EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON THE GROWTH AND YIELD OF BROCCOLI (*Brassica oleracea* L. var. *italica*)

LAILA YESMIN

DEPARTMENT OF SOIL SCIENCE
SHER-E-BANGLA AGRICULURAL UNIVERSITY
DHAKA-1207

JUNE 2021

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON THE GROWTH AND YIELD OF BROCCOLI (*Brassica oleracea* L. var. *italica*)

BY

LAILA YESMIN

REG. NO. 14-05964

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

MASTERS OF SCIENCE (MS)
IN
SOIL SCIENCE

SEMESTER: JANUARY-JUNE, 2021

APPROVED BY:

……...……………………..……….	……………………………
Prof. Dr. Alok Kumar Paul	***Prof. Dr. Md. Asaduzzaman Khan***
Department of Soil Science	Department of Soil Science
SAU, Dhaka	SAU, Dhaka
Supervisor	**Co-supervisor**

……………………………………………

Prof. A. T. M. Shamsuddoha
Chairman
Department of Soil Science
SAU, Dhaka

Department of Soil Science

Sher-E-Bangla Agricultural University
Sher-E-Bangla Nagar
Dhaka-1207

Ref: - ....   Date:…………………

CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON THE GROWTH AND YIELD OF BROCCOLI (*Brassica oleracea* L. var. *italica*)"** *submitted to the Department of* Soil Science*, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in*** **SOIL SCIENCE***, embodies the result of a piece of bona fide research work carried out by* **LAILA YESMIN,** *Registration No.* ***14-05964*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2021
Dhaka, Bangladesh

Prof. Dr. Alok Kumar Paul
Department of Soil Science
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka- 1207
Supervisor

DEDICATED TO-

My Beloved Parents and Respected Research Supervisor

ACKNOWLEDGEMENTS

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

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

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

*The author feels to express his heartfelt thanks to the honorable chairman of Soil Science **Prof. A. T. M. Shamsuddoha** along with all other teachers and staff members of the department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka.*

The author wishes to express his wholehearted thanks to his well-wishers, classmates Sudipto Chandan, Md. Rasel Kabir, Md. Abdus Samad, for their keen help as well as heartiest co-operation and encouragement.

June, 2021 ***The Author***

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON THE GROWTH AND YIELD OF BROCCOLI (*Brassica oleracea* L. var. *italica*)

BY

LAILA YESMIN

ABSTRACT

The experiment was conducted at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from October 2019 to February 2020 to find out the effect of integrated nutrient management the growth and yield of broccoli. The experiment consisted of eight treatments viz. T_1=control, T_2=recommended fertilizer dose (RFD), T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost. BRRI broccoli-1 was used as a test crop for the experiment. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Results showed that the highest plant height (44.02cm, 61.25cm and 69.71cm) of broccoli at 40, 60 DAT and at harvest, number of leaves (6.50, 12.01, 17.93 and 23.03) at 20, 40, 60 DAT and at harvest, leaf length (50.10 cm), leaf breadth (21.89 cm), stem length (28.10 cm), stem diameter (3.78 cm), the highest primary curd weight (396.82 g), numbers of secondary curds (3.87), secondary curd weight (68.58 g) and yield (15.95 t/ha) were recorded from T_3 treatment. The lowest results on the respected parameters were found from T_1 (No fertilizer; control). The highest value of the N, P and K content in post-harvest soil was obtained from treatment T_3 and T_1 (No fertilizer; control) treated soil showed the lowest.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ABBREVIATIONS AND ACRONYMS

BARI	=	Bangladesh Agricultural Research Institute
AEZ	=	Agro-Ecological Zone
BCR	=	Benefit cost ratio
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
m	=	Meter
DAT	=	Days after sowing
M. S.	=	Master of Science
et al	=	and others (*at elli*)
VC	=	Vermicompost
SAU	=	Sher-e-Bangla Agricultural University
Kg/ha	=	Kilogram/hectare
g	=	Gram
ml/l	=	Milliliter per liter
LER	=	Land Equivalent Ratio
m^2	=	Meter squares
LSD	=	Least Significant Difference
CV%	=	Percent of coefficient of Variation
MoP	=	Muriate of Potash
PGR	=	Plant growth regulator
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Per cent

CHAPTER I

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica*) is the most important herbaceous biennial "Cole" crop under Brassicaceae family which is one of the leading vegetables in the world. Broccoli originated in west Europe. There are three classes of sprouting broccoli, i.e. green, white and purple, but the green type is the most popular broccoli (Shoemaker and Teskey, 1962). In Bangladesh it is planted in early September to late November (Ahmad and Shahjahan, 1991). Broccoli is generally grown in cool winter months in Bangladesh as an annual crop. It is one of the uncommon winter vegetables in Bangladesh which is a horticultural hybrid closely related to cauliflower and is considered as a commercial crop in India (Nonnecke, 1989). Its cultivation in Bangladesh has not been extended much beyond the farms of different agricultural organization. This is mainly due to the lack of awareness regarding its nutritive value and appropriate method of production technology. It is fairly rich in vitamin A, ascorbic acid and contains appreciable amounts of calcium, phosphorus, riboflavin, thiamin, niacin and iron. Watt (1983) reported that broccoli is more nutritious than any other cole crops such as cabbage, cauliflower and kohlrabi. On the other hand, broccoli is environmentally better adapted than cauliflower, and reported to withstand higher temperature than cauliflower (Rashid, 1976). Its wider environmental adaptability, higher nutritive value, good taste and less risk to crop failure due to various biotic and abiotic factors indicates that there is enough scope for its promotional efforts.

Unfortunately, the average yield of broccoli is quite low in Bangladesh in comparison to other broccoli growing countries of the world. Imbalanced fertilizer application is one of the major causes of low yield of broccoli in Bangladesh. Soil fertility status is a major constraint for higher crop production in Bangladesh. The increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic fertilizer have caused severe fertility deterioration of our soils resulting in stagnation or even decline of crop productivity. The excessive use of urea, imbalance use of phosphate and potassium fertilizers in the field of horticulture and agronomic crops without considering the other micro or macronutrients are a common practice in Bangladesh. Due to the deterioration of soil fertility and lack of sufficient amount of organic matter in the soil, the yield of vegetables, fruits and other crops are not satisfactory. A balanced supply of essential nutrients is indispensable for optimum plant growth.

Continuous use of large amounts of only N, P and K is expected to influence not only the availability of other nutrients to plants because of possible interaction between them but also the build of some of the nutrients creating imbalances in soils and plants leading to decreased fertilizer use efficiency (Nayyar and Chhibba, 1992). Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long-term sustainable crop productivity.

The application of different fertilizers and manures influences the physical and chemical properties of soil and enhance the metabolic activities of soil. The organism and chemical fertilizers are also positively correlated with soil porosity, enzymatic activity and CO_2 production. Organic matter stimulates soil biological activity. Among the different sources of organic manure, vermicompost is important in maintaining and enhancing the quality of environment and conserving resources for sustainable agriculture (Simanaviciene *et al.,* 2001). Taking into account the environmental and public health benefits of vermicompost farming, there is a considerable potential to maximize the use of vermicompost to increase yield and to reduce unnecessary usages of chemical fertilizer for crops production in Bangladesh. Vermicompost can only be done on compostable or decomposable organic matter. The compost prepared by using earthworms is called vermicompost. Vermicompost is the outcome of earthworm activities. Vermicompost is very important aspect of organic farming package today. It is easy to prepare, has excellent properties and is absolutely harmless to environment, soil and plants. Vermicompost is generally more beaded, crisped and micronized, that binds soil particles and contains several enzymes, microorganisms and plant nutrients. It has many functions, namely, micronizing soil particles to medium sized particles, re-distribution of nutrients, reduce runoff of nutrients from surface soil, increasing availability of phosphorous, potassium and nitrogen to plants and mixing of various nutrients. It can also be an important agent of pedogenesis.

Vermicompost is a potential source due to the presence of readily available plant nutrient, growth enhancing substances and number of beneficial micro-organisms like N fixing, P solubilizing and cellulose decomposing organisms (Sultan, 1997). About 10^6 bacteria, 10^5 fungi and 10^5 actinomycetes were reported to be present in per gram vermicompost. Vermicompost contains 2.29 times of more organic carbon; 1.76 times total N_2, 3.02 times phosphorus and 1.60 times potassium than natural compost. Earthworm decreased the C: N ratio from 14.21 to 10.11 on an average 56.03% of organic waste can be converted into vermicompost by the activities of earthworms in short time (Sohrab and Sarwar, 2001). It was showed that warm-worked composts have better texture and soil enhancing properties, hold typically higher percentages of N, P and K (Zahid, 2001). Harris *et al*. (1990) reported that earthworm excreta are an excellent soil conditioning material with higher water holding capacity for releasing N_2 in the soil. Vermicompost is important for the farmers to get better quality crop yields.

Integrated use of vermicompost and chemical fertilizers would be quite promising in providing greater stability in production and also in maintaining better soil fertility. Therefore, it is necessary to use fertilizer and vermicompost in an integrated way in order to obtain sustainable yield without affecting soil fertility.

Based on above points the present study was undertaken with the following objectives:

(a)To observe the effect of intregated nutrient management on the growth and yield of broccoli

(b) to find out the optimum dose or ratio of chemical fertilizer and vermicompost for maximum growth and yield of broccoli

CHAPTER II

REVIEW OF LITERATURE

Rabbee *et al.* (2020) carried out at Agricultural Research field, Noakahali Science and Technology University, Noakhali, Bangladesh during the period from September 2018 to February 2019 to find out the effects of Vermicompost and Farmyard manure growth and yield of Broccoli. From the study, it could be revealed that significant effect on growth and yield contributing characters of Broccoli to vermicompost application. Recorded data regarding on plant height, number of leaves/plant, leaf length, leaf diameter, plant spread, 50% curd initiation, 50% curd maturation, curd diameter, marketable curd weight, net curd weight and yield/plot were superior to vermicompost compared to farmyard manure than control. Finally, they stated that using of vermicompost treated plants gave better growth and yield contributing characters of Broccoli in contemporary with other treatments.

Singh *et al,*. (2020) carried out an experiment entitled “Integrated nutrient management studies on growth and yield of Broccoli (*Brassica oleracea var. italica*)” during 2018-19 at vegetable research farm of Lovely Professional University, Phagwara, Punjab, India. The treatment consisted of T_0: Control, T_1: 100 % RDF *i.e.* N: P: K @120:60:60 kg/ha, T_2: 20 t/ha FYM + 50 % RDF, T_3: 20 t/ha FYM + 25 % RDF, T_4: 10 t/ha FYM + 50% RDF, T_5: 10 t/ha FYM + 25% RDF, T_6: 10 t/ha V.C. + 50% RDF, T_7: 10 t/ha V.C. + 25% RDF, T_8: 5 t/ha V.C. + 50% RDF, T_9: 5 t/ha V.C. + 25% RDF. Application of integrated nutrient management significantly increased the growth and yield of broccoli. The treatment T_6 (10 t/ha Vermicompost + 50% RDF) recorded maximum plant height (39.53 cm and 54.87 cm) and maximum number of leaves/plant (8.20 and 13.60) at 45 and 60 days after transplanting respectively. This treatment also recorded the earliest days to head initiation (57.13 days) and first harvesting (80.07 days), maximum head weight (190 g), head diameter (110.33 mm), yield/plot (4.50 kg) and yield/ha (50.29 q) which was followed by treatment T_2 (20 t/ha FYM + 50% RDF). They concluded that, among all the treatments under study, the treatment T_6 the best for obtaining better growth and optimum yield.

A field experiment was conducted by Mohanta *et al.,* (2018) in the research farm of All India Coordinated Research Project on Vegetable, Orissa University of Agriculture and Technology, Bhubaneswar during 2014-15 to study the integrated nutrient management in Sprouting Broccoli cv. Shayali for growth, yield, quality and economics in a randomised block design with 10 treatments. The soil test based recommended fertiliser dose applied was NPK @ 200: 50: 150 kg/ha. The Treatment, T_7 i.e., 50% NPK + Vermicompost @2.5t/ha recorded maximum values for plant height (51.56cm), plant spread N-S (61.63cm) and E-W (64.91cm), number of leaves per plant (22.27), leaf area (405.45cm2), leaf length (23.15cm), leaf width (18.18cm), days to 50% head initiation (50.67days) and days to first harvest (51.00). The treatment, T_7 also recorded highest head girth (42.76cm), head diameter (14.16cm), terminal head weight (327.57g), head volume (595.67 cc), gross yield (233.56 q/ha), marketable yield (163.63 q/ha), vitamin C (80.24 mg/g), dry matter (11.77%), gross returns (Rs.700680.00/ha), net returns (Rs. 525510.00/ha) and benefit cost ratio (4.0). This was followed by treatment T_9 (50% NPK +poultry manure @ 2.5t/ha). Among all the treatments, the Treatment T_7 i.e., application of 50% recommended dose of NPK/ha with 2.5 tonnes of vermicompost in sprouting broccoli was found to be the best for obtaining better growth, optimum yield, better quality produce, highest net returns as well as cost benefit ratio and is recommended for Odisha condition.

Dipika *et al.,* (2015) conducted an experiment to evaluate the response of vermicompost and inorganic fertilizers on growth, yield and quality of sprouting broccoli during 2011-13 at UBKV, Pundibari, West Bengal, India. The treatments comprised of five levels of vermicompost (0, 2.5, 5, 7.5 and 10 t ha^{-1}) and four levels of inorganic fertilizers (0, 50, 75 and 100% of recommended dose). They reported that vermicompost offers great potential as organic amendment and it can be used beneficially in combination with inorganic fertilizers for broccoli cultivation. Combined application of 10 t ha^{-1} vermicompost and 100% recommended inorganic fertilizers proved its superiority in enhancing the growth, yield and quality attributes of broccoli. A judicious integration of vermicompost and recommended inorganic fertilizers seems to be appropriate for sustainable production of sprouting broccoli under eastern Himalayan region.

Chatterjee *et al*. (2013) conducted a field experiments at UBKV, Pundi bari, West Bengal, India to access the influence of different organic amendments on growth, head yield and nitrogen use efficiency in cabbage. The experiment comprised of 15 different nutrients source combining inorganic fertilizers, organic manures (farmyard manure and vermicompost) and Azophos biofertilizers were laid out in RBD with 3 replications. Growth and head attributes of cabbage were significantly influenced by different nutrient combination and vermicompost emerged as better organic nutrient source over farmyard manure. Inoculation with biofertilizers exerted more positive result over uninoculated treatments. The nutrient schedule comprising of higher amount of vermicompost (5 t/ha) along with 75% of recommended inorganic fertilizers in presence of biofertilizer inoculation emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, advanced head maturity, maximum curding percent and highest head yield as compared other nutrient combination. The different parameters of nitrogen use efficiency (PFP, AE, PUE and AR) were markedly enhanced by the same nutrient combination.

Pour *et al.* (2013) conducted an experiment to evaluate the possible effects of different concentrations of vermicompost on the growth and physiology of cabbage seedling (*Brassica oleracea var. capitata*). Vermicompost were used at five different levels (0, 10%, 20%, 40% and 80%). The seeds were planted in five different prepared soil mixtures with vermicompost and gouped in five different treatment groups including control (C), vermicompost of 10% (V10), vermicompost of 20% (V20), vermicompost of 40% (V40) and vermicompost of 80% (V80). The utilization of different levels of vermicompost had significantly enhancing effects on the Zn and auxin contents in leaf tissues. The results indicated that there were significantly positive correlations between the Zn and auxin contents. The applied vermicompost affected the leaf characteristics including the number of produced leaves, leaf area, fresh and dry mass. These findings indicated that the effects of vermicompost on plant growth and development not only were nutritional but also hormonal and biochemical and the utilization of high levels of vermicompost, especially at seedling stage, neither is not only economic but also may have adverse effects on the plant growth and development.

Getnet and Raja (2013) conducted an experiment during October 2011 to February 2012 to study impact of vermicompost on growth and development of Cabbage, *Brassica oleracea* Linn. and their sucking pest. Vermicompost was applied at the rate of 25, 50, 100 and 200 gm/plant individually. Each application 10 plants were selected and vermicompost application was continued on bimonthly basis. Totally 40 plants were used for control group in which 10 plants were selected randomly. Total number of leaves per plant; leaf length and width; plant stand height and root length; cabbage head round distance and weight and aphid population built-up were the parameters studied in experimental and control cabbage plants. Significant differences ($p<0.05$; LSD) were observed in the growth and development and pest infestation level between vermicompost applied and control plants. The number of plant stand height, cabbage head, leaves of cabbage were also significantly different ($p<0.05$; LSD) in experimental cabbage compared to control. Maximum number of cabbage plant was infested by aphid in control than experimental groups. In conclusion vermicompost have significant impact on cabbage growth promotion and reduce the aphid infestation.

Rai *et al*. (2013) studied an experiment to assess the effect of vermicompost, integrated with different rates of recommended doses of NPK for growth, yield and quality of cabbage. The investigation was laid out in RBD with ten treatments viz., T_1: 100% NPK (RR), T_2:75% NPK (RR)+VC 3 ton/ha, T_3:75% NPK (RR)+VC 2 ton/ha, T_4:75%NPK (RR)+VC 1 ton/ha, T_5:75% NPK (RR), T_6:50% NPK (RR)+VC 3 ton/ha, T_7:50% NPK (RR)+VC 2 ton/ha, T_8: 50% NPK (RR)+VC 1 ton/ha, T_9:50% NPK (RR) and T_{10}: VC 5 ton/ha. The results revealed that combined use of vermicompost and recommended dose of NPK were statistically significant towards the growth and yield of cabbage. The combined use of recommended dose of 75% NPK (RR) +VC 3 ton/ha, had recorded the maximum gross weight of the plant and net weight of the head. Application of vermicompost along with inorganic fertilizers reduced the days taken to maturity. The minimum days to 100% head maturity was also obtained from combined application of vermicompost. Most of the quality attributes like, total protein, total sugar, starch and ascorbic acid were found to be highest with 75% NPK (RR)+VC 3 ton/ha vermicompost except total chlorophyll content. It was concluded that application of vermicompost in combination with inorganic NPK fertilizers increased the productivity of cabbage besides sustaining soil fertility status.

Ghuge *et al.* (2007) conducted a field experiment during 2002-03 in Parbhani, Maharashtra, India to assess the effect of combined use of organic and inorganic nutrients sources on the growth and yield of cabbage. The experiment was consisted of 10 treatments. Among the treatments 50% RDF + 50% Vermicompost i.e. treatment T_2 gave the maximum plant spread, head circumference and head weight.

Azarmi *et al.* (2008) in their study analyzed the effects of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicon esculentum* var. *super beta*) in a field condition. The experiment was a randomized complete block design with four replications. The different rates of vermicompost (0, 5, 10 and 15 t ha^{-1}) was incorporated into the top 15 cm of soil. During experiment period, fruits were harvested twice in a week and total yield were recorded for two months. At the end of experiment, growth characteristics such as leaf number, leaf area and shoot dry weights were determined. The results revealed that addition of vermicompost at rate of 15 t ha^{-1} significantly (at $p < 0.05$) increased growth and yield compared to control. Vermicompost with rate of 15 t ha^{-1} increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe and Zn in the plant tissue increased 55, 73, 32 and 36% compared to untreated plots respectively. The result of our experiment showed addition of vermicompost had significant ($p <0.05$) positive effects on growth, yield and elemental content of plant as compared to control.

An experiment was conducted by Jahan *et al*. (2014) at experimental field of the Soil Science-1 Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during the period from October 2008 to March 2009 to study the effect of vermicompost and conventional compost on the growth and yield of cauliflower. The experiment comprised of twelve treatments viz. T_1: 100% Recommended Dose of Chemical Fertilizer (RDCF; RDCF= $N_{250}P_{35}K_{65}S_{40}$ Zn_5B_1 $kgha^{-1}$); T_2: 80% RDCF; T_3: 60% RDCF; T_4: 100% RDCF + Vermicompost @ 1.5 tha^{-1}; T_5: 80% RDCF + Vermicompost @ 3 tha^{-1}; T_6: 60% RDCF +Vermicompost @ 6 tha^{-1}; T_7: Vermicompost @ 6 tha^{-1}; T_8: 100% RDCF +Conventional compost @ 1.5 tha^{-1}; T_9: 80% RDCF +Conventional compost @ 3 tha^{-1}; T_{10}: 60% RDCF + Conventional compost @ 6 tha^{-1}; T_{11}: Conventional compost @ 6 tha^{-1} and T_{12}: Control (No fertilization) following Randomized Complete Block Design with three replications. Maximum plant height (49.4 cm), number of leaves $plant^{-1}$ (16.3), circumference of curd (46.5 cm), curd height (20.7 cm), total weight (1.60 kg $plant^{-1}$), marketable weight (13.0 kg $plant^{-1}$), curd yield (37.6 tha^{-1}) and stover yield (29.7 tha^{-1}) were found from T_4 which was statistically identical with or followed by T_8 and T_5. From the experiment it was found that vermicompost was better that conventional compost in combination with chemical fertilizers.

John *et al.* (2013) studied the effect of vermicompost on the growth and yield of Capsicum annum. Their study revealed that the total macronutrients and micronutrients showed elevated levels in vermicompost when compared to control. The vermicompost applied plant Capsicum annum showed an increased shoot length and number of leaves when compared to the inorganic fertilizer applied plant.

Yoldas *et al.* (2008) conducted an experiment to find out effect of nitrogen on yield, quality, and nutrient content in broccoli heads. Treatments consisted of 0, 150, 300, 450, and 600 kg N/ha. Application of nitrogen rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli. The highest total yield (346.31 q/ha) was obtained at 300 kg N/ha. Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) content increased with increase in nitrogen treatments but, phosphorus (P), copper (Cu), manganese (Mn), boron (B), and sodium (Na) contents were not influenced. It also, removed nutrients by broccoli head.

Ouda and Mahadeen (2008) conducted an experiment with nitrogen @ 0, 30 and 60 kg/ha to find out effects of fertilization on growth, yield quality and certain nutrient contents in broccoli. It was reported that head number per plant, chlorophyll content, head diameter and total yield was significantly higher when a combination of organic and inorganic fertilizers was added as compared with their individual addition. Application of 60 kg nitrogen as inorganic fertilizers with 60 tonnes of organic manure per hectare produced the highest broccoli yield (40.05 t/ha), whereas fresh and dry weight of broccoli shoots were not significantly affected by the application of different doses of fertilizers. Leaf macro-(N, P and K) and micronutrient (Fe, Mn and Zn) contents increased with the application of either organic manure or inorganic fertilizer compared to the control.

Giri *et al.* (2013), at Rampur-Chitwan (Nepal), using Calabrese and Green Sprouting cultivars under different nitrogen dose, found that increasing up to 200 k ha^{-1} the doses of N, a 33% higher than the used by Puenayan *et al.* (2010), significant inflorescence yield continued growing (14.5 t ha^{-1}) because of a mayor photosynthates production available for inflorescence filling.

El-Helaly (2012) studied the effects of nitrogen, sulphur and growing seasons on yield and the content of nitrate and vitamin C on broccoli (*Brassica oleracea* L. var *italica*). Three N fertilizers (ammonium sulphates, ammonium nitrate and urea) were side-dressed, while two levels of sulphur (0.0 and 0.5%) were sprayed on broccoli plants grown in both spring and fall-winter seasons. It was reported that application of urea as N-source decreased the yield by approximately 13-15% than other N-source.

Cutcliffe *et al.* (2013) studied the effects of nitrogen @ 0, 40, 80 and 120 kg/fed, phosphorus and potassium and their interaction on vegetative growth, yield and quality as well as chemical composition of broccoli. It was reported that an increase in nitrogen dose up to 80kg/fed considerably improved curd weight. While, dry matter was reduced with increased application of nitrogen led to improve vitamin C and sulforaphane by nitrogen levels up to 120 kg/fed and 40 kg/fed respectively.

A field experiment was conducted by Reddy and Rao (2004) to study the Growth and yield of bitter gourd (*Momordica charantia* L.) as influenced by vermicompost and nitrogen management practices in Hyderabad, Andhra Pradesh, India, consisting of 4 levels of vermicompost (0, 10, 20 and 30 t/ha) and 3 levels of N (20, 40 and 80 kg/ha). Application of vermicompost and N significantly increased the vine length, number of branches, number of fruits per vine and fruit yield/ha. Delayed flowering was observed with higher levels of N and Vermicompost. Application of 13.8 t vermicompost and 34.18 kg N (through urea)/ha was found beneficial in improving the yield of bitter gourd.

Giri *et al.* (2013) evaluated the effect of nitrogen rates on growth and yield of two varieties of broccoli i.e. Green sprouting and Calabrese in western chitwan, Nepal using 5 nitrogen levels @ 0, 50, 100, 150 and 200 kg/ha. It was reported that yield was significantly influenced with cultivar and nitrogen. There was increase in curd production up to 200 kg N/ha which was 14.47 t/ha. While, Green sprouting produced 11% higher total curd than another cultivar.

A study was conducted by Reddy and Reddy (2005) in Andhra Pradesh, India during 1996-98 to determine the effects of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen fertilizer (0, 50, 100, 150 and 200 kg/ha) on the growth and yield of onion (cv. N-53) and their residual effect on succeeding radish in an onion-radish (cv. Sel-7) cropping system. The plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion increased significantly with increasing levels of vermicompost (from 10 to 30 t/ha) and nitrogen fertilizer (from 50 to 200 kg/ha). A similar increase in radish yield was also observed due to the residual effect of different levels of vermicompost and nitrogen applied to the preceding crop (onion). Among the various treatment combinations, vermicompost at 30 t/ha + 200 kg N/ha recorded the highest plant height and number of leaves per plant in onion and radish, but was at par with the treatment with vermicompost at 30 t/ha + 150 kg N/ha in terms of bulb length, bulb weight and onion yield recorded.

Mahtoj and Yadav (2005) conducted a pot culture experiment during winter season of 2001-02 to investigate the effect of vermicompost on growth and productivity in vegetables peas. The dry weight in vegetable peas was significantly influenced by vermicompost.

Rodriguez *et al*., (2000) investigated the effect of vermicompost on plant nutrition, yield and incidence of root and crown rot of gerbera. Vermicompost incorporation at 20%, with or without chemical fertilizer, reduced the incidence of diseased plants and the disease growth rate. The macro and micronutrient content except (K and Mn) were at optimum level in plants treated with 20% vermicompost with or without chemical fertilizer. In contrast, plants from treatments without vermicompost had the lower content of macro and micronutrient, except K and Mn.

Premi *et al.* (2005) conducted a field experiment to study the effect of organic and inorganic nutrients on the growth. yield attributes, seed yield and oil content of Indian mustard. Application of vennicompost at 5.0 t/ha *75%* recommended dose of fertilizer (80 kg N and 40 kg P_20_5/ha) recorded maximum plant height. number of primary and secondary branches per plant. number of siliquae per plant and number of seeds per siliqua, which in turn resulted in higher seed yield. It was at par with farmyard manure at 10.0 t/ha + 75% recommended fertilizer and recommended dose of fertilizer.

Singh *et al.*, (2005) conducted a study to assess the effect of vermicompost on cauliflower productivity and profitability considering soil health under small production systems. The data were gathered through farmer participatory verification trials during 2002-04 in five villages of Rajaulatu Panchayats of Namkum Block in Ranchi district, Jharkhand. It was found that the return per rupee spent in plots with vermicompost was Rs. 3.30, Rs 1.98 in plots applied with chemical fertilizers. The farmer's reaction on the use of vermicompost was highly positive because of its simplicity and compatibility with the farming system components and with the household internal resources, as well as its cost effectiveness.

Sohrab and Sarwar (2001) conducted an experiment and found that in case of Lady's finger (okra), the vermicompost had played very effective role in all economic aspects of the vegetables crop. The yield of lady's finger was 18.40 t ha^{-1} from the experimental plots treated with vermicomposts in one season. On the 13 contrary, production of 12.43 t ha^{-1} was estimated on the basis of harvested crop from untreated plots.

A number of field experiments have reported positive effect of quit low application rate of vermicompost to field crop. These applications were comparable with rates that improved growth on the same crops in greenhouse experiment. When cabbage was grown in compressed blocks made from pig waste vermicompost, after transplanting to the field they were larger and more mature at harvest compared to those grown in commercial blocking material (Edwards and burrows, 1988).

An experiment was conducted by Siag and Yadav (2004) in Rajasthan, India, during 1999-2001 to study the effect of vermicompost (0, 1, 2 and 3 t ha^{-1}) and fertilizers (0, 50 and 100% recommended dose) on mungbean (*Vignaradiata*) yield. Significant increase in seed yield was observed by the application of vermicompost up to 2 t ha^{-1} owing to increased secondary branches per plant, pods per plant. Increased in secondary branches and nodules per plant resulted in improved yield attributes and seed yield over the control. Application of vermicompost (2 t ha^{-1}) along with 50% recommended dose of fertilizers (10 kg N and 8.7 kg P ha^{-1}) was found to be the optimum dose for mugbean grown on sandy-loam soil.

Subler (1998) reported that in all growth trials the best growth responses were exhibited when the vermicompost constituted a relatively small portion (10% - 20%) of the total volume of the container medium. Valani (2009) found that 200g of vermicompost applied in plot soils performed better growth in wheat crop than those of 400g and 500g of vermicompost. Sinha *et al.*, (2009) found that vermicompost was applied in the 2nd, 3rd and 4th successive years, the growth and yield of wheat crops increased gradually over the years at the same rate of application of vermicomposti.e @20 Q/ha.

Patil (1995) reported that application of vermicompost at 75 and 95 days after planting helps in obtaining maximum plant height in onion. He also indicated that application of vermicompost and 50% of recommended dose of fertilizer helps in increasing the number of leaves per plant compare to control in potato.

Vadiraj *et al.* (1998) compared vermicomposts application rates of 5 t/ha up to 25 t/ha in 5 t/ha increments on growth of three varieties of coriander. The responses to the vermicompost applications differed for all three varieties tested. However, he reported RCr-41 produced the most herbage among the three. Maximum herbage yields from all three were occurred 60 days after sowing. The varieties RCr-41, Bulgarian, and Sakalespur Local attained largest yields at vermicompost applications rates of 15 t/ha, 10-25 t/ha, and 20 t/ha, respectively.

Food waste and recycled paper vermicomposts were applied at rates of 10 t/ha and 5 t/ha in 2000 to strawberries (*Fragaria spp*.). All of the vermicompost treated plots were supplemented with inorganic fertilizers to equalize the available N levels in all plots at transplanting. The marketable tomato yields in the vermicompost (plus fertilizers) plots were consistently and significantly greater than those from inorganic-fertilizer only treated plots. There were significant increases in shoot weights, leaf areas and marketable fruit yields of pepper plants grown in plots that were treated with vermicompost compared to those of plants grown in inorganic fertilizers. Leaf areas, numbers of strawberry suckers, numbers of flowers, shoot weights, and marketable fruit yields of strawberries all increased significantly in response to supplemented vermicompost applications compared to those from strawberries that received inorganic fertilizers only (Arancon *et al*, 2004).

Kumhar (2004) conducted an experiment on cauliflower and found that an application of 7.5 t vermicompost increased the volume of curd significantly.

Hiranmai *et al.* (2003) reported that vermicompost in combination with NPK fertilizers significantly increased the yield parameters of chilli. Whereas, Zhang *et al.* (2003) observed that compost combined with inorganic fertilizers in tomato significantly increased the early, large fruit and total marketable yields by 10.6, 10.4 and 18.4 per cent more, respectively, than the inorganic fertilizers alone.

Hangarge *et al.* (2002) observed that when 5 t ha^{-1} vermicompost combined with chemical fertilizers (N:P:K 25, 50 and 100 percent), there was significant increase in yield attributes of chilli cv. Parbhani Tejas compared to organic and chemical fertilizers alone.

Singh *et al.* (2002) reported that in broccoli the maximum head diameter was obtained when the dose of NPK was 200 : 120 : 80 kg ha^{-1} respectively. Similarly, Gupta *et al.* (2002) observed that application of 200 kg N ha^{-1} increased leaf growth in cauliflower significantly over control.

Babik and Elkner (2002) conducted an experiment on broccoli and reported that with higher nitrogen fertilization (600 kg ha^{-1}), sugar content increased but level of ascorbic acid decreased and also reported that nitrate content in broccoli heads also increased with higher nitrogen does.

Hangarge *et al.* (2002) observed that when 5 t ha^{-1} vermicompost combined with chemical fertilizers there was significant increase in growth attributes of chilli cv. Parbhani Tejas compared to organic and chemical fertilizers alone.

Naidu *et al.* (2002) obtained highest fruit girth, 50% flowering and benefit :cost ratio of brinjal cv. JB-64 with 75:35:0 kg ha^{-1} NPK along with organic manures (FYM, poultry manure and vermicompost).

Karitonas (2001) reported that an increased level of N supply (60 to 300 kg ha^{-1}) slightly reduced the vitamin C content from 83 to 73 mg/100 g of fresh weight in broccoli flowers and also improved the chlorophyll contents in florets.

Patil and Biradar (2001) obtained the highest fruit yield (19.12 q ha^{-1}) of chilli cv. Byadgikaddi with the application of 200 per cent RDF + FYM +VC. The N, P and K uptake also increased with the increase in nutrient levels. The different levels studied were 100 per cent recommended dose of fertilizer (150:75:75) kg ha^{-1} + farm yard manure 10 t ha^{-1}, 100 per cent RDF + FYM + vermicompost @ 2.5 t ha^{-1}, 150 per cent RDF + FYM + VC, 200 per cent RDF +FYM + VC. While, Sharu and Meerabai (2001) recorded highest fruit yield (9.66 t ha^{-1}) with 50 per cent poultry manure + 50 per cent inorganic N.

Jana and Mukhopadhyay (2001) concluded that increase in nitrogen levels upto 150 kg N ha^{-1} increased plant height, leaf length, leaf width, days to curd initiation days to curd maturity and curd diameter in cauliflower.

Samawat *et al.* (2001) reported that vermicompost had a significant effect on number of fruits in tomato. In 100 per cent vermicompost treatment, fruit numbers were four times more than the control treatment.

Shreeniwas *et al.* (2000) conducted a field experiment on ridge gourd and observed that the increasing levels of vermicompost (0, 5, 10 and 15 t ha^{-1}) increased the fruit weight and fruit volume.

Atiyeh *et al.* (2000) conducted an experiment in which tomatoes were grown in a standard commercial greenhouse container medium (Metro- Mix 360) considered as control, substituted with 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 per cent (by volume) pig manure vermicompost. They obtained highest marketable yield (5.1 kg per plant) and weight of fruit in substitution of Metro Mix 360 with 20 per cent vermicompost. Substitution of Metro-Mix 360 with 10, 20 and 40 per cent vermicompost reduced the proportion of fruit that were non-marketable and produced larger size (diameter > 6.4 cm) than small size (diameter < 5.8 cm) fruits.

Singh and Singh (2000) reported that the highest net head yield and weight were obtained when nitrogen (150 kg ha^{-1}) and potassium (50 kg ha^{-1}) were applied in broccoli.

Das *et al.* (2000) reported that the highest yield in cabbage was obtained by the application of NPK fertilizers at the rate of 120, 90 and 75 kg ha^{-1} respectively.

Rutkauskiene and Poderys (1999) reported that the highest yield of curd in cauliflower crop was obtained by use of 240 kg N ha^{-1}. Similarly, Cai *et al.* (1999) observed that the application of 15 g urea + 10 g, potassium chloride per plant produced the earliest curds of high yield while application of 30 g urea + 10 g potassium chloride per plant produced the highest yield. Whereas, application of 30 g urea + 30 g potassium chloride plant ha^{-1} gave the least satisfactory results in broccoli.

Vadiraj *et al.* (1998) studied the response of coriander to graded levels of vermicompost in comparison with chemical fertilization (NPK), the study indicated that application of vermicompost significantly increased herbage and seed yield of coriander and was comparatively higher to chemical fertilization.

Sharhidhara *et al.* (1998) reported that application of 100% recommended dose of fertilizer (NPK 150 : 75 : 75 kg ha^{-1}) together with 2.5 t ha^{-1} vermicompost increased dry pod yield in chilli.

Patil *et al.* (1998) recorded highest net income (Rs 28970), highest increase of net income (24.18%) over recommended dose of fertilizer and high cost :benefit ratio (1:3.47) in the treatment, recommended dose of fertilizer + 50% vermicompost in tomato crop. Likewise, Sharhidhara *et al.* (1998) reported that application of 100 per cent recommended dose of NPK (150:75:75 kg ha^{-1}) together with 2.5 t ha^{-1} vermicompost increased dry fruit yield significantly over 50 per cent recommended dose of fertilizer and control in chilli.

Reddy *et al.* (1998) recorded maximum plant height at harvest, days to first flowering and branches per plant with the application of vermicompost 10 t ha^{-1} and recommended dose of NPK 27.5 :60:50 kg ha^{-1} in garden pea cv. Sel. FC-1.

Chee *et al.* (1998) studied the effect of vermicompost incorporation and arbuscular mycorrhizae inoculation on onion yield and nutrient content in Mexico. Long white onion *(Alliurn cepa)* was sown in milled, sieved (2 mm mesh) and fumigated (with C11313r). temperate soil from Ilueyotlipan, TIax, Mexico, with vermicompost (8 t/ha) made of coffee pulp. with and without arbuseular mycorrhizac inoculation. In general. 120 days after sowing, plant yield and nutrient content increased with applied vermicompost or mycorrhizal inoculation. This nutrient increase was attributed to nutrients supplied by the vermicompost or the establishment of mycorrhizal symbiosis. The combined application of verm icompost and niycorrhizal inoculation slightly decreased arbuscular colonization without affecting yields. but contrarily increased P and K content, demonstrating that simultaneous application of 2 or more biofertilizers is not always profitable

Masciandro *et al*. (1997) investigated the effects of direct applications of vermicomposts produced from sewage sludge into the soil as well fertiirrigation with humic extracts from vermicomposts. They reported a greater growth index of garden cress (*Lepidium sativum)* treated with vermicomposts than in control treatments with no vermicompost applications. Soil analyses after the vermicompost applications showed marked improvements in the overall physical and biochemical properties of the soil. A surface application of vermicompost derived from grape marc, spread under grape vines covered with a straw and paper mulch increased yields of a grape variety Pinot Noir by 55% (Buckerfield and Webster, 1998).

Singh *et al.* (1997) studied the response of chilli to vermicompost and observed that application of vermicompost increased the microbial activities, which have its positive effect on the performance of plants as indicated by higher number of branches and fruits.

Wang *et al.* (1997) studied the effects of N, P and K on yield of broccoli and concluded that to obtain higher yield, N, P and K application should be balanced. Whereas, Rooster and Spiressens

(1998) found that yield of cauliflower were higher with 99-107 kg /acre as compared to 89-93 kg/acre.

Ying *et al*. (1997) conducted a pot experiment to determine the effect of N P and K on yield and quality of broccoli. They observed K was the most important element for yield and dry weight. Additive effects were observed on yield and vitamin C (ascorbic acid) content when K was applied together with N or N + P. Application of N+P gave 110.8% higher yields than N alone. Nitrogen application advanced the harvesting date. Significant positive correlations were found between yield and dry weight of leaves and plant size. They also suggested that N, P and K application should be balanced to obtain high yields and quality of broccoli.

Lopes *et al.* (1996) reported that an increase in the levels of vermicompost upto 10 t ha^{-1} significantly increased the total N content in cow pea plant. Similarly, The highest TSS and ascorbic acid were recorded in cabbage with the application of 75 per cent of the recommended does of NPK combined with digested organic supplement and vermicompost (Mahendran and Kumar, 1997).

Tesi *et al.* (1996) studied the effect of increasing N rates (0, 50, 100, 200, 400 and 600 kg ha^{-1}) on cauliflower curd and plant height, nitrate accumulation, mineral uptake and N utilization ratio in an early (cv. SG 118) and late (cv. Dova) cultivars and they concluded that the increasing N levels of nitrogen increased plant and curd weight by applying 100 and 200 kg N ha^{-1}.

Thakur *et al.* (1991) observed that by increasing the dose of nitrogen, curd maturity was delayed and dry matter content and leaf area of cauliflower was increased. Whereas, Booij (1992) reported that increased nitrogen content upto 0.47 g lit^{-1}, increased dry weight, plant height and leaf area of cauliflower.

Welch *et al.* (1987) reported that an application of 270 kg N ha-1 through ammonium sulphate resulted the maximum plant growth in cauliflower at California. Likewise, Trembely (1989) studied the effect of nitrogen on broccoli cv. Green Valiant at Canada. He found that nitrogen levels of 75, 150 and 225 kg ha^{-1} resulted in greater vegetative growth.

Mangal *et al.* (1984) observed that maximum plant height of cabbage was found with the application of 150 kg ha^{-1}. Whereas, Sharma and Lal (1986) observed that by increasing the levels of nitrogen from 60 to 120 kg ha^{-1}, the plant height, plant spread and number of outer leaves increased in cabbage.

Roy (1981) while working on cauliflower cv. Dania West- Bengal observed that with the increase in nitrogen levels, the diameter of the curd was increased and the maximum diameter was obtained with 200 kg N ha-^{1}. He also reported that there was no significant difference to maturity in different treatment including control. Similarly, Letey *et al.* (1983) working with three nitrogen levels 90, 180 and 270 kg ha^{-1} on broccoli, observed that plant growth were increased significantly with increasing levels of nitrogen.

Gill *et al.* (1975) obtained maximum plant height, number of branches per plant and curd size in cauliflower, cv. Snowball-16 at Katrain by the application of 375 kg N ha^{-1} and followed by 250 kg P_2O_5 ha^{-1}. It was further observed that curd formation was delayed with every ascending level of nitrogen, however, the difference amongst different treatments for these characteristics were non significant. Likewise, Raut and Kedar (1981) reported that application of 100 kg N ha^{-1} was found to be the best in respect of plant growth of cauliflower.
A study *was* conducted in India on two wheat cultivars to investigate the effect of chemical fertilizers (NPK fertilizer), and organic manure (verniicornpost). Results showed that plant height. dry matter production and grain yield were higher at higher dose of vermieompost. Number of tillers and leaves per plant *were* very low at early stages of growth and suddenly increased after adding different doses of vermicompost and organic manure (Khandal and Nagendra, 2002).

A field experiment was conducted by Ranwa and Singh (1999) at Hisar, Ilaryana, India during the winter seasons of 1994-96 to study the effect of integration of nitrogen with vermicompost on wheat crop. The treatment comprised 5 levels of organic manures. viz., no organic manure. Farmyard manure at l0 t/ha, vermicompost at *5. 7.5* and 10 t/ha and 5 levels of N viz. 0, *50,* 100 and 150 kg/ha and recommended fertilizer. They reported that the application of organic manures improved yield attributes and grain, straw and biological yields of wheat. Application of vermicompost at *7.5* or 10 t/ha resulted in higher yields than 10 t/ha FYM.

A field experiment was conducted in Orissa, India. during the *kharif* season of 1999 to determine the effect of integrated application of vermicompost and chemical fertilizer on rice cv. Lalat. Yield components were increased by integrated application of vermicompost and chemical fertilizes compared to the other treatments. The highest results in terms of straw and crop yields were obtained with 50% vermicompost -I- 50% chemical fertilizers (Das *et al. 2002).* The continued application of organic and inorganic N sustained the productivity. Soil available nutrients like N. P and K increased significantly with the application of various organic sources of nutrients in combination with fertilizers over the fertilizer alone. The highest grain yields of *rabi* sorghum and chickpea were obtained with 50 percent N through green manure plus 50 percent fertilizer N (Tolanur and Badanur. *2003).*

Vasanthi and Kuniaraswamy (1999) from an experiment with vermicompost and NPK fertilizers showed that the grain yields of rice were significantly higher in the treatments that received vermicompost from any of the *5* to 10 t/ha organic materials (sugarcane trash, Ipomea, banana peduncle etc) with N, P and K at recommended levels than in the treatment that received N. P and K alone. Organic carbon content and fertility status as reflected by the available status of' N. P. and K, micronutrients and CEC were higher and bulk density were tower in the treatments that received vermicompost plus N. P and K than in the treatments with N. P and K alone. It was found that vermicompost at *5t/*ha would be sufficient for rice crop when applied with recommended levels of

N. P and K.

Vachhani and Patel (1993) studied the effect of different levels of nitrogen (50, 100 or 150 kg/ha), phosphorus (25, 50, *75* kg P_20_5 ha^{-1}) and potash (50, 100 or 150 kg K_20 ha^{-1}) on the growth and yield of onion. They found that plant height; number of leaves plant": bulb weight and yield were highest with 150 kg N ha^{-1}. although bulb weight and yield with 100 kg N $\mathbf{ha^{-1}}$ were not significantly different. Increasing phosphorus application increased the number of leaves per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plants.

Vermicompost produced higher yield of tomato than the chemical fertilizer treated and control plots. Same margin of production was obtained in snake gourd, bitter gourd and lady's finger. All the plots of lady's finger at one time were completely damaged due to severe virus attack. It was observed that crops grown under chemical fertilizer became yellowish rapidly while crops grown under vermicompost remained green. Germination of different seeds in the vermicomposted plots were higher than the control and chemical fertilizer treated plots (Zahid. 2001).

Akbasova *et al.* (2015) conducted an experiment and reported that the increase of root crops yield 1.2-1.5 times in with 8 t ha-1 vermicompost in gray soils was established. It was shown that the use vermicompost as a fertilizer was more expedient, as it contains more nutrients (NPK) and organic humic acids compared to conventional compost. Vermicompost has a direct physiological effect on plants; it stimulates the development of root systems and reduces the harmful effects of pollutants.

Shirzadi (2015) conducted an experiment to evaluate the use of organic fertilizers (Vermicompost and Chicken manure) on the plant height and number and weight of micro tuber Marfona cultivator potato (diameter of 25-35mm) with 2 factors of vermicompost in 4 levels (0, 3, 6 and 9 t ha-1) and chicken manure in 4 levels (0, 10, 12 and 14 t ha-1). The result showed that with increasing vermicompost fertilizer, plant height was increased. Also highest number and weight of tubers with a diameter of 25-35 mm belonged to 12 ton Chicken manure treatment with vermicompost.

Ramamurthy *et al*. (2015) was conducted an experiment to show the influence of different percentages of vermicompost (25%, 50%, 75% and 100%) on the tuber length, width, circumference and weight of the radish plant (*Raphanus sativus* L.) was carried out at different period of exposures (30, 60 and 90 days). The maximum tuber length (20.67, 23.67 and 27.55 cm) and weight (189.31, 215.31 and 244.64 g) were noticed in 75% of vermicompost concentration at 30, 60 and 90 days respectively except tuber width and circumference. During 60 and 90 days of exposure the maximum width and circumference were noticed in 50% of vermicompost and thereafter both width and circumference decreased in commensurate with increasing vermicompost concentration. The study reveals the 75% concentration of the vermicompost influence the tuber yield status of Radish plant.

Kashem *et al.* (2015) conducted a study attempted to compare the effect of cow manure, vermicompost and inorganic fertilizers on the vegetative growth and fruits of tomato plant (*Solanum lycopersicum* L.). An air dried sandy loam soil was mixed with five rates of vermicompost equivalent to 0 (control), 5, 10, 15 and 20 t ha-1 and three rates of NPK fertilizer equivalent to 50% (N-P-K = 69-16-35 kg ha-1), 100% (N-P-K = 137-32-70 kg ha-1) and 200% (N-P-K = 274-64-140 kg ha-1). The data revealed that shoot length, number of leaves, dry matter weight of shoots and roots, fruit number and fruit weight were influenced significantly by the application of vermicompost and NPK fertilizer in the growth media. The highest dose of vermicompost of 20 t ha-1 increased dry weight of shoot of 52 folds and root of 115 folds, number of fruit(s) plant-1 of 6 folds and mean fruit weight of 29 folds while the highest rate of NPK fertilizer of 200% increased dry weight of shoot of 35 folds and root of 80 folds, number of fruit(s) plant-1 of 4 folds and mean fruit weight of 18 folds over the control treatment. The growth performance of tomato was better in the vermicompost amended soil pots than the plants grown in the inorganic fertilizer amended soil pots.

Mojtaba *et al.* (2013) conducted an experiment on nitrogen fertilizer with three levels (50, 100 and 150 kg ha-1 as urea) and vermicompost with 4 levels (0, 4.5, 9, and 12 ton ha-1). Results illustrated that the highest amount of plant height, leaf and stem dry weight, leaf area index (LAI), fresh and dry weight of tuber, total tuber weight, total number of tuber, tuber diameter, nitrogen percent of tuber, potassium percent of tuber and phosphorous percent of tuber were found from application of 150 kg N ha-1. Data also demonstrated that vermicompost application at the rate of 12 ton ha-1 promoted all above traits except plant height in compared to control treatment. Furthermore, the Combined effects between different nitrogen rates and vermicompost application significantly improved growth parameters, yield and NPK content of tuber compared with nitrogen and/or vermicompost alone treatments. To gain highest yield and avoidance of environments pollution use of 150 kg ha-1 nitrogen fertilizer and vermicompost application of 12 t ha-1 are suggested.

Maria *et al.* (2013) conducted an experiment with potatoes included 7 treatments of fertilization. The first treatment was a control treatment, i.e., without the appliance of dry granulated vermicompost. In treatment 2 to 6 increasing doses of vermicompost (3.3, 6.6, 9.9, 13.2 and 19.8 t ha-1, respectively) were applied. Through the following doses of granulated vermicompost were applied to the soil 40, 80, 120, 160 and 240 kg ha-1 N. The increasing doses of vermicompost significantly increased the yield of potato tubers, starch content and dry matter content in tubers. The application of granulated vermicompost reduced vitamin C content in potato tubers. The use 40
of fertilizers resulted to increasing the nitrate content in potato tubers however the application of granulated vermicompost has increased the contents of nitrates to a lesser extent than the joint application of NPK fertilizer and granulated vermicompost.

Raja and Veerakumari (2013) conducted an experiment and find the impact of vermicomposts *viz.* Cowdung vermicompost, leaf ash vermicompost and poultry feather vermicompost on the yield and alkaloid content of medicinal plant, *Withania somnifera* were assessed and compared with the plants cultivated in the soil amended with chemical fertilizer and the plants cultivated without any fertilizer (control). The plant growth parameters such as shoot length, root length, shoot dry weight, root dry weight, shoot wet weight, root wet weight, shoot: root ratio and the alkaloid withaferin A and withanolide D were significantly increased in the plants cultivated in the soil amended with poultry feather vermicompost.

Kumar *et al*. (2012) conducted a field experiments with farm yard manure (FYM), poultry manure (PM), vermicompost (VC) and solubilizing bacteria (PSB) and *Azotobacter* + PSB) in sub plots. The results showed that 50 % of the recommended dose of NPK through inorganic + 50% recommended dose of nitrogen (RDN) through organic manures (FYM, PM or VC) or 100% recommended dose of NPK through inorganic fertilizers alone favorably influenced the tuber yield, nutrient uptake, soil fertility and paid higher returns compared to other treatments. Seed treatment with *Azotobacter* + PSB proved better in tuber yield, nutrient uptake and recorded higher returns as compared to sole treatment of either *Azotobacter* or PSB. Three years pooled result revealed that integrated application of 50 % of recommended NPK through inorganic and 50 % RDN through PM recorded significantly highest tuber yield (22.73 t ha-1) closely followed by 100 % recommended NPK through inorganic (22.20 t ha-1) which were 228 % and 223 % respectively, higher than control. Integrated application of inorganic and organic fertilizers and seed treatment with *Azotobactor* + PSB biofertilizers improved tuber yield, nutrient uptake, and gave higher return as compared to other treatment combinations. Total organic carbon (TOC), soil microbial biomass carbon (SMBC), available N, P, and K status of the soil after 3 years were maximum when 50 % recommended dose of NPK were applied through inorganic and remaining 50 % RDN through PM.

Hsieh *et al.* (1996) conducted an experiment on conventional farming and partial organic farming and showed that growth and yield of Broccoli in the organic treatments were greater than in the control. Poultry manure compost treatment gave the highest yield, which was 26.28% higher than that of the control, followed by pig manure compost treatment, which was 18.38% higher.

Bracy *et al*. (1995) a field trails were conducted on direct sown Broccoli cv. Early (Dawn) during the autumn of 1991 and 1992 and reported that the effects of replanting NPK fertilizer at a rate of 45kg N + 59kg P + 112 kg K and 90 kg N + 118 kg P + 118 kg P +224 kg /ha plus side dressed N fertilizer at 134, 196 or 258 kg/ha, either dropped onto or knifed into the bed were determined. The marketable yield, early yield, curd weight and percentage of early to total yield were unaffected by fertilizer rate or method of application.

Sharma (2000) studied and observed that integration of organic and inorganic fertilizer application on Broccoli production (variety Green curd) significantly increased the curd yield over inorganic fertilizer alone and also over control. The treatment N 175 kghi', P *75* kghi', K 60 kghi' and FYM 12.60 tonhi' gave the maximum yield (63.12 q/ac) which was at far with N 160 kgbt', P 75 kg hi', K 60 kghi' and FYM 12.60 ton ha (57.59 q/ac) but significantly superior to rest of the treatments in terms of yield and net profit.

Sharma *et al.* (2002) conducted a field experiment to evaluate the effects of N (60,120,180 and 240 kg hi') and p (60,120 and 180 kg hi') on the growth and seed yield of Broccoli cv. Green curd and observed that plant height, number of branches per plant, number of seeds per siliqua, seed yield, 1000 seed weight, germination percentage, seedling length and vigor index. In general, all parameters significantly improved with increasing concentrations of N and P.

Feller *et al.* (2005) reported on the nitrogen requirement of broccoli (*Brassica oleracea* var. *italica*) ranges from 300 to 465 kg/ha. Recommendations for N fertilizer application are accordingly high. High fertilizer rates applied at planting result in a high soil mineral N content that remains high for weeks because the N requirement of the crop is low at early growth stages. Therefore, the risk of leaching is high for several weeks until the available N is finally taken up by the crop. Their study had two objectives: (1) to quantify yield responses to preplant fertilizer application, and (2) to test our hypothesis that the preplant fertilizer rate could be reduced without yield losses by increasing the N content in the transplants and improving crop establishment. Field experiments (on a sandy soil, an Arenic Luvisol, in Germany, during 2000 and 2001) were carried out on transplants with four levels of N content in dry matter (0.018 to 0.038 g g-1 dry weight), which were tested in all combinations with four fertilizer application timings. All treatments received the same amount of N fertilizer (270 and 272 kg/ha in 2001 and 2002, respectively), but with different rates of supply at the time of planting (0 to 90 kg N fertilizer per ha plus 30 and 28 kg soil mineral N/ha in 2001 and 2002, respectively). Total and marketable yields increased significantly with an increasing N supply at time of planting. In our experiments, in which topdressing was applied 25 days after planting, N supply at planting of 80 to 118 kg/ha was required to obtain maximum marketable yields. The N content in transplants had little effect on growth and yield, and there were no significant interactions between the N content in the transplant and fertilizer timing.

CHAPTER-III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of integrated nutrient management the growth and yield of broccoli. This chapter deals with the materials and methods that were used in execution of the experiment. It includes a short description of experimental site, characteristics of soil, climate, materials used, data collection, statistical analysis and cost and return analysis. The details of these are described below.

3.1 Experimental Site

The experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2019 to February 2020. The experimental site was previously used as vegetable garden and recently developed for research work. The location of the site is 23° 74'N latitude and 90° 35 E longitude with an elevation of 8.2 meter from sea level. The experimental site is presented in Appendix I.

3.2 Climate

The geographical location of the experimental site was under the subtropical climate which is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and details has been presented in Appendix-1.

3.3 Soil

The soil belongs to “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture. Soil pH was 6.4 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The initial soil samples at a depth of 0-15 cm were collected prior to transplanting. The details of the initial soil have been presented in Appendix-2.

3.4 Plant Materials

BARI Broccoli-1 was used as the test crop in this experiment. Seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

For raising seedlings, the soil was ploughed and converted into loose friable and dried masses. All weeds, stubbles and dead roots were removed. Cowdung was applied to the prepared seed beds at the rate of 10 t/ha. The seeds were sown in the seed beds of 2.5 m x l m size on 26 October 2019. After sowing, the seeds were covered with a thin layer of soil. When the seeds germinated, shade by bamboo mat (Chatai) was provided to protect the young seedlings from scorching sun-shine and rain. Light watering, weeding and mulching were done as and when necessary. No chemical fertilizers were applied for raising the seedlings. Seedlings were not attacked by any kind of insects or diseases. The healthy 27 days old seedlings were transplanted in the experimental field on 22 November 2019.

3.6 Land preparation

The experimental plot was opened first on the 2nd week of November 2019 by a power tiller for growing the desired crop. Ploughing and cross ploughing was provide several times with a power tiller followed by laddering to bring until good tilth suitable for establishing the seedlings. Then the land was leveled and the corners of the experimental plot were shaped and the clods were broken into pieces. The land was cleaned of weeds and stubbles and was finally leveled.

3.7 Treatments of the experiment

The experiment consisted of one factor. The treatments were as follows:

T_1=control

T_2=recommended fertilizer dose (RFD)

T_3=80% RFD + 20% RFD supplemented by vermicompost (VC)

T_4=60% RFD + 40% RFD as VC

T_5=50% RFD + 50% RFD as VC

T_6=40% RFD + 60% RFD as VC

T_7=20% RFD + 80% RFD as VC

T_8=only vermicompost

3.8 Fertilizer application

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MoP, Gypsum and zinc sulphate respectively were applied The entire amounts of vermicompost (as per treatments), triple superphosphate, muriate of potash, gypsum, zinc sulphate, boric acid and one third of urea (as per treatments) were applied as basal dose at 3 days before broccoli transplanting. Rest of the urea was applied in two equal installments i.e., first was done at 30 days after transplanting (DAT) and second was at 50 DAT.

3.9 Experimental design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 258.50 m^2 was first divided into three equal blocks. Each block consisted of 10 plots. Thus the total number of plots was 30. Different combinations of organic manures and cultivars were assigned randomly to each block as per design of the experiment. Layout of the experiment was done on November 21, 2019. The size of a unit plot was 3 m x l.8 m and the spacing was 0.5 m x 0.6 m. The distance between the two blocks and the plots were kept 0.75 m and 0.50 m respectively.

3.10 Transplanting and after care

Healthy 27 days old seedlings were transplanted on 22nd November, 2019 in the afternoon and light irrigation was given around each seedlings for their better establishment. Each unit plot accommodated 18 plants. The transplanted seedlings were protected from scorching sunlight early in the morning by providing shed using banana leaf sheath and remove just before sun set daily, until the seedlings were good established. A number of seedlings were planted in the border of the experimental plots for gap filling.

3.11 Gap filing

Dead, injured and weak seedlings were replaced by new healthy seedlings from the stock kept on the border line of the experiment.

3.12 Intercultural operation

3.12.1 Weeding

Weeding was done three times in each plot to keep clear.

3.12.2 Irrigation

Light irrigation was given just after transplanting of the seedlings. A week after transplanting the requirement of irrigation was envisaged through visual estimation. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.12.3 Pest and Disease control

Few plants were damaged by mole crickets and cut worms after the seedlings were transplanted in the experimental plots. Cut worms were controlled both mechanically and spraying Diazinon 60 EC @ 0.55 Kg per hectare. Some of the plants were infected by *Alternaria brassicae.* To prevent the spread of the disease Rovral @ 2g /liter of water was sprayed in the field. Bird pests such as Nightingale (Common Bulbuli) visited the fields from 8 to 11 a.m. and 4 to 6 p.m. The birds were found to make puncture in the soft leaves and initiating curd and they were controlled by striking of a metalic container.

3.13 Harvesting

The harvesting was not possible on a particular date because curd initiation as well as curd maturation period in different plants were not similar probably due to use of different manures and genetic characters of varieties. The compact mature curds were only harvested. After harvesting the main curd, secondary shoots were developed from the leaf axils, and produced small secondary curds. Those were harvested over a period of time. The crop under investigation was harvested for the first time on January 24, 2020 and the last harvesting was done on February 20, 2006. The curds were harvested in compact condition before the flower buds opened (Thompson and Kelly, 1988).

3.14 Methods of Data collection

The data pertaining to the following characters were recorded from ten (10) plants randomly selected from each unit plot, except yield of curds which was recorded plot wise. Data on plant height was collected on 20, 40 and 60 days after transplanting and also at harvest. All other parameters were recorded at harvest.

Data were collected on the following parameters:

1. Plant height

2. Number of leaves per plant

3. Length of leaf

4. Breadth of leaf

4. Days to 1st curd initiation

5. Length of stem

6. Diameter of stem

8. Weight of primary curd

9. Weight of secondary curd

10. Number of secondary curd

11. Yield per ha

3.15.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 20, 40, 60 days after transplanting (DAT) and at harvested from the ground level up to the tip of the longest leaf.

3.15.2 Number of leaves per plant

Number of leaves per plant of ten randomly selected plants were counted at harvest. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

3.15.3 Length of leaf (cm)

A meter scale was used to measure the length of leaves. Leaf length of ten randomly selected plants were measured in centimeter (cm) at harvest. It was measured from the base of the petiol to the tip of the leaf. All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.15.4 Breadth of leaf (cm)

Leaf breadth of ten randomly selected plants were measured in centimeter (cm) at harvest from the widest part of the lamina with a meter scale and average breadth was recorded in centimeter (cm). All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.15.5 Days required for curd initiation

Total number of days from the date of transplanting to the date of visible curd initiation.

3.15.6 Length of stem

When the central curd reached mature and marketable stage then the head was cut off and at that point the length of the stem was measured. The length of stem was recorded in three dimensions and the average of the three figures was taken into account.

3.15.7 Diameter of stem

When the central curd reached mature and marketable stage then the head was cut off and at that point the diameter of the stem was measured. The diameter of stem was recorded in three dimensions and the average of the three figures was taken into account.

3.15.8 Weight of primary curd (g)

Weight of the central curd was recorded excluding the weight of all secondary curds and was expressed in gram (g).

3.15.9 Weight of secondary curd (g)

Weight of secondary curd was recorded by weighing the total secondary curds of an individual plant and was expressed in gram (g).

3.15.10 Number of secondary curds

When the secondary curds reached marketable size they were counted; the small shoots were not taken into consideration.

3.15.11 Yield per hectare (ton)

The yield per hectare was calculated by converting the per plot yield data to per hectare and was expressed in ton (t).

3.15.12 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.16 Post harvest soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, available sulphur and exchangeable K contents. The soil samples were analyzed by the following standard methods as follows:

3.16.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al.*, 1982.

3.16.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.16.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 2000C and added 3 ml H_2O_2 and then heating at 3600C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al*., 1982). Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where, T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.16.4 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al*., 1982).

3.16.5 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al*., 1982).

3.17 Statistical analysis

The data obtained from the characters were statistically analyzed to find out the variation resulting from experimental treatments following F variance test. The difference between treatments was adjusted by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHAPTER-IV

RESULTS AND DISCUSSION

This chapter comprises of the presentation and discussion of the results obtained due to the influence of integrated nutrient management on the growth and yield of broccoli. The results are presented in tables 1 to 4, figures 2 to 6 and necessary discussions have been presented under the following sub-headings.

4.1 Plant height

Significant differences were found among the different level of nutrients in respect of plant height of broccoli at 20, 40, 60 DAT and at harvest (Figure 1 and Appendix IV). At 20 DAT the longest (23.58 cm) plant was found from T_4 which was statistically similar (22.10 cm) to that of T_3 treatment and the shortest (12.92 cm) plant was found from T_1 treatment. At 40 DAT, the longest (44.02cm) plant height was recorded from T_3 treatment which is similar (42.66 cm) to that T_4 treatment and the smallest plant (31.39 cm) was found from T_1 treatment. At 60 DAT the tallest plant height (61.25 cm) was recorded from T_3 treatment which was statistically similar (59.65 cm) to that of T_4 treatment and shortest plant (48.75 cm) was recorded from T_1 treatment. Finally at harvest the tallest plant height (69.71 cm) was recorded from T_3 treatment which was statistically similar (66.92 cm) to that of T_4 treatment and shortest plant (51.44 cm) was recorded from T_1 treatment. The plant height increased with the increase of period of time. The plant height reached to its maximum at harvesting time in all the treatments. The might be due to the fact that supplied adequate plant nutrients help to produce better vegetative growth of the broccoli plants which ultimately increased plant height. Vermicompost and inorganic fertilizer might have positive role on the soil moisture content, soil porosity and other plant growth enhancing characters and for that reason vermicompost and inorganic fertilizer increased plant height. The findings of the present study corroborates with the findings of Rabbee *et al.* (2020), Singh *et al,.* (2020). Vermicompost is of value as a source of humus, a source of both major and minor nutrients as a carrier and promoter of beneficial organisms and possibly as a source of growth promoting substances. On decomposition of the organic matter carbon dioxide is set free and this may be of direct value in increasing the carbon dioxide content of the air and of indirect value in making available some of the mineral elements in the soil.

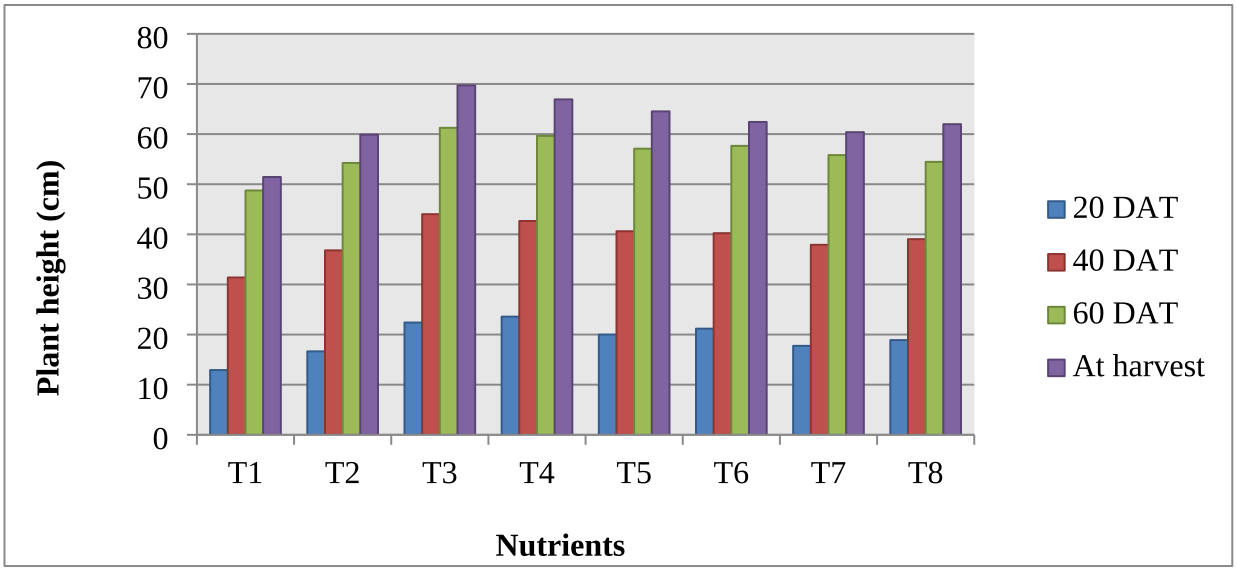


Fig. 1. Effect of nutrients on plant height of broccoli.

Where, T_1=control, T_2=recommended fertilizer dose (RFD), T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.2 Number of leaves per plant

Application of nutrients showed a significant influence on the number of leaves of broccoli plants at 20, 40, 60 DAT and at harvest (Table 1 and Appendix: V). The maximum number of leaves (6.50) was found from T_3 treatment which is statistically similar (6.29 and 6.07) to T_4 and T_6 treatment and minimum number of leaves (4.12) was found from T_1 treatment at 20 DAT per plant. At 40 DAT, the maximum number of leaves (12.01) was found from T_3 treatment which is statistically similar (11.50) to T_4 treatment and the minimum number of leaves (6.31) was found from T_1 treatment. At 60 DAT, the maximum number of leaves (17.93) was found from T_3 treatment statistically similar (16.60) to T_4 treatment and the minimum number of leaves (9.37) was found from T_1 treatment. At harvest, the maximum number of leaves (23.03) was found from T_3 treatment which is statistically similar (22.48) to T_4 treatment and the minimum number of leaves (12.05) was found from T_1 treatment. This result was coincided with those reported by Singh *et al*, (2020). John *et al.* (2013) indicated that the vermicompost applied plant Capsicum showed an increased number of leaves.

Table 1. Effect of nutrients on leaf number of broccoli.

Treatment	Leaf number			
	20 DAT	40 DAT	60 DAT	At harvest
T_1	4.12 f	6.31 g	9.37 e	12.05 g
T_2	5.31 e	9.12 ef	13.53 d	17.54 f
T_3	6.50 a	12.01 a	17.93 a	23.03 a
T_4	6.29 ab	11.50 ab	16.60 ab	22.48 ab
T_5	5.99 bcd	10.41 cd	14.86 cd	21.04 bc
T_6	6.07 abc	10.84 bc	14.23 cd	20.46 cd
T_7	5.78 cde	9.78 de	15.57 bc	19.29 de
T_8	5.53 de	8.55 f	14.17 cd	18.24 ef
CV%	4.93	5.57	5.90	5.02
LSD .05	0.4920	0.9574	1.5028	1.6937

Where, T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

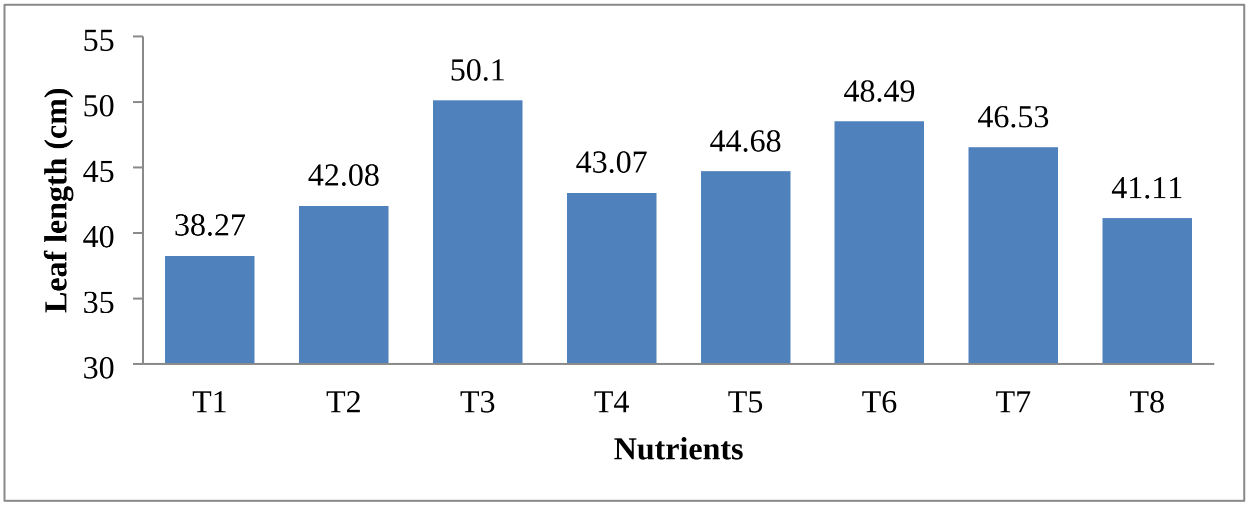


Fig. 2. Effect of nutrients on leaf length of broccoli.

Where, T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.3 Leaf length

There was significant variation on the length of leaf due to different sources of nutrients (Figure 2 and Appendix VI). The leaf length ranged from 38.27 cm to 50.10 cm. The largest leaf (50.10 cm) was recorded from T_3 treatment which is statistically similar (48.49 cm) to T_6 treatment while the smallest leaf (38.27 cm) was recorded from T_1. Mohanta *et al.* (2018), John *et al.* (2013) found similar result.

4.4 Leaf breadth

Statistically significant differences were observed in leaf breath of broccoli plant as affected by different level of nutrients (Figure 3 and Appendix: VI). The maximum (21.89 cm) breadth of leaf was obtained from T_3 treatment which is statistically similar (20.67, 19.98) to T_4 and T_5 treatment and the lowest (14.42 cm) was found from the control treatment T_1.

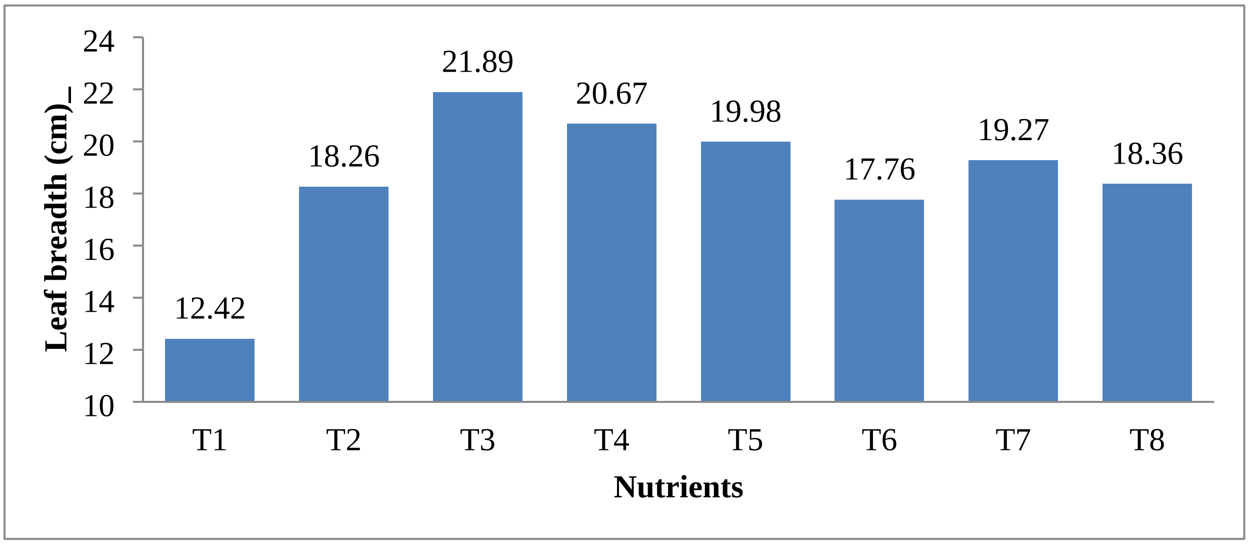


Fig. 3. Effect of nutrients on leaf breadth of broccoli.

Where, T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.5 Length of stem

Significant variation among the different sources of nutrients had been observed in the length of stem (Table 2 and Appendix: VI). The highest (28.10 cm) stem length was obtained from T_3 treatment which is statistically similar (26.78) to T_4 treatment and the lowest (17.37 cm) was found from the control treatment T_1. This result is similar with the findings of Singh *et al*,. (2020).

4.6 Diameter of stem

No significant variation among the different sources of nutrients had been observed in the diameter of stem (Table 2 and Appendix VI). The highest (3.78 cm) stem diameter was obtained from T_3 treatment and the lowest (2.56 cm) was found from the control treatment T_1. The present study shows that the application of vermicompost increases the stem diameter of broccoli plant. Getnet and Raja (2013) reaveled that vermicompost have significant impact on plant growth.

4.7 Days to require for curd initiation

Days to curd initiation of broccoli showed significant difference due to application of nutrients (Table 2, Appendix VI). It was ranged from 48.01 to 58.87 days. The lowest (48.01 days) days were required curd initiation by the (T_3) treatment which is statistically similar (49.10) to T_6 and the highest (58.87 days) days were required in control treatment (T_1). The result indicated organic and inorganic fertilizer plays role for vegetative growth and forced the plants to reach reproductive stages earlier. Effect of organic manure (Vermicompost) due to the fact high content of phosphorus is mainly responsible for improving the quality and quantity of produce by way of increasing metabolic activities in the plant system.

Table 2. Effect of nutrients on stem length, stem diameter and days to 1st curd initiation of broccoli.

Treatment	Stem length (cm)	Stem diameter (cm)	Days to 1st curd initiation
T_1	17.37 f	2.55	58.87 a
T_2	21.48 e	3.08	53.87 b
T_3	28.10 a	3.78	48.01 f
T_4	26.78 ab	3.34	50.71 cde
T_5	24.27 cd	3.45	51.59 cd
T_6	25.51 bc	3.59	49.10 ef
T_7	22.98 de	3.67	50.18 de
T_8	22.23 de	3.21	52.34 bc
CV%	5.49	6.61^{NS}	1.90
LSD .05	2.2690	1.3887	1.7248

Where, T_1=control, T_2=recommended fertilizer dose (RFD), T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.8 Weight of primary curd

Different source plant nutrients exhibited a significant influence on primary curd weight of broccoli (Figure 4, Appendix VII). The maximum primary curd weight (396.82 g) was recorded from T_3 treatment which is statistically similar (374.45) to T_4. While the minimum primary curd weight 235.33 g was observed in control treatment (T_1). It was probably due to the fact that the vermicompost and inorganic fertilizer provided good soil conditions for plant growth as well as supplied sufficient plant nutrients and it supplied rapidly available of macro and micro nutrients that helped the production of large size of curd with maximum weight. Azarmi *et al.* (2008) reaveled similar result.

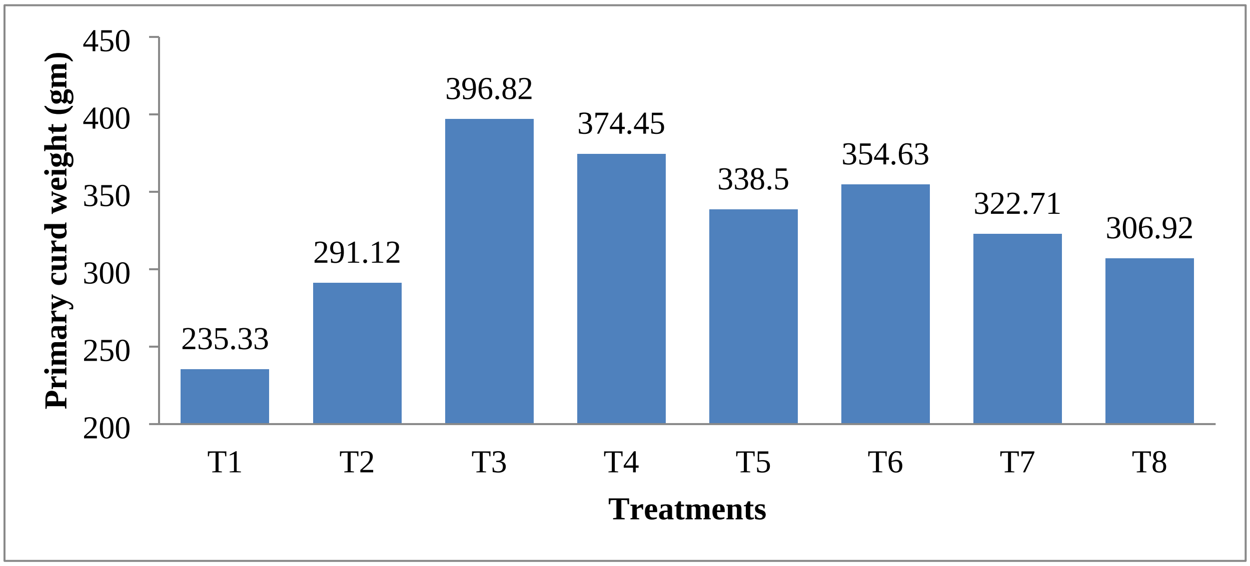


Fig. 4. Effect of nutrients on primary curd weight of of broccoli.

Where, T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.9 Number of secondary curd per plant

The secondary curds were those, which develop after harvest of the main curd. Number of secondary curd of broccoli plant is important for increasing total production. Application of nutrients exhibited a significant influence on number of secondary curd of broccoli plants (Table 3, Appendix VII). The maximum numbers of secondary curds (3.87) were recorded from the T_3 treatment which is statistically similar (3.64, 3.54) to T_4, T_6, while the Minimum (2.56) were observed in control treatment (T_1). This might be caused of photosynthesis, cell division and cell enlargement. In organic manure (vermicompost) has higher content phosphorus and inorganic application of phosphorus help to increase the yield.

4.10 Secondary curd weight

Secondary curd weight of broccoli plant is important for increasing total yield. Application of nutrients had a significant influence on secondary curd weight of broccoli plants (Table 3, Appendix VII). The maximum secondary curd weight (68.58 g) was recorded from T_3 treatment which is statistically similar (66.82 g) to T_4 treatment and the minimum (52.82 g) was observed in T_1 treatment. This might be caused of photosynthesis, cell division and cell enlargement. Similar effects of have been reported by Singh *et al.,* (2005).

Table 3. Effect of nutrients on secondary curd number and secondary curd weight of broccoli.

Treatment	Secondary curd number	Secondary curd weight (gm)
T_1	2.56 e	52.82 f
T_2	2.83 de	59.22 e
T_3	3.87 a	68.58 a
T_4	3.64 ab	66.82 ab
T_5	3.32 bc	63.92 bcd
T_6	3.54 ab	64.68 bc
T_7	3.27 bcd	60.72 de
T_8	3.05 cd	62.34 cde
CV%	7.61	3.17
LSD .05	0.4342	3.4669

Where, T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.11 Yield per hectare

Application of nutrients exhibited a significant influence on yield per hectare of broccoli plants (Figure 5, Appendix VII). The maximum yield (15.95 t/ha) was recorded from T_3, while the minimum yield (9.89 t/ha) was observed in T_1 treatment. The yield per ha in sprouting broccoli consists of the main curd and the secondary curd those develop after the removal of the main one. It was possible that combination organic and inorganic fertilizer provided availability of plant nutrients, improved good soil condition, increase water holding capacity and microbial activity and possibly as source of growth promoting substance that helped in the production of higher curd yield of broccoli. Mahtoj and Yadav (2005) indicated that production of peas is influenced by vermicompost and inorganic fertilizer. Singh *et al.*, (2005), Sohrab and Sarwar (2001) reported similar effect.

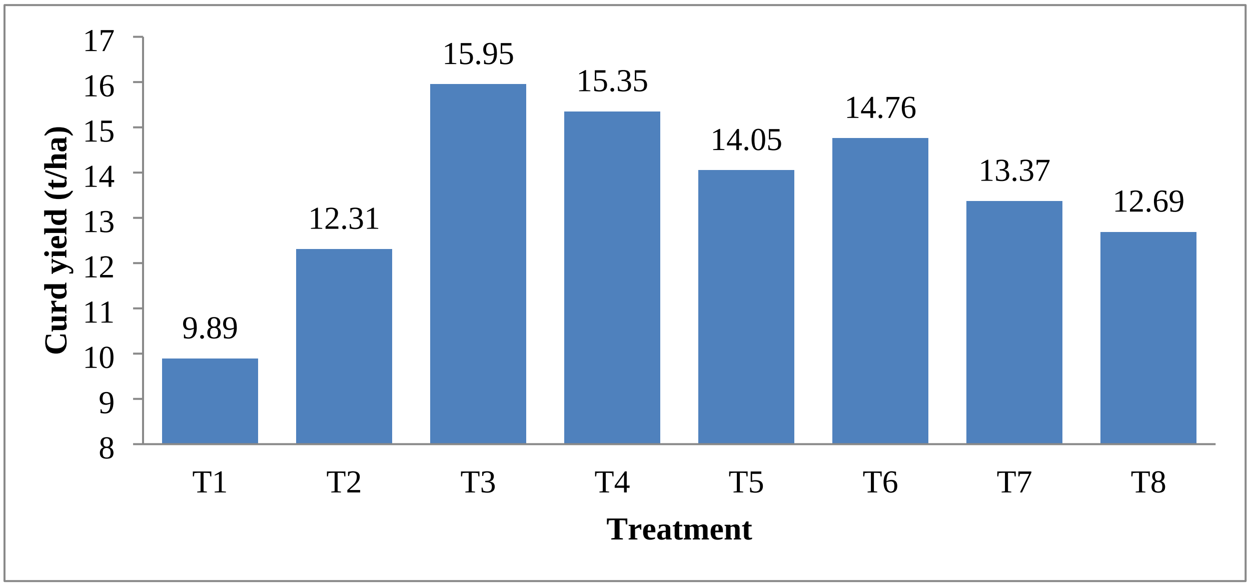


Fig. 5. Effect of nutrients on curd yield of broccoli.

Where, T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

4.12 pH

Statistically non significant variation was recorded for pH in post harvest soil due to different sources of nutrients (Table 4, Appendix VIII). The highest pH (6.14) was observed from T_2 treatment whereas the lowest pH (5.53) was found from T_4 treatment.

4.13 Organic matter

Statistically significant variation was recorded for organic matter in post harvest soil due to different sources of nutrients (Table 4, Appendix VIII). The highest organic matter (1.55%) was observed from T_8 treatment which is statistically similar (1.52%) to T_7 treatment, whereas the lowest organic matter (1.21%) was found from T_1 treatment.

4.14 Total N

Statistically significant variation was recorded for total N in post harvest soil due to different sources of nutrients (Table 4, Appendix VIII). The highest total N (0.096 %) was observed from T_3 treatment which is statistically similar (0.090, 0.087%) to T_6, T_5 treatment whereas the lowest total N (0.044 %) was found from T_1 treatment.

4.15 Available P

Different sources of nutrients showed statistically significant variation was recorded for available P in post harvest soil (Table 4, Appendix VIII). The highest available P (23.72 ppm) was observed from T_3 treatment and they were statistically identical (23.18. 22.94 ppm) to T_4 and T_7 treatment whereas the lowest available P (15.36 ppm) was found from T_1 treatment.

4.16 Exhalable K

Statistically significant variation was recorded for exchangeable K in post harvest soil due to different sources of nutrients (Table 4, Appendix VIII). The highest exchangeable K (0.129 me%) was observed from T_3 treatment which were statistically identical (0.126 me%) to T_4 treatment, whereas the lowest exchangeable K (0.110 me%) was found from T_1 treatment.

4.17 Available S

Different sources of nutrients showed statistically significant variation was recorded for available S in post harvest soil (Table 4, Appendix VIII). The highest available S (20.66 ppm) was observed from T_3 treatment that was statistically similar (19.86 ppm) to T_4 treatment whereas the lowest available S (12.52 ppm) was found from T_1 treatment.

Table 4. Effect of nutrients on pH, organic matter (%), total N (%), available P (ppm), exchangeable K (meq/100 g soil) and available S (ppm) of broccoli.

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)	Available S (ppm)

T_1	5.80	1.21 e	0.044 d	15.36 e	0.110 d	12.52 f
T_2	6.14	1.39 bcd	0.074 bc	19.24 c	0.119 b	18.00 cd
T_3	5.62	1.38 bcd	0.096 a	23.72 a	0.129 a	20.66 a
T_4	5.53	1.31 cde	0.072 bc	23.18 a	0.126 a	19.86 ab
T_5	5.94	1.46 abcd	0.087 ab	21.78 ab	0.121 b	17.44 cde
T_6	6.13	1.35 cde	0.090 ab	17.54 d	0.112 d	16.93 de
T_7	5.75	1.52 ab	0.084 b	22.94 a	0.120 b	16.05 c
T_8	5.83	1.55 a	0.080 b	19.66 c	0.116 c	18.90 bc
LSD0.05	NS	0.145	0.014	1.032	0.013	1.664
CV (%)	4.24	6.03	3.146	3.067	2.841	3.243

Where, T_1=control, T_2=recommended fertilizer dose (RFD), T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from October 2019 to February 2020 to find out the effect of integrated nutrient management on the growth and yield of broccoli. The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of eight treatments viz. T_1=control, T_2=recommended fertilizer dose (RFD),T_3=80% RFD + 20% RFD supplemental vermicompost (VC), T_4=60% RFD + 40% RFD as VC, T_5=50% RFD + 50% RFD as VC, T_6=40% RFD + 60% RFD as VC, T_7=20% RFD + 80% RFD as VC, T_8=only vermicompost. BARI Broccoli-1 was used as the test crop in this experiment. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The experiment was laid out following split plot design with three replications. There were 24 unit plots. The size of unit plot was 3 m x 1.8 m. Results revealed that the entire treatments had significant effect on different growth yield and yield contributing parameters and also nutrient content in post-harvest soil.

Results also revealed that the maximum plant height (23.58 cm) plant was found from T_7 (20% RFD + 80% RFD as VC.) at 20 DAT. The maximum plant height at 40, 60 DAT and at harvest (44.02, 61.25 and 69.71 cm), number of leaves of broccoli plants at 20, 40, 60 DAT and at harvest (6.50, 12.01, 17.93 and 23.03), length of leaf (50.10 cm), breadth of leaf (21.89 cm), stem length (28.10 cm), stem diameter (3.78 cm), highest primary curd weight (396.82 g), numbers of secondary curds (3.87), secondary curd weight (68.58 g) and yield (15.95 t/ha) were recorded from T_3 treatment. The maximum days to curd initiation (58.87 days) days were required in control treatment (T_1). The highest pH (6.14) was observed from T_2 treatment. The highest organic matter (1.55%) were observed from T_8 treatment. The highest total N (0.096 %), available P (23.72 ppm), exchangeable K (0.129 me%, highest available S (20.66 ppm) were observed from T_3 treatment.

On the other hand, the minimum plant height at 20, 40, 60 DAT and at harvest (12.92, 31.39, 48.75 and 51.44 cm), the number of leaves of broccoli plants at 20, 40, 60 DAT and at harvest

(4.12, 6.31, 9.37 and 12.05), leaf length (38.27 cm), breadth of leaf (14.42 cm), stem length (17.37cm), stem diameter (2.56 cm), primary curd weight (235.33 g), numbers of secondary curds (2.56), secondary curd weight (52.82 g), minimum yield (9.89 t/ha), organic matter (1.21%), total N (0.044 %), available P (15.36 ppm), exchangeable K (0.110 me%) and available S (12.52 ppm) were found from T_1 treatment. The lowest (48.01 days) days were required for curd initiation was found from T_3 treatment and the lowest pH (5.53) was found from T_4 treatment.

It can be concluded that the treatment T_3 gave the best results regarding growth, yield and yield contributing parameters and it can be more beneficial for farmers to get better yield.

REFERENCES

Ahmad, K. U and Shahjahan, M. 1991. Homestead Vegetable Production: Training Mannual, OFRD, BARI, Gazipur. pp.1-24.

Akbasova, A. D., Sainova, G. A., Aimbetova, I. O., Akeshova, M. M. and Sunakbaeva, D. K. (2015). Impact of vermicompost on the productivity of agricultural crops. *Res. J. Pharma. Biol. Chem. Sci*. **6**(4): 20-24.

Atiyeh, R.M.; Arancon, N.; Edwards, C.A. and Metzger, J.D. (2000). Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes. Bioresour - technol Oxford, U.K. : *Elsevier Sci Lim*, 75 (3) : 175-180.

Arancon, N. Q., Edwards, C. A., Atiyeh, R. M. and Metzger, J. D. 2004. Effects of vermicomposts produced from food waste on greenhouse peppers. *Bioresource Technology*, 93: 139-144 .

Azarmi, R., Ziveh, P. S. and Satari, M. R. 2008. Effect of vermicompost on growth, yield and nutrition status of tomato (*Lycopersicum esculentum*). *Pak J Biol. Sci*, 11(14):1797-802.

Babik, I. and Elkner, K. (2002). The effect of nitrogen fertilization and irrigation on yield and quality of broccoli. *Acta Hort*. 571 : 73-43.

Bracy, R. P., Parish, R. I., and Burgeron, P. E. (1995). Sidedress N application methods for broccoli production. *J. of Vegetable crop Production.* Dhaka. **1** (1): 7, 63-71.

Buckerfield, J. C. and Webster, K. A. 1998. Worm-worked waste boosts grape yields: prospects for vermicompost use in vineyards. *The Australian and New Zealand Wine Industry Journal*, 13: 73-76.

Chatterjee, R., Bandhopadhyay, S. and Jana, J. C. 2013. Influence of different organic amendments on growth, head yield and nitrogen use efficiency in cabbage. *American International Journal of Research in Formal, Applied & Natural Sciences*, 5(1): 90-95

Chee. L. C., Garcia, C.. Ferrera, R. And Cerrato, R. (1998). Onion bioferti lization with vermicompost and arbuscular mycorrhizae. Universidad Autonoma Chapingo, 56230 Chapingo, Mexico. Annual International Meeting, Orlando, Florida. USA. 12-16-July.

Cutcliffe, J.A., Munro, D.C. and MacKay, D.C. (2013). Effect of nitrogen, phosphorus, potassium, and manure on terminal, lateral, and total yields and maturity of broccoli *Can. j. plant sci.*, **48(**5), p.439-446.

Das, P. K.. Jen, *M.* K. and Sahoo, K. C. (2002). Effect of integrated application oiverniicompost and chemical fertilizer on growth and yield of paddy in red soil of South Eastern Ohat Zone of Orissa. Environment and Ecology. **20** (1): 13-15.

Das, J., Phookan, D.B. and Gautam, B.P. (2000). Effect of level of NPK and plant densities for curd production of early cauliflower (*Brassica oleracea* var. *botrytis*) cv. Pusa Katki. *Haryana J. Hort. Sci*. **29** (3&4): 265-266.

Dipika, M., Ranjit, C and Nimbalkar, K. 2015. Effect of vermi-compost and inorganic fertilizers on growth, yield and quality of sprouting Broccoli (*Brassica oleracea* L. var. *italica Plenck*). International Journal of Bio-resource and Stress Management. 5(4): 507-512.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People’s Republic of Bangladesh. p. 118.

Edwards, C. A. and Burrows, I. 1988. The potential of earthworms composts as plant growth media. In: Edward, C.A. and E. F. Neuhhauser (Eds.), Earthworms in waste and environmetnal management, SPB Academic Publishing, the Hague, pp: 21-32.

El-Helaly, M.A. (2012) Effect of nitrogen fertilization rates and potassium sources on broccoli yield, quality and storability. *Res. J. Agric. Biol. Sci.*, **8**:385-94.

FAO. 2020. World Food and Agriculture - Statistical Yearbook 2020

Feller, C. and Fink, M. 2005. Growth and yield of broccoli as affected by the nitrogen content of transplants and the timing of nitrogen fertilization. *Hort. Sci.*, **40**(5): 1320-1323.

Getnet, M. and Raja, N. 2013. Impact of Vermicompost on Growth and Development of Cabbage, *Brassica oleracea* Linn. And their Sucking Pest, *Brevicorynebrassicae* Linn. (Homoptera: Aphididae). *Res. J. Env. Earth Sci.*, **5**(3): 104-112.

Ghuge, T. D., Gore, A. K. and Jadav, S. B. 2007. Effect of organic and inorganic nutrient sources on growth, yield and quality of cabbage. *J. Soils Crops*, **17**(1): 89-92.

Gill, H.S.; Thakur, P.C. and Bhullar, B.S. (1975). Effect of nitrogen and phosphorus fertilization on seed yield of late cauliflower (*Brassica oleracea* Var. *botrytis*). *Indian J. Hort*. **32** (1-2): 94-97.

Giri, R.K., Sharma, M.D., Shakya, S. M. and Kandel, T.P. (2013). Growth and yield responses of broccoli cultivars to different rates of nitrogen in western Chitwan, Nepal. *Agric. Sci.*, **4**:8-12.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedure for agricultural research. Second Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. pp. 1-340.

Hangarge, D.S.; Raut, R.S.; Malewar, G.V.; More, S.D. and Keshbhat, S.S. (2002). Yield attributes and nutrients uptake by chilli due to organics and inorganics on vertisol. *J. Maharashtra Agric. Univ*. **27**: 109-110.

Harris, G. 1990. Use of earthworm biotechnology for the management of the effluence from intensively housed livestock. Outlook in Agriculture, **180**(2): 72-76.

Hiranmani Y.; Vijayakumari, B. and Yadav, H. (2003). Influence of vermicompost with organic and inorganic manures on biometric and yield parameters of chilli (*Capsicum annuum* L.) var. Plri. *Crop Res.* (Hisar). 25 : 2, 236-243.

Hsieh C., Hsu K., Hsieh, C. F. and HSU, K. N. (1996). An xperiment on the organic farming of broccoli. Bulletin of Taichung District Agriculture Improvement Station. No.**53** (35-40): 18.

Jahan, F. N., Shahjalal, A. T. M., Paul, A. K., Mehraj, H. and Uddin, A. F. M. J. 2014. Efficacy of Vermicompost and Conventional Compost on Growth and Yield of Cauliflower. *Bangladesh Res. Pub. J.* 10(1): 33-38

Jana, J.C. and Mukhopadhyay, T.P. (2001). Effect of nitrogen and phosphorus on growth and curd yield of cauliflower var. “Aghani” in Terai zone of West Bengal. *Veg, Sci.* 28 (2) : 133-136.

John, B. and Prabha, M. L. 2013. Effect of vermicompost on the growth and yield of Capsicum annum. *International-Journal-of-Pharma-and-Bio- Sciences*, 4(3): 1284-1290

Mohanta, R., Nandi, A. K. Mishra, S. P., Pattnaik, A. Hossain, M. M. and Padhiary, A. K. 2018. Effects of integrated nutrient management on growth, yield, quality and economics of sprouting broccoli (*Brassica oleracea var. italica*) cv. Shayali. *J. Pharmaco. Phytoch.* 7(1): 2229-2232

Karitonas, R. (2001). Effect of nitrogen supply on yield and quality of broccoli. Dordrect, Netherlands, Kluwer Academic Publishers. 298-299.

Kashem, M. A., Ashoka, S. Imam, H. and Islam M. S. (2015). Comparison of the effect of vermicompost and inorganic fertilizers on vegetative growth and fruit production of tomato (*Solanum lycopersicum* L.). *Open J. Soil Sci.* **5**: 53-58.

Khandal, D. K. and Nagendra. B. B. N. (2002). Effect of vermicompost of Eichhrnia on two cultivars of wheat. *J. Eco PhysioL* 5(3-4): 143-148.

Kumhar, Ramdhan (2004). Effect of NPK and vermicompost on growth, yield and quality of cauliflower cv. Pusa Katki. M.Sc. (Ag.) Thesis, submitted to *Rajasthan Agri. Univ*, Bikaner, Campus-Jobner (Raj.).

Kumar, M., Baishaya, L. K., Ghosh, D. C. and Gupta, V. K. (2012). Productivity and soil health of potato (*Solanum tuberosum* L.) field as influenced by organic manures, inorganic fertilizers and biofertilizers under high altitudes of eastern Himalayas. *J. Agril. Sci.* **4**(5): 2012.

Lopes, A. J.; Stamford, N.P.; Figueired, M.V.B.; Burity, N.A. and Ferraz, E.B. 1996. Effect of vermicompost, mineral nitrogen and mineralizing agent on N fixation and yield in cowpea. *Revista - Brasileira - de-ciencia-do-solo*, **20** : 55-62.

Mahtoj, T. P. and Yadav, R. P. 2005. Effect of vermicompost alone and in combination with chemical fertilizers on stem fly incidence and yield attributes in vegetable peas under Bihar condition. *J. Zoolo. Int. Res*., **16**(1): 70-72.

Mangal, J.L.; Pandita, M.L. and Batra, B.R. (1984). Effect of irrigation intensities and nitrogen levels on growth and yield of cabbage (*Brassica oleracea* L. var. *Capitata*) cv. “Golden Acre”. *Haryana. J. Hort. Sci*., **11** : 92-96.

Maria, K. Peter, K. and Marek, R. (2013). The effect of different doses application of dry granulated vermicompost on yield parameters of maize and potatoes. *Res. Gate.***1**: 8-14.

Masciandaro, G., Ceccanti, B. and Garcia, C. 1997. Soil agro-ecological management: fertirrigation and vermicompost treatments. *Bioresource Technology*, **59**: 199-206.

Mojtaba, S. Y., Mohammadreza, S. H. and Mohammad, T. D. (2013). Effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato (Agria CV.). *Intl. J. Agric. Crop Sci*. **5**(18): 2033-2040.

Naidu, A.K.; Kushwah, S.S. and Dwivedi, Y.C. (2002). Influence of organic manures, chemical and bio-fertilizers on growth, yield and economics of brinjal. *South Indian Hort*., **50**(7) : 370-376.

Nayyar, V. K. and Chibba, I. M. 1992. Interactions of zinc with other plant nutrients in soils and crops. **In:** Management of Nutrient Interactions in Agriculture. (Ed. H. L.S. Tandon). FDCO, New Delhi, India. pp. 116-142.

Nonnecke, I. L. 1989. Vegetable Production. Vein Nostrand Reinhold, New york. p.12.

Olsen, S.R.: Cole, C.V.; Vatanabe, F.S. and Dean. L.A. 1954. Estimation of' available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Agric. Cire. p. 929.

Ouda, B.A. and Mahadeen, A. Y. (2008) Effect of fertilizers on growth, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea* var *italica*). *Int J Agric Biol* **10**:627-32.

Page, A. L., Miller, R. H. and Keeney, D. R. (1982). Methods of analysis part 2, Chemical and Microbiological Properties, Second Edition American Society of Agronomy, Inc., Soil Science Society of American Inc. Madson, Wisconsin, USA. pp. 403-430.

Patil, K.B. and Biradar, D.P. (2001). Nutrient uptake of chilli as influenced by plant population and integrated nutrient levels in vertisols. *J. Maharashtra Agric. Univ*. **26**: 337-339.

Patil, M.P.; Hulamani, N.C.; Athani, S.I. and Patil, M.G. (1998). Response of new tomato genotype megha to integrated nutrient management. *Ad. Agric. Res. Indian*, **9** : 39-42.

Patil, M. S. 1995. Integrated nutrient management in commercial vegetables. M. Sc. (Agri.) thesis, Uni. Agric. Sci., Dharwad (India).

Pour, A. A., Moghadam, A. R. L. and Ardebili, Z. O. (2013). The effects of different levels of vermicompost on the growth and physiology of cabbage seedlings. *Int. Res. J. of App. Basic Sci.*, **4**(9): 2726-2729

Premi. 0. P., Sinsinwar. B. S.. Manoj. K.. and Arvind. K. (2005). Influence of organics and inorganics on yield and quality of Indian mustard. l3rassica juncea (L.) Czern & Coss in semi-add region of Rajasthan. *J. Oilseeds Res.*, **22**(l): 45-46.

Rabbee, H. E. Methela, N. J., Hossain, B. and Suhel M. R. I. (2020). Growth and yield response of Broccoli to vermicompost and farmyard manure. *J. Biosci. Agric. Res*. **25(**02): 2107-2113

Rai, R., Thapa, U., Mandal, A. R. and Roy, B. (2013). Growth, yield and quality of cabbage (*Brassica oleracea* var *capitata* L.) as influenced by vermicompost. *Environment and Ecology*, **31**(1): 314-317.

Raja, M. and Veerkumari, K. (2013). Impact of Vermicompost on Growth and Development of Cabbage, *Brassica oleracea* Linn. and their Sucking Pest, *Brevicoryne brassicae* Linn. (Homoptera: Aphididae). *Res. J. Environ Earth Sci*. **5**(3) : 104-112.

Ramamurthy, M., Umavathi, S., Thangam, Y. and Mathivanan, R. (2015). Effect of vermicompost on tuber yield status of radish plant *Raphanus sativus*. L. *Intl. J. Adv. Res. Biol. Sci.* **2**(8): 50-55.

Ranwa, R. S. and Singh. K. P. (1999). Effect of integrated nutrient management with verrnicompost on productivity of wheat. *Indian J. Agron.* **44**(3): 554-559.

Rashid, M. M. 1976. Vegetables of Bangladesh (in Bengali). First edition. Bangla Academy, Dhaka, p. 283.

Reddy, R.; Reddy, M.; Reddy, T. Y. N.; Reddy, N. S. and Anjnappa, M. (1998). Effect of organic and inorganic sources of NPK on growth and yield of pea (*Pisum sativum*). *Legume Res*. **21** (1) : 57-60.

Reddy, P. K. and Rao, P. V. (2004). Growth and yield of bitter gourd (M*omordica charantia* L.) as influenced by vermicompost and nitrogen management practices. *Journal-of-Research-ANGRAU,* **32**(3): 15-20.

Reddy, K. C. and Reddy, K. M. (2005). Differential levels of vermicompost and nitrogen on growth and yield in onion (*Allium cepa* L.) – radish (*Raphanus sativus* L.) cropping system. *Journal of Research ANGRAU*, **33**(1): 11-17

Rodriguez, N. J. A., Zavaleta, M. E. and Sanchez, G. P. (2000). The effect of vermicompost on plant nutrition, yield and incidence of root and crown rot gerbera. *Fitopatologia*, **35** (1): 66-79.

Roy, H.K. (1981). Effect of nitrogen on curd size and yield of cauliflower. *Veg. Sci*. **8** (2) : 75-78.

Rutkauskiene, G. and Poderys, M. (1999). Influence of NPK fertilizers on the yield and quality of white cabbage heads. *Sodininkyste or Darzininkyste*, **18** : 155-162.

Simanaviciene .0., Mazvila. J., Vaisvila, Z., Ryliakiene, E., Arbacauskas, J. and Eitminavicius, L. 2001. Comparison of the efficacy of NPK fertilizer rates, calculated by different methods and the effect of farmyard manure and straw in the crop rotation.75 (14): 14-28.

Shoemaker, J. S. and Teskey. 1962. Practical Horticulture. John Wiley & Sons. Inc. New York. p. 219.

Sohrab, A. and Sarwar J. M. 2001. Production of vermicompost and its use in upland and horticultural crops, Project Report of Rajshahi University.

Sultan, A.I. 1997. Vermicology, The Biology of Earthworms. Pp. 47-53.

Samawat, S.; Lakzian, A. and Zamirpour, A. (2001). The effect of vermicompost on growth characteristics of tomato. *Agric. Sci. and Tech*., **15** (2): 83-89.

Sharma, S. K., 2000. Integrated nutrient management on the growth and seed yield of *broccoli cv.* Green Head. *Hort. J. Society Adv. Hort.,* Mohanpur, India. **15**(2): 87-90.

Sharma, S. K., S. Rajender and B. N. Korla. (2002). Effect of nitrogen and phosphorus on the growth and seed yield of sprouting broccoli cv. Green Head. *Hort. J. Society Adv. Hort* Mohanpur, India. **15**(2): 87-90.

Sharhidhara, G.B.; Baravaraja, P.K.; Basarajapoa, R.; Jagadesh, R.C. and Nandagonds, V.B. (1998). Effect of organic and inorganic fertilizers on growth and yield of byadagi chilli. In water and nutrient management for sustainable production and quality of spices. *Proceeding of the National Seminar Medikari*, Karnataka, 59-61.

Shreeniwas, C.H.; Murlidhar, S. and Rao, M.S. (2000). Yield and quality of ridge gourd fruits as influenced by different levels of inorganic fertilizers and vermicompost. *Ann. Agric. Res*., **21**: 262-266

Shirzadi, F. (2015). Evaluate the use of organic fertilizers on the plant"s height and size and number of micro tubers potato in Mahidasht of Kermanshah. *Intl. J. Res. Study Agrl. Sci.* **1**(4): 21-24.

Siag, R. K. and Yadav, B. S. 2004. Effect of vermicompost and fertilizers on productivity of gram *(Cicerarietinum*) and soil fertility. *Indian J. Agric. Sci.,***74**(11): 613-615.

Singh, S., Chamroy, T., Malik, S. and Kundu, S. 2020. Integrated nutrient management (inm) studies on growth and yield of Broccoli (*Brassica oleracea var. italica*). *Plant archives,* **20**(2): 9651-9654

Singh R. K., Bara, N. and Singh, R. P. 2005. Verification trial on use of vermicompost in cauliflower in farmer's fields. *J. Res. Birsa Agric. Univ.*, **17**(2): 237-240.

Singh, B.; Phookan, D.B.; Gautam, B.P. and Bora, D.K. (2002). Effect of nitrogen, phosphorus and potassium on production of broccoli (*Brassica oleracea* var. *italica*) cv. KTS-1. *Veg. Sci*. **29**(2):154-156.

Singh, A.K. and Singh, A. (2000). Influence of nitrogen and potassium on growth and head yield of broccoli (*Brassia olereacea* var. *italica*) under low hills subtropical condition of H.P. *Veg. Sci.*, **27**(1):99-100.

Singh, J.; Bhat, S.S.; Sudharshan, M.R.; Jasvir-Singh and Sreekrishna-Bhat, S. (1997). Performance of Scotch Bonnet chilli in Karnataka and its response to vermicompost. *Indian Coca, Arecanut and Spices Journal*, **21**: 9-10.

Sinha, R. K., Heart, S., Valani, D., Soni. B. K. and Chandran, V. 2009. Studies on Earthworms Vermicompost as a Sustainable Alternative to Chemical Fertilizers for Production of Wheat Crops. Collaborative Research on Vermiculture Studies, College of Horticulture, Noorsarai, Bihar, India and Griffith University, Brisbane, Australia.

Sohrab, A. and Sarwar, J. M. 2001. Production of vermicompost and its use in upland and horticulture crops.Project Report of Rajshahi University. pp. 152-155.

Subler, S., Edwards, C. and Metzger, J. 1998. Comparing vermicomposts and composts. *Biocycle*, **39**: 63-66.

Tesi, R.; Nncini, A.; Botrini, L. and Graifenberg, A. (1996). Effect of increasing doses of nitrogen on cauliflower. *Rivista di Agronomia*, **30**(2): 174-180.

Thakur, O.P.; Sharma, P.P. and Singh, K.K. (1991). Effect of nitrogen and phosphorus with and without boron on curd yield and stalk rot incidence in cauliflower. *Veg. Sci.*, **18**: 115-121.

Tolanur, S. I. And Badanur, V. P. (2003). Effect of integrated use of organic manure, green manure and fertilizer nitrogen on sustaining productivity of Rabi sorghum-chickpea system and fertility of a verisol. *J. Indian* Sac. *Soil Set,* **51(1):** 41-44.

Vadiraj, B.A.; Siddagangaiah, Narayan and Potty, S. (1998). Response of coriander (*Coriandrum sativum* L.) cultivars to graded levels of vermicompost. *J. Spices Aromatic Crops*, **7**: 141-143.

Vadiraj, B. A., Siddagangaiah, B. and Poti, N. 1998. Effect of vermicompost on the growth and yield of turmeric. *South-Indian-Horticulture*, **46**(3/6): 176-179

Valani, D. 2009. Study of Aerobic, Anaerobic and Vermicomposting Systems for Food and Garden Wastes and the Agronomic Impacts of Composts on Corn and Wheat Crops; Report of 40 CP Honours Project for the Partial Fulfillment of Master of Environmental Engineering Degree, Griffith University, Australia (Supervisors : Dr. Rajiv K, Sinha and Dr. Sunil Heart).

Vasanthi, D. and Kumaraswarny, K. (1999). Effect of vermicompost to improve soil fertility and rice yield. *J. hid. Soc Soil Sd.* **47**(2): 268- 272.

Vachhani. M. V. and Patel. *Z.* G. (1993). Growth and yield of onion *(Alliunm cepa* L.) as inliunced by nitrogen, potash and phosphorus under South Gujrat Condition. Prog. Hon., **25**(3-4): 166-167.

Watt, B. K. 1983. Nutritive value of fruits and vegetables. USAID, Handbook No. 8. [Cited from Vegetable Production, Nonnecke I.L., An Avi Book published by Van Nostrand Reinhold, New York. 369- 414.

Welch, N.C.; Tyler, K.B. and Ririe, D. (1987). Split nitrogen application is best for cauliflower. *Calif. Agri*. **11** (11/12): 21-22.

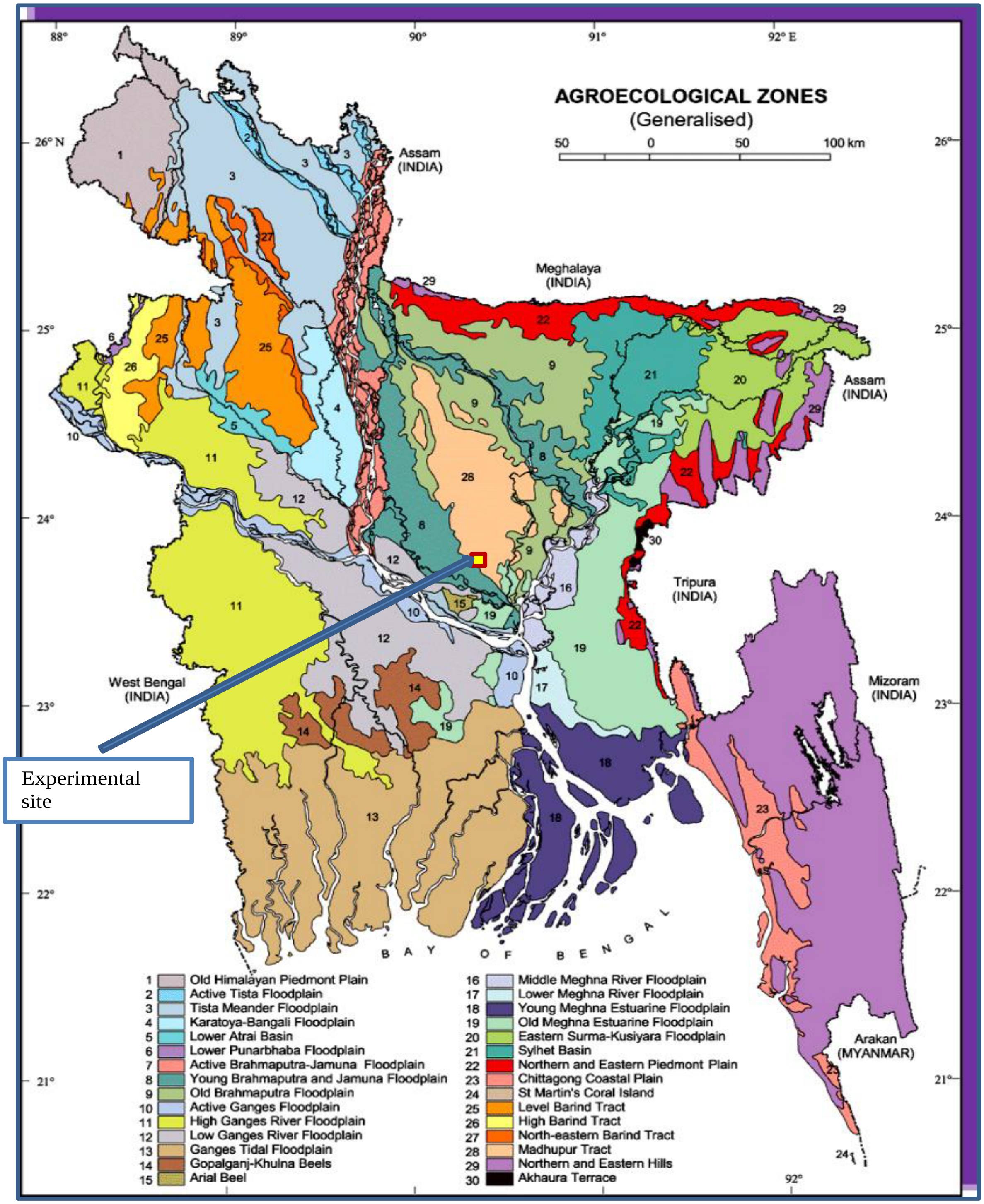
Ying, W. G., Zheng, Z. C. and Fushan, Z. (1997). Effect of nitrogen, phosphorus and potassium fertilizer on the yield and physiology target of broccoli. *China Veg.,* **1**:14-17.

Yoldas, F. Ceylan, S. Yagmu, B. and Mordoga, N. (2008) Effects of nitrogen fertilizer on yield, quality and nutrient content in broccoli. *J. Plant Nutr.,* **31**:1333-43.

Zahid. H. M. 2001. Production of vermicompost and its use in upland and horticultural crops. Annual Report of Bangladesh Agricultural Research Council, Framegate, Dhaka.Pp: 15-17.

APPENDICES

Appendix-I. Map showing the experimental site



Appendix II:Characteristics of Sher-e-Bangla Agricultural University soil is analysed by Soil Science department, Sher-e-Bangla Agricultural University, Dhaka.

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of initial soil

CHARACTERISTICS	**VALUE**
Partial Size Analysis	
% Sand	27
% Silt	43
% Clay	30
Textural Class	
PH	6.12
Organic carbon (%)	0.46
Organic matter (%)	0.83
Total N (%)	0.05
Available P (ppm)	20.00
Exchangeable K (me/100 gm soil)	0.12
Available S (ppm)	17.15

Appendix III: Monthly record of annual temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from September 2019 to March 2020 (Site-Dhaka).

Year	Month	Air temperature			Relative humidity (%)	Rainfall (mm)	Sunhine
		Maximum	Minimum	Average			
2019	September	31.35	25.15	28.25	71.02	26	20.33
	October	30.60	24.2	27.40	75.87	04	206.9
	November	29.85	18.50	24.17	70.12	00	235.2
	December	26.76	16.72	21.74	70.63	00	190.5
2020	January	24.05	13.82	18.93	62.04	00	197.6
	February	28.90	18.03	23.46	68.79	09	220.5
	March	32.24	22.10	27.17	78.82	68.5	208.2

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

Appendix IV: Analysis of variance of the data on plant height at different days after transplanting (DAT) of broccoli as influenced by different nutrients.

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm)			
		20 DAT	40 DAT	60 DAT	At harvest
Replication	2	0.8532	0.6109	1.2923	0.8501
Treatment	7	35.2033**	45.6601**	44.0767**	89.4586**
Error	14	0.5977	1.5692	1.5968	3.8375

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

Appendix V: Analysis of variance of the data on leaf number at different days after transplanting (DAT) of broccoli as influenced by different nutrients.

Source of variation	Degrees of freedom	Mean square			
		Leaf number			
		20 DAT	40 DAT	60 DAT	At harvest
Replication	2	1.86765	1.2791	1.396	5.7541
Treatment	7	1.66838**	10.0468**	19.2257**	36.48**
Error	14	0.07894	0.2989	0.7365	0.9354

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

Appendix VI: Analysis of variance of the data on leaf length (cm), leaf breadth (cm), days to 1st curd initiation, stem length (cm) and stem diameter (cm)of broccoli as influenced by different nutrients.

Source of variation	Degrees of freedom	Mean square				
		Leaf length (cm)	Leaf Breadth (cm)	Days to 1st curd initiation	Stem length (cm)	Stem diameter (cm)
Replication	2	1.0475	4.0495	0.8566	3.84	3.00208
Treatment	7	46.8363**	24.2599**	34.2971**	34.2814**	0.4607^{NS}
Error	14	2.0236	1.5646	0.9701	1.6787	0.30682

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

Appendix VII: Analysis of variance of the data on primary curd weight (gm), number of secondary curd, secondary curd weight (gm) and curd yield (t/ha) of broccoli as influenced by different nutrients.

Source of variation	Degrees of freedom	Mean square			
		Primary curd weight (gm)	Secondary curd	Secondary curd weight (gm)	Curd yield (t/ha)
Replication	2	207.63	2.97515	12.2177	6.4555
Treatment	7	7770.92**	0.56408**	72.8175**	11.2981**
Error	14	216.78	0.06147	3.9193	0.6055

** : Significant at 0.01 level of probability

Appendix VIII: Analysis of variance of the data on pH, organic matter (%), total N (%), available P (ppm), exchangeable K (meq/100 g soil) and available S (ppm) of broccoli as influenced by different nutrients.

Source of variation	Degrees of freedom	Mean square					
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)	Available S (ppm)
Replication	2	0.0001	0.01	0.002	0.001	0.001	0.319
Treatment	7	0.007^{NS}	0.034**	0.882**	0.406**	0.516**	25.703**
Error	14	0.062	0.11	0.007	0.006	0.003	1.25

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

Plate 1: Experimental view

Plate.2 : Harvesting Stage

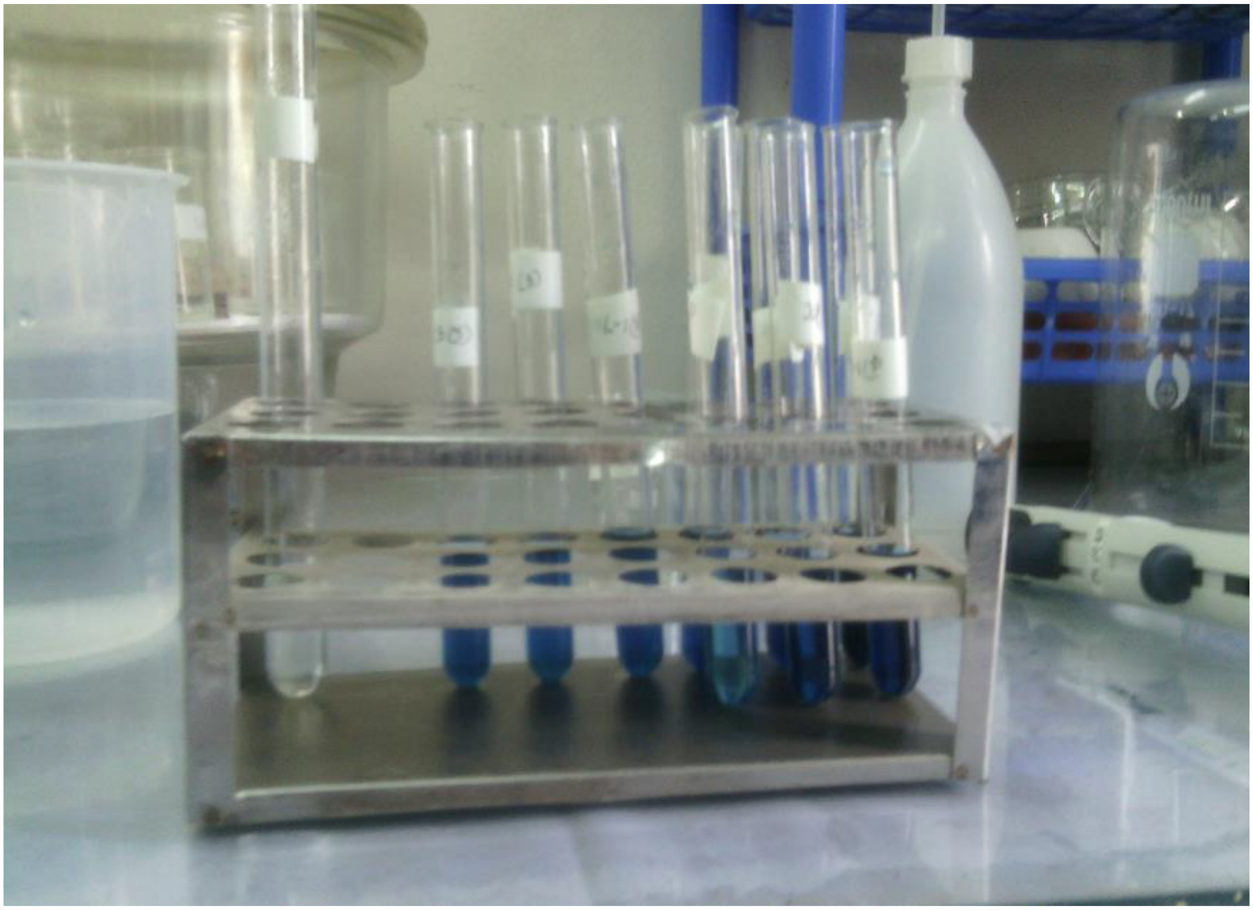


Plate.3: Processing Stage