EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CUCUMBER (*Cucumis sativus* L.) IN WINTER SEASON

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CERTIFICATE

This is to certify that the thesis entitled, **"Effect of Integrated Nutrient management on growth and yield of Cucumber (*Cucumis sativus* L.) 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* ***Kakon Malo****, Registration number:* ***18-09267*** *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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DEDICATED

TO MY PARENTS

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the effect of integrated nutrient management on growth and yield of Cucumber in winter season during the period of October 2019 to March 2020. The experiment consisted of single factor. The experiment was conducted in randomized complete block design (RCBD) Using thirteen treatments and replicated three times. The treatments used were T_0=Absolute control, T_1= $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (RDF 50%), T_2= $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (RDF 50%) + Vermicompost (3ton/ha), T_3=$N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (RDF 50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha), T_4=$N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (RDF 50%) + Vermicompost (3t/ha)+ Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha), T_5= $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (RDF 75%), T_6=$N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (RDF 75%) + Vermicompost (3t/ha), T_7 = $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (RDF 75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha), T_8 = $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha), T_9= $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (RDF 100%), T_{10}= $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (RDF 100%) + Vermicompost (3t/ha), T_{11}= $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (RDF 100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) and T_{12}= $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (RDF 100%) + Vermicompost (3t/ha)+ Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha). In this study different treatments showed significant variations on most of the parameters. The highest number of fruits per plant (17.0), individual fruit weight (181.67g) and fruit yield (34.32 t/ha) was recorded from T_{12}.Whereas the lowest number of fruits per plant (8.51), individual fruit weight (120.62 g) and fruit yield (11.44 ton/ha) was recorded from treatment T_0 (control). The results revealed that there were significant difference between the application of nutrients and bio-fertilizers for yield and yield component traits. So, the economic analysis revealed that the maximum benefit cost ratio (3.03) was noted from T_{12} and the lowest (1.50) from T_0 treatment.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
et al.	(And others) at alibi
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
°C	Degree Celsius
DMRT	Duncan's Multiple Range Test
DAS	Date After Sowing
etc.	Etcetera
g	Gram
ha	Hectare
hr	Hour
kg	Kilogram
m	Meter
mm	Millimeter
mo	Month
MoP	Murate of Potash
no.	Number
%	Percent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
m^2	Square meter
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an ancient annual vegetable belongs to the family Cucurbitaceae. It is mainly grown for its edible tender fruits, used for salad and pickles. Nowadays it's cultivated year round. Cucumber was originated from an area in India between the Himalayas and the Bay of Bengal and the cultivation of cucumber was started about 3000 years ago. It was probably introduced to other parts of Europe by the Greeks or Romans. In world vegetable market, the cucumber is fourth important vegetable crop in Asia (Eifediyi and Remison, 2010) .China, Turkey, Iran, Russia and USA are peak cucumber producing countries in the world (Uma and Pokhriyal, 1997).In Bangladesh about 24413acres of land is under cucumber cultivation and total production is approximately 82963 metric tons (BBS, 2020). Thus, the average yield of cucumber production per hectare is very low compared to other countries of the world.

Cucumber contains almost 95% of water but high in nutrients like vitamins A, B and C, and antioxidant but are low in calories, fat, cholesterol and sodium. Cucumbers gives a number of health benefits like- preventing dehydration, lowering Blood Sugar and blood pressure, maintaining a healthy intestine, avoiding kidney stones, Aid in Weight Loss and remove free radical substances from the body. Fruits have cooling effect and also very effective to prevent jaundice, indigestion and constipation (Mohan *et al*., 2016). The Dietary Guidelines for Americans (2015–2020) recommend an intake of: 90 mcg of cucumber a day for females aged 19 years and over, 120 mcg for males of the same age are good for their health and nutrition.

It is warm-season crop that has little or no tolerance to frost. Growth and development are favored by temperature above 20°C. The optimum temperature for growing is between 20°C and 30°C. It can be grown in well drained any type of soil but silty-loam and clay loam soil with a PH 6.5 or slightly above containing sufficient organic matter are the most suitable for production of cucumber. In Bangladesh, cucumber is available in all the year round. As ours is a tropical country, it is cultivated both in summer and rainy season. There are two types of cucumber plants -vining cucumbers

and bush cucumbers found in our country. A wide range of variability is seen in farmers' field with low yield potential. There is no released variety of cucumber but research is going on at BARI and it has developed some promising lines which are yet to be released. BADC is producing seeds of two local cultivars namely Baromashi and Patia Giant. Some commercial cucumber varieties available in the market from local and exotic sources. The plant starts flowering early and producing marketable fruits within about two of three months depending upon cultivar, region, soil climate, etc.

Among the different agronomic practices nutrient management is one of the prime considerations for getting higher yield of any crop. Inorganic fertilizers NPK are commonly used by most of the farmers because of quick availability of nitrogen, phosphorus and potasium to the plants. However, indiscriminate use of synthetic fertilizer for a long period of time, the soil become loses their fertility status day by day. Infertile soils result in bitter and misshapen fruits which are often rejected by consumers, thereby reducing Farmers income (Eifediyi and Remison, 2010). Thus there is urgency in orientation of research towards efficient and judicious utilization of available nutrient resources to increase the production, productivity and profitability per unit area to meet out the food and other demands of ever increasing population. Emphasis should be given on management of natural resources like vermicompost, bio-fertilizers, neem oil cake etc. All of this are also known as organic fertilizer. Application of organic fertilizer increase cucumber production vitamin C, protein and decrease nitrate accumulation in cucumber fruit (Hong-mei *et al.,* 2014). Vermicompost (vermi-compost) is the product of the decomposition process using various species of worms, usually red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast. It helps to improve soil aeration, enriches soil with micro-organisms, increase water holding capacity of soil, enhance germination, plant growth and crop yield.

Bio-fertilizer as a substance which contains living organisms which, when applied to seed, plant surface, or soil, colonize the rhizosphere or interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant (Isfahani and Besharati, 2012). Though bio-fertilizers are not the substitute, but a supplement to the chemical fertilizers for maximizing not only yield but also to

maintain balance in agro-ecosystem. Bio-fertilizer is natural materials contain one or more than one kind of beneficial microorganisms which is safety and hasn't any harmful chemical materials or pesticides. Bio-fertilizers and organic fertilizer have important role to improving nutrient supplies for yield. Bio-fertilizers are ecofriendly, save soil environment from pollution, low coast and safety source for nutrition (Ramakrishnan and Bhuvaneswari, 2014). Bio-fertilizers like, azoto bactre is an important free living nitrogen fixer used in vegetable crops. This bacteria promotes growth and development of crop plants by helping in synthesis of Auxins, vitamins, growth substances and antibiotics. Different phosphate solubilizing bacteria (PSB) poses the ability to bring insoluble phosphate into soluble forms by secreting organic acids. There are several reports on the efficacy of bio-fertilizers in vegetable crops. Neem oil cake is also a good source of organic fertilizers obtained from neem tree fruits and kernels. Neem seed/oil cake acts as a nutrient reservoir providing favorable pH, aeration and improving other physical and chemical properties of the soil (Uma Singh and Pokhriyal, 1997). Neem seed cake is a rich source of organic carbon inhence organic matter content which is a rich source of plant nutrients (Effediyi *et al.,* 2015).

In recent years green or raw vegetable consumption has increased. The productivity of cucumber per unit area is quite low in Bangladesh as compared to the other developed countries of the world. Considering this, it is very much important to sustain the production of cucumber. Vermicompost, neem oil cake, bio-fertilizer with inorganic fertilizer NPK very important factors which can have the influence on cucumber production. However very limited research was done regarding bio-fertilizer with neem oil cake and vermicompost using.

Considering the above situation, the present investigation was undertaken with the following specific objectives or aims-

1. To find out the optimum dose of integrated nutrient management for cucumber production in winter season under AEZ-28
2. To evaluate the combined effect of inorganic fertilizer, organic fertilizer and bio-fertilizer on the growth and yield parameters of cucumber production economical for farmers.

CHAPTER II

REVIEW OF LITERATURE

Cucumber *(Cucumis sativus* L.) is a popular and important vegetable crop of the world. Many research works have been done in different parts of the world to study the effects of integrated nutrient management on the growth and yield of Cucumber during winter season. But in Bangladesh, available literature regarding effects of nutrients and bio-fertilizers on Cucumber production is insufficient and sometimes conflicting. However, some of the literatures relevant to effects of integrated nutrients along with bio-fertilizers and vermicompost and neem oil cake on growth and yield of cucumber production are reviewed in this chapter.

Anjanappa *et al.* (2012) carried out an experiment on influence of organic, inorganic and bio-fertilizers on yield and economics of cucumber grown under protected condition during the year 2005 and 2006. The results revealed that the plants treated with 75% RDF + 75% FYM + AZT + PSB + TD (T_2) registered lowest number of days for male (30.00 ; 30.40) and female (30.36 ; 36.00) flower appearance, lowest node of first male female(3.30 ; 3.16) flower appearance, lowest sex ratio (4.60 ; 4.88 %), highest fruit length (18.16 ; 20.81 cm), fruit diameter (22.23 ; 22.40 mm), fruit weight (309.01 ; 324.94 g), and total fruit yield hectare^{-1} (17.60 ; 18.22 t ha^{-1}) during summer 2005 and rabi 2006 respectively. Whereas, the same treatment also recorded least number of nodes of first female (2.46) flower appearance and highest number of male flower (93.00) per vine during summer 2005, highest fruit cavity (4.55 cm) during rabi 2006. With this the treatment T_2, 75% RDF + 75% FYM + *Azotobacter* + *Phospobacteria* + *Trichoderma* is identified as best for earliness and higher productivity.

Alkharpotly *et al.* (2019) also conducted experiment on two plastic house experiments were conducted during 2016/ 2017 and 2017/2018 seasons on a sandy textured soil under unheated plastic houses. The target of fertilization program seeks to achieve the best combination of various organic and NPK mineral fertilization that lead to the highest yield and quality of cucumber especially during the winter season. Therefore, 12 treatments were arranged in a split plot layout in complete randomize block design

with three replicates. Chicken manure at the rates of (10, 15 and 20 m^3/fed.) were randomly arranged in the main plots, while NPK mineral fertilization at rates of (0:0:0, 50:30:50, 100:40:80, and 150:50:110 Kg N: P_2O_5: K_2O/fed., respectively, were randomly distributed in the sub-plots. The obtained results demonstrated that the treatment combination of chicken manure at 20 m^3/fed. Plus 150:50:110 kg. NPK/fed. exhibited the highest significant mean values of most studied characters as vegetative growth characters (i.e. number of leaves/plant, the number of branches /plant, plant fresh weight and chlorophyll index); yield characters (i.e. no. fruits /plant, average fruit weight in g, total yield/m^2 in kg and early yield/m^2 in kg); fruit quality (i.e. TSS %, vitamin C, and reducing, non-reducing and total sugars); fruits chemical analysis characters (N, P, K contents in fruits) during both seasons of the study as compared to the other treatments. Based upon, the reported results, it is possible to conclude that, the combination among 20 m^3/fed.of poultry manure plus 150:50:110 Kg. NPK/fed. Considered as the optimal combination treatment whereas it gave the highest mean values of vegetative growth characters, yield and its components and fruit quality of cucumber plants grown under plastic houses conditions at Aswan governorate and similar regions.

Marliah *et al. (*2020) conducted a study is to determine the effect of combine organic fertilizer (manure) and inorganic fertilizer (NPK and Micro fertilizer) on the growth and yield of cucumber (*Cucumis sativus* L.). This study was conducted in the Experimental station from February to April 2018. This experiment was arranged in a factorial randomized completely block design with two factors and three replications. The first factor was the provision of organic fertilizer (manure) with 3 levels: 10 t ha^{-1}(K_1), 20 t ha^{-1} (K_2), and 30 t ha^{-1} (K_3). The second factor was the provision of inorganic NPK fertilizer with 3 treatments: Without NPK fertilizer (control-N_0), NPK Fertilizer(N 50 kg ha^{-1}, P_2O_5 50 kg ha^{-1}, and K_2O 50 kg ha^{-1} (280 kg ha^{-1}Phonska 16-16-16-N_1), and NPK + Micro Fertilizer (N 50 kg ha^{-1}, P_2O_5 50 kg ha^{-1}, and K_2O 50 kg ha^{-1} (280 kg ha^{-1}Phonska 16-16-16 + 2% Micro fertilizer-N_2). Results show that organic fertilizers (20 and 30 ton ha^{-1}) increase fruit weight of each sample and fruit weight of each plant. The application of NPK + Micro Fertilizer produces in the best fruit weight of each sample and fruit weight of each plant. The combination of organic fertilizer (20 ton ha^{-1}) and inorganic NPK + Micro Fertilizer results in the best fruit weight each plant of cucumber.

According to Abbasi *et al.* (2005) the effects of neem cake, a nutrient-rich organic material derived from neem seed, on plant-parasitic nematodes, *Verticillium dahliae*, and seedling damping-off diseases caused by *Rhizoctonia solani* and *Pythium aphanidermatum* were investigated. In greenhouse trials, 1% neem cake (mass/mass soil) caused a 67%–90% reduction in the number of lesion (*Pratylenchus penetrans*) and root-knot (*Meloidogyne hapla*) nematodes in tomato roots grown in three different soils. In the field, 1% neem cake (mass/mass soil) reduced the number of lesion nematodes by 23% in corn roots and 70% in soil around roots. Population densities of free-living nematodes were either enhanced or not affected by neem cake treatment. In laboratory tests, addition of 3% neem cake (mass/mass soil) to soil killed *V. dahliae microsclerotia* and increased soil pH from 5.2 to 8.7. Killing of microsclerotia appeared to be caused by generation of ammonia during decomposition of neem cake. In growth room assays, addition of 2% neem cake (mass/mass peat-based mix) to *R. solani*-infested peat-based mix 28 days before planting radishes reduced damping-off severity. In a sandy loam soil artificially infested with *R. solani* and a muck soil naturally infested with damping-off pathogens, addition of 0.5% neem cake (mass/mass soil) had no immediate effect on damping-off, whereas incubation of the amended soil for 7 days before planting radish or cucumber reduced damping-off severity.

Bindiya *et al.* (2014) conducted a research to study the effect of combined application of organic manures, bio-fertilizers and fertilizers on growth, yield and quality of cucumber (*Cucumis sativus* L.) during rabi 2003 to 2004.The results of the study revealed that, application of vermicompost @ 2t/ha + 50% recommended dose of fertilizers (50:30:30 NPK kg/ha) + bio-fertilizers (Azotobacter and phosphate solubilizing bacteria each @ 5 kg/ha) resulted in maximum growth, yield and yield attributes with good quality cucumber.

Ramakrishnan and Bhuvaneswari (2014) have been used bio-fertilizers as sources to improve plant nutrients in sustainable agriculture.Earthen pot experiments were carried out to study the inoculation effect of *Arbuscular Mycorrhizal* (AM) fungi (*Glomus mossease*), *Azospirillium brasilens*e and PSB on plant height, dry weight of root and shoot, per cent root colonization, spore number, P and N uptake. Experimental pots were filled with 4 kegs of sterilized soil and maintained in green

house at 25-30 °C temperature. Single inoculation of AM fungi and combined inoculation of AM fungi with *Azospirillium brasilense* or PSB was found to be moderately increased in all the growth parameters. However triple inoculation of AM fungi, *Azospirillium brasilense* and PSB was found to have highest growth parameters.

Dash *et al.* (2018) conducted an experiment on yield improvement in cucumber through integrated nutrient management practices was conducted in a randomized block design with three replications. Application of half rec. NPK + FYM @ 10 t/ha + Vermicompost @ 2 t/ha + Bio-fertilizer (4.0 kg *Azotobacter*/ha+ 4.0 kg PSB/ha) i.e. T_{11} had the greatest impact on fruit weight invariably in all the experimental years. T_{11} recorded average fruit weight of 174.84 g, 180.45 g and 171.40 g during 2014, 2015 and 2016 respectively. From pooled data over three years it was observed that amongst the treatments T_{11} recorded the highest yield (105.44 q/ha) whereas the lowest yield was recorded in T_2 (56.70 q/ha). From the present investigation it may be suggested that application of half rec. NPK + FYM @ 10 t/ha + Bio-fertilizers (4.0 kg *Azotobacter*/ha + 4.0 kg PSB/ha) i.e., T_8 was the best integrated nutrient management practice to be followed.

According to Eifediyi and Remison (2010), the growth and yield of Ashley variety of cucumber in response to the effect of farmyard manure and inorganic fertilizer NPK 20:10:10. The farmyard manure was applied at the rates of 0, 5 and 10 t/ha and the inorganic fertilizer at 0, 100, 200, 300 and 400 kg/ha. The layout was a 3 × 5 factorial scheme with three replicates. The combined rates of farmyard manure at 10 t/ha × 400 kg/ha fertilizer increased the growth characters such as the vine length and the number of leaves. At 8 weeks after planting (WAP), the application of 10 t/ha of farmyard manure × 400 kg/ha of fertilizer gave the longest vine length of 276.93 cm and the highest number of leaves. The fruit length, fruit girth, fruit weight per plant and fruit weight per hectare were significantly influenced by the application of farmyard manure × fertilizer. The highest weight of 2.43 kg per plant and yield per hectare of 43,259 kg/ha were obtained with 10 t/ha farmyard manure and 400 kg/ha of fertilizer which were 166.42% higher than the control.

Eifediyi *et al.* (2015) reported that effects of neem (*Azadirachta indica* L.) seed cake on the growth and yield of okra (*Abelmoschus esculentus* L.) Moench. Soils of the

southern Guinea savannah are generally inherently infertile owing to low vegetation cover, soil erosion and low organic matter content due to constant bush fire. Consequently, farmers move close to streams and rivers in the dry season where okra is cultivated by irrigation. Field experiments were conducted during the 2012 and 2013 cropping seasons to evaluate the effects of neem seed cake on the performance of okra. The neem seed cake was incorporated into the soil one week before sowing of the okra seeds at the rate of 0, 1, 2, 3 and 4 t/ha. The experiment was laid out as a randomized complete block design replicated thrice. Data were collected on growth parameters (plant height, number of leaves and number of branches) and yield parameters (fruit length and girth, number of fruits per plant, fruit weight per plant and fruit weight per hectare). The result indicated that applying neem seed cake significantly affected the growth and yield parameters that were evaluated. Applying neem seed cake, however gave the highest yield at 3t/ha. Percentage mean for the two years combined was 75.81% over the control.

Ghayel *et al.* (2017) conducted a field experiment to assess the "Effect of different organic manures and inorganic fertilizers on chemical properties of cucumber *(Cucumis sativus* L.) in lateritic soils of Konkan" during kharif season in the year 2015-16. The experiment was laid out in Randomized Block Design (RBD) with three replications. The present study was formulated to reduce the inorganic fertilizer dose by using various organic manures and there combinations. The experiment comprised thirteen treatments with the combined application of chemical fertilizers, FYM, poultry manure and vermicompost in cucumber resulted increased the all chemical properties. The application of 50% RDF through inorganic plus 50% RDN through poultry manure had shown its influence on the soil pH, electrical conductivity and organic carbon as well as available nutrient status of Nitrogen (477.70, 337.67, 254.01 kg ha^{-1}) at 30 DAS, 60 DAS and at harvest, Phosphorus (19.27, 15.80, 12.43 kg ha^{-1}) at 30 DAS, 60 DAS and at harvest and Potassium (582.40, 417.54, 362.43 kg ha^{-1}) at 30 DAS, 60 DAS and at harvest respectively. In general, it was concluded that the application of 50% RDF through inorganic plus 50% RDN through poultry manure was found to be suitable for improving chemical properties of lateritic soils of Konkan.

Hamdi *et al.* (2017) conducted an outdoor experiment during the summer seasons of 2015 and 2016.to evaluate the positive interaction effects among different types of organic fertilization forms and levels alongside with bio fertilizer applications on quantitative and qualitative yield characteristics of cucumber grown under an organic farming conditions.. Thirty treatments were arranged in a split-split plot design with three replicates, which were the simple combination of three types of organic amendments (compost, FYM, and *biochar*), two rates of soil application (5 and 10 ton fed^{-1}) and five types of bio fertilizer application forms i.e. (1) *microbien* + *phosphorien*, (2) *microbien* + *phosphorien*+ effective microorganisms (EM), (3) EM, (4) poultry manure extract, and (5) control (without bio-fertilization). Compost proved its effectiveness in improving yield characteristics, nutrients content and quality indices as compared with other organic amendments. The application level of 10 ton fed^{-1} was the optimum rate for providing sufficient needs of plant during its whole growth stage. The combined bio-fertilization treatment (*microbien* + *phosphosien*+ EM) was the most effective treatment for improving quantitative and qualitative yield characteristics. The obtained results concluded that the integrated treatment of compost application at 10 ton fed^{-1} alongside with *microbien* + *phosphosien*+ EM bio-fertilization is recommended to produce the highest productivity and quality indices of cucumber yield grown on a sandy soil condition.

Isfahani and Besharati (2012) has been defined Bio-fertilizer as a substance which contains living organisms which, when applied to seed, plant surface, or soil, colonize the *rhizosphere* or interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant. Bio-fertilizers are well recognized as an important component of integrated plant nutrient management for sustainable agriculture and hold a great promise improve crop yield. The present study for the sake of evaluating the use of plant growth promoting *rhizobacteria* produced by *Pseudomonas* sp. and phosphate bio-fertilizers produced by *Pseudomonas putida* strain P_{13} and *Pantoea agglomerans* strain P_5 and chemical fertilizers in the separate treatments on yield and yield components of cucumber by using a factorial experiment in completely randomized block design with three repetition were performed in the field. The symbol of P represents chemical fertilizer by amount of respectively (0, 25%, 50%, 75%, 100%), B_1 shows plant growth promoting *rhizobacteria* (PGPR) and B_2 indicates bio-fertilizer-2. The results showed

that P_1B_0 has the most yield, and control treatments has the least yield. $P_{100}B_1$ has the most length of plant and $P_{100}B_0$ has the least length of plant, $P_{25}B_1$ has the most amount of chlorophyll and $P_{75}B_2$ has the least chlorophyll. $P_{75}B_2$ has the most shoots dry weight and $P_{100}B_0$ has the least shoots dry weight. B_1P_{50} has the most shoots fresh weight and $P_{25}B_2$ has the least shoots fresh weight. B_1P_{50} has the most roots dry weight and $P_{100}B_0$ has the least roots dry weight. B_1P_{50} has the most roots fresh weight and $P_{25}B_2$ has the least roots fresh weight. So the results indicate that use of biological fertilizers have caused increase yield and components yield of cucumber.

According to Jilani *et al.* (2009) an experiment was conducted to check the effect of different levels of NPK on the growth and yield of hybrid cucumber. Application of NPK fertilizer (100-50-50) showed the best performance in almost all the parameters studied, as it took least days to flowering (39.33), fruit setting (11.55), maturity (7.88), maximum fruit per plant (35.5), maximum fruit length (18.36 cm), maximum fruit weight (136.03 g) and yield per hectare (60.02) tons. Application of NPK fertilizers @ 120-60-60 kg ha^{-1} also showed some beneficial effect on some parameters including fruit weight (150.69 g) and vine length (3.85 m). Control plots showed un-satisfactory results regarding all the parameters.

Joshiya *et al.* (2020) conducted a field experiment entitled, effect of organic nutrient management on yield and quality of cucumber (*Cucumis sativus* L.) was carried out during summer-2016.Total nine treatments of organic nutrients were tested in the Factorial Randomized Block Design with three replications and evaluated on the basis of yield and quality characteristics of cucumber. Treatment (T_9) 50% N through caster cake + 50% N through poultry manure + bio-fertilizers + *Trichoderma viride* + neem oil recorded significantly maximum yield and quality parameters *viz*., number of fruits per plant, average weight of fruit, yield per plant, yield per meter square; as well as quality parameters *viz*., fruit length and diameter of fruit.

Mahmoud *et al.* (2009) conducted a study is to evaluate the effect of three compost types (plant residues, animal residues and mixed) when mixed with mineral nitrogen fertilizers, on cucumber (*Cucumis Sativus* L.) plants and soil properties. The experiment was carried out during the two successive summer seasons of 2007 and 2008. The results showed that the mature compost of plant residues was higher in saturation percent and lower in C/N ratio, pH, electrical conductivity and bulk density

than the animal and mixed composts. The study demonstrated that the average cumulative cucumber yield was higher with 75% mineral N + 25% organic N treatments compared to other treatments throughout the experiment, especially in the plots treated with plant compost during the two successive summer seasons of 2007 and 2008.The experimental results confirmed that the combination of organic and inorganic fertilizers could increase plant growth, yield quality and soil fertility. It also confirmed that composted organic wastes can be used to substitute for around 25% of chemical nitrogen fertilizers.

Mohan *et al.* (2016) The present investigation was carried out in order to study the effects of integrated nutrient management on cucumber cv. Swarna Ageti under polyhouse conditions conducted during the *Kharif* season of 2015.Later it is concluded that the application of various combinations of organic, inorganic and bio-fertilizer sources of nutrients at optimum level evidenced to be effective in promoting germination per cent, growth, flowering and yield of the cucumber. The most effective among all the combinations of organic, inorganic and bio-fertilizer sources of nutrients for minimum number of days to 50 per cent flowering (44.33), fruit length (15.11 cm), fruit weight (176.22 g), number of edible fruits per vine (9) and maximum edible fruit yield per hectare (58.73 t/ha) is found to be 60 per cent each of RDF and vermicompost along with *Azotobacter*, *Trichoderma* and PSB. From the results it can be concluded that the application of different combinations of organic, inorganic and bio-fertilizer source of nutrients at optimum level proved to be effective in promoting germination per cent, growth, flowering and yield of cucumber.

According to Manoj *et al.* (2018) Cucumber (*Cucumis sativus* L.) is a warm season vegetable, grown throughout the world under tropical and sub-tropical conditions. It is said to be the native of northern India. It is an important salad crops grown extensively throughout India as well as the world. It is having high medicinal value so it is becoming popular day by day in the country. To achieve higher production of cucumber the expensive commercial fertilizers are recommended but use of excess inorganic fertilizers as per the recommendations soil health and environment sustainability is on sake. So to achieve higher productivity and to maintain the environment balance judicious use of chemical fertilizers is needed. Intensive use of only chemical fertilizers to achieve high production has created problems. Therefore

Bio-fertilizers have emerged promising components of nutrient supply system. Application of bio fertilizers which is environment friendly and low cost input with inorganic fertilizers as part of an integrated nutrient management strategy and play significant role in plant nutrition. The application of bio-fertilizers has received great attention in sustainable agriculture.

Kanwaljit and Amarjeet (2018) conducted an experiment during 2017-2018 to study the Influence of integrated nutrient management practices in cucumber (*Cucumis sativus* L.) cv. Punjab Naveen. The seeds were sown in mid-February. The experiment was laid out in RBD with 10 treatment combinations replicated thrice. The results of the study showed that the combined application of organic and inorganic fertilizers had significant effect on the physical and biochemical characteristics of cucumber. The results of the experiment revealed that among the different treatments the application of NPK 75% RDF + FYM 25% showed maximum growth attributes. Maximum vine length (2.34 m), number of branches (16.90), number of leaves per vine (128.07), fruit length (22.20 cm), fruit breadth (5.37 cm), fruit weight (285.71 g) and TSS (3.07 °B) were recorded with the application of NPK 75% RDF+ FYM 25% as compared to other treatments of nutrient management. The yield (17.10 tha^{-1}) was also found to be maximum under NPK 75% (RDF) + FYM 25%.

Okoli and Nweke (2015) conducted an experiment on Effect of poultry manure and organic fertilizer (NPK 20:10:10) on the growth and quality of cucumber fruits The experiment was laid out in a randomized complete block design (RCBD) with four levels of treatments consisting of 4 tha^{-1} poultry manure (PM), 900 $kgha^{-1}$ NPK in a ratio of 20:10:10 (NPK), 2 tha^{-1} poultry manure + 450 $kgha^{-1}$ NPK fertilizer (PM + NPK) and 0 tha^{-1} control (CO), where no treatment was applied. The results obtained from the study indicated that the numbers of leaves of cucumber increased as weeks after planting (WAP) increased. The highest leaves numbers was observed in the plots treated by PM. The length of fruits, number of fruits, the quality of marketable fruits and weight of fruits increased proportionately in PM treated plots and were significantly (P=0.05) different among the other treatments except for quality of marketable fruits. The highest value of 171.25cm (length of fruits), 10.75 (number of fruits) and 2.38$kgha^{-1}$ (weight of fruits) were obtained in PM treated plots. Based on the results obtained it is evident that poultry manure as organic manure and its

mixture (PM + NPK) is a good source of soil amendment, since it influenced the growth and yield components of cucumber.

According to Patil and Narayana (2017) an experiment on gherkin (*Cucumis anguria* L.) was carried out at farmer's field, Fattepur village of Haveri District Karnataka during 2014 to study the impact of bio fertilizers along with combination of different level of N, P and K on nutrient uptake in gherkin. The results of the experiment data revealed that the application of 100% NPK + *Azotobacter chroococcum* + *Trichoderma viridae* + *Glomus fasciculatum*, recorded highest vine length (143.33cm), more number of leaves per plant (47.23), more number of branches per plant (2.72), lowest days to flowering (28.00) and highest fruit yield (12.70 t/ha). Significantly highest nutrient uptake (194.60 N, 55P and 237 K kg/ha) was recorded with the same treatment.

Patle *et al*. (2018) conducted an investigation entitled on Integrated nutrient management studies in bottle gourd (*Lagenaria ciceraria* L.). The experiment conducted in Randomized Block Design with three replications using cv. Samrat, with thirteen treatments, two kinds of organic manures (FYM and vermicompost) alone and in combination with two kinds of bio-fertilizers (*Azotobacter* and PSB) and reduced doses of chemical fertilizers were tested in comparison with control i.e. without any nutrient application. On the basis of results, the application of 50% RDCF (50:25:25 NPK kg ha-1) + 2.5 t ha^{-1} FYM + 1.65 t ha^{-1} vermicompost and *Azotobacter, PSB* each 5 kg ha^{-1} to the crop found to be sound integrated practice, where it recorded maximum vine length (551.56 cm), length of internode (15.88 cm), number of female flowers (17.44), fruit set percent (75.11%), yield per vine (7.61 kg), yield per hectare (380.61q). According to the B: C ratio, the treatment T_{12} was found to be profitable and remunerative.

Prabhu *et al*. (2006) conducted a study during December 2003 in cucumber var. Green Long. The results revealed that application of 50 per cent recommended dose of fertilizers + vermicompost @ 2 t/ha + bio-fertilizers (2 kg in each of *Azospirillum* and *Phosphobacteria* @ 2 kg ha^{-1}) increased the vine length, earliness in flowering, yield and yield components. The highest yield of 32.80 t/ha and B: C ratio of 2.24 was also recorded in the same treatment. Hence application of 50 per cent recommended dose of fertilizers + vermicompost @

2 t ha^{-1} + bio-fertilizers (2 kg in each of *Azospirillum* and *Phosphobacteria*) is recommended for cucumber crop.

According to Saeed *et al*. (2015) a comparative study on the effect of chemical fertilizers and bio-fertilizers was done on growth and biochemical parameters in cucumber plant (*Cucumis sativus* L.). The experiment was conducted in Randomized Completely Blocks Design (RCBD) with four replicates. The treatment were (T_1 = Control, T_2 = Bio-fertilizer, T_3 = Chemical and T_4 = Combination treatment (bio-fertilizer and 1/2 chemical)). The bio-fertilizer used in this study was *Azoto barwar1* and chemical fertilizer was urea. The results indicated that there were significant difference between the application bio-fertilizer and chemical fertilizer for yield and yield component traits. Comparison means were conducted by Duncan method. This study indicated that a combination treatment of bio-fertilizer and chemical fertilizer had significant effect and increased the yield and growth traits of cucumber. The correlation analysis showed that the strongest positive relationship was between fruit yield and total fruit weight per plant (r = 0.89). The results of regression analysis by stepwise method for fruit yield in cucumber indicated that individual fruit weigh can justify 50.9% of the fruit yield variation. According to this study using bio-fertilizers has increased yield and yield component of cucumber significantly.

Sing *et al*. (2017) conducted a field experiment at India, during the rabi season of 2016-17, to study the effect of different organic and inorganic fertilizers on cucumber yield under protected cultivation. The experiment was laid out in randomized block design with three replications consisted of nine treatment combinations viz. T_0 (Control), T_1 (FYM 75% + NPK 25%), T_2 (FYM 50% + NPK 50%), T_3 (Vermicompost 75% + NPK 25%), T_4 (Vermi Compost 50% + NPK 50%), T_5 (Poultry manure 75% + NPK 25%), T_6 (Poultry manure 50% + NPK 50%), T_7 (FYM 50% + Poultry manure 25% + Vermi Compost 25%)and T_8 (FYM 25% + Poultry manure 25% + Vermi Compost 25% + NPK 25%) were allocated randomly in each plot. The results showed that the treatment T_8 significantly found best among the all treatments at all successive growth stages in term of maximum plant height (370.00cm), Number of leaves (119.84) and Number of Branches per plant (3.51) as growth parameters whereas maximum length of fruit (15.03cm), fruit diameter (14.07cm), average fruit weight (198.93g), fruit yield per plot (11.87kg) and fruit

yield per hectare (824.30q/ha) as yield related traits and also recorded maximum with TSS (4.10 0 Brix) and vitamin C (8.39mg/100g of fruit pulp) with lowest acidity (0.90 per cent) as quality parameters while lowest response in term of growth, yield and quality of cucumber was recorded with T_0 (control) which received only recommended dose of NPK (120:60:120 kg per hectare).

Singh *et al*. (2018) conducted an experiment on cucumber with using various INM treatments during the summer season of year 2018 to find out the effect of integrated nutrient management on growth, flowering and yield attributes of cucumber. Total ten treatments were tried in Randomized Block Design (RBD) with three replications. Out of these an application of 75% RDF + 12.5% FYM + 12.5% VC ha^{-1} had a beneficial effect on growth parameters like maximum vine length (137.70 cm), number of leaves $plant^{-1}$ (97.80), maximum number of primary branches $plant^{-1}$ (8.50), maximum length and width of leaf i.e. 16.20 cm and 17.70 cm. flowering parameters viz. minimum days to first flower formation (37.80), minimum number of days to first male and female flower formation i.e. 39.70 and 44.57, lowest number of male flowers $plant^{-1}$ (52.20), maximum number of female flowers $plant^{-1}$ (27.70), lowest sex ratio (1.90) and yield and yield attributing characters like minimum days taken to first fruit formation (53.40), maximum number of fruits $plant^{-1}$ (8.35), length of fruit (20.20 cm), width of fruit (4.38 cm), weight of fruit (161.50 g), maximum fruit yield $plant^{-1}$ (1.34 kg), fruit yield $plot^{-1}$ (8.04 kg), highest fruit yield (148.88 q ha^{-1}), maximum TSS of edible fruit (4.11 0Brix) and peel thickness(1.33 cm) as compared to control. Similarly, maximum net return (Rs. 66747 ha^{-1}) and cost benefit ratio (2.27) were also found in the treatment 75% RDF + 12.5% FYM + 12.5% VC ha^{-1}.

Sahu *et al*. (2020) conducted a Field experiment to study the efficacy of different sources of nutrients on growth and yield of cucumber. The experiment was laid out in RBD replicated thrice having twelve INM modules including absolute control. The results revealed significant variations among different treatments for growth and yield in cucumber. Invariably, integrated application of 50% of RDF + FYM @ 10 t ha^{-1} + vermicompost @ 2 t ha^{-1} + bio-fertilizer recorded not only significantly highest vine length (1313.00 cm), primary branches $vine^{-1}$ (3.00), fruit length (19.79 cm), fruit girth (15.13 cm), average fruit weight (194.13 g) and fruit $vine^{-1}$ (11.07) but also fruit

yield (214.05 q ha^{-1}) than rest of the treatments. Similarly, the module also showed significantly lowest sex ratio (3.43) and maximum extended period of fruit harvesting (41.00 to 68.00 days). On the other hand, significantly lowest vegetative growth (i.e., vine length of 550.67 cm and primary branches $vine^{-1}$ of 1.93), delayed in 1st fruit harvest (44.33 days), lowest yield attributing parameters (i.e., fruit length: 12.76 cm, fruit girth: 10.57 cm, average fruit weight: 92.00 g, fruits $vine^{-1}$: 4.20) and total fruit yield (53.70 q ha^{-1}) in plots without any fertilizer and bio-fertilizer. The next better treatment was integrated application of 100% RDF + FYM @ 10 t ha^{-1} + bio-fertilizer for growth and yield in cucumber. Thus, it may be concluded that integrated application of 50% RDF + FYM @ 10 tha^{-1} + Vermicompost @ 2 t ha^{-1} + bio-fertilizer not only increases vegetative growth but also fruit yield in cucumber

Sudeshna *et al*. (2019) conducted an experiment to study the effect of integrated nutrient management on growth and yield of cucumber (*Cucumis sativus* L.) grown under protected condition. It was laid out in Randomized Block Design comprising of thirteen treatments replicated thrice. The experiment was conducted during the off season with gynoecious hybrid variety KSP-1301. The results revealed that the vines of cucumber fertilized with T_5 (75% of RDF of NPK + vermicompost @ 7.5 t/ha) recorded maximum vine length (190.26 cm), number of branches per plant (12.97) and internodal length (13.86 cm). However, the superior response in terms of flowering and the yield attributing parameters like minimum days to 50% flowering (34.01), minimum days to 50% fruiting (45.01), fruit length (16.20 cm), fruit breadth (4.21 cm), fruit girth (13.18 cm), fruit weight (197.39 g), yield of fruits per vine (1.75 kg), yield of fruits per plot (12.43 kg), number of fruits per vine (10.81), number of fruits per plot (91.51) and total yield (287.89 q/ha) was recorded from T_{13} (50% of RDF of NPK + vermicompost @ 5 t/ha + *Azotobacter* @ 5 kg/ha + PSB @ 5 kg/ha).

Waleed *et al.* (2017) carried out An experiment during the spring growing season of 2016 to study the combined effect of bio-organic fertilization in some nutrients availability, growth and yield of cucumber (*Cucumis sativus* L.). A randomized Complete Block Design (RCBD) with two levels of bio-fertilizer (with and without) and three levels of organic fertilizer (0, 10 and 20 ton h^{-1}) with three replications were used. Results showed that bio-fertilizing was significantly better than no bio-fertilizing in increasing Nitrogen Availability, plant height, leaf chlorophyll content,

fruit moisture percentage and total yield. The different levels of organic fertilizer also affected the nutrients concentration and the availability of nitrogen, phosphate and potassium as well as other growth parameters including plant height, leaf chlorophyll content and total yield. Results also showed that nutrients availability and concentrations, growth parameters and total yield were more positively affected with organic fertilizer than with bio-fertilizer especially at the level of 20 ton h^{-1}. This level of the organic fertilizer combined with bio-fertilizer had the best effect on plant growth parameters and availability of nutrients in soil which was 36.3, 16.1 and 36.3 mg kg^{-1} in N, P and K respectively.

Waseem *et al*. (2008) conducted an experiment to check the effect of different levels of NPK on the growth and yield of hybrid cucumber. Application of NPK fertilizer (100-50-50) showed the best performance in almost all the parameters studied, as it took least days to flowering (39.33), fruit setting (11.55), maturity (7.88), maximum fruit per plant (35.5), maximum fruit length (18.36 cm), maximum fruit weight (136.03 g) and yield per hectare (60.02 t). Application of NPK fertilizers @ 120-60-60 kg ha^{-1} also showed some beneficial effect on some parameters including fruit weight (150.69 g) and vine length (3.85 m). Control plots showed un-satisfactory results regarding all the parameters.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of integrated nutrient management on growth and yield of cucumber (*Cucumis sativus* L.) in winter season. This chapter includes materials and methods i.e. description of experimental site, Experimental period, climate, characteristics of the soil, treatments of the experiment, planting materials, design and layout of the experiment, land preparation, fertilizer application, sowing of seeds, intercultural operation, harvesting, collection of data and both statistical and economic analysis.

The materials and methods used in conducting the experiment have been presented in this chapter under the following headings:

3.1 Description of the experimental site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207,Bangladesh**.** The location of the experimental site is situated between $90^0$22/E longitude and $23^0$41/N latitude and at an elevation of 8.6 m above the sea level which presented in Appendix II.

3.2 Experimental period

The experiment was conducted in Rabi season during the period from October, 2019 to March, 2020.

3.3 Climate

The experimental area belongs to subtropical climatic zone which is characterized by scarce rainfall, low humidity, low temperature and short day period during "Rabi" season (October-March). The experiment was carried out during the winter or dry season to from October to March. The monthly average temperature, humidity, rainfall and sunshine hour during the study period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix I. During the experimental period the maximum temperature (32.5 ^{0C}), minimum temperature (20.5^{0}C) and highest rainfall (65.8 mm) was recorded in the month March 2020. Highest relative humidity (76%) was recorded in the month of October 2019.

3.4 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the general soil type is Shallow Red Brown Terrace soil. Soil analysis report of the experimental area was collected from Khamarbari, Dhaka which was determined by SRDI, Soil testing Laboratory. The soil was having a texture of sandy loam with pH and organic matter 5.47 –5.63 and 0.83% which have been presented on appendix-II.

3.5 Treatments of the experiment

The experiment involved single factor, with 13 treatments. They are-

Treatment combinations:

T_0=Absolute control (Native soil nutrient)

T_1=Recommended N_{75kg} P_{60kg} K_{50kg} /ha (RDF 50%)

T_2= Recommended N_{75kg} P_{60kg} K_{50kg} /ha (RDF 50%) + Vermicompost (3t/ha)

T_3= Recommended N_{75kg} P_{60kg} K_{50kg} /ha (RDF 50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)

T_4 = Recommended N_{75kg} P_{60kg} K_{50kg} /ha (RDF 50%) + Vermicompost(3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

T_5= Recommended $N_{112.5kg}$ P_{90kg} K_{75kg} /ha (RDF 75%)

T_6 = Recommended $N_{112.5kg}$ P_{90kg} K_{75kg} /ha (RDF 75%) + Vermicompost (3t/ha)

T_7 = Recommended $N_{112.5kg}$ P_{90kg} K_{75kg} /ha (RDF 75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)

T_8= Recommended $N_{112.5kg}$ P_{90kg} K_{75kg} /ha (RDF 75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40kg/ha)

T_9= Recommended N_{150kg} P_{120kg} K_{100kg} /ha (RDF 100%)

T_{10}= Recommended N_{150kg} P_{120kg} K_{100kg} /ha (RDF 100%) + Vermicompost (3t/ha

T_{11}= Recommended N_{150kg} P_{120kg} K_{100kg} /ha (RDF 100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)

T_{12}= Recommended N_{150kg} P_{120kg} K_{100kg} /ha (RDF 100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40kg/ha)

(N.B. Recommended doses of Fertilizer was applied according to Fertilizer book of BADC).

3.6 Planting materials

Seed of “Madhumati” Baromasi local variety of cucumber were collected from Agargaon market, Sher- e-Bangla Nagar, Dhaka. Seed rate was 2.5 kg per hectare.

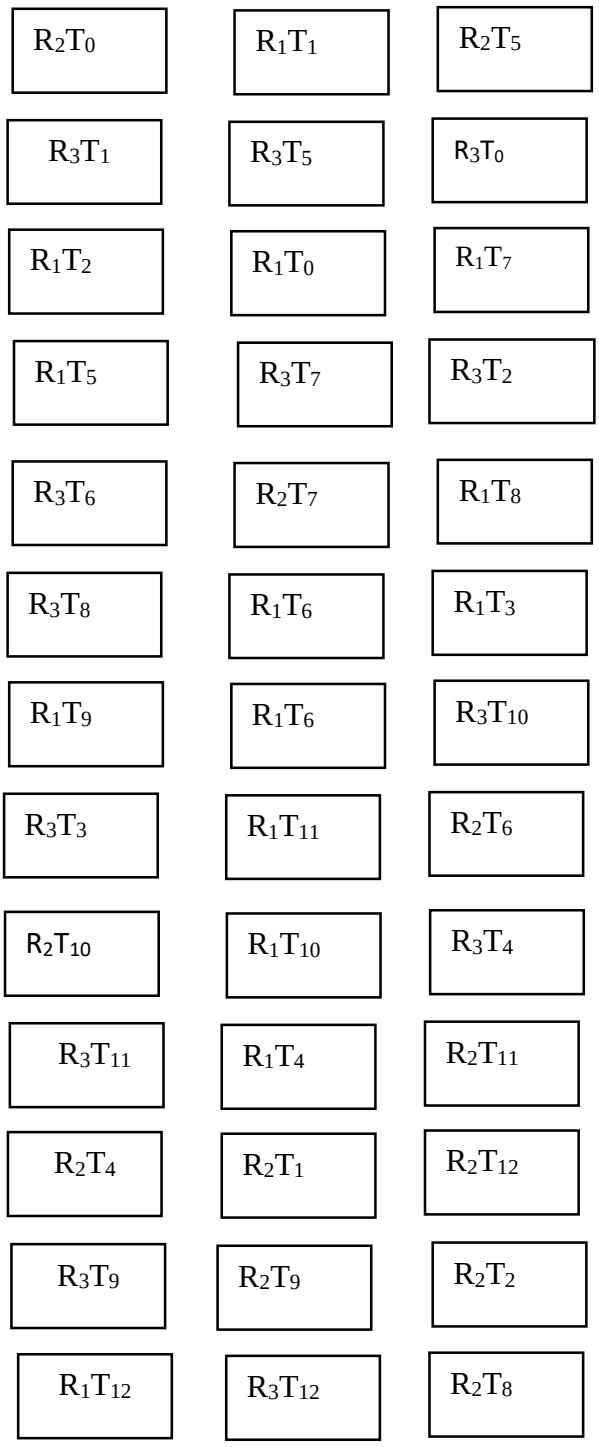
3.7 Design and layout of the experiment

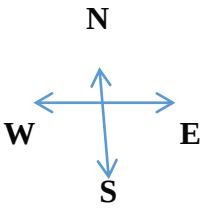
The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The experiment field was divided into equal 3 blocks. Each block was divided into 13 plots where 13 treatments combination were allotted at random. There were 39 unit plots and the size of each plot was 3 m × 1.8 m. The distance between two blocks and two plots were .75 m and 0.6 m, respectively. The layout of the experimental field presented in Figure 1.

3.8 Land preparation

At first the land was ploughed with a power-tiller on 3 October, 2019 and kept open to sunlight. Afterwards the experimental plot was brought into desirable fine tilth by ploughing and cross-ploughing, harrowing and laddering. The weeds and stubble of previous crops were collected and removed from the soil. After final land preparation Experimental land was divided into unit plots following the experimental design.

DESIGN AND LAYOUT OF THE EXPERIMENT:





Legend,

Plot Size = 3m× 1.8 m

Plant spacing = 60 cm ×60 cm

Block-Block dist. = 75 cm

Plot- Plot Dist. =60 cm

Plot length = 47.4 m

Plot Breadth = 8.4 m

Area = 398.16m^2

Total number of plot= 39

Fig.1: Field layout of the experimental plot.

3.9 Fertilizer application

One third amount of recommended doses of Urea at 50%,75% and 100%, Full amount of MP, full amount of TSP (all together as NPK source) and Vermicompost (3t/ ha), Bio-fertilizer (67 kg/ha) and Neem oil cake (40kg/ha) were applied on research (for different treatment combinations) field as basal dose during the final land preparation. The rest amount of nitrogen fertilizer (as urea) was applied in the specified plots in 25 and 45 days splits after seed germination as side dressing after weeding and earthling up. So that vegetative growth of plants are good.

Following doses of nutrients and bio-fertilizers were recommended for cucumber production by BARC (Source: Fertilizer recommendation gide-2005) and bio-fertilizer (Source: Chemicon Bio-Agro company) and neem oil cake (Source: Anumar fertilizer) given below-

Table-1: Manures and fertilizers for one hectare of land.

Manures and fertilizer	Dose per hectare
Vermicompost	3 t
Urea	150 kg
TSP	120 kg
MP	100 kg
Bio-fertilizer	67kg
Neem oil cake	40 kg

Manures and fertilizers applied uniformly in the experimental plots and pits as per following doses in accordance with the recommended dose.

Table 2: NPK Doses

Fertilizers	Doses per plot			Doses per pit		
	50%	**75%**	**100%**	**50%**	**75%**	**100%**
Urea	45g	67.5g	90g	7.5g	11.25	15g
TSP	37.5g	56.25g	75g	6.25g	9.375g	12.5g
MP	30g	45g	60g	5g	7.5g	10g

Table 3: Others Nutrients and Bio-fertilizer (Chemicon bio-fertilizer) doses

Organic fertilizers	Doses per plot	Doses per pit
Vermicompost	9.72 kg	1.62 kg
Bio-fertilizer (Chemicon)	6 g	1g
Neem oil cake	22 g	3.66g

3.10 Sowing of seeds

Three treated seeds were sown each pit at a depth of 3.0 cm. Seeds were treated with Sevin to protect from seed borne diseases before that seeds are soaked in water overnight to soften the seed coat which helps to germinate seeds easily. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 27 November, 2019 in pits and at spacing of 60cm x 60 cm. The seeds were covered with loose soil.

Plate 1.Seedling stage (at 13 day age)

3.11 Intercultural operations

3.11.1 Irrigation

Irrigation was provided when necessary for optimizing the vegetative growth of cucumber for the all experimental plots equally as the experimental period is winter.

3.11.2 Thinning

Almost 80% seeds germination was seen at 6 DAS (Days after Sowing) and 100% seeds germination was seen at 11 DAS (Day's After Sowing). Thinning was done two times; first thinning was done at 15 DAS and second was done at 30 DAS to maintain optimum plant population in each plot.

3.11.3 Gap filling

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

3.11.4 Weeding

The experimental plots were kept weed free by hand weeding as and when necessary. Weeding done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of seedlings whenever it is necessary.

3.11.5 Earthling up

Earthling up was done at 25 and 45 days after sowing followed by the application of fertilizers(Urea as side dressing) on both sides of rows by taking the soil from the space between the rows by a small spade.

3.11.6 Vine management

For proper growth and development of the plants the vines were managed upward by hand and with the help of iron rope and nylon net and bamboo may be used as supporting material to made trellis or macha. So, the rainy and stormy weather could not damage the growing vines and fruits of the plants. When the seedling were

established, staking was given to each plant to keep them straight. Bamboo sticks were used to given support to the growing plants.

3.11.7 Hand pollination

For hand pollination of cucumbers, use only fresh male flowers. Flowers open in the morning is only viable during that day. To hand pollinate, remove the petals from a male blossom to reveal the stamen at its center. If you look closely, you'll see pollen clinging to it. Touch it with your finger or a small paintbrush and carry the pollen on your finger or the brush to the female blossoms and Touch them at their center.

Plate.2. Fruit

3.11.8 Fruit bagging

Polythene bags were used to protect the fruits from fruit borer insects.

Plate 3: Fruit Bagging (done before fruit harvesting)

3.11.9 Plant protection

Insect pests:

At early stage of growth few worms (*Agrotis ipsilon*) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Ripcord 10 EC was sprayed with 1 liter water for two times at 15 days interval after seedlings germination to control the insects.

Diseases:

Seedlings were attacked by Downy mildew which controlled by spraying Mancozeb or Chlorothalonil 2 g/lit twice at 10 days interval.

3.12 Harvesting

The plant bears flowers within 27-33 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. In salad as slicing cucumber, dark green color not turn into brownish-yellow or russeting and white spine color will also be useful indication for edible maturity. Optimum length of the fruit will be around 12-18 cm at edible maturity stage, depending upon the cultivar in case of slicing cucumber. On an average 12– 13 harvests has been done.

Plate**.4.** Last fruit harvesting

3.13 Collection of experimental data:

Data were recorded on the following parameters-

Plant height

The plant height was recorded at 30, 45 and 60 days after sowing (DAS). The plant height was taken from ground level to the tip of the largest leaf of the plants. Plant heights were recorded from each plants of per plot (6 plants/plot) and mean was calculated in centimeter (cm).

Number of leaves per plant

The number leaves of per plant were selected from each unit plot at 30, 45 and at 60 days after sowing (DAS) was counted and mean were calculated.

Number of branches per plant

Average number of branches per plant was found from each plants of per unit plot at 30, 45 and 60days after sowing (DAS) and mean was recorded.

Number of male flowers per plant

The number of male flowers per plant was counted from each unit plot after flowering and mean values are recorded per plant basis. Male flower selected based on the absence of initial oval shape fruit like structure at the base of flower.

Plate. 5. Male flower

Number of female flowers per plant

The number of female flowers per plant was counted from each plot after flowering and recorded per plant basis. Female flower selected based on the presence of initial oval shape fruit like structure at the base of flower.

Plate. 6. Female flower

Ratio of male and female flower

The ratio of male and female flower was calculated by dividing male flowers to female flowers recorded from at least 3 selected plants

Number of fruits per plant

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

Length of fruit

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

Plate.7. Length of fruit

Diameter of fruit

Diameter was measured by slide calipers and expressed in cm.

Individual fruit weight

The weight of individual fruit was recorded in gram (g) by a digital weighting machine from all fruits of selected plants and converted individually.

Plate.8. Individual fruit weight

Yield per plant

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

Plate.9. Fruit Yield per plant (kg)

Yield per plot

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

Yield per ha

Yield per ha was computed and expressed in ton per hectare

3.14 Statistical analysis

The collected data as per specific parameters were statistically analyzed to find out the significant variation between different treatments. The mean values were evaluated to measure the analysis of variance by the "F" (Variation ratio) test following Statistics 10 software program with the least significant difference (LSD) test at 5% level of significance.

3.15 Economic analysis

Economic analysis were done in order to find out the most profitable treatment combinations.

3.15.1 Gross return

Gross return was calculated on the sale price of marketable fruit of cucumber. The price of cucumber fruits in the market was considered at Tk.40.00 tk. /kg.

3.15.2 Net return

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

3.15.3 Benefit cost ratio (BCR)

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

Benefit cost ratio (BCR) = Gross return/

Total cost of production

CHAPTER IV

RESULTS AND DISCUSSIONS

The research work was carried out at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2019 to March, 2020 to investigate the effects of nutrients and bio-fertilizers on growth and yield of cucumber. The analysis of variance (ANOVA) of the data on different growth and yield parameter are presented in Appendix. The results have been presented with the help of table and graphs and discussed, and possible interpretations were given under the following headings:

4.1 Plant height

It is considered that plant height is the most influential parameter among others, which is positively correlated with the yield of cucumber. Plant height of cucumber plants showed statistically significant differences due to different treatments at 30, 45 and 60 DAS. At 60 DAS, the tallest plant (186.67 cm) was found from T_{12} treatment, which was statistically similar (186.23 cm) to T_{11} treatment. Whereas the shortest plant height (131.32 cm) was recorded from T_0 (control) treatment at the same DAS (Table 4). Data revealed that the T_{12} produced the longest plant followed by T_{11} and T_0 produced the shortest plant due to absolute control. The other highest and lowest plants height were found as per treatments (Table 4). From the above findings, it is becomes apparent that growth characters of cucumber depend on steady supply of nutrient. In addition to application of plant nutrients through inorganic and organic sources. Like *Azotobacter* fixed extra amount of atmospheric nitrogen which enhanced the vegetative growth resulting in higher photosynthetic activity. Besides PSB convert the soil phosphorus into available form required for the plants and these factors may be reasoned to better results of growth characters plant height in the present explained.

Bindiya *et al.* (2014) and Waleed *et al.* (2017) also reported similar findings from their experiments. Cucumber grown in Bangladesh needs suitable nutrients combination for its optimum growth and development and the growth of cucumber plants are gradually influenced by different nutrient treatments.

Table 4. Effect of different Treatments on plant height at different days after sowing (DAS)

Treatments	Plant height at(cm)		
	30 DAS	45 DAS	60 DAS
T_0	24.25l	57.3m	131.32m
T_1	27.50k	59.40l	148.35l
T_2	29.53i	63.45k	153.50k
T_3	32.50h	76.35g	161.43h
T_4	34.48f	77.21f	162.48g
T_5	28.53j	65.43j	157.28j
T_6	33.51g	73.33h	159.38i
T_7	36.46d	82.10d	178.25d
T_8	37.50c	83.61c	179.57c
T_9	32.51h	69.36i	162.82f
T_{10}	35.40e	79.40e	175.80e
T_{11}	38.46b	84.53b	186.23b
T_{12}	40.50a	86.25a	186.67a
$LSD_{(0.05)}$	0.05	0.11	0.13
CV%	6.41	8.67	8.25

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.2 Number of leaves per plant

Statistically significant variation was recorded due to different treatments number of leaves per plant of cucumber at 30, 45and 60 DAS (Fig.2). At 60 DAS, the maximum number of leaves per plant (77.0) was found from T_{12} treatment which was statistically similar (76.50) to T_{11} treatment, whereas the minimum number of leaves per plant (56.25) was recorded from T_0 (control) treatment. From the results it may be concluded that the application of various combinations of inorganic, organic, neem oil cake and bio-fertilizer sources of nutrients at optimum level evidenced to be effective in promoting germination percentage, growth of plant, flowering and yield of cucumber. Bindiya *et al*. (2014) and Sahu *et al*. (2020) also reported similar findings from their experiments.

In terms of no. of leaves in relation with different treatments at 30 DAS, 45 DAS and 60 DAS a statistically significant difference was recorded and a figure given below.

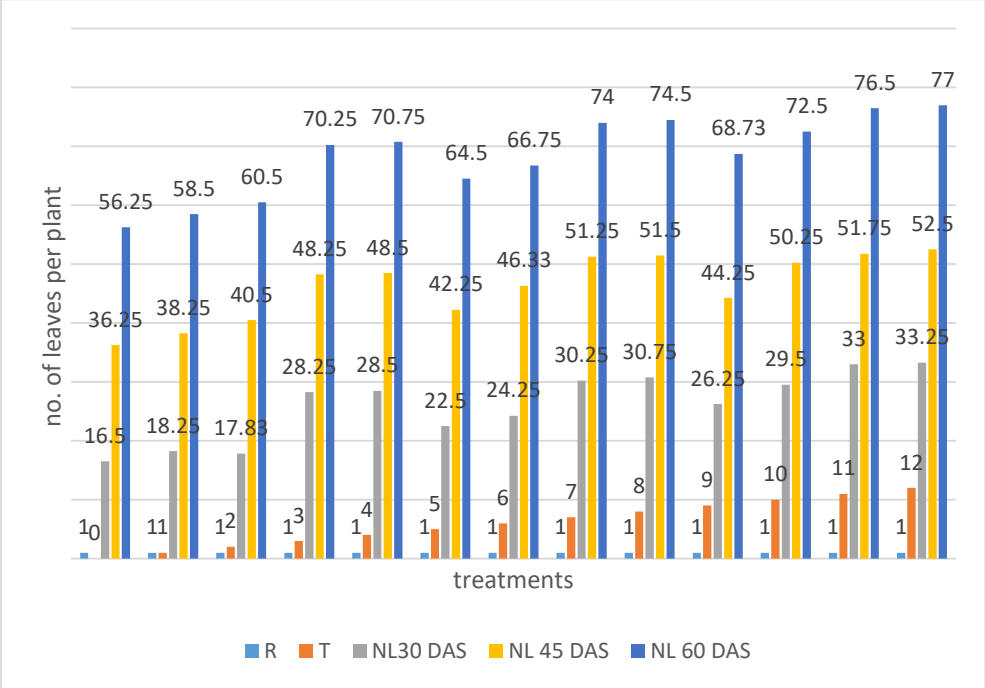


Fig.2.Effect of different treatments on no. of leaves per plant at different days after sowing (DAS).

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control

T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.3 Number of branches per plant

Number of branches per plant of cucumber showed statistically significant differences due to different treatments at 30, 45 and 60 DAS (Table.5). At 60 DAS, the maximum number of branches per plant (12.83) was found from T_{12} treatment, which was statistically similar (12.58) to T_{11} treatment, whereas the minimum number of branches per plant (8.58) was recorded from T_0 (control) treatment. It was found that the maximum no. of branches () in plants which were grown with the maximum amount of NPK with vermicompost, bio-fertilizer and neem oil cake. This might be due to the fact that combined application of organic and inorganic sources of nutrients act as tonic or stimulant to plants. It improves the nutrient assimilation. Organic manures with bio-fertilizer may contain numerous plant growth promoting bacteria (PGPB), which may enhance plant growth by nitrogen fixation, growth hormone production. Neem cake may have created a biological climate that was suppressive to diseased and control pathogens and helps in increasing the plant growth with number of branches per plant. This result is in accordance with the findings of Bindiya *et al*. (2014) and Sahu *et al*. (2020).

Table 5. Effect of different treatments on no. of branch per plant at different days after sowing (DAS)

Treatments	No. of branch at		
	30 DAS	45 DAS	60DAS
T_0	1.50j	5.50j	8.58j
T_1	2.25i	6.25i	9.25i
T_2	2.50h	6.50h	10.50g
T_3	3.50f	7.58f	11.58e
T_4	4.00d	8.00d	11.83d
T_5	3.25g	7.25g	10.25h
T_6	3.50f	7.33g	11.33f
T_7	4.25c	8.25c	12.25c
T_8	4.50b	8.50b	12.58b
T_9	3.50f	7.50f	11.25f
T_{10}	3.75e	7.75e	11.50e
T_{11}	4.58b	8.50b	12.58b
T_{12}	4.83a	8.83a	12.83a
$LSD_{(0.05)}$	0.09	0.10	0.12
CV%	8.98	8.16	11.97

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.4 Number of male flowers per plant

Number of male flowers per plant showed statistically significant variation due to different treatment combinations of cucumber (Table 6). The maximum number of male flowers per plant (32.66) was recorded from T_{12} treatment, whereas the lowest number of male flowers per plant (16.50) was found from T_0 (control) treatment .The maximum no. of male flower in this treatment was due to the treatment combinations like-NPK at75% and 100%, vermicompost, bio-fertilizer and neem oil cake.

Anjanappa *et al*. (2012) and Sudeshna *et al*. (2019) also reported similar findings from their earlier experiment. In winter no. of male flower per plant was increased then compared to summer.

4.5 Number of female flowers per plant

Different treatments showed statistically significant variation in terms of number of female flowers per plant of cucumber (Table 6). The highest number of female flowers per plant (22.0) was recorded from T_{12} treatment whereas the lowest number of female flowers per plant (10.50) was found from T_0 (control) treatment. This might be due to the enhanced production of growth substances like gibberellic acid, indole acitic acid, dihydro zeatin from bio-fertilizer which had positive influence on the physiological activity of plants which could assist the plants to induce female flowers; thereby it favorably modified the sex ration.

Mulani *et al.* (2007) and Anjanappa *et al*. (2012) also reported similar findings from their earlier experiment. In winter female flower is lower compared to summer.

4.6 Ratio of male and female flowers

Statistically significant variation was recorded in terms of ratio of male and female flowers of cucumber due to different treatment combinations (Table 6).The highest ratio of male and female flowers (1.57) was found from T_0 (control) treatment, while the lowest ratio of male and female flowers (1.32) was found from T_{12} treatment, which was identically similar to T_7 treatment and T_8 treatment (1.32 and 1.33).

Anjanappa *et al*. (2012) and Sudeshna *et al*. (2019) also reported similar findings from their earlier experiment. In winter No. of male flower per plant was increased then compared to female flower.

Table 6: Effect of different treatments on no. of male and female flowers and their ratios of cucumbers

Treatments	Male Flower	Female Flower	Male and Female flower Ratio
T_0	16.50h	10.50m	1.57a
T_1	18.50gh	12.33l	1.51c
T_2	20.25fg	13.50k	1.50c
T_3	24.75cd	16.50g	1.50c
T_4	25.00cd	16.75f	1.49c
T_5	21.50ef	14.00j	1.54b
T_6	21.58ef	15.50i	1.39f
T_7	25.75cd	19.50d	1.32g
T_8	26.25bc	19.75c	1.33g
T_9	23.33de	16.00h	1.46d
T_{10}	25.33cd	18.25e	1.39f
T_{11}	29.00b	20.50b	1.41e
T_{12}	32.66a	22.00a	1.32g
$LSD_{(0.05)}$	2.76	0.06	0.01
CV%	9.62	8.35	11.65

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.7 Number of fruits per plant

Number of fruits per plant is one of the precious parameter which determines the yield. Different treatments remarkably influenced production of fruit per plant. Significant variation was recorded due to different treatment combinations in terms of number of fruits per plant of cucumber (Fig.3). The highest number of fruits per plant (17.0) was recorded from T_{12} treatment which is statistically similar (16.25) from T_{11} treatment, whereas the lowest number of fruits per plant (8.51) was found from T_0 (control) treatment. The results of the study revealed that in most of the cases effects due to combined application of NPK + vermicompost+ bio-fertilizer+ Neem oil cake per hectare varied significantly from other treatments in relation to different yield attributes. Performance of all the different yield attributes were less under control. In T_{12} application of inorganic and organic sources of plant nutrients in combination with bio-fertilizer lead plant growth favorably with the production of more carbohydrates which perhaps accelerated better results of fruit number in these treatments.

Saeed *et al*. (2015) and Sudeshna *et al*. (2019) also reported similar findings from their earlier experiment.

In terms of no. of fruit per plant in relation with different treatments statistically significant difference was recorded and a figure given below.

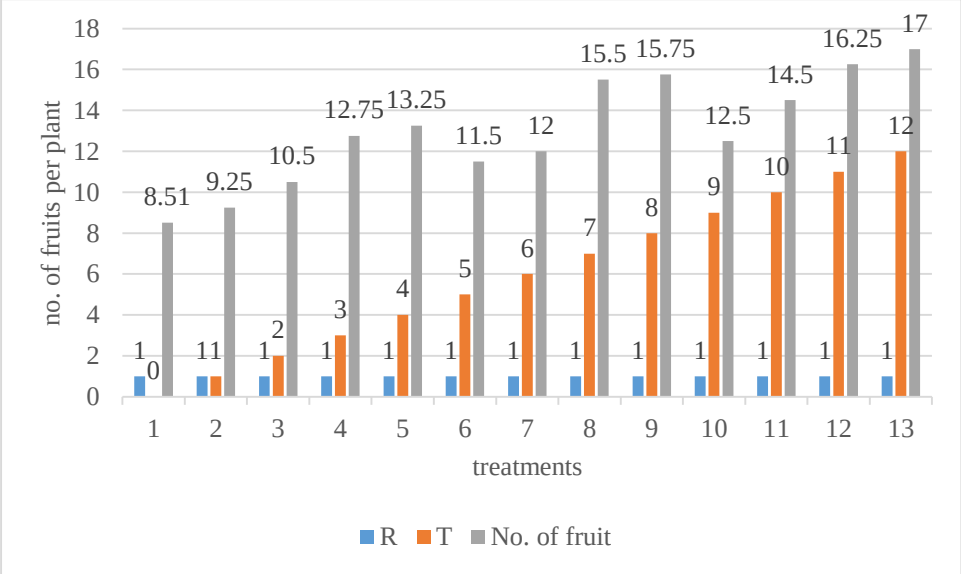


Fig.3.No. of fruits per plant in different treatments.

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.8 Average length of fruits

Different Treatments showed statistically significant variation in terms of length of fruits of cucumber (Table 7). The longest fruit (18.36 cm) was recorded from T_{12} treatment which was statistically similar to (17.57 cm) treatment T_{11}, whereas shortest fruit (12.46 cm) was found fromT_0 (control) treatment. Combined application of inorganic and organic sources of nutrients in combination with bio-fertilizers lead plant growth favorably with the production of more carbohydrates which perhaps accelerated better fruit length of cucumber. In this situation flow of assimilates of sink was high and might be reason of higher fruit length. A synergistic interaction among the inputs in the promising treatments might contribute to the results of yield attributes as explained from the findings of Nirmala and Vadivel (1999) in cucumber and Mulani *et al.* (2007) in bitter gourd.

4.9 Average diameter of fruits

Statistically significant variation was recorded in terms of diameter of fruits of cucumber due to different treatments (Table 7). The highest diameter of fruits (5.30 cm) was recorded from T_{12} treatment which was statistically identical (5.16 cm) to T_{11}, whereas the lowest diameter of fruits (3.46 cm) was found from T_0 (control) treatment. To increase in fruit size might be due to improved physiological activity

like photosynthesis and translocation of food material. Similar observation were reported by Waleed *et al.* (2017).

Table 7: Effect of different treatments on fruit length and fruit diameter of cucumber.

Treatments	Fruit length(cm)	Fruit diameter(cm)
T_0	12.46l	3.46i
T_1	14.20k	3.76h
T_2	14.26k	4.06g
T_3	15.38g	4.50de
T_4	15.66f	4.66cd
T_5	14.42j	4.23fg
T_6	14.57i	4.33ef
T_7	16.79d	4.76c
T_8	17.14c	5.00b
T_9	14.75h	4.46e
T_{10}	16.29e	4.76c
T_{11}	17.57b	5.16ab
T_{12}	18.36a	5.30a
LSD	0.14	0.19
CV%	12.43	9.27

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)

T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.10 Individual fruit weight

Distinct variation was observed among the treatments in respect of individual weight of fruits (Table 8). The highest individual fruit weight (181.67 g) was recorded from T_{12} treatment which was identically similar to (179.48 g) T_{11} treatment, whereas the lowest individual fruit weight (120.62 g) was found from T_0 (control) treatment. It was observed that individual weight of fruit increased with the increasing NPK levels upto optimum dose with organic manures and in combination with bio-fertilizers. On the other hand the lowest fruit weight was noted without fertilizer application. The increase in individual weight of fruit might be due to higher assimilate production and translocation of food material. Patil *et al.* (2018) and Sudeshna *et al.* (2019) also reported similar findings from their earlier experiment.

4.11 Fruit yield per plant

Different treatment combinations varied significantly in terms of fruit yield per plant of cucumber (Table 8). The highest fruit yield per plant (3.09 kg) was recorded from T_{12} treatment and the lowest fruit yield per plant (1.03kg) was found from T_0 (control) treatment. Rest others found as per treatments. The results clearly indicates that the necessity of application of inorganic and organic nutrients in combination with bio-fertilizers. Besides, quick availability of plant nutrient from inorganic sources, balanced C/N ratio, synthesis of auxin, growth substances, anti-fungal due to inoculation of *Azotobacter* and conversion of insoluble phosphate to soluble form by PSB perhaps helped to increase fruit yield of cucumber in T_{12} treatment. In addition to these factors growth and yield attributing characters may reasoned to such results. The present results are in accordance with the findings of Nirmala and Vadivel (1999) and Sudeshna *et al.* (2019).

Table 8: Effect of different treatments on yield and yield contributing characters of cucumber

Treatments	Individual fruit weight(g)	Yield per plant (Kg)	Yield per plot (Kg)	Yield per hectare (t/ha)
T_0	120.62m	1.03m	6.18m	11.44m
T_1	130.63l	1.21l	7.28l	13.48l
T_2	137.53k	1.45k	8.70k	16.11k
T_3	163.47g	2.09g	12.53g	23.20g
T_4	165.21f	2.19f	13.13f	24.32f
T_5	142.30j	1.64j	9.83j	18.20j
T_6	148.47i	1.79i	10.69i	19.80i
T_7	176.50d	2.74d	16.42d	30.40d
T_8	178.61c	2.82c	16.88c	31.26c
T_9	150.25h	1.88h	11.27h	20.87h
T_{10}	174.12e	2.52e	15.15e	28.05e
T_{11}	179.4 8b	2.92b	17.50b	32.41b
T_{12}	181.67a	3.09a	18.53a	34.32a
$LSD_{(0.05)}$	0.13	0.01	0.06	0.11
CV%	9.56	12.87	10.37	10.42

In a column means having similar letter(s) are statistically identical and those having dissimilar Letter (s) differ significantly as per 0.05 level of probability. Here different treatments of this experiment are given below-

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

4.12 Fruit yield per plot and per hectare

Statistically significant variation was recorded in terms of fruit yield per plot and per hectare of cucumber due to different treatment combinations (Table 8).The highest fruit yield per plot (18.53 kg) was recorded from T_{12} treatment, whereas the lowest fruit yield per plot (6.18 kg) was found from T_0 (control) Treatment. The highest fruit yield per hectare (34.32 ton) was recorded from T_{12} treatment, whereas the lowest fruit yield per hectare (11.44 ton) from T_0 treatment (control).

Waleed *et al*. (2017), Patil *et al*. (2018) and Sudeshna *et al*. (2019) also reported similar findings from their earlier experiment.

4.14 Economic analysis

Input costs for land preparation, seed cost, fertilizers, irrigation, manpower and others cost required for all the operations from planting to harvesting of cucumber were recorded for unit plot and converted into cost per hectare. Price of cucumber was considered as per market rate. The economic analysis presented under the following headings-

4.14.1 Gross return

The combination of Nutrients and Bio-fertilizers showed different gross return. The highest gross return (1372800Tk/ha) was obtained from T_{12} treatment and the second highest gross return (1296400Tk/ha) was found in T_{11}. The lowest gross return (457600Tk/ha) was obtained from T_0 treatment (Table 9).

4.14.2 Net return

In case of net return different treatments showed1 different net return. The highest net return (920,381 Tk/ha) was found from T_{12}. The lowest (154,228Tk/ha) net return was obtained T_0 treatment (Table 9).

4.14.3 Benefit cost ratio

In the combination of Nutrients and bio-fertilizers highest benefit cost ratio (3.03) was noted from T_{12} treatment and the second highest benefit cost ratio (2.93) was estimated from T_{11} treatment. The lowest benefit cost ratio (1.50) was obtained from T_0 (control) treatment from economic point of view, it was apparent from the results that the T_{12} treatment was more profitable than rest of the treatments (Table 9).

Table 9: Cost and returns of cucumber cultivation as influenced by different treatments.

Treatment	Cost of production (Tk./ha)	Yield of Cucumber (t/ha)	Gross Return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
T_0	303372	11.44	457600	154228	1.50
T_1	312576	13.48	539200	226624	1.72
T_2	423876	16.11	644400	220524	1.52
T_3	438763	23.20	928000	489237	2.11
T_4	448780	24.32	972800	524020	2.16
T_5	314396	18.20	728000	413604	2.31
T_6	425696	19.80	792000	366304	1.86
T_7	440582	30.40	1216000	775418	2.75
T_8	450599	31.26	1250400	799801	2.77
T_9	316216	20.87	834800	518584	2.63
T_{10}	427516	28.05	1122000	694484	2.62
T_{11}	442402	32.41	1296400	853998	2.93
T_{12}	452419	34.32	1372800	920381	3.03

Here,

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

Net return = Gross return – Cost of production

BCR = Gross return/Total cost of production

Market price:

Control @ 60tk/kg

Inorganic fertilizer @40tk/kg

Inorganic with Vermicompost @45tk/kg

Inorganic with Vermicompost and Bio-fertilizer @50tk/kg

Inorganic with Vermicompost, Bio-fertilizer and neem oil cake @55tk/kg

Market price varies as due to different treatments and their costs related with the crop production

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh from October, 2019 to March, 2020 to find out the effect of integrated nutrient management on growth and yield of cucumber (*Cucumis sativus* L) in winter season. Seeds of 'Madhumati' baromasi cucumber variety were used as the test crop. The experiment comprised of single factor. Treatments are-T_0=Absolute control, T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%), T_2= Recommended N_{75} P_{60} K_{50} (50%) + Vermicompost (3t/ha), T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha),T_4 = Recommended $N_{75kg/ha}$ $P_{60\ kg/ha}$ $K_{50\ kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha),T_5= Recommended $N_{112.5\ kg/ha}$ $P_{90\ kg/ha}$ $K_{75\ kg/ha}$ (75%), T_6 = Recommended $N_{112.5\ kg/ha}$ $P_{90\ kg/ha}$ $K_{75\ kg/ha}$ (75%) + Vermicompost (3t/ha), T_7 = Recommended $N_{112.5\ kg/ha}$ $P_{90\ kg/ha}$ $K_{75\ kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha), T_8= Recommended $N_{112.5\ kg/ha}$ $P_{90\ kg/ha}$ $K_{75\ kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha),T_9= Recommended $N_{150\ kg/ha}$ $P_{120\ kg/ha}$ $K_{100\ kg/ha}$ (100%), T_{10}= Recommended $N_{150\ kg/ha}$ $P_{120\ kg/ha}$ $K_{100\ kg/ha}$ (100%) + Vermicompost (3t/ha), T_{11}= Recommended $N_{150\ kg/ha}$ $P_{120\ kg/ha}$ $K_{100\ kg/ha}$ (100%) + Vermicompost (3t/ha)+ Bio-fertilizer (67 kg/ha), T_{12}= Recommended $N_{150\ kg/ha}$ $P_{120\ kg/ha}$ $K_{100\ kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

For Different treatments at 30, 45 and 60 DAS, the tallest plant (40.50, 86.25and 186.67 cm, respectively) was found from T_{12}, whereas the shortest plant (24.25, 57.33 and 131.32cm, respectively) was recorded from T_0. The maximum number of leaves per plant (33.25, 52.50 and 77.0, respectively) was found from T_{12}, whereas the minimum number of leaves per plant (16.50, 36.25 and 56.25, respectively) was recorded from T_0 at 30, 45 and 60 DAS. The maximum number of branches per plant (4.83, 8.83, and 12.83, respectively) was found from T_{12}. Whereas the minimum number (1.50, 5.5 and 8.58, respectively) was recorded from T_0 at 30, 45 and 60DAS.The highest number of

male flowers per plant (32.66) was recorded from T_{12}, whereas the lowest number (16.50) was found from T_0. The highest number of female flowers per plant (22.0) was recorded from T_{12}, whereas the lowest number (10.50) was found from T_0. The highest ratio of male and female flowers (1.57) was recorded from T_0, whereas the lowest ratio (1.32) was found from T_{12} (due to winter season).

The highest number of fruits per plant (17.0) was recorded from T_{12}, whereas the lowest number (8.51) was found from T_0. The highest length of fruits (18.36cm) was recorded from T_{12}, whereas the lowest length of fruits (12.46 cm) from T_0. The highest diameter of fruits (5.3 cm) was recorded from T_{12}, whereas the lowest (3.46 cm) from T_0. The highest weight of individual fruits (181.67 g) was recorded from T_{12}, whereas the lowest weight (120.62g) was found from T_0.The highest fruit yield per plant (3.09 kg) was recorded from T_{12}, whereas the lowest fruit yield per plant (1.03kg) was found from T_0. The highest fruit yield per plot (18.53kg) was recorded from T_{12}, whereas the lowest fruit yield per plot (6.18 kg) from T_0. The highest fruit yield per hectare (34.32 ton) was recorded from T_{12}, whereas the lowest fruit yield per hectare (11.44 ton) fromT_0.

Though the major challenging factor for growth and yield parameters of cucumber was the growing period (winter).The fruit production rate of cucumber could be lower as compared to summer as photoperiod is not same in winter essential for plants growth and yield parameters. But using of different treatments like vermicompost, bio-fertilizers, neem oil cake along with recommended doses of NPK helps in flowering and Fruit setting. And in winter the product price got high 40tk. per kg. The highest gross return (1372800Tk.) was obtained from T_{12} and the lowest gross return (457600Tk.) was obtained from T_0, from all the treatments. In case of net return the highest net return (920381Tk.) was found from T_{12} and the lowest (154228Tk.) net return was obtained T_0. In different treatments the highest benefit cost ratio (3.03) was noted from T_{12} and the lowest benefit cost ratio (1.50) was obtained from T_0.

CONCLUSION AND RECOMMENDATION

Regard as the above summary, it can be concluded that T_{12} treatment performed as an excellent result among other treatments in terms for growth and yield attributes of Cucumber. As the yield of cucumber was higher in recommended doses of NPK 100%, vermicompost (3t/ha), Bio-fertilizer (67kg/ha) and Neem oil cake (40kg/ha), than other treatments.

Another experiment may be carried out with another application time for more appropriate result. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

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APPENDICES

Appendix I: Monthly average 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	October	32	23	32	76	7.9
	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

*Monthly average

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

Appendix II. Characteristics of soil of experimental field

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), Khamar Bari, Farmgate, Dhaka.

B: Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	28
%Silt	42
%Clay	30
Textural class	Silty clay
P^H	5.47-5.63
Organic matter (%)	0.83%
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (meq/100 g soil)	0.10
Available S (ppm)	23

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

Appendix III. Analysis of variance of the data on plant height of cucumber as Influenced by different treatments.

Sources of variation	Degrees of freedom (df)	Mean square of		
		Plant height (cm)		
		30 DAS	45 DAS	60 DAS
Replication	2	0.77	0.36	0.35
Treatment	12	66.38 **	290.07**	770.84**
Error	24	0.0009	0.005	0.006

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

Appendix IV. Analysis of variance of the data on no. of leaves per plant of cucumber as influenced by different treatments.

Sources of variation	Degrees of freedom (df)	Mean square of		
		No. of leaves		
		30 DAS	45 DAS	60 DAS
Replication	2	0.22	0.87	0.81
Treatment	12	99.51**	90.99**	139.95**
Error	24	0.410	0.0016	6.410

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

Appendix V. Analysis of variance of the data on no. of Branches per plant of Cucumber as influenced by different treatments.

Sources of variation	Degrees of freedom (df)	Mean square of		
		No. of branches		
		30 DAS	45 DAS	60 DAS
Replication	2	0.69	0.63	0.45
Treatment	12	2.859 ^{NS}	2.826 ^{NS}	5.064 ^{NS}
Error	24	0.0029	0.004	0.005

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant.

Appendix VI. Analysis of variance of the data on yield contributing characters of Cucumber as influenced by different treatments.

Sources of variation	Degrees of freedom (df)	Mean square of			
		Male flower	Female flower	Male and female ratio	No. of fruits per plant
Replication	2	6.011	0.876	0.001	0.8001
Treatment	12	56.12^{NS}	34.69^{NS}	0.214 ^{NS}	21.66**
Error	24	2.698	0.0016	0.00007	0.0001

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

Appendix VII. Analysis of variance of the data on yield contributing Characters and yield of cucumber as influenced by different treatments.

Source of variation	Degrees of freedom (df)	Mean square of					
		Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight(g)	Yield per plant (kg)	Yield per plot (kg)	Yield per ha (ton)
Replic-ation	2	0.47	0.78	0.49	0.023	0.80	2.73
Treatm-ent	12	8.14 ^{NS}	0.84 ^{NS}	1272.76*	1.37**	49.21**	168.65**
Error	24	0.007	0.012	0.01	0.00004	0.0013	0.005

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

Appendix VIII: Per hectare production cost of Cucumber

A. Input cost

Treat-ments	Labour Cost	Ploug-hing Cost	Seed Cost	Irrigation Cost	Sticking Cost	Fruit Bagging Cost	Insecti-cides/ Pesticide	Manure and fertilizers						Sub Total (A)
								Urea	TSP	MP	Vermi-compost	Bio-fertilizer	Neem oil cake	
T_0	55,000	35,000	7000	40,000	50,000	7000	10,000	-	-	-	-	-	-	204000
T_1	60,000	35,000	7000	40,000	50,000	7000	10,000	1200	1320	750	-	-	-	212270
T_2	70,000	35,000	7000	40,000	50,000	7000	10,000	1200	1320	750	90,000	-	-	312270
T_3	75,000	35,000	7000	40,000	50,000	7000	10,000	1200	1320	750	90,000	8375	-	325645
T_4	80,000	35,000	7000	40,000	50,000	7000	10,000	1200	1320	750	90,000	8375	4000	334645
T_5	60,000	35,000	7000	40,000	50,000	7000	10,000	1800	1980	1125	-	-	-	213905
T_6	70,000	35,000	7000	40,000	50,000	7000	10,000	1800	1980	1125	90,000	-	-	313905
T_7	75,000	35,000	7000	40,000	50,000	7000	10,000	1800	1980	1125	90,000	8375	-	327280
T_8	80,000	35,000	7000	40,000	50,000	7000	10,000	1800	1980	1125	90000	8375	4000	336280
T_9	60,000	35,000	7000	40,000	50,000	7000	10,000	2400	2640	1500	-	-	-	215540
T_{10}	70,000	35,000	7000	40,000	50,000	7000	10,000	2400	2640	1500	90,000	-	-	315540
T_{11}	75,000	35,000	7000	40,000	50,000	7000	10,000	2400	2640	1500	90,000	8375	-	328915
T_{12}	80,000	35,000	7000	40,000	50,000	7000	10,000	2400	2640	1500	90,000	8375	4000	337915

Here.

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
+ Bio-fertilizer (67 kg/ha
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
+ Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
+ Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
+ Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
+ Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
+ Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)

B. Overhead cost (Tk. /ha).

Treat-ments	Cost of lease of land for 6 months (12% of value of land tk6 lakh/year	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk. 12% of cost/year	Sub Total (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
T_0	72000	10200	17172	99372	303372
T_1	72000	10613	17693	100306	312576
T_2	72000	15613	23993	111606	423876
T_3	72000	16282	24835	113117	438763
T_4	72000	16732	25402	114134	448780
T_5	72000	10695	17796	100491	314396
T_6	72000	15695	24096	111791	425696
T_7	72000	16364	24938	113302	440582
T_8	72000	16814	25505	114319	450599
T_9	72000	10777	17899	100676	316216
T_{10}	72000	15777	24199	111976	427516
T_{11}	72000	16445	25041	113487	442402
T_{12}	72000	16895	25608	114504	452419

Here,

T_0=Absolute control
T_1=Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%)
T_2= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha)
T_3= Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha
T_4 = Recommended $N_{75kg/ha}$ $P_{60kg/ha}$ $K_{50kg/ha}$ (50%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_5= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%)
T_6 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha)
T_7 = Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_8= Recommended $N_{112.5kg/ha}$ $P_{90kg/ha}$ $K_{75kg/ha}$ (75%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)
T_9= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%)
T_{10}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha)
T_{11}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha)
T_{12}= Recommended $N_{150kg/ha}$ $P_{120kg/ha}$ $K_{100kg/ha}$ (100%) + Vermicompost (3t/ha) + Bio-fertilizer (67 kg/ha) + Neem oil cake (40 kg/ha)