INFLUENCE OF BIOFERTILIZER APPLICATION METHOD WITH ORGANIC AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF BITTER GOURD IN WINTER SEASON

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CERTIFICATE

This is to certify that the thesis entitled, **"Influence of bio-fertilizer application method with organic and in-organic fertilizer on growth and yield of bitter-gourd in winter season."** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***Mst. Umme Habiba****, Registration number:* ***18-09210*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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TO

MY BELOVED

SUPERVISOR

GREAT GRAND PARENTS

HUSBAND

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INFLUENCE OF BIOFERTILIZER APPLICATION METHOD WITH ORGANIC AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF BITTER GOURD (*Momordica charantia L.*) IN WINTER SEASON

BY

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ABSTRACT

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period of November 2019 – May 2020 to find out the influence of bio-fertilizer application method with organic and in-organic fertilizer on growth and yield of bitter-gourd in winter season. The experimentwas double factorial : as- Factor A: Fertilizer (4 levels) T_0: control i.e. no fertilizer ,T_1: Organic (kitchen compost @1000 kg/ha),T_2: in-organic (N_{46} P_{40} K_{45}) Kg/ha and T_3: Organic (kitchen compost @1000 kg/ha) + in-organic (N_{23} P_{20} K_{23}) kg/ha Factors B: Bio-fertilizer application method (3 levels) F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed,F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling. And F_3: Soil treatment with bio-fertilizer @.046 g/m^2. The double factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Maximum plant height (299.69 cm), fruit diameter(4.6 cm),fruit length(27.11 cm), yield/plant (1.05 kg), and total yield (19.44 t/ha) were found from T_3F_3 treatment. fruit diameter(1.00cm),fruit length(4.49 cm), yield/plant (.046 kg), and total yield (.86 t/ha) were found from T_0F_2(control) treatment .All growth related parameter was collected up to 75 DAS due to COVID-19.This study suggests that T_3F_3 treatment acts as a potential source of plant nutrients for suitable bitter gourd production. The combination of organic ,In-organic and soil application of bio-fertilizer (T_3F_3) gave the highest gross return (Tk. 1458000). The combination of organic, inorganic and soil application of bio-fertilizer (T_3F_3) gave the highest benefit cost ratio (3.16).

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ABBREVIATIONS AND ACRONYMS

SAU	Sher-e-Bangla Agricultural University
SAURES	Sher-e-Bangla Agricultural University Research System
SG	SAU Germplasm
CD	Cowdung
PM	Poultry Manure
VC	Vermicompost
CF	Chemical Fertilizer
FYM	Farmyard Manure
FCD	Farm Cowdung
AEZ	Agro-Ecological Zone
ANOVA	Analysis of Variance
df	Degrees of freedom
CV(%)	Percentage of Coefficient of Variation
FAO	Food and Agriculture Organization
LSD	Least Significant Difference
MSTATC	Computer based statistical software package

CHAPTER I

INTRODUCTION

For peoples sound health vitamins and minerals is very essential. Vegetables are rich and easily achieveable source of vitamins and minerals . This food also called as Protective food. Bitter gourd (*Momordica charantia* L.) is an internationally known cucurbitaceous crop extensively grown throughout the country for many year for many of its beneficial health effect and has been used for a long time throughout the world. This most important popular vegetable crop grown mainly in the south east Asia. The genus name Momordica is derived from Latin word 'Mordeo' indicating jagged seeds and belongs to the family Cucurbitaceae. Bitter-gourd (*Momordica charantia*), locally known as "Korolla" English bitter gourd, bitter melon, balsam pear.

Bitter gourd originated in the Old World, and was first domesticated in eastern India and Southern China (Salunkhe *et al*., 1987). Bitter gourd mainly cultivated in China, India, Pakistan, Central America, East America and South America (Nadkarni, 2000). Unlike other cucurbitaceous vegetables, the bitter fruit flavour of *Momordica charantia* is considered desirable for consumption, and thus bitter flavour has been selected during domestication (Marr *et al*., 2004). According to BBS 2019-2020 total bitter gourd production in Bangladesh 59371 metricton in 27484 acre area of land. (BBS 2020) Bitter gourd fruit contains 70.4 g moisture, 1.6 g protein, 1.7 g fibre, 4.7 g carbohydrates, 20 mg calcium, 20 mg phosphorus, 1.8 mg iron and 88 mg vitamin C per100 g of edible portion (Gopalan *et al*., 1982) It ranks first among the cucurbits in respect of iron and vitamin C content (Araujo *et al.*,2013).Bitter gourd has been used for a long time in various Asian and African traditional medicines (Paul and Raychaudhuri, 2010).The fruits, leaves and even the roots of *Momordica charantia* have been used in Ayurveda for the cure of a number of diseases such as a bitter stomachic, laxative and anathematic. Bitter gourd has been found highly beneficial in lowering the blood and urine sugar level (Bharati *et al*., 2018). The leaf extract of Bitter gourd is also having a very good mosquitocidal effect (Muralee *et al*.,2008).The

fruit has wormicidal properties and extracts are used to cure rheumatism (Indira,1981).Plant nutrition is one of the most important factors that increase plant production.Nitrogen (N) is the most recognized in plant for its presence in the structure of the protein molecule. It plays an important role in synthesis of plant constituents through the action of different enzymes. Phosphorus (P) is required in large quantities in young cells such as shoot and root tips. It aids in root development , flower initiation, seed and fruit development. Potassium (K) is an important macro nutrient and the most abundant cation in higher plants. Micro nutrients are involved in all metabolic and cellular function.

But during last four decades indiscriminate use of inorganic fertilizers, pesticides and fungicides caused environmental pollution, especially into the soil there by affecting its fertility on long term basis (Das *et al*., 2015). To avert this situation, reduced use of fertilizers without compromising on yield and quality can be achieved if the nutrient supply through organic manures, are used (Sheeba *et al*., 2015). Again it can better address the important threats of food security such as soil degradation, climate change and pest problems. (Azarmi *et al*., 2009).So for sustainable production maintenance of soil health is prerequisite in intensive cultivation.

Organic matter plays a key role in achieve sustainability on agricultural production because it possesses many desirable properties such as high water holding capacity, cations exchange capacity, beneficial effect on the physical, chemical and biological characteristics of soil. It also adds organic matter to the soil which may improve soil structure, aeration, soil moisture holding capacity and water infiltration (Sundararasu K, 2017).Kitchen waste is one kind of solid waste which is produced from kitchen during the time of preparing and processing food that makes a large portion (50-60%) of the total solid waste produced in Bangladesh (Rahman and Ali 2000). Anumar kitchen compost was used here .The main ingredient of this compost is kitchen waste beside this other valuable nutrient rich ingredient like cowdung, crop residue ,water hyacinth, saw dust, ash, bone meal ,press mud, leaves, poultry litter also included. The nutrients percentage of this compost is showed in (appendix VII). Moreover, inorganic fertilizers are relatively expensive that they are out of reach of small and marginal farmers. In this regard, to reduce and eliminate the adverse effects of chemical fertilizers, new agricultural practices have been developed in the so-called organic agriculture, ecological agriculture or sustainable agriculture. As the mode of

release of essential nutrients from organic fertilizer is quite slow, suitable substitute or technique to improve the efficacy is required. Bio-fertilizer can be used here to increase the efficacy of organic fertilizer. PSB, Azotobactor, Rhizobium, SSB, Azospirillum etc is used at a large scale as bio-fertilizer.

Actually bio-fertilizers are microorganisms that help plants to grow by increasing the quantity of nutrients crucial for the overall productivity of the soil. An increasing number of farmers and agriculturist are turning to use of bio-fertilizer as these are gentler on the soil comparing with the chemical fertilizers (Mahdi *et al* 2010). Recent attention has been given to less pollution practices in modern agriculture. Bio-fertilizers besides increasing yield also help in improving the nutrient status of soil. Azotobactor is an aerobic free living gram negative bacterium which fixes nitrogen from the atmosphere. Application of phosphate solubilizing bacteria (PSB) can help in reducing the input of chemical fertilizer as well as maintaining better soil health. The bacteria promotes growth and development of crop plants by helping in synthesis of auxins. There are very limited studies available on use of organic manure with bio-fertilizer or with inorganic fertilizer and integrated management of organic, inorganic and bio-fertilizer in vegetable crops. Therefor the present study was designed to evaluate the effect of bio-fertilizer application method with organic and inorganic fertilizer on growth and yield of bitter gourd.

Objectives :

1. To determine the appropriate nutrient management for maximum yield of bitter gourd .
2. To assess the optimum level and application method of bio-fertilizer for higher growth and maximum yield of bitter gourd.
3. To investigate the combined effect of organic, inorganic and bio-fertilizer on growth and yield of bitter gourd.

CHAPTER II

REVIEW OF LITERATURE

Bitter gourd (*Momordica charantia* L.) is a popular and important vegetable crop of the world. Many research works have been performed in different parts of the world to study the effects of fertilizer and Bio-fertilizer application method on the growth and yield of bitter gourd. But in Bangladesh, available literature regarding effects of Nutrients and Bio-fertilizers on bitter gourd or any cucurbitaceae crop production is not sufficient and sometimes very rear. However, some of the literatures relevant to effects of Nutrients and Bio-fertilizers application method on growth and yield of bitter gourd production are reviewed in this chapter.

Thriveni *et al*.(2013) The experiment was conducted on bitter gourd at College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar during Kharif 2013 to find out the effect of inorganic and organic fertlizers and biofertilizers on growth, flowering, yield and yield attributes of bitter gourd (*Momordica charantia*). Experimental factors included N:P:K three levels (50, 75, 100% RDF) alone or in integration with vermicompost or vermicompost + biofertilizers. The results illustrated that the plants treated with 100 per cent N:P:K + vermicompost + biofertilizers (*Azotobacter, Azospirillum* and phosphate solubilizing bacteria) had a beneficial effect on bitter gourd viz maximum vine length (534 cm), number of branches per vine (18.0), minimum days taken to appearance of first male (39.6 days) as well as female flower anthesis (44.0 days) that appeared at earliest node (24.6^{th} node). The same treatment recorded maximum number of fruits/plant (40.0), fruit weight (86.4 g), fruit girth, fruit yield (4036 kg/ha), ascorbic acid (111.1 mg/100 g), TSS (2.10^{o}Brix) and protein content (1.76%). Application of 100 per cent N:P:K integrated with vermicompost and biofertilizers turned to be the best treatment for increasing growth, early flowering, yield and quality attributes of bitter gourd.

Tilak *et al*. (2003) conducted a field study to determine the effect of plant growth promoting rhizobacteria (PGPR) on growth and yield of bitter gourd. Four PGPR strains (Azospirillum, Phosphorous solubilising bacteria, Pseudomonas flourescens

and Bacillus subtilis), one commercial organic product (Aishwarya) and non inoculated control were used. The study revealed that seeds inoculated with Azospirillum (basal @ 5 kg ha-1 + 40 days after sowing (DAS) @ 5 kg ha-1) recorded early germination (6.48 days). The maximum vine length (4.42 m) was recorded in basal @ 2 l/plant application of both Bacillus subtilis and Pseudomonas flourescens @ 2.5 kg ha-1. Number of primary branches was maximum (4.80) in plants applied with phosphorous solubilising bacteria (PSB) as basal @ 5 kg/ha and 40 DAS @ 5 kg/ha. Tap root length (23.57 cm) and secondary root length (39.88 cm) were highest in the plants supplied with Azospirillum (basal @ 5 kg ha-1 + 40 DAS @ 5 kg ha-1) where as, dry root weight (4.64 g) was more in case of double application of Bacillus subtilis basal @ 2 l plant -1 + 40 DAS @ 2 l plant -1. Two time application of Bacillus subtilis basal + 40 DAS @ 2 l plant -1 produced the maximum yield plant -1 and yield plot -1 (2.72 kg and 16.33 kg respectively)

A field study was conducted by Kumar *et al*. (2011) to determine the effect of plant growth promoting rhizobacteria (PGPR) on growth, flowering and yield attributes of bitter gourd. Four PGPR strains (Azospirillum, Phosphorous solubilising bacteria (Pseudomonas flourescens & Bacillus subtilis), one commercial organic product (Aishwarya) and non inoculated control were used. The study revealed that plants treated with double application of Azospirillum (T3) were statistically superior to all other treatments with a maximum tap root length (23.6 cm) and secondary root length (39.9 cm). There was an increase of 50.8 % in tap root length and 97.6 % in secondary root length over control. With respect to the dry root weight, one time application of Bacillus subtilis suspension (108 cfu/ml) (T8) was found to be superior with a root weight of 4.64 g followed by Azospirillum application (T3) which recorded 4.54 g.

Ashraf *et.al* (2019) conducted an experiment on Role of Different Levels of Nitrogen, Phosphorus and Potassium on Growth, Yield and Quality Attributes of Bitter Gourd (Momordica charantia L.) Bitter gourd is an important crop in Pakistan. Bitter gourd has a lot of dietary and medicinal importance. In Pakistan, there is a tremendous potential for using the inorganic fertilizer, but unfortunately adequate amount of fertilizer regarding the bitter gourd crop are lacking. The experiment was studied at the Vegetable Research Area, Institute of Horticultural Sciences, University of

Agriculture, Faisalabad during the year 2014-2015, to see the efficacy of inorganic fertilizers on vegetative and reproductive attributes of bitter gourd. Faisalabad Long variety of bitter gourd was used. The experiment was laid out according to Randomized Complete Block Design consisting of six treatments with four replications. The response of vegetative parameters like growth, yield and quality were recorded and analyzed statistically at the 5 % level of significance. Different doses of inorganic fertilizers showed variations among, germination, fruit, fresh weight, fruit diameter and chemical parameter like vitamin C, pH and phenolic compound of fruit. This experiment showed that treatment (T4) N: P: K (250,100,80 kg/ha) gave more fresh and dry weight of the fruit and Vitamin C. Treatment (T5) N: P : K (300, 120, 100 kg/ha) showed increased the vegetative growth, vine length, number of leaves but showed least reproductive phase. It is concluded that dose of nitrogen (250kg/ha) and adequate amount of potassium (100kg/ha) along with phosphorus (80kg/ha) fertilizers increase the vegetative growth as well as reproductive growth.

Bharati *et al*. (2018) conducted a field study at Bihar Agricultural University, Sabour, Bhagalpur during summer season of 2011-12 to explore the possibilities of enhancing the productivity of bitter gourd with better quality by foliar application of different micronutrients in view of rising temperature. Fifteen treatments were arranged in randomized block design replicated thrice. The plot size used for raising the crop was 3.0m x 3.0m and the spaying of micronutrients was done at 30, 40 and 50 days after sowing. The data were recorded on growth, yield and quality traits of bitter gourd. Economic feasibility of crop production was also calculated. It was observed that the foliar application of mixture of all micronutrients @ 100ppm being at par with boric acid @100 ppm sprayed at 30, 40, 50 DAS resulted in the maximum length of vines (5.58 m), fruit length (25.01 cm), fruit girth (10.75 cm), fruit weight/vine (2.197 kg), yield (197.01 q/ha) and vitamin C (64.65 mg/100gm). Highest B: C ratio (2.69) was also noticed under this treatment. Therefore, on the basis of economic feasibility, it can be inferred that mixture of all micronutrients as well as boric acid @ 100ppm at 30, 40 and 50 DAS is more beneficial in mitigating the problems and improving the growth, yield and quality of bitter gourd under existing climate.

Kumar *et al*. (2011) conducted a field study to determine the effect of plant growth promoting rhizobacteria (PGPR) on growth and yield of bitter gourd. Four PGPR strains (Azospirillum, Phosphorous solubilising bacteria, Pseudomonas flourescens and Bacillus subtilis), one commercial organic product (Aishwarya) and non inoculated control were used. The study revealed that seeds inoculated with Azospirillum (basal @ 5 kg ha-1 + 40 days after sowing (DAS) @ 5 kg ha-1) recorded early germination (6.48 days). The maximum vine length (4.42 m) was recorded in basal @ 2 l/plant application of both Bacillus subtilis and Pseudomonas flourescens @ 2.5 kg ha-1. Number of primary branches was maximum (4.80) in plants applied with phosphorous solubilising bacteria (PSB) as basal @ 5 kg/ha and 40 DAS @ 5 kg/ha. Tap root length (23.57 cm) and secondary root length (39.88 cm) were highest in the plants supplied with Azospirillum (basal @ 5 kg ha-1 + 40 DAS @ 5 kg ha-1) where as, dry root weight (4.64 g) was more in case of double application of Bacillus subtilis basal @ 2 l plant -1 + 40 DAS @ 2 l plant -1.Two time application of Bacillus subtilis basal + 40 DAS @ 2 l plant -1 produced the maximum yield plant -1 and yield plot -1 (2.72 kg and 16.33 kg respectively).

Geethu *et al*. (2018) present an investigation entitled “Effect of organic manures and inorganic fertilizers on plant growth and fruit yield of bitter gourd (Momomordica charantia) under Allahabad agro climatic conditions “cv. Preethi” was under taken at vegetable research field, Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences (SHUATS), Allahabad during kharif season (2017-2018). The experiment was laid out in Randomized block design with 12 treatments and each replicated thrice. The treatments consist different combinations of micronutrients i.e., urea DAP, MOP, FYM, poultry manure, vermicompost. Among these 12 treatments, treatment T8 (25% NPK+2tonnes of vermicompost+5 tonnes of poultry manure) was recorded the maximum vine length (236.41), maximum fruit yield per plant(kg)(2.61), maximum weight of fruits (57.77).T8 is the better treatment combination of applying plant growth and fruit yield of bitter gourd.

Prasad *et al.* (2009) demonstrate an experiment at Horticultural Research Station Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the period between May and August, 2008. The experiment was laid out in randomized block design with three replications. Seeds of bitter gourd cv. Pusa Vishesh were sown at the spacing of 1.5 m (row to row) x 60 cm (hill to hill). Treatments consisting

of *Azotobacter*, PSB and Nitrogen with their different combinations were used in the experiment. Bio-fertilizers namely, azotobacter and PSB each @ 200 g for one kg seed were used as seed treatment. Observations were recorded in respect growth, flowering, yield attributing characters and fruit yield from selected vines and analyzed statistically according to the method described by Panse and Sukhatme (1978).Among the different treatments azotobacter + PSB + 20 kg N/ha (T6) recorded to be superior for number of branches, nodes per vine and length of vine followed by azotobacter + PSB (T5). Maximum length of internodes was also recorded under T6.

Mulani *et al*. (2007) conducted an experiment in Rahuri, Maharashtra, India, during the kharif season of 2004 to study the effects of organic manures and biofertilizers on the growth, yield and quality of bitter gourd (*M. charantia*). The combined application of organic manures and biofertilizers had beneficial effects on bitter gourd production. Among the organic N sources, poultry manure was more effective than farmyard manure and neem cake at different levels and combinations. The application of 25% nitrogen through neem cake and 75% through poultry manure was superior in the enhancement of the growth, yield and quality parameters of bitter gourd: average vine length (5.38 m), fruit weight (84.80 g), fruit length (26.94 cm), fruit girth (3.48 cm), pulp thickness (1.03 cm), number of fruits per vine (63.11), fruit yield (263.33 kg/ha) and shelf life (7.33 days).

Suresh *et al*. (2018) investigate the effect of organic nutrients on certain growth and yied characters of bitter gourd (*Momordica charantia* L.) ecotype Mithipagal through organic nutrient management practices was carried out at the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2016-17.The experiment comprised of 13 treatments replicated thrice was executed following the principles of Randomized Block Design. Results of the experiment revealed that the application of vermicompost @ 5t ha-1 and sea weed extract 3% along with *Azospirillum* @ 2 kg ha-1 improved the growth, yield and quality performance of bitter gourd ecotype "Mithipagal". Among the treatments, T5 (vermicompost 5t + sea weed extract 3% + *azospirillum* 2kg ha-1) selected the highest in growth parameters *viz.*, vine length, number of primary branches, number of leaves per plant. It was closely followed by T2 (vermicompost 5t + humic acid 2% + *Azospirillum* 2 kg ha-1). Regarding with yield characters fruit weight, fruit yield per

plant (36.39 kg) and fruit yield per ha (2.92 t). And it was followed by T2 which registered the yield per plant (35.35 kg) and fruit yield per ha (2.72t).

Pot experiment was accompanied by Kumar *et al*. (2015) to evaluate the effect organic manure (Farm Yard Manure, vermicompost and press mud) and biofertilizers (*Azotobacter*, phosphate solubilizing bacteria and *Azospirillum*) on growth and quality factors of strawberry. The experiment was tested in Complete Randomized Design (CRD) with three replications and consisted of ten treatments namely T1 (FYM + Azotobacter), T2 (FYM + PSB), T3 (FYM + Azospirillum), T4 (Vermicompost + Azotobacter), T5 (Vermicompost + PSB), T6 (Vermicompost + Azospirillum), T7 (Pressmud + Azotobacter), T8 (Pressmud + PSB), T9 (Pressmud + Azospirillum) and T10 (Control). Each treatment combination has exposed significant effects on most of the parameters, but the combination of vermicompost and PSB showed highest plant height (23.59 cm), leaves plant-1 (12.67), primary branches plant-1 (10.50), secondary branches plant-1 (27.35), first flowering (61.06 days), flowers plant-1 (15.33), first fruit setting (72.80 days) and fruits plant-1 (8.33). Similarly, the treatments combination of vermicompost and PSB significantly synthetic the Total Soluble Solids (TSS) (10.75° Brix), titrable acidity (0.82), vitamin C (57.24 mg/100gm fruit), total sugars (5.95 %) and juice content (79.50 %).

Ekinci *et al*. (2014) carried out an experiment to decide the effects of nanotechnology liquid fertilizer on the plant growth and yield of cucumber (*Cucumis sativus* L.). The doses of 2.0, 3.0 and 4.0 L ha-1 of Nanonat and Ferbanat were recycled as fertilizer source. The plant leaves were sprayed with Nanonat and Ferbanat suspension until becoming wet at ten day intermissions for three times during plant growth. The results showed that the fertilizer treatments significantly improved the yield related to control. The highest yield (149.17 t ha-1) occurred in Ferbanat 4.0 L ha-1 application. As a result, 7 this study proposed that the foliar applications of liquid fertilizer could improve the plant growth and yield of cucumbers.

Mehdizadeh *et al*. (2013) conducted an experiment to evaluation the vegetative growth yield quantity of tomatoes as affected by different organic fertilizers. The results showed that adding of organic fertilizers at rate of 20 ton ha-1 significantly increased tomato growth and yield compared to control (no fertilizer application). Also obtained results demonstrated that tested treatments could be arranged in

decreasing order as follows: municipal waste compost>poultry manure>cow manure>sheep manure>no fertilizer. Compost and poultry manure had a synergistic effect on both fresh and dry weights of tomato shoots and roots and related to other treatments. As a general result using of organic fertilizers especially in composted form had positive effect on soil health and fertility, which consequent proliferation yield in long term can be expected.

Uddin *et al.* (2015) stated the performance of strawberry as affected by different organic manure. The experiment was conducted with 13 treatments and 3 replications. The treatment T4 (RDF + Vermicompost 5 t/ha + Neem Cake 4 t/ha) was found significantly superior compared to other treatment combinations, which recorded highest mean value of plant height (21.20cm), plant spread (26.62 cm2), number of leaves per plant (16.23), petiole length (13.93cm), number of fruits per plant (4.20) and average fruit weight (19.51g). The highest yield per plant (286.56g) and yield per hectare (17.19 t/ha) were also obtained from treatment T4 (RDF + Vermicompost 5 t/ha + Neem Cake 4 t/ha) followed by T3 (RDF + Vermicompost 5 t/ha + Neem Cake 2 t/ha) and lowermost yield was obtained from T0 (control).

Rasool *et al*. (2008) obtained that vermicompost at rate of 15 t/ha significantly improve growth, yield of bitter gourd compared to other treatments (0, 5, 10 t/ha). It also increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe and Zn in the plant tissue increased 55, 73, 32 and 36% relate to untreated plot respectively Vermicompost applications in strawberries can progress helpful microbial populations, which rise production of plant growth hormones auxin, gibberellin, cytokinin and humic acid. Several experiments in strawberry have designated that these hormones and acids may develope plant growth, leaf area, shoot biomass, number of flowers and runners (Arancon *et al.*, 2004) and yield (Arancon *et al*., 2004). According to Arancon *et al*. (2006) vermicompost uses are recognized to improve microbial biomass N and protect fruit marketability through reduction in physiological disorders and fruit disease.

Subbaiah *et al*. (1985) conducted an trial with tomato and bitter gourd to evaluate the effect of FYM and micronutrients lower than soil fertility status. The author determined that the main object for extended mean fruit weight and fruit yield by the

application of FYM with NPK and vermicompost was attributed to solubilization effect of plant nutrients by the addition of vermicompost and FYM leading to highly uptake of NPK.

Sharhan *et al*.(2008) conducted this study, at the Vegetable Research Farm, College of Agriculture, University of Dhok, Iraq during spring season of 2009, was to obtain high production with better quality of two summer squash cultivars (Mullah Ahmed No.1 and Sucheimie No. 2) by using a bio-fertilizer i.e. Azotobacter with a control treatment, and three levels (0, 1.5 and 3.0 t dunam -1 ; 1 dunam equals 0.1 hectares) of an organic fertilizer i.e. heep residues, thus making a total of 12 treatments. The experiment was implicated in a Factorial Randomized Complete Block Design (F-RCBD) and replicated three times. Data were collected on vegetative parameters of summer squash plants including plant height (cm), number of branches plant -1 , number of leaves plant -1 , fresh weight of the plants, dry weight of the plants, and total chlorophyll; and also on yield characteristics such as number of fruits plant -1 , fruit length (cm), fruit diameter (cm), percent TSS, early yield (kg plant -1) and total yield (t dunam -1). The results revealed that Azotobacter alone or in combination with sheep residues had significant effects on vegetative (shoot) parameters, and substantially improved the quantitative and qualitative traits of fruit yield of the two cultivars. The interaction effect of both the bio and organic fertilizers was also significant and resulted in best performance of both the summer squash cultivars in terms of vegetative as well as reproductive character

CHAPTER III

MATERIALS AND METHODS

This chapter demonstrates information regarding methodology that was exploited in accomplishment of the experiment. It encompasses a brief outline of the location of the experiment, climate conditions and the materials used for the experiment. It also flourishes the treatments of the experiment, data collection and data analysis procedures

3.1 Experimental site:

The research was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University. The study was carried out during the period from November2019 to May 2020 at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. It lies within the $23^0$74' N latitude and $90^0$35' E longitudes with an elevation of 8.2m from sea level (FAO) in the Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Climatic condition

The Experimental site was located in the subtropical monsoon climatic zone, characterized by a heavy rainfall during the months from April to September (Kharif season) and a scantly rainfall during the rest of the year Rabi season (7.7-65.8mm) . Plenty of sunshine and moderately low temperatures prevail during October to March (Rabi season)(32-14)^{0}c (Appendix VI), which is suitable for bitter gourd growing in Bangladesh. Temperatures above 25^0c accompanied by high humidity and strong wind, result in reduced yield. Night temperature above 20ºC accompanied by high humidity and low sunshine lead to excessive vegetative growth and poor fruits production. High humidity leads to a greater incidence of pests and diseases and fruit rotting. Summer season is therefore preferred for bitter gourd production. But in winter the price of bitter gourd turn into double. So farmer cultivate this high demanding vegetable though its yield is a little bit lower than summer season.

3.3 Geology and Soil

The inherent soil character closely related to "The Modhupur Tract", AEZ-28. Upper layer of soil was silt clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The area was well furnished with irrigation and drainage network and above level. The selected plot was medium high land. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI),Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 6.2 and 1.16, respectively. The results showed that the soil composed of 28% sand, 42% silt an 30% clay (Appendix VII).

3.4 Planting materials

Seeds of Bitter gourd a local variety were collected from a local nursery Agargaon, Dhaka-1207 named korola Hasan-2. This is a product of Siddique Seed Corporation.

3.5 Treatments of the experiment

The experiment comprised of two factors

Factor A: Fertilizer (4 levels)

T_0: Control i.e. no fertilizer
T_1: Organic (kitchen compost @1000 kg/ha)
T_2: In-organic (N_{46} P_{40} K_{45}) Kg/ha
T_3: Organic (kitchen compost @1000 kg/ha) + in-organic (N_{23} P_{20} K_{23}) kg/ha

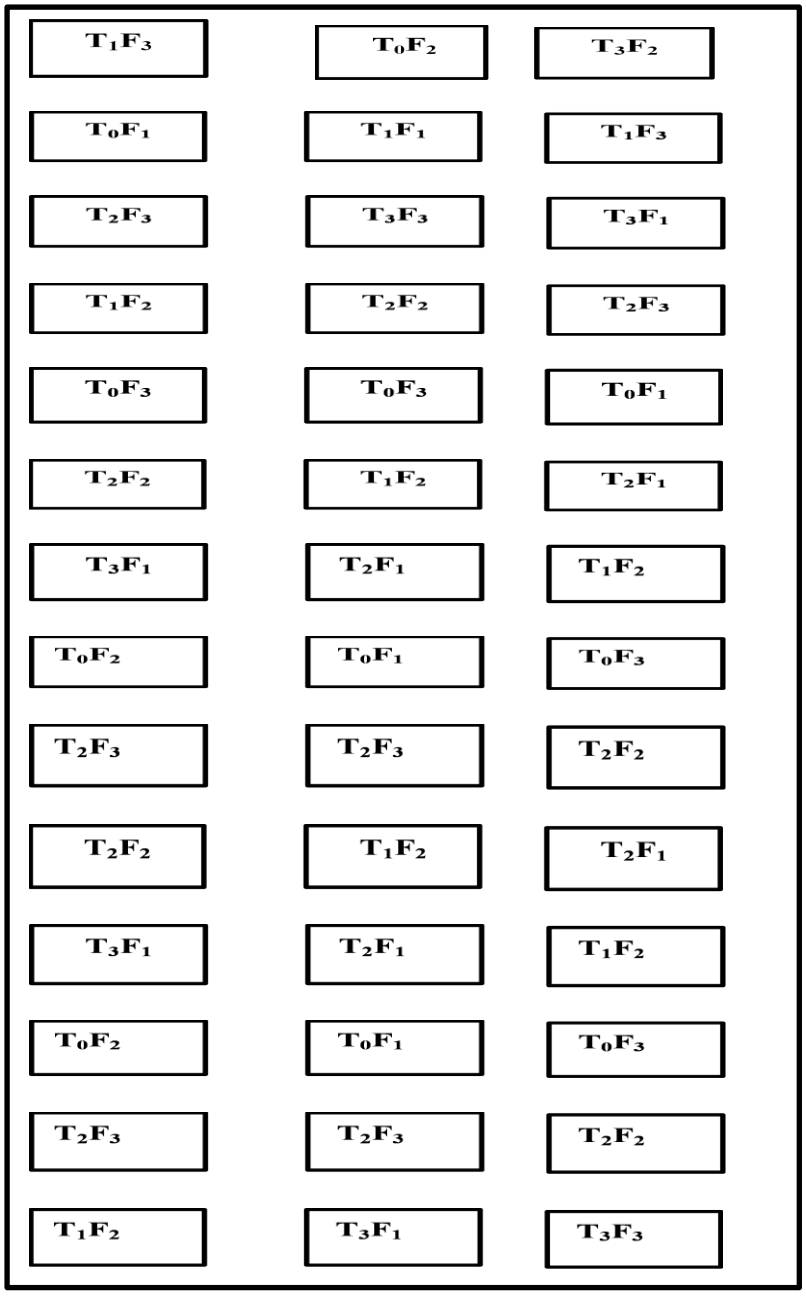
Factor B: Bio-fertilizer application method (3 levels)

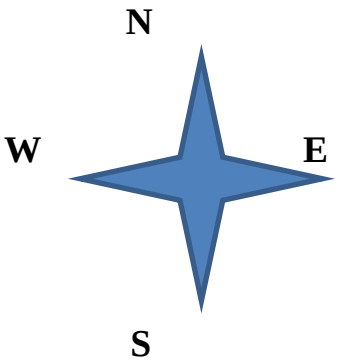
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed

F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.

F_3: Soil treatment with bio-fertilizer @ 0.046 g/m^2.

There were in total 12 (4×3) treatment combinations such as T_0F_1,T_0F_2, T_0F_3,T_1F_1,T_1F_2,T_1F_3,T_2F_1,T_2F_2,T_2F_3,T_3F_1,T_3F_2,T_3F_3





Plot Size-1.8×1.8

Row to Row Distance 1m

Factor A: Fertilizer (4 levels)
i) T_0- control
ii) T_1 – organic fertilizer
iii) T_2- In-organic fertilizer
iv) T_3 -Organic + Inorganic fertilizer

Factors B: Bio-fertilizer application method (3 levels)
i) F1- seed treatment with bio-fertilizer
ii) F2-seedling treatment with bio-fertilizer
iii) F3-soil treatment with bio-fertilizer

Fig: 1.Field layout

3.6 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into three blocks and consisted of 36 plots. Each unit plot in from of raised bed was 3.24 m^2 (1.8m x 1.8m) in size. Altogether there were 36 unit plots in experiment and required 116.64 m^2 land. Row to row and plant to plant distance were 1 m and 25 cm respectively. The treatments were randomly assigned to each of the block. Each unit plot had 2 rows and each with 3 plants. So there were 6 plants per unit plot.

3.7 Land preparation

The land was first started to prepare at 15th November 2019 with the power tiller. Ploughed soil was brought into desirable fine tilth by ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 22th November and 25th November, 2019, respectively. Experimental land was divided into unit plots following the experimental design.

3.8 Manures and fertilizer application

The chemical fertilizers like Urea (100kg), TSP(200kg), M_OP(90kg) were mixed with soil as the source of nitrogen, phosphorus and potassium were used during final land preparation (BARI, 2011). Organic kitchen compost @ 1000 kg/ha and bio-fertilizer @ 0.046 g/meter square .All this fertilizer were used according to the recommended combination as basal dose. Only urea was applied at 30 days interval on inorganic with biofertilizer combination. Kitchen compost was applied just after weeding and before flowering.

Plate 1: Image of fertilizer which was used

Biofertilizer was collected from chemicon bio-product company located at Gazipur. Azotobactor Rhizobium,PSB,SSB and Azospirillum is the element of this biofertilizer. Chemical fertilizer was collected from the local market. Kitchen compost was collected from Anumar Agro. Innovation company located at Kushtia.

3.9 Sowing of seeds on main plot:

Seeds were sown in main plot at 27 November on the field. Germination completed within 09 December. Seeds were sown @ 5.5kg/ha.

3.10 Sowing of seeds and transplanting of seedling for treatment F_2

Seeds were sown in polybags having compost mixed soil on 27 November 2019 for germination and seedling raising. Two seeds were sown in each polybag. The polybags were kept in shady place. They were watered regularly during the seedling raising period. When the seedlings (15 days old) attained 4 leaves and hard enough, they were transplanted in the main field on 24 December 2019.It takes too much time because of hard seed coat and worst weather.

3.11: Intercultural operations

3.11.1 Gap filling

Weak ,dead and injured seedlings were replaced by new vigor seedling from the same stock of the experiment.

3.11.2 Weeding

Weeding was operated after a certain period to prevent competition between the plants and weeds. Weeding was done with a hoe about four times during the study period. First weeding was carried out four weeks after sowing and the second , third and fourth weeding were carried out about 25 days interval respectively. First weeding of seedling treatment was done at 25 days after transplanting. Then it became regular with main field.

3.11.3 Irrigation

Flood irrigation was commonly practiced during the experimental period. At the early stage only the plots was irrigated but at flowering and fruiting stage the whole land was irrigated. For better growth and yield irrigation has been successfully applied throughout the growing season.

Plate: 2.This image was captured during irrigation

3.11.4 Vine management

The tendering vine of the plants fell down from the supports (Trellis) when it became larger. For proper growth and development of the plants the vines were managed upward with the help of thick thread by hand.

3.11.5 Trellis

Six bamboo poles were set straightly keeping 5 feet high from the ground level in every plot. The poles were connected to one another tightly by nylon rope in such a way that they make rectangular shaped. A net from rope were placed on this rope. Thus a trellis for each plot was made for creeping of the vines.

3.11.6 Pest control

For protection from the attack of insects-pests specially fruit flies and fruit borer neem liquid pesticide was used at 7 days interval. To protect from fungus ashes was used several times.

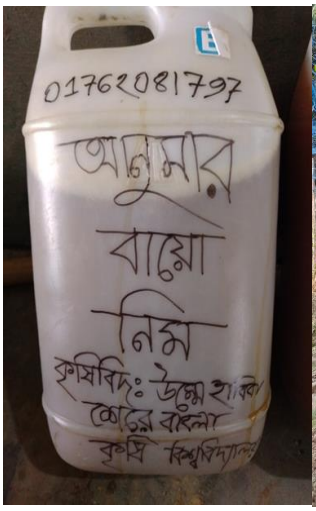


Plate: 3.Image of bio neem was used Plate: 4. Yellow sticky trap

3.12 Harvesting

The plant bears flowers and fruit within 85-90 days after sowing of seeds and the fruit goes to edible stage 10-15 days after fruit setting. The tender fruits are harvested, which is helpful for increasing the number of flower. Picking of fruit at the right edible maturity stage but it dependent upon individual kinds and varieties. It takes a lot of time because it is a summer vegetable but cultivated in winter. At first the growth was very slow. It also took a long time to germinate because of hard seed coat. Harvesting was continued for two and a half month

Plate: 5. Bitter gourd (just after harvest)

3.13 Collection of experimental data

Data were recorded on the following parameters.

Growth related parameters

Plant height (cm), no. of leaves/plant, no of branches /plant and length of inter-node (cm)

Flowering related parameter: Days to first female flower initiation

Yield related parameters

No of fruit per plant ,fruit length (cm) ,fruit diameter (cm),yield / plant (kg),yield / plot (kg) and yield ton /hectare

3.13.1 Plant height (cm)

Plant height was measured with a ruler. It was done by measuring the plant from the base at the ground level to the terminal growth point. The height was recorded for the sampled plants and the mean was determined by dividing the total heights with total number of plants at final harvest.

3.13.2 Number of leaves per plant

This was determined by single counting the mature leaves per plants and average was taken at mature stage.

3.13.3 Days to 1st female flower open

Each plot was daily observed to record the date of first female flowering. The period from sowing and transplanting to the date of first flowering was recorded and

expressed in term of number of days. The average values per line were calculated on plot basis.

Plate: 6.First female flower open

3.13.4 Number of fruits per plant

The number of fruits in every plant of bitter gourd was counted at every harvest and thus the total number of fruits per plant was recorded and average number of fruits was calculated.

3.13.5 Number of branches

Number of branches per plant was counted from 60 DAS and average was calculated.

3.13.6 Length of fruit (cm)

Length of fruit was measured by using a measuring scale. Then the average length was calculated

3.13.7Diameter of fruit (cm)

Diameter was measured by slide calipers.

3.13.8 Yield /plant (kg)

Fruit yield/ plant were calculated from weight of total fruits divided by number of total plants.

3.13.9 Yield/plot (kg)

Fruit yield/ plot were calculated by multiplying the weight of fruit per plant with total number of plant of that plot.

3. 13.10 Yield ton / ha

Yield ton/ ha was computed and expressed in ton per hectare.

3.13.11 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of planting time and organic manure. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 14% in simple rate. The market price of bittergourd was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

BCR (Benefit cost ratio) = Gross return /Total cost of production

3.13.12 Statistical analysis

The data obtained for different characters on effect of organic and in-organic fertilizer with different bio-fertilizer application method on growth and yield of bitter-gourd in winter season were statistically analyzed to find out the significance of the difference. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was performed to evaluate growth and yield of bitter gourd and its yield performance against fertilizer (organic and inorganic) with different bio-fertilizer application method . Findings of the research work have been presented and discussed in this chapter. Illustration of this chapter has been focused by tables and figures to enhance their parallel and dissimilar character through discussion, comprehension and perceiving. A summary of the analysis of variances in regard to all parameters have been shown in appendix. Results have been presented, discussed and possible interpretations are given under the following headings.

4.1 Plant height (cm)

It is considered that plant height is the most influential parameter among others, which is positively correlated with the yield of bitter gourd. Plant height was recorded at 75 DAS,due to covid-19 pandemic data before final harvest could not be taken. Fertilizer(organic and inorganic) influence plant height of bitter gourd and height of bitter gourd exposed statistically significant (Appendix I). The mean plant height ranged from 93.08cm to 249.67cm. Highest plant height (249.67cm) was collected from T_3 treatment whereas lowest plant height (93.08cm) (Fig 2) was in T_0 treatment at 75 days after sowing of different bitter gourd. Study referred that organic compost increase plant height and judgment represents similar findings to Federico *et al.* (2007).From the above findings it becomes apparent that growth character plant height of bitter gourd depend on proper supply of nutrition. In addition to application of kitchen compost is rich in plant nutrients and these are released slowly and consistently for continuous use by plants.

Application method of bio-fertilizer also influence the plant height of bitter gourd and plant height showed statistically significant (Appendix I). The highest plant height was recorded (219.02cm) at F_3 (soil treatment) whereas lowest plant height (154.83cm) (Fig:3) was recorded in F_2 treatment at 75 DAS of different bitter gourd. In addition to application of bio-fertilizer azotobactor fixed extra amount of atmospheric nitrogen which enhance the vegetative growth resulting in higher

photosynthetic activity. Besides Phosphate solubilizing bacteria converted the soil phosphorus into available form required for the plants and the factors may be reasoned to better result of growth character under F_3 treatment in the present experiment.

Combined effect of fertilizer and different bio-fertilizer application method showed statistically significant variation in terms of plant height of bitter gourd (Appendix I). The maximum plant height was (299.69cm) observed in T_3F_3 treatment whereas the minimum (90.67cm) plant height was recorded in T_0F_1 treatment at 75 days after sowing of different bitter gourd (Table 1)Study referred that Effect of Kitchen Waste Compost and Vermicompost in Combination with Chemical Fertilizer on the Production of Summer Bottle Gourd represents similar findings by Rahman *et.al*.(2019).

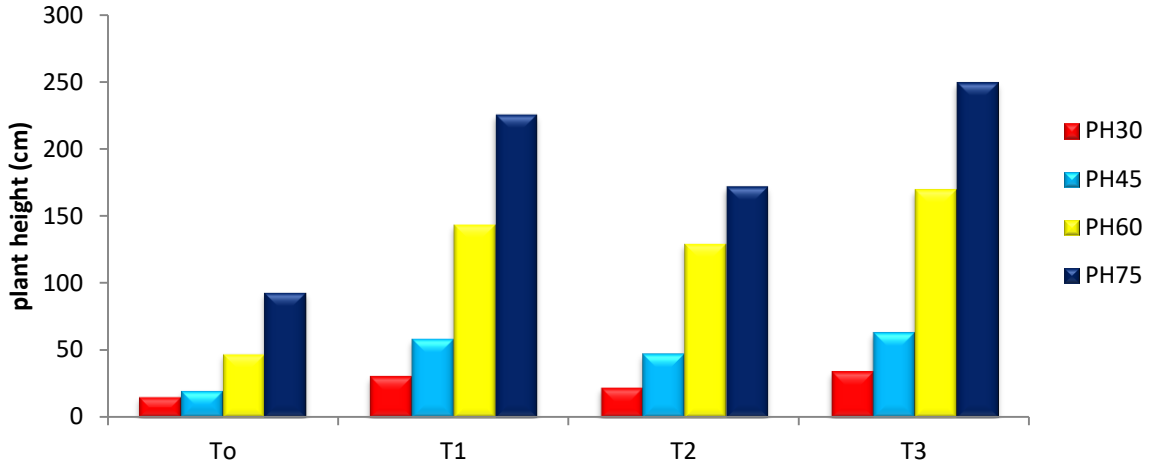


Fig :2. Effect of fertilizer on plant height(cm) of bitter gourd

Here:
T_0: control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:in-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23})kg/ha

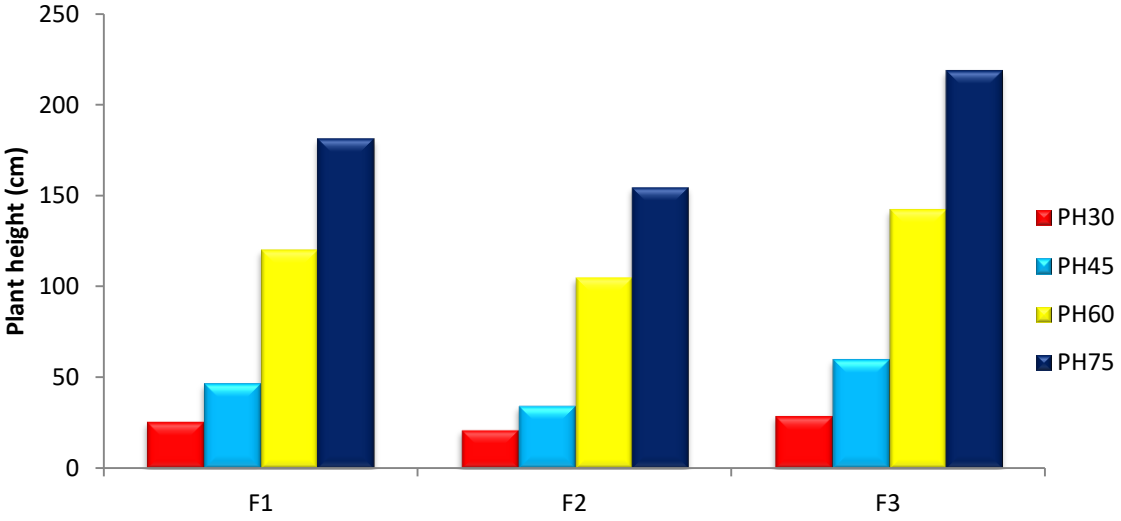


Fig :3. Effect of different bio-fertilizer application method on plant height (cm)

Here:

F_1: Seed treatment with bio-fertilizer @100ml/250g seed

F_2: Seedling treatment with bio-fertilizer @ 400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table : 1 Combined effect of fertilizer(organic and inorganic) and different bio-fertilizer application method on plant height (cm)

Treatments	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
T_0F_1	15.83 i	20.00 j	44.53 l	90.67 l
T_0F_2	13.42 j	18.61 k	50.03 j	92.69 k
T_0F_3	15.75 i	20.64 j	47.33 k	95.89 j
T_1F_1	29.42 d	55.89 e	135.58 f	210.14 d
T_1F_2	25.75 f	44.50 f	114.33 h	172.00 h
T_1F_3	34.83 c	74.25 b	181.00 b	295.00 b
T_2F_1	20.42 g	41.11 g	120.97 g	174.78 g
T_2F_2	18.08 h	35.55 i	110.78 i	155.75 i
T_2F_3	26.58 e	65.42 d	156.42 d	185.50 f
T_3F_1	36.00 b	70.17 c	179.75 c	250.44 c
T_3F_2	26.77 e	38.94 h	144.66 e	198.89 e
T_3F_3	37.86 a	79.86 a	184.58 a	299.69 a
CV %	7.41	8.67	8.25	9.98
LSD (0.05)	0.74	0.96	0.81	0.78

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

4.2 Number of leaves per plant

Significant variation was recorded due to different fertilizer application at 75 days after sowing (Table 2 and Appendix I), the maximum number of leaves per plant (87.48) was found from T_3 treatment Whereas the minimum number of leaves per plant (12.76) was recorded from T_0 treatment (Table 2) .Benzioni *et al*. (1991) also reported similar findings from their earlier experiment which showed that early planting increased number of leaves per plant.

Due to different application method of bio-fertilizer a significant variation was recorded at 75 DAS (Appendix I). The maximum number of leaves per plant (55.64) was found from F_3 treatment which was statistically identical with F_1 treatment Whereas the minimum number of leaves per plant (50.39) was recorded from F_2 treatment (Table 3).Microbes like fungi, bacteria, yeasts, actinomycetes, algae etc are capable of producing auxins, gibberellins etc in appreciable quantity during vermicomposting (Brown, 1995; Arancon *et al*., 2004), which affects plant growth appreciably (Arancon *et al*., 2006).

Combined effect of organic and inorganic fertilizer with different bio-fertilizer application method showed statistically significant variation in terms of leaf number of bitter gourd (Appendix I). The maximum leaf number was (92.99) observed in T_3F_1 treatment whereas the minimum (11.28) leaf number was recorded in T_0F_1 treatment at 75 DAS of different bitter gourd (Table 4) Mehdizadeh *et al*. (2013) also reported similar findings from their earlier experiment

Table: 2 Effect of fertilizer (organic and inorganic) related to leaf number of bitter gourd at different days after sowing.

Treatments (Fertilizer)	Number of leaves per plant			
	30 DAS	45 DAS	60 DAS	75 DAS
T_o	3.56 c	5.61 d	10.21 d	12.76 c
T_1	9.03 a	12.36 c	20.67 c	57.39 b
T_2	8.28 b	14.56 b	21.95 b	57.74 b
T_3	8.61 ab	15.52 a	25.67 a	87.48 a
CV %	8.16	10.97	10.68	11.58
LSD (0.05)	0.42	0.35	0.49	0.45

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

T_0:Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3:Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha

Table: 3 Performance of different bio-fertilizer application method on bitter gourd related to Number of leaf at different DAS

Treatments (Method)	Number of leaves per plant			
	30 DAS	45 DAS	60 DAS	75 DAS
F_1	7.39 b	11.93 b	18.37 b	55.48 a
F_2	5.92 c	10.56 c	18.01 b	50.39 b
F_3	8.79 a	13.54 a	22.49 a	55.64 a
CV %	8.16	10.97	10.68	11.58
LSD (0.05)	0.37	0.30	0.42	0.39

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table: 4 Combined effect of organic, inorganic fertilizer and different bio-fertilizer application method on number of leaf per plant of bitter gourd.

Treatments	Number of leaves per plant			
	30 DAS	45 DAS	60 DAS	75 DAS
T_0F_1	2.42 f	4.08 j	9.22 i	11.28 k
T_0F_2	4.17 e	6.00 i	10.42 h	13.07 j
T_0F_3	4.09 e	6.75 h	11.00 h	13.92 i
T_1F_1	8.83 b	11.25 f	15.83 g	60.12 e
T_1F_2	7.08 c	10.58 g	19.07 f	54.96 g
T_1F_3	11.17 a	15.25 c	27.10 ab	57.11 f
T_2F_1	9.17 b	14.00 d	22.08 e	57.55 f
T_2F_2	6.42 cd	12.92 e	19.55 f	54.11 h
T_2F_3	9.25 b	16.75 b	24.22 c	61.55 d
T_3F_1	9.17 b	18.39 a	26.33 b	92.99 a
T_3F_2	6.00 d	12.75 e	23.00 d	79.44 c
T_3F_3	10.67 a	15.42 c	27.66 a	89.99 b
CV %	8.16	10.97	10.68	11.58
LSD (0.05)	0.75	0.60	0.85	0.78

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

4.3 Branch number:

Number of branches per plant of bitter gourd was varied significantly due to the different levels of manure and inorganic fertilizer application (Appendix II).The maximum number of branches per plant was obtained from T_3 treatment (13.65) and the minimum number of branches was in T_0 (.94) at 75 DAS (Table :5).Organic manure might have reduced soil compactness and improve soil aeration which help better root growth and development which helps in absorption of major and minor nutrients. These may be reasoned to better plant growth and increased number of branches per plant. Present findings is in agreement with the findings of Reddy and Rao (2004) in bitter gourd production.

Highly significant variation was found in respect of total number of branches per plant at 75 DAS due to different method of bio-fertilizer application practice (Appendix II). The maximum number of branches per plant was obtained from F_3 treatment (11.09) and the minimum number of branches was in F_2 (7.12) which was statistically identical to F_1 at 75 DAS (Table 6) .These might be application of bio-fertilizer contained living cells or of efficient strains of micro-organism with decompose organic substance that help plants uptake of nutrients by their interaction in the rhizosphere. They help in restoring soil health and thus provide plant growth and development. This result is an agreement with the findings of Prasad *et al*. (2009) in bitter gourd.

Combined effect of organic, inorganic fertilizer and different bio-fertilizer application method showed statistically significant variation in terms of branch number of bitter gourd (Appendix II). The maximum branch number was (17.99) observed in T_3F_3 treatment whereas the minimum (0.75) branch number was recorded in T_0F_2 treatment at 75 DAS which is statistically identical to T_0F_1 and T_0F_3 treatment (Table 7) respectively. Study referred that effect of plant growth promoting rhizobacteria on growth and yield of bitter gourd represents similar findings by Kumar *et.al*. (2015).

Table: 5 Performance of fertilizer (organic and inorganic) related to branch number of bitter gourd at different days after sowing.

Treatments (Fertilizer)	Number branches per plant	
	60 DAS	75 DAS
T_o	0.35 c	0.94 d
T_1	2.95 b	9.10 c
T_2	3.05 b	10.20 b
T_3	5.61 a	13.65 a
CV %	10.45	9.62
LSD (0.05)	0.35	0.41

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:
T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 :Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} $P_{20}K_{23}$) kg/ha

Table: 6 Performance of different bio-fertilizer application method on bitter gourd related to branch number at different days after sowing

Treatments (Method)	Number of branches per plant at	
	60 DAS	75 DAS
F_1	2.96 b	7.21 b
F_2	2.15 c	7.12 b
F_3	3.86 a	11.09a
CV %	10.45	9.62
LSD (0.05)	0.30	0.35

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table: 7.Combined effect of fertilizer (organic and inorganic) and different bio-fertilizer application method on branch number of bitter gourd.

Treatments	Number of branch per plant	
	60 DAS	75 DAS
T_0F_1	0.17 i	1.00 h
T_0F_2	0.33 i	0.75 h
T_0F_3	0.55 i	1.08 h
T_1F_1	2.33 g	6.25 g
T_1F_2	1.53 h	7.90 f
T_1F_3	5.00 c	13.16 b
T_2F_1	3.58 de	8.13 f
T_2F_2	3.00 ef	10.33 d
T_2F_3	2.58 fg	12.14 c
T_3F_1	5.75 b	13.44 b
T_3F_2	3.75 d	9.49 e
T_3F_3	7.32 a	17.99 a
CV %	10.45	9.62
LSD (0.05)	0.61	0.71

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

4.4 Length of inter-node and days to first female flower initiation

Length of inter-node per plant showed highly significant variation influenced by the application of recommended dose of fertilizer (organic and inorganic) (Appendix III).The largest length of internode (8.95cm) was obtained from T_3 treatment and the shortest length of internode (4.76s) was recorded in T_0.On the other hand days to first female flower initiation also showed significantly varied in this treatment (Appendix III). T_0 (control) took the longest time (81.69 DAS) whereas T_3 took the shortest time (70.19 DAS) (Table 8)

Length of inter-node of plant showed highly significant variation influenced by the application of recommended method of bio-fertilizer application (Appendix III).The largest length of internode is (7.86 cm) was obtained from F_1 treatment which was statistically identical to F_3 and the shortest length of internode (6.72cm) was recorded in F_2.On the other hand days to first female flower initiation also showed highly significant variation in this treatment (Appendix III). F_2 (seedling treatments) took the longest time (76.77 DAS) whereas F_3 (soil treatment) took the shortest time (72.52 DAS) (Table 9)

Combined effect of fertilizer and different bio-fertilizer application method showed statistically significant variation in terms of length of inter-node of bitter gourd (Appendix III). The maximum length was (9.99cm) observed in T_3F_3 treatment which was very close to Thakur *et al*. (2018) whereas the minimum (4.19cm) length was recorded in T_0F_3 treatment . On the other hand days to first female flower initiation also showed statistically significant variation in this treatment (Appendix III). T_0F_1 took the longest time (84.83 DAS) whereas T_3F_3 took the shortest time (66.67 DAS) (Table: 10).

Significantly minimum days for first female flower appearance was obtained by the treatment combination of T_3F_3 (organic ,inorganic fertilizer with soil application of bio-fertilizer).On the other hand maximum days was taken in this respect by the control treatment. Earliness might be due to the enhanced production of growth substances like gibberallic acid , indole acetic acid, dihydrozeatin from bio-fertilizer which had positive influence on the physiological activity of plants which could assist the plants to induce female flower: thereby it favorably modified the sex ratio.(Mulani *et al.* 2007)

Table: 8 Effect of fertilizer (organic and inorganic) on length of inter-node and days to first female flower initiation of bitter gourd at different treatment.

Treatments (Fertilizer)	Length of internode(cm)	Days to first female flower initiation
T_o	4.76 d	81.69 a
T_1	8.54 b	73.72 c
T_2	7.49 c	74.39 b
T_3	8.95 a	70.19 d
CV %	8.35	9.27
LSD (0.05)	0.26	0.59

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} $P_{20}K_{23}$) kg/ha

Table: 9 Performance of different bio-fertilizer application method on bitter gourd related to length of inter-node and days to first female flower initiation of bitter gourd at different treatment.

Treatments (Method)	Length of internode(cm)	Days to first female flower initiation
F_1	7.86 a	75.71 b
F_2	6.72 b	76.77 a
F_3	7.72 a	72.52 c
CV %	8.35	9.27
LSD (0.05)	0.22	0.51

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:

F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table: 10 Combined performance of fertilizer (organic and inorganic) and different bio-fertilizer application method on length of inter-node and days to first female flower initiation of bitter gourd at different treatment.

Treatments	Length of internode(cm)	Days to first female flower initiation
T_0F_1	5.18 g	84.83 a
T_0F_2	4.90 g	79.83 b
T_0F_3	4.19 h	80.42 b
T_1F_1	9.45 b	73.83 e
T_1F_2	7.50 e	75.50 d
T_1F_3	8.66 c	71.83 f
T_2F_1	7.80 de	74.42 e
T_2F_2	6.64 f	77.58 c
T_2F_3	8.03 d	71.17 f
T_3F_1	9.00 bc	69.75 g
T_3F_2	7.85 de	74.17 e
T_3F_3	9.99 a	66.67 h
CV %	8.35	9.27
LSD (0.05)	0.45	1.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 :Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha
F_1:Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2:Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3:Soil treatment with bio-fertilizer @ .046 g/m^2.

4.5 Number of fruit per plant, Fruit length and Fruit diameter:

Fertilizer (organic and inorganic) influence on fruit no per plant, fruit length and fruit diameter of bitter gourd are exposed highly significant (Appendix IV). The maximum fruit number per plant (15.47) was recorded from T_3 treatment whereas minimum fruit number per plant (1.68) was recorded from T_0 treatment. (Fig 4). Highest fruit length (23.71cm) also recorded at T_3 treatment and the lowest length

(5.06cm) was recorded at T_0 treatment. Maximum diameter of fruit (3.89cm) recorded at T_3 treatment which is statistically identical with T_1 treatment whereas the minimum (1.13 cm) was recorded at T_0 treatment (Table : 11)

Application method of bio-fertilizer also influence Fruit no per plant, Fruit length and Fruit diameter of bitter gourd and exposed highly significant (Appendix IV). The maximum fruit number per plant (12.86) was recorded from F_3 treatment whereas minimum fruit number per plant (7.82) was recorded from F_2 treatment.(Fig:5). Highest fruit length (17.75cm) also recorded at F_3 treatment and the lowest length (12.09cm) was recorded at F_2. Maximum diameter of fruit (3.31 cm) recorded at F_3 treatment which is statistically identical with F_1 treatment whereas the minimum (2.62cm) was recorded at F_2 treatment (Table: 12)

Combined effect of fertilizer and different bio-fertilizer application method showed statistically significant variation in terms of Fruit no per plant, Fruit length and Fruit diameter (Appendix IV). The maximum fruit number per plant (19.96) was recorded from T_3F_3 treatment whereas minimum fruit number per plant (1.27) was recorded from T_0F_2 treatment which was statistically similar with T_0F_1. Dudhat MA and Patel KD (2020) also show the same result. Highest fruit length (27.11cm) also recorded at T_3F_3 treatment showing a very close result with Abraham *et al*. (2017) and the lowest length (4.49cm) was recorded at T_0F_2 treatment which was statistically similar with T_0F_1 treatment .Maximum diameter of fruit (4.6cm) recorded at T_3F_3 treatment very close to Thakur *et al.* (2018) whereas the minimum (1.00cm) was recorded at T_0F_3 treatment which is statistically identical with T_0F_2 and T_0F_1 treatment (Table: 13). It was observed that treatments rendered their significant effects on all the yield attributes of bitter gourd. Yield attributes normally number of fruit per plant, fruit length, fruit diameter were maximum in combined treatment T_3F_3 and performance of all the yield attributes were under control. The possible reason is due to combined application of organic inorganic and bio-fertilizer. Similar observations were reported by Mulani *et al.* (2007) and Prasad *et al*. (2009) in bitter gourd.

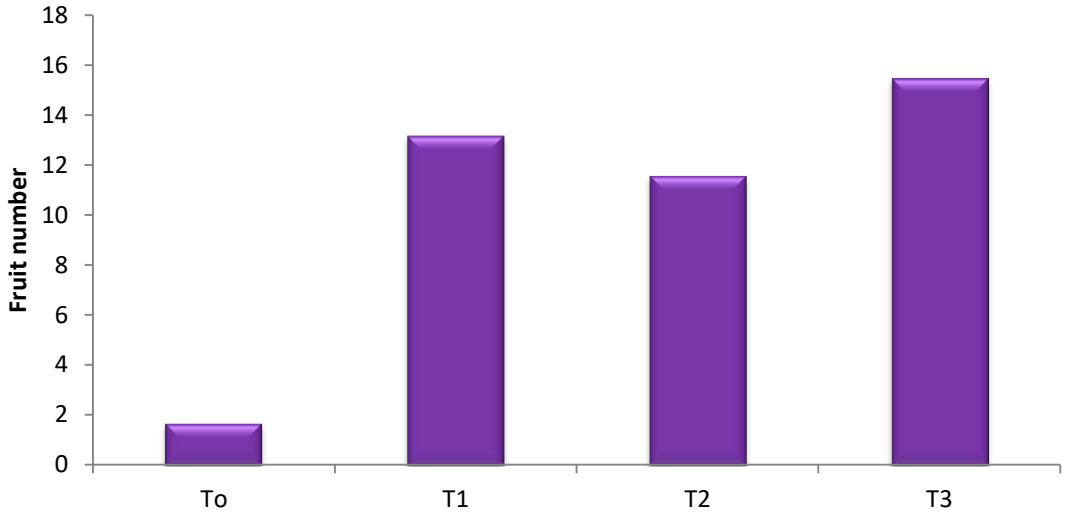


Fig: 4. Effect of fertilizer on number fruit per plant of bitter gourd

Here

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3: Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} $P_{20}K_{23}$) kg/ha

Table : 11 Performance of fertilizer (organic and inorganic) related to fruit length and fruit diameter at different treatment

Treatments (Fertilizer)	Length of fruit (cm)	Diameter of fruit (cm)
T_o	5.06 d	1.13 c
T_1	18.03 b	3.83 a
T_2	13.17 c	3.30 b
T_3	23.71 a	3.89 a
CV %	10.66	11.43
LSD (0.05)	0.50	0.24

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 :Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} $P_{20}K_{23}$) kg/ha

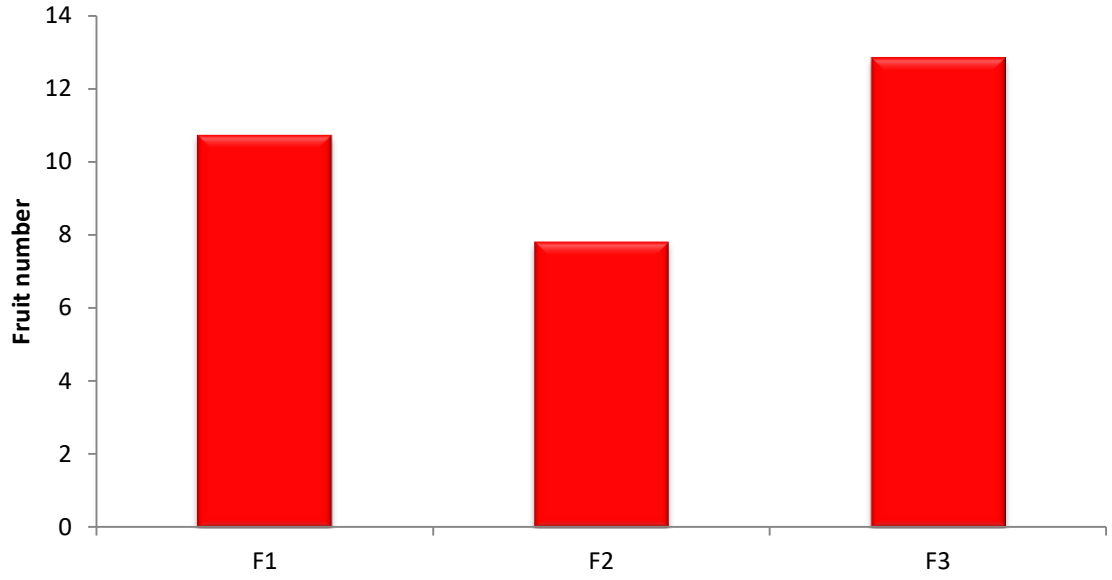


Fig:5. Effect of different bio-fertilizer application method on fruit number per plant

Here
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table: 12 Performance of different bio-fertilizer application method on bitter gourd related to Fruit length and Fruit diameter at different treatment

Treatments (Method)	**Length of Fruit (cm)**	**Diameter of Fruit (cm)**
F_1	15.14 b	3.18 a
F_2	12.09 c	2.62 b
F_3	17.75 a	3.31 a
CV %	10.66	11.43
LSD (0.05)	0.43	0.21

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table: 13 Combined performance of fertilizer (organic and inorganic) and different bio-fertilizer application method on fruit number per plant ,fruit length and fruit diameter at different treatment.

Treatments	Number of fruit per plant	Length of Fruit (cm)	Diameter of Fruit (cm)
T_0F_1	1.75 hi	5.02 ij	1.20 g
T_0F_2	2.03 h	4.49 j	1.19 g
T_0F_3	1.27 i	5.66 i	1.00 g
T_1F_1	13.93 d	18.77 e	3.90 bc
T_1F_2	8.96 g	12.87 g	3.43 de
T_1F_3	16.63 b	22.44 c	4.15 b
T_2F_1	11.54 e	12.74 g	3.67 cd
T_2F_2	9.58 g	10.99 h	2.77 f
T_2F_3	13.58 d	15.78 f	3.47 de
T_3F_1	15.75 c	24.02 b	3.97 bc
T_3F_2	10.71 f	19.99 d	3.10 ef
T_3F_3	19.96 a	27.12 a	4.60 a
CV %	13.65	10.66	11.43
LSD (0.05)	0.64	0.87	0.43

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

4.6 Yield /plant, yield/plot and yield ton/ha:

Fertilizer (organic and inorganic) influence Yield/plants (kg), Yield/plot(kg) and yield ton/ha of bitter gourd are exposed highly significant (Appendix V). The maximum yield per plant (0.88 kg) was recorded from T_3 treatment whereas minimum yield per plant (0.06kg) was recorded from T_0 treatment. Highest yield per plot (5.27kg) also recorded at T_3 treatment and the lowest yield per plot (0.36 kg) was recorded at T_0. (Table 14) . Maximum yield ton/ha (16.27) recorded at T_3 treatment whereas the minimum yield ton/ha (1.10) was recorded at T_0 (Fig 6). From this result

application of organic and inorganic sources of plant nutrients lead the plant growth favourably with the production of more carbohydrates which perhaps accelerated better fruit weight of bitter gourd .The present results are in accordance with the findings of Mulani *et al*. (2007) in bitter gourd.

Application method of bio-fertilizer also influence yield/plants , yield/plot and yield ton/ha of bitter gourd and exposed highly significant (Appendix V). The maximum yield per plant (.70 kg) was recorded from F_3 treatment whereas minimum yield per plant (.40kg) was recorded from F_2 treatment. Highest yield per plot (4.24 kg) also recorded at F_3 treatment and the lowest yield per plot (2.35 kg) was recorded at F_2 . (Table : 15) . Maximum yield ton/ha (12.95) recorded at F_3 treatment whereas the minimum yield ton/ha (7.23) was recorded at F_2 treatment (Fig 7)

Combined effect of fertilizer and different bio-fertilizer application method showed highly significant variation in terms of yield/plants (kg), yield/plot(kg) and yield ton/ha of bitter gourd (Appendix V). The maximum yield per plant (1.05 kg) was recorded from T_3F_3 treatment

Dudhat MA and Patel KD (2020) found same types of result whereas minimum yield per plant (.05kg) was recorded from T_0F_2 treatment which was statistically similar with T_0F_1.Maximum yield per plot (6.30kg) also recorded at T_3F_3 treatment and the lowest yield per plot (.28 kg) was recorded at T_0F_2 which was statistically identical with T_0F_1 and T_0F_3 . Maximum yield ton/ha (19.44) was recorded at T_3F_3 treatment Ashraf *et al*. (2019) also reported same types of result but in this experiment it found a little higher because chemical fertilizer and kitchen compost also used here. Whereas the minimum yield ton/ha (0.86) was recorded at T_0F_2 treatment which was statistically similar with T_0F_1 treatment (Table 16).This result clearly indicated that the integrated nutrient management that is organic fertilizer , minimum uses of inorganic fertilizers with bio-fertilizer helps quick availability of plant nutrient. From organic and inorganic sources balanced C/N ratio synthesis of auxin growth substances, anti-fungal due to azotobactor and conversion of insoluble phosphate to soluble form by PSB perhaps helped to increase fruit yield of bitter gourd and a synergistic interaction among the inputs in the promising treatments might contribute to the result of yield attributes as explained from the findings of Mulani *et al.* (2007) and Kumar *et al*. (2015) in bitter gourd.

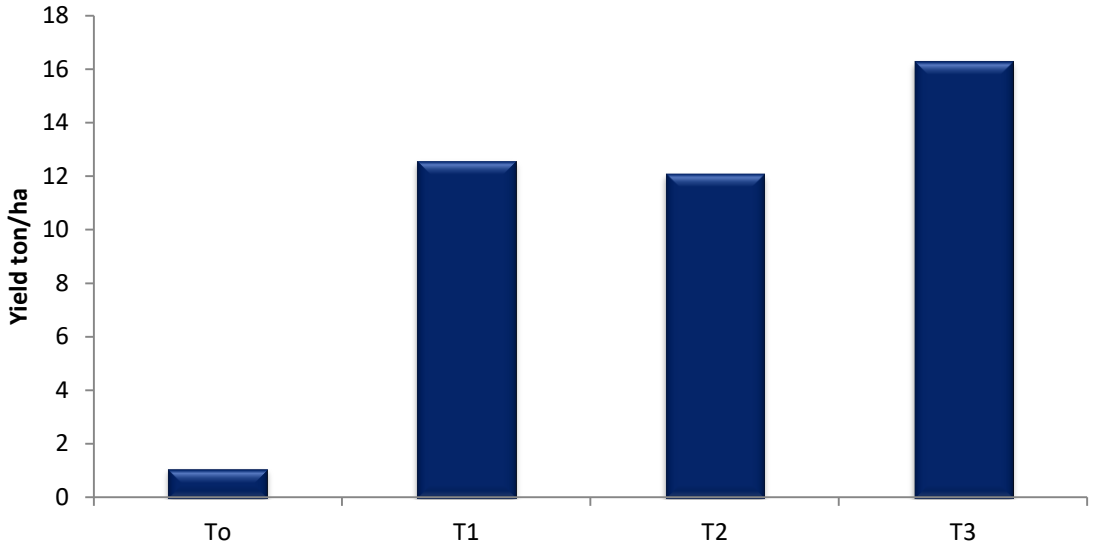


Fig:6. Effect of fertilizer on yield (ton per ha) of bitter gourd

Here:
T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha

Table: 14 Performance of fertilizer (organic and inorganic) related to yield parameter like Yield/plant and Yield/plot at different treatment

Treatments (Fertilizer)	Yield/plant (kg)	Yield/plot (kg)
To	0.06 d	0.36 d
T_1	0.68 b	4.13 b
T_2	0.65 c	3.92 c
T_3	0.88 a	5.27 a
CV %	9.56	12.87
LSD (0.05)	0.01	0.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here:
T_0: Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha

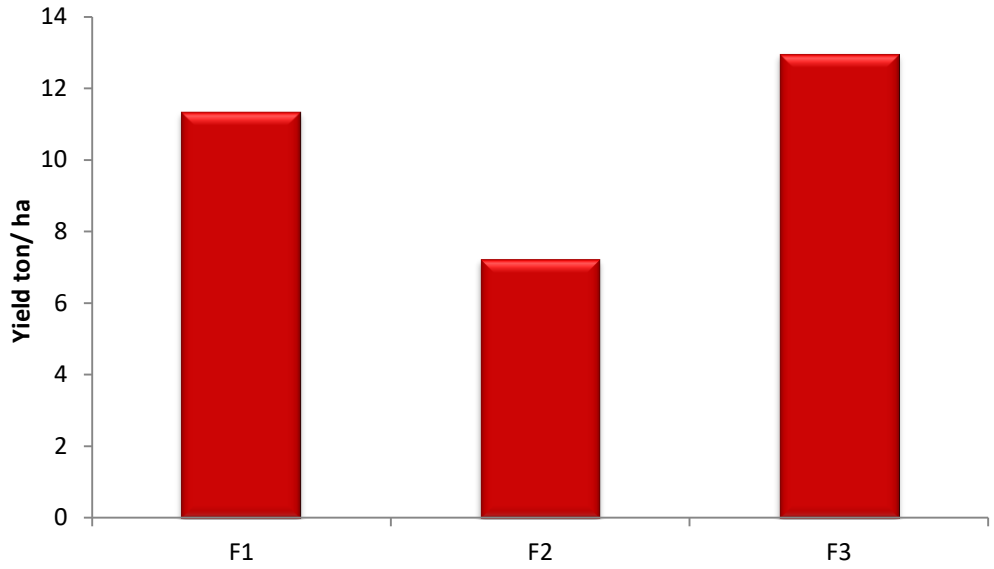


Fig :7. Effect of different bio-fertilizer application method on yield ton per ha of bitter gourd.

Here:
F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table: 15 Performance of different bio-fertilizer application method on bitter gourd related to yield related parameter like yield/plant and yield/plot at different treatment

Treatment (Method)	Yield/plant (kg)	Yield/plot (kg)
F_1	0.61 b	3.67 b
F_2	0.40 c	2.35 c
F_3	0.70 a	4.24 a
CV %	9.56	12.87
LSD (0.05)	0.01	0.09

In a column means having similar letter(s) are statistically similar and those having dissimilar Letter (s) differ significantly at 0.05 level of probability

Here:

F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @ 400 ml/500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Table : 16 Combined performance of fertilizer(organic and inorganic) and different bio-fertilizer application method on Yield/plant (kg) ,Yield/plot (kg) and yield ton/ha at different treatments.

Treatments	Yield/plant (kg)	Yield/plot (kg)	Yield ton/ha
T_0F_1	0.06 jk	0.38 j	1.16 jk
T_0F_2	0.05 k	0.28 j	0.86 k
T_0F_3	0.07 j	0.42 j	1.28 j
T_1F_1	0.75 e	4.50 e	13.88 e
T_1F_2	0.51 h	3.05 h	9.38 h
T_1F_3	0.78 d	4.84 d	14.44 d
T_2F_1	0.66 f	3.96 f	12.22 f
T_2F_2	0.40 i	2.40 i	7.40 i
T_2F_3	0.90 c	5.40 c	16.66 c
T_3F_1	0.98 b	5.86 b	18.09 b
T_3F_2	0.61 g	3.66 g	11.29 g
T_3F_3	1.05 a	6.30 a	19.440 a
CV %	9.56	12.87	9.37
LSD (0.05)	0.02	0.19	0.36

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here

T_0:Control i.e. no fertilize
T_1:Organic(kitchen compost @1000 kg/ha)
T_2:In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 :Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha
F_1:Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2:Seedling treatment with bio-fertilizer @400 ml/500 seedling.
F_3:Soil treatment with bio-fertilizer @ .046 g/m^2.

4.7 Benefit cost ratio:

Maximum benefit cost ratio (3.16) was found at T_3F_3 treatment whereas the minimum (0.60) was found at T_0F_2 treatment. Dudhat MA and Patel KD (2020) also found same types of lowest BCR on their control condition .The maximum gross return (1458000tk) was found from T_3F_3 (T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha.+ bio-fertilizer F_3: Soil treatment with bio-fertilizer @ .046 g/m^2) and the minimum (85600tk) was found from T_0F_2 (T_0: control i.e. no fertilize) (Table 17).

Table: 17 Combined performance of fertilizer (organic and inorganic) and different bio-fertilizer application method on cost and return of bitter gourd

Treatments	Cost of production (tk /ha)	Yield of bitter gourd (ton/ha)	Gross return(tk/ha)	Net return(tk/ha)	Benefit cost ratio
T_0F_1	144849	1.16	116000	28849	.80
T_0F_2	144849	.86	85600	59249	.60
T_0F_3	144849	1.28	128000	16849	.88
T_1F_1	484063	13.88	1179800	695737	2.44
T_1F_2	484506	9.38	797300	312794	1.65
T_1F_3	483896	14.44	1227400	743504	2.54
T_2F_1	437707	12.22	794300	356593	1.81
T_2F_2	438152	7.40	481000	42848	1.09
T_2F_3	437484	16.66	1082900	645416	2.48
T_3F_1	462171	18.09	1356750	894579	2.94
T_3F_2	462617	11.29	846750	384133	1.83
T_3F_3	462005	19.44	1458000	995995	3.16

T_0: Control i.e. no fertilize
T_1: Organic(kitchen compost @1000 kg/ha)
T_2: In-organic(N_{46} P_{40} K_{45})Kg/ha
T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} P_{20} K_{23}) kg/ha

F_1: Seed treatment with bio-fertilizer @ 100ml/250g seed
F_2: Seedling treatment with bio-fertilizer @ 400 ml /500 seedling.
F_3: Soil treatment with bio-fertilizer @ .046 g/m^2.

Gross return = Total yield(ton/ha) *market price

Net return = Gross return – Cost of production

BCR = **Gross return/Total cost of production**

Market price:

Control @ 100tk/kg

Inorganic with bio-fertilizer @65 tk/kg

Organic with bio-fertilizer @ 85 tk/kg

Organic & inorganic with bio-fertilizer @75tk/kg

CHAPTER V

SUMMARY

Bitter gourd is mostly grown mainly in summer. It is a cucurbitaceous crop which is one of the important vegetables in Bangladesh. For higher yield of bitter gourd, nutrient rich and fertile soil is necessary, but deficiency of nutrient due to repeated cultivation, people use different type of chemical and organic fertilizer. Application of organic fertilizer with bio-fertilizer is the best option for growth and yield attributes and environmental perspective.

A field experiment was conducted in the Horticulture Farm of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2019 to May 2020 to study the Influence of bio-fertilizer application method with organic and in-organic fertilizer on growth and yield of bitter-gourd in winter season. The experiment considered of two factors, Factor A: different fertilizer (4 levels): T_0: control i.e. no fertilize T_1:Organic(kitchen compost @1000 kg/ha) ,T_2:in-organic(N_{46} P_{40} K_{45})Kg/ha and T_3 : Organic(kitchen compost @1000 kg/ha) + in-organic(N_{23} $P_{20}K_{23}$) kg/ha and Factor B:Biofertilizer application method(3 levels): F_1: Seed treatment with bio-fertilizer at the rate of 100ml/250g seed ,F_2: Seedling treatment with bio-fertilizer at the rate of 400 ml/500 seedling and F_3: Soil treatment with bio-fertilizer at the rate of .046 g/m^2. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. After emergence of seedlings, various intercultural operations were practiced for easy and smooth growth and development of the plant. Data were collected in respect of the bitter gourd growth related characters, yield and yield contributing characters. The data obtained for different characters were statistically analyzed to find out the significance of the fertilizer and bio-fertilizer application method. In case of fertilizer the tallest (249.67cm) plant at 75 DAS was recorded for the (T_3) treatment and the shortest plant at 75 DAS (93.08cm) was recorded in control condition. On the other hand in bio-fertilizer application method the tallest (219.02cm) plant at 75 DAS was recorded for the (F_3) treatment and the shortest plant at 75 DAS (154.83cm) was recorded in F_2 treatment. . In combination the tallest (299.69cm) plant at 75 DAS was recorded for the (T_3F_3) treatment and the

shortest plant at 75 DAS (90.67cm) was recorded in T_0F_1 condition. The maximum branches (13.65) per plant were recorded in treatment T_3 and the minimum (.94) branch per plant was recorded in control condition. In case of application method of bio-fertilizer the maximum branches (11.10) per plant were recorded in treatment F_3 and the minimum (7.12) branch per plant was recorded in F_2 treatment.In combination the maximum branches (17.99) per plant were recorded in T_3F_3 and the minimum (.75) branch per plant was recorded in T_0F_2 condition. The highest leaf number per plant (87.48) was recorded at treatment T_3 whereas the lowest (12.76) was recorded at treatment T_0. On the other hand In case of application method of bio-fertilizer the maximum leaves (55.64) per plant were recorded in treatment F_3 and the minimum (50.39) leaves per plant was recorded in F_2 treatment and in combination the maximum leaves (92.99) per plant were recorded for the application of treatment T_3F_1 and the minimum (.75) branch per plant was recorded in T_0F_1 treatment. In bio-fertilizer application method the highest length of internode (7.86 cm) recorded in the (F_1) treatment and the shortest length of internode was recorded (6.72cm) in F_2 treatment. . On the other hand in case of fertilizer application highest (8.95 cm) was recorded at T_3 treatment and the lowest (4.76 cm) was recorded at control condition. In combination the largest (9.99cm) was recorded in (T_3F_3) treatment and the shortest (4.19cm) was recorded in treatment T_0F_3. The minimum (70.19 days) time of first female flower was recorded for the application of treatment T_3 and the maximum (81.69 days) time of first female flower was recorded in control condition. In case of application method of bio-fertilizer the maximum (76.77 day) were recorded for the application of treatment F_2 and the minimum (72.52 day) was recorded in F_3 treatment. Maximum fruit number per plant (15.47) was recorded in treatment T_3 where the minimum (1.68) was recorded in T_0 treatment. In case of application method of bio-fertilizer the maximum fruit number per plant (12.86) was recorded at treatment F_3 where the minimum (7.82) was recorded in F_2 treatment. In combination The maximum number of fruit per plant (19.96) was recorded at treatment T_3F_3 where the minimum (1.27) was recorded in T_0F_3 treatment. . In bio-fertilizer application method the highest length of fruit (17.75 cm) was recorded in (F_3) treatment and the shortest length of fruit was recorded (12.09 cm) in F_2 treatment.On the other hand in case of fertilizer application highest (23.71 cm) was recorded at T_3 treatment and the lowest (5.06 cm) was recorded at control condition. In combination the largest (27.11cm) was

recorded in (T_3F_3) treatment and the shortest (4.49 cm) was recorded in treatment T_0F_2. In case of fertilizer the maximum fruit diameter (3.89cm) was recorded for the (T_3) treatment application and the minimum (1.13cm) was recorded in control condition. On the other hand in bio-fertilizer application method the maximum (3.31cm) was recorded for the (F_3) treatment application and the minimum (2.62 cm) was recorded in F_2 treatment. . In combination the maximum (4.6cm) was recorded in (T_3F_3) treatment and the minimum (1.00cm) was recorded in T_0F_3 condition. Maximum yield per plant (kg), per plot (kg) and ton/ha respectively (.88, 5.27 and 16.27) was recorded in (T_3) treatment whereas the minimum (.06, .36 and 1.10) was recorded in (T_0) treatment. In bio-fertilizer application method The maximum yield per plant (kg), per plot(kg) and ton/ha respectively (.70, 4.24 and 12.95) was recorded in (F_3) treatment application and the minimum (.40, 2.35 and 7.23) was recorded in F_2 treatment. And in combination the maximum yield per plant (kg), per plot(kg) and ton/ha respectively (1.05, 6.30 and 19.44) was recorded at T_3F_3 treatment where the minimum (.05, .28 and .86) was recorded in T_0F_2 treatment.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

From the study, it might be concluded that both fertilizer management practices and bio-fertilizer application method had the positive effect up to a certain limit on fruit set and yield of bitter gourd. Among the four treatments of fertilizer application practices significantly the highest positive effect was recorded on plant height , branch number, length of internode, fruit length, fruit diameter, fruit set and yield of bitter gourd from(T_3) treatment (organic and inorganic) fertilizer. Again, among the three treatments of bio-fertilizer application method significantly the highest positive result was obtained on the plant height , branch number, length of internode, fruit length, fruit diameter, fruit set, fruit length and yield of bitter gourd from F_3 treatment (Application of bio-fertilizer on soil)

Thus from results obtained the following recommendations may be forwarded organic and in-organic fertilizer with soil application of bio-fertilizer may be used to get desirable plant height, leaf number, branch number, female flower initiation, fruit set and yield of bitter gourd. The application method may be used to enhance the activity of all fertilizer to get faster growth of bitter gourd.

As plants treated with (organic, inorganic and bio-fertilizer) and bio-fertilizer application method produced higher yield compared to untreated control plants, it may provide substantial benefit to the farmers. From the above findings it is suggested that application of Organic (kitchen compost @1000 kg/ha) + in-organic(N_{23} $P_{20}K_{23}$) kg/ha with soil application of bio-fertilizer @ 0.046g/m^2 for highest fruit yield of bitter gourd .So it may be recommended to the farmer for application, who is not familiar with it yet.

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APPENDICES

Appendix I. Analysis of variance on plant height and leaf number of Bitter gourd at different days after Sowing.

Source of variation	Degrees of freedom (df)	Mean Square of Plant height at different DAS			
		30 DAS	45 DAS	60 DAS	75 DAS
Replication	2	5.533	66.809	0.353	0.486
Factor A (Fertilizer)	3	11.377*	88.242**	7.767**	3.380*
Factor B (Method)	2	16.576*	95.986**	12.098**	5.015*
A x B	6	21.049*	67.771*	4.026*	2.704*
Error	22	6.566	21.538	1.152	0.713
Source of variation	**Degrees of freedom (df)**	**Mean Square of Leaf number at different DAS**			
		30 DAS	45 DAS	60 DAS	75 DAS
Replication	2	3.021	0.787	8.902	20.701
Factor A (Fertilizer)	3	26.481*	44.896**	18.875*	94.121**
Factor B (Method)	2	29.095*	49.280**	25.623**	104.005**
A x B	6	22.282*	19.005*	31.516*	78.951*
Error	22	7.458	6.046	7.932	31.059

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix II. Analysis of variance on branch number of Bitter gourd at different days after Sowing.

Source of variation	Degrees of freedom (df)	Mean square of Branch number at different DAS	
		60 DAS	75 DAS
Replication	2	0.041	5.472
Factor A (Fertilizer)	3	1.262*	101.372**
Factor B (Method)	2	4.093**	125.430**
A x B	6	1.406*	61.426*
Error	22	0.643	21.988

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significan

Appendix III. Analysis of variance on length of internode and Days to first female flower Initiation of bitter gourd.

Source of variation	Degrees of freedom (df)	Mean Square of	
		Length of internode	Days to first female flower initiation
Replication	2	249.51	9.991
Factor A (Fertilizer)	3	1406.03**	97.014**
Factor B (Method)	2	5201.43**	42.570**
A x B	6	411.14*	44.302*
Error	22	132.67	15.549

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non- significant

Appendix IV. Analysis of variance of Number of fruit per plant, Fruit length and Fruit diameter of bitter gourd.

Source of variation	Degrees of freedom (df	Mean square of		
		Number of fruit per plant	Fruit length	Fruit diameter
Replication	2	2.290	2.108	0.021
Factor A (Fertilizer)	3	29.637**	64.250**	16.195**
Factor B (Method)	2	24.808**	75.811**	10.876**
A x B	6	19.771*	35.811*	15.697**
Error	22	7.142	23.237	1.005

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix v. Analysis of variance of yield/plant, yield/plot and yield ton /ha of Bitter gourd.

Source of variation	Degrees of freedom (df)	Mean square of		
		yield/plant	yield/plot	yield ton/ha
Replication	2	3.5	.184	1.208
Factor A (Fertilizer)	3	24.3**	51.504**	21.686**
Factor B (Method)	2	450.2**	72.251**	78.063**
A x B	6	42.8**	61.488**	30.935**
Error	22	5.4	4.196	3.917

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VI: Monthly recorded of air temperature, rainfall, relative humidity and sunshine hours during the period from November 2019 to March 2020.

Year	Month	Average air temperature (^{0}C)		Total rainfall (mm)	Average humidity (%)	Total sunshine hours
		Max.	Min.			
2019	November	29.6	19.2	34.4	53	8
-	December	26.4	14.1	12.8	50	9
2020	January	25.4	12.7	7.7	46	9
-	February	28.1	15.5	28.9	37	8.1
-	March	32.5	20.4	65.8	38	7

Source: Dhaka meteorology center

Appendix VII. Characteristics of Horticulture Farm soil and anumar kitchen compost is analyzed by Soil Resources Development Institute (SRDI), khamar Bari, Farmgate, Dhaka.

A. morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden ,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resources Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
% Sand	28
% Silt	42
% clay	30
Textural class	Silty clay
pH	5.47 –5.63
Organic matter (%)	0.83%
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

C:Physical and chemical properties of kitchen compost

Colour	Dark gray
Physical condition	Non granular
Odour	Absence of foul odour
Moisture	15%
P^H	6.9
Organic carbon	8.6%
Total Nitrogen	1.26
C:N	12:1
Phosphorus (P)	1.5
Potassium (K)	1.56
Chromium (Cr)	19.37ppm
Lead (Pb)	9.45ppm
Nickle (Ni)	7.54ppm

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix VIII. Per hectare production cost of bitter gourd
A. Input cost

Treatments combination	Labour cost	Ploughing cost	Seed cost	Water for plant establishment	Sticking cost	Manure and fertilizer					Insecticide/ pesticides	Sub Total A
						Kitchen compost	Biofertilizer	urea	TSP	M_OP		
T_0F_1	15000	30000	16500	5000	6000	0	0	0	0	0	500	73000
T_0F_2	15000	30000	16500	5000	6000	0	0	0	0	0	500	73000
T_0F_3	15000	30000	16500	5000	6000	0	0	0	0	0	500	73000
T_1F_1	160000	45000	16500	50000	40000	54000	275	0	0	0	12000	377775
T_1F_2	160000	45000	16500	50000	40000	54000	675	0	0	0	12000	378175
T_1F_3	160000	45000	16500	50000	40000	54000	125	0	0	0	12000	377625
T_2F_1	165000	45000	16500	50000	40000	0	275	1600	4400	1350	12000	336125
T_2F_2	165000	45000	16500	50000	40000	0	675	1600	4400	1350	12000	336525
T_2F_3	165000	45000	16500	50000	40000	0	125	1600	4400	1350	12000	335925
T_3F_1	180000	45000	16500	50000	40000	10656	275	800	2200	675	12000	358106
T_3F_2	180000	45000	16500	50000	40000	10656	675	800	2200	675	12000	358506
T_3F_3	180000	45000	16500	50000	40000	10656	125	800	2200	675	12000	357956

Appendix IX. Per hectare production cost of bitter gourd
B. Over head cost

Treatment combination	Cost of lease of land for 6 months (12% of value of land Tk. 10,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 12% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
T_0F_1	60000	3650	8199	71849	144849
T_0F_2	60000	3650	8199	71849	144849
T_0F_3	60000	3650	8199	71849	144849
T_1F_1	60000	18888.75	27399.83	106288.56	484063
T_1F_2	60000	18908.75	27425.025	106333.775	484506
T_1F_3	60000	18881.25	27390.375	106271.625	483896
T_2F_1	60000	16806.25	24775.875	101582.125	437707
T_2F_2	60000	16826.25	24801.075	101627.325	438152
T_2F_3	60000	16796.25	24763.275	101559.525	437484
T_3F_1	60000	17905.30	26160.68	104065.98	462171
T_3F_2	60000	17925.30	26185.88	104111.18	462617
T_3F_3	60000	17897.80	26151.23	104049.03	462005