatment (T_5).

1.10.3. Exchangeable K (meq/100 g soil)

Potassium content in soil was increased significantly due to the residual effect of vermicompost along with chemical fertilizer (Table 2). The maximum potassium content in soil (0.129 meq. /100 g soil) was recorded from the treatment T_4 receiving vermicompost along with chemical fertilizer. The effects of this treatment were statistically superior to the rest of treatments of the crop. Treatment T_5 (0.123 meq. /100 g soil) receiving vermicompost along chemical fertilizer was statistically similar related to T_1. The minimum potassium content in soil (0.110 meq. /100 g soil) was recorded.

CHAPTER V
SUMMARY AND CONCLUSION

This experiment was conducted at the Farm division of Sher-e-Bangla Agricultural University, during the rabi season of November 2021 to February 2022 under AEZ 28 (Madhupur tract), Sher-e-Bangla Nagar, Dhaka-1207 to examine the effects of organic and inorganic fertilizers on the performance of Bush bean (*Phaseolus vulgaris*). This experiment utilized “BARI Jhar Sheem-1” as the test crop. The experiment comprised of single factor comprising eight treatments viz. T_1 = 100% RCF + 0 t VC ha^{-1}; T_2 = 75% RCF + 2 t VC ha^{-1}; T_3 = 75% RCF + 4 t VC ha^{-1}; T_4 = 75% RCF + 6 t VC ha^{-1}; T_5 = 50% RCF + 2 t VC ha^{-1}; T_6 = 50% RCF + 4 t VC ha^{-1}; T_7 = 50% RCF + 6 t ha^{-1}. This experiment was laid out in a randomized complete block design (RCBD) with three (3) replications. Data were collected on different aspects of growth, yield attributes, yield and harvest index of bush bean including soil properties and nutrient contents.

The results revealed that treatment T_4 [T_4 = 75% RCF + 6 t VC ha^{-1}] exhibited its superiority compared to other inorganic fertilizers with different doses of vermicompost treatments in terms of yield of bush bean. Treatment T_4 [75% RCF + 6 t VC ha^{-1}] also showed the longest plant (42.65 cm), maximum number of branches $plant^{-1}$ (14.29), highest number of flower $plant^{-1}$ (13.79), highest number of pod $plant^{-1}$ (24.33), maximum pod length (16.20 cm), maximum weight of pods $plant^{-1}$ (147.23 g), maximum pod yield (6239.8 g), highest pod yield (13.14 t ha^{-1}), maximum stover yield (5.43 t ha^{-1}) than other treatments in this experiment. On the other hand, the treatment T_5 [50% RCF + 2 t VC ha^{-1}] returned with 7.37% lower yield than treatment T_6 which was significantly the lowest compare with other treatments under study.

In case of soil properties, the highest soil organic carbon (0.85%) and the maximum soil pH (6.17) was recorded from treatment T_4 in post-harvest soil. Additionally, the highest available P content in soil (23.0 ppm) and the maximum potassium content in soil (0.129 meq. /100 g soil) was recorded from the treatment T_4 receiving chemical fertilizer and vermicompost.

CONCLUSION

From the above result, it was revealed that T_4 [75% RCF + 6 t VC ha^{-1}] gave a higher yield along with higher values in all the growth and yield attributing parameters. It can be said that 6 t ha^{-1} of vermicompost along with 75% chemical fertilizer (RCF) improved soil properties along with increased availability of essential plant nutrients in soil solution. From the result of the experiment, it may be concluded that Vermicompost (6 t VC ha^{-1}) + (75% RCF) application seemed promising for producing higher fruit yield of bush bean and maintaining soil productivity.

RECOMMENDATIONS

Considering the results of the present experiment, further studies in the following areas are suggested:

- Different levels of vermicompost may be used along with different levels of inorganic chemical fertilizer in a bush bean field for getting a variety of specific fertilizer recommendations.

- Studies of similar nature could be carried out in different agro- ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.

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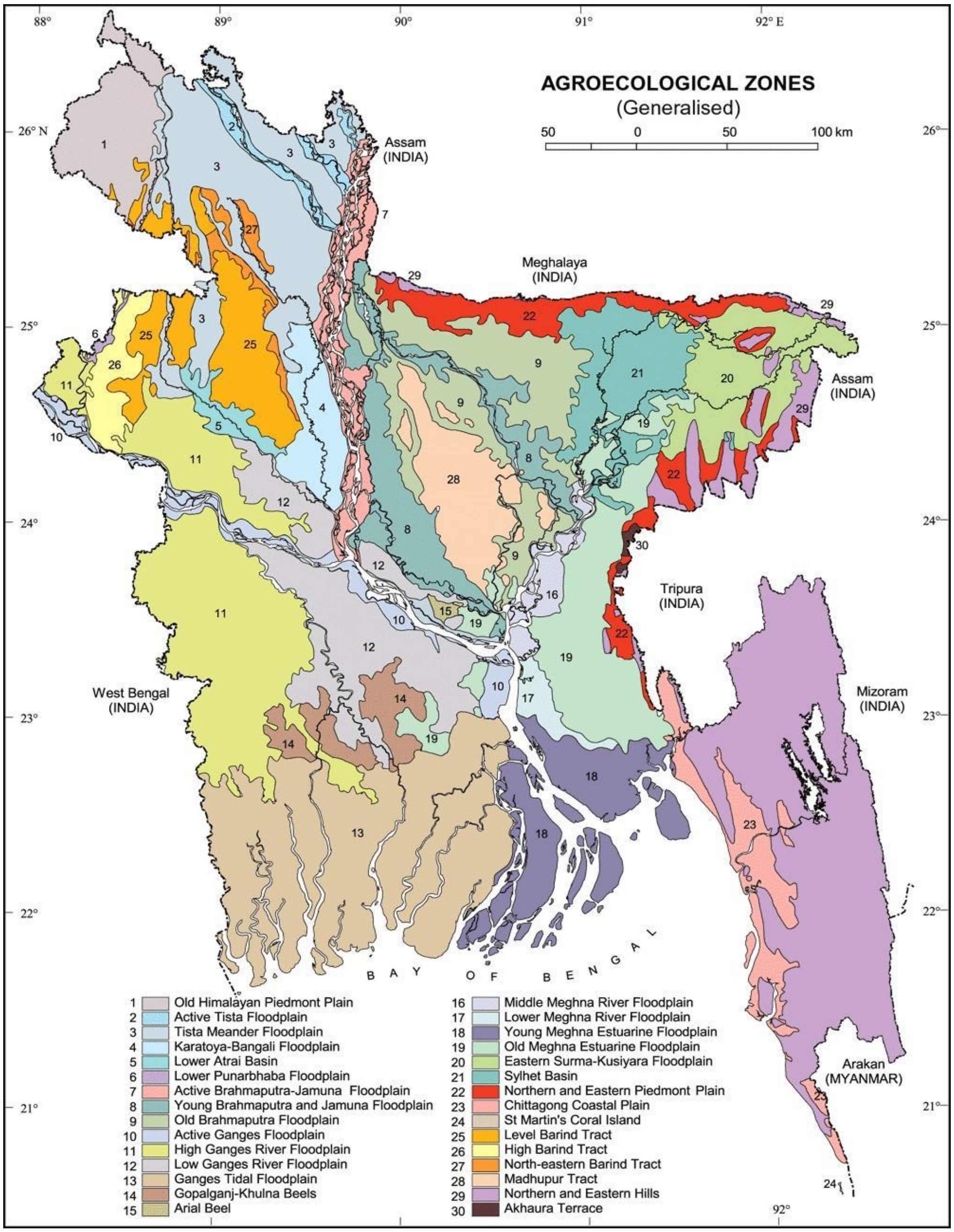
CHAPTER VI

APPENDICES

Appendix I. Map Showing the experimental site under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Agronomy field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical properties of the initial soil

Characteristics	Value
Particle size analysis	
Sand%	25
Silt%	45
Clay%	30
Textural Classes	Silty -Clay
pH	6.00
Particle density (g/cc)	2.68
Organic carbon (%)	0.47
Organic matter (%)	0.80
Available P (ppm)	22.00
Exchangeable K (meq/100g soil)	0.121

Appendix III. Monthly average of relative humidity, air temperature, and total rainfall of the experimental site during the period from November 2020 to April 2021

Month	Average RH%	Average temperature (C^0)		Total Average Rainfall(mm)
		Min.	Max.	
November, 2021	50.45	8.56	24.87	00
December, 2021	52.41	6.04	23.35	00
January, 2022	59.13	12.45	21.32	00
February, 2022	53.66	16.34	24.12	4.34
March, 2022	46.37	19.41	28.54	1.22

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix IV: Schedule of cultural operation in the experiment

Serial No.	Cultural preparation	Date
1.	1st Irrigation	29.11.2021
2.	Tagging	30.11.2021
3.	1st Weeding with mulching	04.12.2021
4.	2nd Irrigation	08.12.2021
5.	Drainage	12.12.2021
6.	2nd Weeding	21.12.2021
7.	Data collection with different parameters	18.01.2022
8.	Final Harvesting	06.02.2022
9.	Collection post-harvest soil	24.02.2022
10.	Analysis of soil sample	20.03.2022

Appendix IV. Error mean square values for Plant height, number of branches plant^{-1} and number of flower plant^{-1} of bush bean

Source of variation	Degrees of freedom	Plant height	No. of branches plant^{-1}	No. of flower plant^{-1}
Replication	2	2.55	7.63	8.22
Treatment	6	64.76	29.48	33.07
Error	12	0.75	0.12	0.11

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix V. Error means square values for number of pods plant^{-1}, pod length, and weight of pods plant^{-1} of bush bean

Source of variation	Degrees of freedom	Number of pods plot^{-1}	Pod length	Weight of pods plant^{-1}
Replication	2	0.1429	0.65	9.68
Treatment	6	70.4127	20.51	488.68
Error	12	1.0317	0.19	4.54

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VI. Error means square values for yield, and stover yield of bush bean

Source of variation	Degrees of freedom	Yield	Stover yield
Replication	2	6.86	4.77
Treatment	6	15.57	2.86
Error	12	0.16	0.02

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VII. Some photos were documented during the experiment.

Plate 1. Land preparation and tagging

Plate 2. Seed sowing in the seedbed

Plate 4. Seedling emergence

Plate 3. Seedling raising

Plate 5. Flowering of Bush bean plant

Plate 6. Fruit setting

Plate 7. Measuring of the length of pod

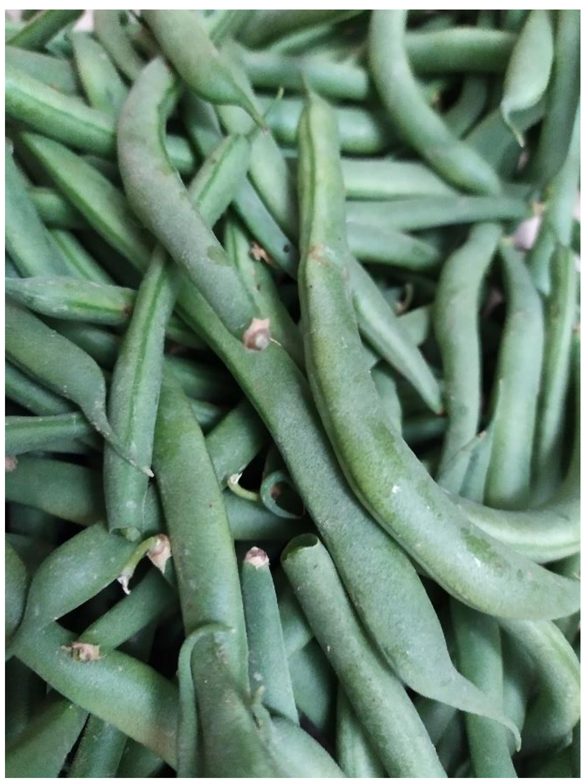


Plate 8. Harvesting of bush bean