INFLUENCE OF ORGANIC MANURE AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF MAIZE

ISRAT JAHAN NISHA

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

DECEMBER 2020

INFLUENCE OF ORGANIC MANURE AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF MAIZE

By

ISRAT JAHAN NISHA
Reg. No.: 18-09146

A Thesis
Submitted to the Faculty of Agrilulture,
Sher-e-Bangla Agrilultural University, Dhaka,
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
AGRONOMY

SEMESTER: JULY-DECEMBER, 2020

APPROVED BY

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(Prof. Dr. A. K. M. Ruhul Amin)	**(Prof. Dr. Tuhin Shuvra Roy)**
Supervisor	Co-supervisor

(Prof. Dr. Tuhin Shuvra Roy)
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF ORGANIC MANURE AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF MAIZE"** submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTERS OF SCIENCE (MS)** in Agronomy, embodies the result of a piece of bonafide research work carried out by **ISRAT JAHAN NISHA**, Registration No. **18-09146** 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.

December, 2020
Dhaka, Bangladesh

(Professor Dr. A. K. M. Ruhul Amin)
Supervisor
Department of Agronomy
SAU, Dhaka

Dedicated

To

My Beloved

Parents

And Respected

Teachers

Whose Prayers,

Efforts And

Wishes Are An

Inspiration

ACKNOWLEDGEMENTS

All the respects, credits, gratefulness and gratuity go on the Almighty Allah who enlightened the author's soul as a human being to breadth in the earth and enabled her to accomplish this manuscript.

*The author expresses her special warm of thanks, heartiest respect and deepest sense of gratitude, profound appreciation to her supervisor, **Professor Dr. A. K. M. Ruhul Amin**, Department of Agronomy, Sher-e-Bangla Agrilultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

*The author would like to express profound respect and heartiest gratuity to her co-supervisor, **Prof. Dr. Tuhin Shuvra Roy**, Department of Agronomy, Sher-e-Bangla Agrilultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

*The author would like to express her deepest sense of respect to **Prof. Dr. Tuhin Shuvra Roy**, Chairman, Department of Agronomy for providing the facilities to conduct the experiment and for his valuable advice and sympathetic consideration in connection with the study.*

The author wishes to pay her gratefulness to all the honorable teachers of the department of Agronomy, Sher-e-Bangla Agrilultural University, Dhaka for illuminating suggestions during the study period and research work.

The author wishes to extend her special thanks to her class mates and friends junior brothers and sisters for their keen help as well as heartiest co-operation and encouragement during experimentation. Special thanks to all other friends for their support and encouragement to complete this study.

The author would like to thank Ministry of Science and Technology, Bangladesh Secretariat for providing financial support by providing NST Fellowship to complete her research work.

It would have been less fun, if, the author does not recognize her parents with warm and special gratefulness and profound gratitude and deepest appreciation, who have brought her on the earth and who lost their joy and happiness for her, have sacrificed and dedicated efforts to educate her to this level.

The Author

INFLUENCE OF ORGANIC MANURE AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF MAIZE

ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University research farm, Dhaka to study the effect of organic manure and inorganic fertilizers on the growth and yield of maize during March to July 2019. Seeds of SAU hybrid vhutta 1 were used as planting material. The experiment was consisted of single factor and laid out in Randomized Complete Block Design (RCBD) with three replications. There were 11 treatments comprised with organic manure and inorganic fertilizers, They were T_0 = Control, T_1 = Recommended dose of chemical fertilizers (RDCF), T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, and T_{10} = Poultry litter + 75% of RDCF. Data on plant height, SPAD value, dry matter weight plant^{-1}, cob to tassel length, tassel length, cob length, cob diameter, number of grains row cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, 100 grain weight, grain yield, stover yield, biological yield and harvest index were taken. Results of the investigation revealed that, organic manure and inorganic fertilizers showed significant effect on most of the growth, yield and yield contributing characters of maize. The experimental result showed the maximum plant height at harvest (268.43 cm), SPAD value at 60 DAS (62.865), dry matter weight at harvest (296.60 g), cob to tassel length (137.98 cm), tassel length (20.490 cm), cob length (46.10 cm), cob diameter (4.3433 cm), number of grain rows cob^{-1} (15.203), number of grains row^{-1} (31.047), number of grains cob^{-1} (458.61), 100 grains weight (29.477 g), grain yield (9.430 t ha^{-1}), stover yield (10.84 t ha^{-1}), biological yield (20.267 t ha^{-1}) and finally harvest index (46.52 %) were observed from treatment T_8 (Poultry litter + RDCF) but treatment T_{10} (Poultry litter + 75% of RDCF), T_5 (Vermicompost + RDCF) and T_7 (Vermicompost + 75% of RDCF) showed statistically similar yield and some yield characters with T_8 treatment. So it may be concluded that the treatment T_{10} (Poultry litter + 75% of RDCF) or treatment T_7 (Vermicompost + 75% of RDCF) could be the best production package for achieving higher yield of maize.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ACRONYMS

AEZ	=	Agro ecological zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimetre
CV	=	Coefficient of Variation
DAS	=	Days After Sowing
et al.	=	And others (et alibi)
FAO	=	Food and Agriculture organization
g	=	Gram
ha	=	Hectare
HI	=	Harvest Index
kg	=	Kilogram
LAI	=	Leaf Area Index
LSD	=	Least Significance Difference
m^2	=	Square meter
MP	=	Muriate of Potash
no.	=	Number
NS	=	Non Significant
Seed cob^{-1}	=	Seeds per cob
SAU	=	Sher-e- Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
TSP	=	Triple Super Phosphate
t ha^{-1}	=	Ton (s) per hectare

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is the world's widely grown highland cereal and primary staple food crop in many developing countries (Kandil, 2013). It has very high yield potential, there is no cereal on the earth, which has so immense potentiality and that is why it is called "Queen of cereals" (FAO, 2002). It ranks 1stin respect of yield per unit area, 2nd in respect total production and 3rd after wheat and rice in respect of acreage in cereal crops (Zamir *et al.,* 2013).

Maize is grown as a fodder, feed and food crop. It is also used as raw material for manufacturing pharmaceutical and industrial products. Wheat, rice and maize are the most important cereal crops in the world but maize is the most popular due to its high yielding, easy of processing, readily digested and costs less than other cereals (Jaliya *et al*., 2008). Maize grain contains 70% carbohydrate, 10% protein, 4% oil, 10.4% albumin, 2.3% crude fiber, 1.4% ash (Nasim *et al*., 2012). Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil.

Introducing of maize in Bangladesh as human food can be a viable alternative for sustaining food security as the productivity of maize much higher than rice and wheat (Ray *et al.*, 2013). Rice-maize cropping system has been expanded (Timsina *et al.*, 2010) rapidly in the northern districts of Bangladesh mainly in response to increasing demand for poultry feed (BBS, 2016). Its world average yield is 27.80 q ha^{-1} maize ranks first among the cereals and is followed by rice, wheat, and millets, with average grain yield of 22.5, 16.3 and 6.6 q ha^{-1}, respectively (Nasim *et al*., 2012). Maize production of Bangladesh increased from 3,000 tons in 1968 to 3.03 million tons in 2017 growing at an average annual rate of 28.35 % (FAO, 2019).

Now-a-days, there are many government and non-government organizations are working for increasing maize production in Bangladesh. Bangladesh Agricultural Research Institute (BARI) has developed seven open pollinated and 11 hybrid varieties whose yield potentials are 5.50–7.00 t ha^{-1} and 7.40–12.00 t ha^{-1}, respectively, which are well above the world average of 3.19 t ha^{-1} (Nasim *et al*., 2012). Different varieties respond differently to input supply, cultivation practices and prevailing environment etc during the growing season. The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices, and limited use of input, insufficient technology generation, poor seed quality, disease, insect, pest and weeds. In general, the yield productivity of any crop in this country is low which is generally attributed to the poor agronomic management (Ullah *et al.*, 2017). Higher yield up to 9-11 t ha^{-1} can be obtained using hybrid seeds, balanced fertilizers and better management practices (Mondal *et al.*, 2014).

Among the agronomic traits that influence growth and yield, fertilizer management is the prominent one. The uses of fertilizers are highly needed to replenish nutrients taken out from the soil by harvest crops and to supplement more nutrients to boost yield (Olatunji and Ayuba, 2012). Although chemical fertilizers are important input to get higher crop productivity, but over reliance on chemical fertilizers is associated with decline in some soil properties and crop yields over time (Hepperly *et al.*, 2009). Appropriate fertilizer use leads to increased crop yields and high crop recovery of the applied nutrients. Some elements may be hazardous to the environment if used in various forms, i.e. nitrates and phosphates (Okalebo, 1987). Efficient fertilization is therefore important in ensuring crops attain maturity within specific growing seasons (Okalebo, 1987). In addition, essential fertilizers are frequently unavailable and unaffordable by most farmers due to high cost of imported materials. Many of the manufactured inorganic fertilizers are known to contain no micronutrients vital for crop growth and development. Since the deficiency of these elements have been reported in some major tropical soils, there is need to apply nutrient sources that will reduce or eliminate such deficiencies.

Organic manure and inorganic fertilizers applied to the soil supply plant nutrients for crop growth and affect the plant's physiological processes, which serve as important instruments in yield development. Use of organic manures alongside inorganic fertilizers often lead to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity (CEC) and soil's biological activity (Saha *et al.*, 2008). Moreover, the use of organic manures may reduce the amount of chemical fertilizers to be applied for successful crop production. Appropriate fertilizer use leads to increased crop yields and high crop recovery of the applied nutrients. Efficient fertilization is therefore, important in ensuring crops attain maturity within specific growing seasons (Okalebo, 1987). Bahrani *et al*. (2007) reported that the use of organic fertilizer together with chemical fertilizer compared to the addition of organic fertilitizer alone had a higher positive effect on microbial biomass and hence soil health. Therefore, an integrated use of inorganic fertilizers with organic manures is a sustainable approach for efficient nutrient usage which enhances efficiency of the chemical fertilizers while reducing nutrient losses (Schoebitz and Vidal, 2016). Ancient farmers used to rely on organic manures for crop production that proved good for soil health but was slow in response on crop yields. In recent, swift economic development has led the farmers to use mineral fertilizers as they are more economical, affordable, easy to use and quick in response. However, their intensive application is leading to land degradation, deteriorated soil health and leaching of nutrients into the underground water thereby posing environmental risks to human and animal health. So, there is a need to draw a mid-way between organic and inorganic extremities that may sustain crop yields without deteriorating soil fertility and/or productivity.

In the light of the above, the use of compost or vermicompost combined with small doses of NPK may be a rational step for soil fertility improvement under intensive farming as it replaces some of the exhausted nutrients from the soil. The use of compost instead of crop residues has an advantage of higher nutrient content and better agronomic effect than the latter. Composting reduces bad odour from manure and is easier to apply on the field. Keeping all these aspects in consideration, the present study was conducted under following

Objectives:

1. To observe the effect of combined application of organic manure and inorganic fertilizer on growth performance of maize,
2. To observe the effect of combined application of organic manure and inorganic fertilizer on yield performance of maize, and
3. To select the suitable combination of organic manure and inorganic fertilizer for growth and yield of maize.

CHAPER II

REVIEW OF LITERATURE

Maize is one of the common and most important cereal crops of Bangladesh and as well as many countries of the world. Growth and yield of maize are largely controlled by the environmental variables notably moisture regimes, temperature and varieties. The growth and yield also influenced by fertilizer management and agronomic practice. Research works have been done by various workers in many parts of the globe to study the effect of different level of fertilizer combination on the yield of maize. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings so far been done at home and abroad on this aspect have been reviewed in this chapter

2.1. Effect of organic manure and inorganic fertilizer on growth characters of maize

Enebe and babalola, (2020) studied on effects of inorganic and organic treatments on the microbial community of maize rhizosphere by a shotgun metagenomics approach. The main drivers of biogeochemical cycling of nutrients, plant growth promotion, and disease suppression are microbes. Organic manure increases soil quality and plant productivity; the same is true of inorganic fertilizer. They used high throughput next-generation sequencing—metagenomics studies to examine the rhizosphere microbial community of maize plants grown in an organic compost manure (8 tons ha^{-1} and 4 tons ha^{-1}) and inorganic (120 kg ha^{-1} NPK and 60 kg ha^{-1} NPK chemical) fertilized soils. An unfertilized soil was used as a control. The taxonomic analysis of the soil revealed that regardless of the fertilization regimes, Proteobacteria and Bacteroidetes are distributed across all the samples, but in varying populations. Higher quantities of organic manure (8 tons ha^{-1}) and lower (60 kg ha^{-1}) nitrogen fertilizer, as well as the untreated control, supports the selection and enrichment of Proteobacteria and Actinobacteria, while lower quantities of organic compost (4 tons ha^{-1}) manure boost the population of *Bacteroidetes*. *Firmicutes*, on the other hand, were most abundant in low organic manure (4 tons ha^{-1}) and higher inorganic (120 kg ha^{-1}) fertilized soil. Fungi were selected and enriched by higher (8 tons ha^{-1}) and lower (4 tons ha^{-1}) compost manure, while archaea were mostly supported by higher doses of inorganic fertilizers (120 kg ha^{-1}) and high compost manure (8 tons ha^{-1}) treatment. Therefore, comprehending the effects of compost and chemical fertilizers (NPK—20% nitrogen, 7% phosphorus, 3% potassium) on the community structure, dynamics, and abundance of rhizosphere microbiome will help in the manipulation of soil microbial community to increase microbial diversity in the agro ecosystem.

Maize is a major crop grown and consumed in throughout the world and it requires a high fertilizer input. However, the existing inorganic fertilizers in the market are often not affordable especially to small scale farmers, which results in decreased maize yields in the country. On the other hand, there is an abundance of unutilized animal manure, which, when treated, can be used to increase maize yields. Jjagwe *et al.* (2020) evaluated the response of maize to products of different cattle manure treatment methods as well as inorganic fertilizer. The treatments such as cattle manure stored under shade (T), cattle manure stored in the open (M), cattle manure slurry digestate (S), vermicompost (V), and an inorganic fertilizer, DAP (D) were all applied in Completely Randomized Block plots at an equal application rate of 50 kg N ha^{-1} with four replications per treatment. Control plots (C) where no fertilizer was applied were also considered. The experiment was done for two planting seasons in 2018. Number of leaves, plant height, cob, and grain yields were used to evaluate the performance of different fertilizer treatments. Economic assessment of all the six treatments was also carried out to determine the economic viability of applying these fertilizers on maize. Maize growth parameters and yields were all significantly increased ($p < 0.05$) with an application of both organic manure and inorganic fertilizers when compared with the control. However, there was no significant difference ($p > 0.05$) in the maize yields under the different fertilizer treatments. Vermicomposting was the most economically viable manure treatment method due to low operating costs and higher returns on investment that are supplemented with the production of chicken fodder (earthworm biomass) and, thus, can be recommended to farmers for production of a fertilizer that increases maize yields with assurance of economic returns. It can be concluded that treating organic materials prior to their use as crop fertilizers improves their quality in terms of the macronutrients (N, P, and K). In addition, organic amendments can perform as good as inorganic fertilizers when the essential crop nutrients (N, P and K) are applied at the same rate. Maize yield was significantly increased with the application of a fertilizer with no significant differences among the fertilizer treatments of DAP, vermicompost, stored manure under shade, stored manure in the open, and cattle manure slurry at the same nitrogen application rate. All the fertilizer application treatments were economically viable much as vermicompost made the most economic sense. Vermicomposting has also been reported to be the most environmentally-friendly technology in terms of reducing gaseous emissions and retaining nutrients within cattle manure. It can, therefore, be concluded that vermicomposting can be adopted as an environmentally safe and economical technology for the production of a fertilizer from organic materials with assurance of increased crop yields. It is worth mentioning that other forms of organic waste management (storage, composting, and anaerobic digestion) can produce products that can replace inorganic fertilizers as long as the right economically optimal quantities are applied.

Kandil *et al.* (2020**)** was conducted an experiment on potentials of organic manure and potassium forms on maize (*Zea mays* L.) growth and production. To conduct the field trials, a split plot system in three replications was established. Three compost levels (0, 5 and 10 t ha^{-1}) were in the main plots, and four potassium forms (untreated, nano-potassium fertilizer, humic acid and potassium sulfate) were in the subplots. Plot size was 10.50 m^2, with 5 ridges with 3 m length and 0.7 m width. The results indicated that the application of compost (as organic manure) and the potassium forms significantly affected the plant height, ear length, grains number $rows^{-1}$, grains number ear^{-1}, 100 grain weight, straw and biological yields, grain protein and K contents in both seasons. Increasing the compost from 5 to 10 t ha^{-1} increased the yield, its components, protein and K contents. The foliar application of nano-potassium followed by humic acid increased all the studied characteristics. The interaction between compost manure (10 t ha^{-1}) and nano-potassium (500 cm^3 ha^{-1}) or humic acid (10 t ha^{-1}) recorded the highest mean values for all parameters during both harvest seasons.

Toungos (2019) conducted an experiment on maize to study the effect of organic and inorganic fertilizer on yield of maize in Mubi North Local Government Area, Adamawa State, Nigeria at the Food and Agricultural organization/ Tree Crop Production (FAO/TCP) Teaching and Research Farm of Adamawa State University Mubi during 2018 cropping season. Mubi is geographically located within Latitude

10^{o} 05" N of the equator and longitude 13^{o} 16" E Greenwich meridian time on altitude of 696 m above the sea level. The mean plant height of maize was different due to sources of fertilizer and levels applied. During the growth stages it showed that, the mean plant heights were recorded after 3, 6 and 9 WAS. Those applied with cow dung had the tallest plant at 3 WAS with 18.27 cm, followed by NPK applied with 18.07 cm. The combination of cow dung and NPK recorded 15.66 cm, while the controlled had 13.96 cm. The trends followed at 6 WAS with cow dung, recorded the tallest plant with 49.02 cm followed by NPK with 48.52 cm while combined had 46.11 cm and the controlled with 41.06 cm. The effect of organic and inorganic fertilizer on the growth and yield parameter of maize has significant difference and subsequently, the tallest plants were obtained with those applied with NPK, while control has the shortest plant.

Woldesenbet and Haileyesus (2016) reported that, maize response to high nitrogenous fertilization levels is a means among other means to know maximum productivity, from this perspective, a field nitrogen management using trial five N levels (0, 23, 46, 69 and 92 kg N ha^{-1}) with three replications. The study was conducted in 2015 in Modyo Gombera Kebele, Kaffa Zone of SNNPR State. The experiment was laid out in RCBD model. The result of this study indicated that effects of different rates of N fertilizer had influenced the growth and yield components of maize. The tallest plant (360.66 cm) was recorded from the application of 92 kg N $ha^{-1}$and the shortest plant (347.33 cm) from no N application.

Gillani *et al.* (2014**)** conducted an experiment at Agronomic Research Area, Faisalabad, Pakistan to check the interactive effect of both macronutrients and micronutrients on the yield and quality of forage maize. The experiment comprised two factors i.e. varieties (Pak Afghoi and Syngenta- 6621) and nutrients (NP and micronutrients). The application of two foliar sprays of micronutrients at 15 and 30 DAS along with NP applied in soil significantly increased the green forage yield (58.63 t ha^{-1}) in Pak Afghoi variety of maize. The qualititative parameters like crude protein (%), crude fiber percentage and ash contents percentage were also significantly affected by the application of micronutrients. Significant differences were also observed among the cultivars regarding with maximum plant height (247.3 cm), leaves number $plant^{-1}$ (18.17) and stem girth $plant^{-1}$ (1.96 cm**).**

Enujeke (2013) conducted an experiment in Teaching and Research Farm of Delta State University which is in Asaba Campus from March, 2008 to June, 2010 to evaluate the effects of ferilizer on growth characters of hybrid maize. It was a factorial experiment carried out in a Randomized Complete Block Design (RCBD) with three replicates. Three hybrid maize varieties were evaluated for such growth characters as plant height, number of leaves, leaf area and stem diameter. The results obtained during the 8th week after sowing revealed that hybrid variety 9022-13 which gave highest number of leaves of 13.2 and the lowest number of leaves 12.2 was recorded from Oba Super 2.

Athar *et al.* (2012) conducted a pot experiment in a wire netting green house at Bahauddin Zakariya University, Multan, Pakistan in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. Corn plants were grown in loam soil with alkaline in reaction. The pots were arranged in a complete randomized manner with six replicates. Two weeks old plants were subjected to different levels of urea (46% N). Five levels of urea (0, 50, 100, 175 and 225 kg ha^{-1}) with constant (150 kg ha^{-1}) TSP (46% P_2O_5) and SOP (50% K_2O) were applied in two steps half dose at the seedling stage and the remaining half was supplied at vegetative stage (6 weeks) at constant (100 kg ha^{-1}) sulfate of potash (SOP) and triple super phosphate (TSP). They reported that, maximum dry matter accumulation $plant^{-1}$ (100.41 g) was recorded for C-79 and the lowest dry matter accumulation $plant^{-1}$ (60.28g) was found from C-20 variety.

Admas *et al.* (2015) reported that, maize (*Zea mays* L.) is one of the most important staple food crops in Ethiopia although its yield is low. Intensive cultivation causes plant nutrient depletion and yield decline. The objective of this experiment was, therefore, to investigate the effects of combined application of organic manure and inorganic fertilizers on yield and yield components and nutrient contents of maize. Field experiments were conducted on Nitisols (acidic soils) for two consecutive cropping seasons. The experiments were laid down in RCBD as factorial combinations of three levels of N (0, 60 and 120 kg N ha^{-1}), compost (0, 5 and 10 ton ha^{-1}) and S (0, 15 and 30 kg S ha^{-1}) fertilizers which were replicated three times. In this experiment, significant ($p \leq 0.05$) differences were observed on maize grain yield, total above ground dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N and S concentration of leaves and grains by such fertilizers combinations.

Ahmad *et al.* (2008) conducted an experiment on effectiveness of organic or bio-fertilizer supplemented with chemical fertilizers for improving soil water retention, aggregate stability, growth and nutrient uptake of maize *(Zea mays* L.). An organic-fertilizer was prepared by composting fruit and vegetable wastes in a locally fabricated unit and enriching it with N applied at the rate of 147 g kg^{-1} compost. This organic fertilizer was also used as a carrier for PGPR strain, *Pseudomonas fluorescens* biotype G (N_3) containing ACC deaminase to formulate a bio fertilizer. The organic were applied at 300 kg ha^{-1} to maize in pots $plots^{-1}$ supplemented with 0, 88 or 132 kg ha^{-1} urea-N. A basal dose of P and K (100 and 50 kg ha^{-1}, respectively) was applied to all pots $plots^{-1}$. Results of two years pot and field trials revealed that the organic fertilizer supplemented with 88 kg ha^{-1} N was equally effective compared to full dose of N-fertilizer (175 kg ha^{-1}) in improving root weight, fresh biomass, and ear and grain yields of maize. However, bio-fertilizer supplemented either with 88 or 132 kg N ha^{-1} significantly increased the growth and yield of maize over full dose of N-fertilizer and exhibited superiority over organic fertilizer. Organic bio-fertilizer application significantly enhanced N and P uptakes while substantially reducing the rate of water loss from the soil and increased aggregate stability. Results may imply that organic waste could be composted into value-added soil amendment by enriching or blending it with N and PGPR containing ACC-deaminase activity. The novelty of this approach is that the organic- or bio-fertilizer was used at a low rate (just 300 kg ha^{-1}). Moreover, this strategy could also be useful to protect our environments against threat posed by organic wastes.

Jamalit *et al.*, (2008) studied about the use of sewage sludge on agricultural land provides an alternative for its disposal. Therefore, the aim of the study was to evaluate the feasibility of using industrial sewage sludge produced in Pakistan, as an agricultural fertilizer. The agricultural soil amended with 250 g kg^{-1} sewage sludge with or without lime treatment was used for the growth of the common local grain crop, maize (*Zea maize*). The mobility of the trace and toxic metals in the sludge samples was assessed by applying a modified BCR sequential extraction procedure. The single extraction procedure was comprised of the application of a mild extractant ($CaCl_2$) and water, for the estimation of the proportion of easily soluble metal fractions. To check the precision of the analytical results, the concentrations of trace and toxic metals in every step of the sequential extraction procedure were summed up and compared with total metal concentrations. The plant-available metal contents, as indicated by the deionized water and 0.01 mol L^{-1} $CaCl_2$ solution extraction fractions and the exchangeable fraction of the sequential extraction, decreased significantly ($P < 0.05$) with lime application because of the reduced metal availability at a higher pH, except in the cases of Cd and Cu, whose mobility was slightly increased. Sludge amendment enhanced the dry weight yield of maize and the increase was more obvious for the soil with lime treatment. Liming the sewage sludge reduced the trace and toxic metal contents in the grain tissues, except Cu and Cd, which were below the permissible limits of these metals. The study demonstrates that liming was an important factor in facilitating the growth of maize in sludge-amended soil.

2.2 Effect of organic manure and inorganic fertilizer on yield contributing characters of maize

Expanding eco-friendly approaches to improve plant growth and crop productivity is of great important for sustainable agriculture. Therefore, a field experiment was carried out by Gao *et al.* (2020) at the Faculty of Agriculture Farm, Mansoura University, Egypt during the 2018 and 2019 growing seasons to study the effects of different bio- and organic fertilizers and their combination on hybrid maize growth, yield, and grain quality. Seeds were treated with *Azotobacter chrocoocum*, arbuscular mycorrhizal fungi (AMF), *Bacillus circulans*, biogas slurry, humic acid (HA), and their combination aiming to increase the growth and yield of maize and to reduce the need for chemical fertilizers. The results showed that combined application of the biofertilizer mixture (*Azotobacter chrocoocum*, AMF, and *Bacillus circulans*) with organic fertilizers enhanced maize growth, yield, and nutrient uptake. Moreover, the bio-organic fertilization has improved the soluble sugars, starch, carbohydrates, protein, and amino acid contents in maize seeds. Additionally, the bio-organic fertilization caused an obvious increase in the microbial activity by enhancing acid phosphatase and dehydrogenase enzymes, bacterial count, and mycorrhizal colonization levels in maize rhizosphere as compared with the chemical fertilization. Additionally, the bio-organic fertilizers has improved α-amylase and gibberellins (GA) activities and their transcript levels, as well as decreased the abscisic acid

(ABA) level in the seeds as compared to the chemical fertilizers. The obtained results of bio-organic fertilization on the growth parameters and yield of maize recommend their use as an alternative tool to reduce chemical fertilizers. . Thus, the research revealed that the integration of bio-organic fertilizer + 50% chemical fertilizer can serve as an effective and alternative fertilizer in order to reduce the consumption of chemical fertilizers for sustainable agriculture.

Kandil *et al.* (2020) conducted an experiment on Potentials of organic manure and potassium forms on maize (*Zea mays* L.) growth and production. To conduct the field trials, a split plot system in three replications was established. Three compost levels (0, 5 and 10 t ha^{-1}) were in the main plots, and four potassium forms (untreated, nano-potassium fertilizer, humic acid and potassium sulfate) were in the subplots. Plot size was 10.50 m^2, with 5 ridges with 3 m length and 0.7 m width. The results indicated that the application of compost (as organic manure) and the potassium forms significantly affected the plant height, ear length, grains number $rows^{-1}$, grains number ear^{-1}, 1000 grain weight, straw and biological yields, grain protein and K contents in both seasons. Increasing the compost from 5 to 10 t ha^{-1} increased the yield, its components, protein and K contents. The foliar application of nano-potassium followed by humic acid increased all the studied characteristics. The interaction between compost manure (10 t ha^{-1}) and nano-potassium (500 cm^3 ha^{-1}) or humic acid (10 t ha^{-1}) recorded the highest mean values for all parameters during both harvest seasons.

Integrated use of lime with organic and chemical fertilizers is considered as a good approach for sustainable crop production under acidic soils. Bekele *et al.*(2018) conducted an experiment about the effects of lime, vermicompost and chemical P fertilizer on yield of maize in Ethiopia. Vermicompost (VC) and chemical phosphorus (P) fertilizer when used with lime play a vital role in enhancing productivity of acidic soils. The experiments were laid out in a randomized complete block design as a factorial combination of two lime rates (0, and 4 t $CaCO_3$ ha^{-1}), three VC rates (0, 2.5 and 5 t VC ha^{-1}) and three chemical P rates (0, 20 and 40 kg P ha^{-1}) which were replicated three times. Relevant crop parameters were measured following standard procedures. Tasseling days (102), silking days (109), highest leaf area index (5.91), plant height (3.48 m), cob length (47.83 cm), number of grain per cob (644) and above ground dry biomass yield (22 t ha^{-1}) were exhibited by 5 t ha^{-1} VC and 40 kg ha^{-1} chemical P fertilizer with lime of 0 and 4 t ha^{-1} while the highest 1000-seed weight (508 g), grain yield (4.87 t ha^{-1}) and harvest index (24%) were obtained at 2.5 t ha^{-1} VC and 40 kg P ha^{-1} with lime. Integrated application of organic and chemical fertilizers with lime amended the acidic soils and improved its fertility which in turn increased crop yields. Combined use of VC at 2.5 t ha^{-1} and chemical P fertilizer at 20 kg ha^{-1} with lime at 4 t ha^{-1} is economically optimum and could be recommended for reclaiming soil acidity and improve nutrients for maize as it enhanced grain yield and yield components of maize plant in strongly acidic soils for the two consecutive years pooled together.

Liverpool-Tasie *et al.* (2017) conducted an experiment about the profitability of using inorganic fertilizer in Nigeria. Inorganic fertilizer use across Sub-Saharan Africa is generally considered to be low. Yet, the notion that fertilizer use is too low is predicated on the assumption that it is profitable to use rates higher than currently observed. There is, however, limited empirical evidence to support this. Using a nationally representative panel dataset, this paper empirically estimates the profitability of fertilizer use for maize production in Nigeria. We find that fertilizer use in Nigeria is not as low as conventional wisdom suggests. Low marginal physical product and high transportation costs significantly reduce the profitability of fertilizer use. Apart from reduced transportation costs, other constraints such as soil quality, timely access to the product, and availability of complementary inputs such as improved seeds, irrigation and credit, as well as good management practices are also necessary for sustained agricultural productivity improvements.

Woldesenbet and Haileyesus (2016) reported that maize response to high nitrogenous fertilization levels is a means among other means to know maximum productivity, from this perspective, a field nitrogen management using trial five N levels (0, 23, 46, 69 and 92 kg N ha^{-1}) with three replications. The study was conducted in 2015 in Modyo Gombera Kebele, Kaffa Zone of SNNPR State. The experiment was laid out in RCBD model. The result of this study indicated that effects of different rates of N fertilizer had influenced the growth and yield components of maize. The tallest plant (360.66 cm) was recorded from the application of 92 kg N ha^{-1} and the shortest plant (347.33 cm) from no N application. The number of kernels per ear showed that the lowest kernels per ear (497.86) were obtained from no N application and the highest kernels per ear (588) were obtained from the application of 92 kg N ha^{-1} although there was no significant difference between the application of 69 and 92 kg N ha^{-1}. Regarding to ear length the data showed that the longest ear (23.63 cm) was obtained from the application of 92 kg N ha^{-1}.

Admas *et al.* (2015**)** reported that, maize (*Zea mays* L.) is one of the most important staple food crops in Ethiopia although its yield is low. Intensive cultivation causes plant nutrient depletion and yield decline. The objective of this experiment was, therefore, to investigate the effects of combined application of organic manure and inorganic fertilizers on yield and yield components and nutrient contents of maize. Field experiments were conducted on Nitisols (acidic soils) for two consecutive cropping seasons at Wujiraba watershed, north western highlands of Ethiopia. The experiments were laid down in RCBD as factorial combinations of three levels of N (0, 60 and 120 kg N ha^{-1}), compost (0, 5 and 10 t ha^{-1}) and S (0, 15 and 30 kg S ha^{-1}) fertilizers which were replicated three times. In this experiment, significant ($p \leq 0.05$) differences were observed on maize grain yield, total above ground dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N and S concentration of leaves and grains by such fertilizers combinations. The highest mean grain yield, dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N concentration in leaf and grain (7.9, 22.4 t ha^{-1}, 2.52 m, 486, 0.44 g, 492 g, 3.25 and 1.4%) were observed in plots treated with fertilizer combinations of 120 kg N ha^{-1}, 10 t $ha^{-1}$and 15 kg S ha^{-1}, respectively.

Nasim *et al.* (2012) reported that organic agriculture combined tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Furthermore, maize (*Zea mays* L.) crop is the 3rd cereal crop of Pakistan after wheat and rice. According to the economic survey of Pakistan, it is cultivated on the area of approximately 1.11 million hectare and production from this area was 4.04 million tones. A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan to examine the effect of organic and inorganic fertilization on maize productivity. The experiment was laid out in Randomized Complete Block Design (RCBD), with four replications. Two maize hybrids were used in this experiment. The results showed that maize yield and its component such as cobs per plant, cob length, number of grains per cob, 1000 - grain weight were maximum when the plots were fertilized at 100 kg

N ha^{-1} as urea + 100 kg N ha^{-1} as poultry manure. Further research is desired to investigate maximum yield by using organic source of fertilizer than inorganic source of fertilizer to avoid lethal effects on human health created by inorganic fertilizers.

Maqbool *et al.* (2016) was conducted a field experiment for two consecutive years to study the effect of fertilizer application methods and inter and intra-row weed-crop competition durations on density and biomass of different weeds and growth, grain yield and yield components of maize. The experimental treatments comprised of two fertilizer application methods (side placement and below seed placement) and inter and intra-row weed-crop competition durations each for 15, 30, 45, and 60 days after emergence, as well as through the crop growing period. Fertilizer application method didn't affect weed density, biomass, and grain yield of maize. Below seed fertilizer placement generally resulted in less mean weed dry weight and more crop leaf area index, growth rate, grain weight per cob and 1000 grain weight. Minimum number of weeds and dry weight were recorded in inter-row or intra-row weed-crop competition for 15 DAE. Number of cobs per plant, grain weight per cob, 1000 grain weight and grain yield decreased with an increase in both inter-row and intra-row weed-crop competition durations. Maximum mean grain yield of 6.35 and 6.33 t ha^{-1} were recorded in inter-row and intra-row weed competition for 15 DAE, respectively**.**

Nutrient management plays a key role in improving crop yield in terms of maintaining soil fertility for sustainable production in intensive cropping. A field experiment was conducted by Baharvand *et al.* (2014) to assess the effect of integrated nutrient management on the growth of three maize cultivar at the Agricultural and Natural Resources Research Centre in Lorestan, Iran. The experimental design was a randomized complete block design arranged in factorial with three replications. The first factor comprised three maize cultivars (single cross 704, single cross 677 and single cross 580) and the second factor was three levels of fertilizers (chemical (100% urea), full organic (100% vermicompost) and integrated (50% urea and 50% vermicompost)). The results showed that maize cultivars vary in some growth parameters such as leaf number, leaf area index and plant height. In addition, vermicompost application had great impact on maize growth especially when it was combined with chemical fertilizer. Integrated fertilizer management significantly increased leaf number, leaf area index, stem diameter, plant height, chlorophyll content and remobilization compared to full chemical and full organic treatments. In general, to get maximum growth and yield, the application of integrated organic manure and inorganic fertilizer is the best option.

Onasanya *et al.* (2009) studied the effect of twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize (*Zea mays* L.) in southern Nigeria. The results of the study showed that application of 120 kg N ha^{-1} + 0 kg P ha^{-1} and 60 kg N ha^{-1} + 40 kg P ha^{-1} significantly increased the growth of maize than other treatments. The application rate of 120 kg N ha^{-1} + 40 kg P ha^{-1} significantly (P =0.05) enhanced grain yield. This study further confirms the role of nitrogen and phosphorus fertilizers in increasing growth and grain yield in maize production. From the result of the study, application rate of 120 kg N ha^{-1} + 40 kg P ha^{-1} may be recommended for increasing maize yield particularly in the study area. However, application of 60 kg N ha^{-1}+ 40 kg P ha^{-1} can also bring about increase in the yield of maize. This will greatly benefit farmers in area where supply of nitrogen fertilizer is low and cases where farmers cannot afford the cost of high fertilizer input.

The use of organic fertilizer source for increasing crop production on sustainable basis has become imperative because of high cost of chemical fertilizer. A field experiment was conducted by Sharif *et al.*(2004) on a silty clay loam soil at Haripur, Pakistan to study the comparative efficiency of organic and inorganic fertilizers applied alone and in combinations on the yield and yield components of maize crop (*Zea mays* L., Kissan). Organic fertilizers, humic acid (HA) at the rate of 200g ha^{-1} and farm yard manure (FYM) at the rate of 5000 kg ha^{-1}, while inorganic fertilizers (NPK) at the rate of 120-90-60 kg ha^{-1} were applied. Humic Acid alone increased grain yield, total dry matter, 1000 grain weight by 72%, 25% and 28% respectively over control. Highest grain yield of 4140 Kg ha^{-1}, total dry matter yield of 13120 Kg ha^{-1} and thousand grain weight of 250 g was obtained by the addition of HA in combination with FYM and NPK. Optimum grain yield of 3900 Kg ha^{-1}, total dry matter yield of 12710 Kg ha^{-1} and thousand grain weights of 240g were obtained by the addition of HA in combination with NPK. The soil analysis showed that both organic sources of fertilizers when combined with NPK increased the P and total N concentrations of maize leaves. Soil organic matter was slightly increased while a decreasing trend was recorded in soil pH values. HA reinforced with 120-90-60 kg ha^{-1} NPK fertilizers may be considered as an optimum dosage for the achievement of production peaks of grains, dry matter yield and 1000grain weight. Results suggest that addition of HA have great potential to improve maize yield and physicochemical and biological properties of soil.

2.3 Effect of organic manure and inorganic fertilizer on yield characters of maize

Sigaya *et al.* (2020) was carried out a study to determine the influence of organic and inorganic fertilizers on maize yield and soil fertility; to determine economically optimum organic manure and inorganic fertilizer combinations for maize production. The study was performed in a randomized complete block design consisting of 10 treatments and 3 replications. The treatments were: Control, 100% of R-NP (138 N and 92 P), 100% of vermicompost, 100% of conventional compost, 25% R-NP +75% of vermicompost, 50% of R-NP + 50% of vermicompost, 75% of R-NP+25% of from vermicompost, 25% of R-NP +75% of conventional compost, 50% of R-NP+50% of conventional-compost, 75% of R-NP +25% of conventional-compost. All rates of vermicompost and conventional compost were applied based on N equivalence. Results indicate that applications of inorganic fertilizers with a combination of organic source fertilizers were increases maize yield and yield components and improves the nutrient status of the soil. The highest maize grain yield (7494.3 kg ha^{-1}) and above-ground biomass yield (18718.0 kg ha^{-1}) was obtained from the applications of 50% recommended NP fertilizer plus 50% vermicompost which is based on the recommended N equivalent respectively. Similarly, we found that a combination of both inorganic and organic fertilizers application also is the best strategy to improve major soil nutrients, maintain soil fertility. The economic analysis revealed that the highest net benefit of (108,872.00 ETB ha^{-1}) was obtained from the application of 50% recommended NP fertilizer plus 50% vermicompost. Yet, the lowest yield and net benefit value were attained from the control or unfertilized plot. Therefore, this study suggests that an appropriate proportion of organic fertilizer with inorganic fertilizer not only for higher yield maize production with an assurance of potential economic returns to the small hold farmers but also improve and maintain the soil fertility and should be adopted with similar soil type and agro-ecologies.

Kandil *et al.* (2020) was conducted an experiment on potentials of organic manure and potassium forms on maize (*Zea mays* L.) growth and production. To conduct the field trials, a split plot system in three replications was established. Three compost levels (0, 5 and 10 t ha^{-1}) were in the main plots, and four potassium forms (untreated, nano-potassium fertilizer, humic acid and potassium sulfate) were in the subplots. Plot size was 10.50 m^2, with 5 ridges with 3 m length and 0.7 m width. The results indicated that the application of compost (as organic manure) and the potassium forms significantly affected the plant height, ear length, grains number $rows^{-1}$, grains number ear^{-1}, 1000 grain weight, straw and biological yields, grain protein and K contents in both seasons. Increasing the compost from 5 to 10 ton ha^{-1} increased the yield, its components, protein and K contents. The foliar application of nano-potassium followed by humic acid increased all the studied characteristics. The interaction between compost manure (10 ton ha^{-1}) and nano-potassium (500 cm^3 ha^{-1}) or humic acid (10 t ha^{-1}) recorded the highest mean values for all parameters during both harvest seasons.

Mahmood *et al.* (2017) investigated the effects of organic and inorganic manures on maize and their residual impacts on soil physico-chemical characteristics. Sheep manure (SM), poultry manure (PM) and farmyard manure (FYM) were applied as organic nutrient source while urea, diammonium phosphate (DAP) and sulphate of potash (SOP) were used at different concentrations as inorganic nutrients source *viz.*, T_1 : Unfertilized control; T_2 : NPK at 250-150-125 kg ha^{-1}; T_3 : SM at 15 t ha^{-1}; T_4 : FYM at 16 t ha^{-1}; T_5 : PM at 13 t ha^{-1}; T_6 : NPK at 150-85-50 + 8 t ha^{-1} SM; T_7 : NPK at 150- 85-50 + 8.5 t ha^{-1} FYM and T_8 : NPK at 150-85-50 + 7 t ha^{-1} PM. Results showed that growth and yield of maize were substantially improved by fertilizer application alongside organic manures whereas soil total organic C and total N, P, K contents increased when inorganic fertilizers were applied alone or in combined with organic manures. However, soil pH and soil bulk density decreased due to application of organic fertilizer and showed a negative correlation with grain yield. Further, a significant and positive correlation (R_2 = 0.52, 0.91 and 0.55) was observed among maize grain yield and available N, P and K contents, respectively in the soil. Conclusively, integration of inorganic fertilizers with organic manures can be used with optimum rates to improve crop productivity on sustainable basis.

Nasim *et al.* (2012) reported that, organic agriculture combined tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Furthermore, maize (*Zea mays* L.) crop is the 3rd cereal crop of Pakistan after wheat and rice. According to the economic survey of Pakistan, it is cultivated on the area of approximately, 1.11 million hectare and production from this area was 4.04 million tones. A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan to examine the effect of organic and inorganic fertilization on maize productivity. The experiment was laid out in Randomized Complete Block Design (RCBD), with four replications. Two maize hybrids were used in this experiment. The results showed that maize yield and its component such as cobs per plant, cob length, number of grains per cob, 1000 - grain weight were maximum when the plots were fertilized at 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as poultry manure.

Verma *et al.* (2012) conducted an experiment during rabi season of 2006-07 and 2007-08 to study the effect of sowing dates and integrated nutrient management on growth, yield and quality of winter maize. The trial was laid out in split plot design with three replications, assigning total 27 treatment combinations i.e. three sowing dates (15 Oct., 25 Oct. and 5 Nov.) in main plots and three levels of nitrogen from inorganic fertilizer urea (50, 100 and 150 N_20 kg ha^{-1}) and two organic fertilizer (FYM, Azospirillum) and control in sub plots. The crop sown on 25 Oct. significantly enhanced the growth and grain yield than early sowing 15 Oct. and late sowing 5 Nov. While, 150 kg of N_2O ha^{-1} application significantly increased over 100 and 50 kg N_2O ha^{-1}. However, N_2O application through FYM was found statistically at par with N_2O application through the Azospirillumin growth and grain yield during both years. But, application of 100 kg ha^{-1} with 7.50 t ha^{-1} FYM at the sowing of 25 Oct. significantly influenced the growth, yield and quality of maize and was recorded 9.35 and 23.07 percent more grain yield over the other treatment combinations.

Tejada and Benitez (2011) conducted an experiment to study the effect of two vermicomposts [animal (VCD) and vegetal origin (VGF)] and a cotton gin compost (C) at rates of 1780 and 3560 kg fresh organic matter ha^{-1} for 3 years on an Typic Xerofluvent located near Seville (Spain) on soil biological properties, nutrition (leaf N, P and K concentration, pigments and soluble carbohydrate concentrations) and yield parameters of maize (*Zea mays* cv. Tundra) crop. All organic waste materials had a positive effect on the soil biological properties, plant nutrition and crop yield parameters, although at the end of the experimental period and at the high organic matter rate, the soil microbial biomass and dehydrogenase, urease, β-glucosidase, phosphatase and arylsulfatase activities increased more significantly in the VCD-amended soils (86.4, 85.8, 94.5, 99.3, 70.1 and 63.8%, respectively) respect to the control soil, followed by VGF-amended soils (84.8, 80.6, 92.7, 99.1, 68.3 and 61.6%, respectively) and CC-amended soils (80.5, 75.9, 89.7, 99, 65.7 and 59.9%, respectively). Leaf N, P and K contents and pigments and soluble carbohydrate contents were highest in VCD-amended soils, followed by VGF and CC treatments. Compared with the control soil, the application of VCD in soils at high doses increased the crop yield parameters, followed by VGF and CC treatments. This may have been due to a greater labile fraction of organic matter in the VCD than the VGF and CC, respectively.

Ayoola and Mankinde (2009) were conducted an experiments in the growing seasons of 2005 and 2006 at Ibadan, Nigeria, in the degraded tropical rain forest zone to assess the growth and yield of maize with Nitrogen-enriched organic fertilizer made from municipal waste and cow dung (2.5 t ha^{-1} Pacesetter fertilizer + 100 kg ha^{-1} urea) and also with Nitrogen-fortified poultry manure. Their performance was compared with those of inorganic NPK fertilizer and no fertilizer control. Maize growth was significantly (P=0.05) affected by an enrichment of the organic manures. They had plants comparable in height with inorganic fertilizer application. At harvest, plants treated with fortified poultry manure were about 259cm tall while those treated with fortified Pacesetter fertilizer and the plants treated with inorganic fertilizer were about 253 cm tall. Average plant leaf areas were similar with the fortified fertilizers and with inorganic fertilization. Length of days taken to achieve 50% tasselling was also reduced with fertilization. Inorganic fertilizer application gave plants that achieved 50% tasselling in 50days while fortified poultry manured plants took 52 days and the fortified Pacesetter fertilizer – treated plants took 53 days. Fertilization of maize gave significantly (P=0.05) higher seed yields. Fortified poultry manure gave an average yield of 3.97 t ha^{-1} while fortified Pacesetter fertilizer had an average of 3.78 t ha^{-1}.Inorganic fertilizer gave a yield of 3.70 t ha^{-1} while a significantly lower yield of 2.48 t ha^{-1} was given by the unfertilized plants. Maize growth and yield from the enriched organic manures were comparable with inorganic fertilizer, indicating the potentials of the use of fortified organic manures as alternatives to inorganic fertilizers. Poultry manure required lesser N-fortification to give comparable seed yields as cow dung. Although both organic manures increased the soil N and P, poultry manure gave higher values while the soil K, Ca and Mg contents were more increased with the cow dung than poultry manure. Poultry manure, fortified with 100 kg Urea can be applied at 2.5 t ha^{-1} to cultivate maize. It gives a comparable yield as inorganic fertilizer and increases the soil N and P.

Rameshwar and Totawat (2002) conducted a field experiment during the kharif season of 1999 in Rajasthan, India, to determine the effect of using biogas slurry and Azotobacter as supplement of N fertilizer on maize cv. Navjot performance. Treatments were: chemical urea at 100% (90 kg N ha and 50 and 75%; organic biogas slurry at 100% (90 kg N ha^{-1}), and 50 and 75%, with or without Azotobacter and combination of chemical and organic fertilizer at 1:1 ratio. All treatments significantly increased maize grain and stover yield, yield attributes and nutrient uptake. The available nutrient status of the soil after maize harvest was highest in the organic treatment, followed by the integrated chemical + organic fertilizer treatment.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted during the period from March to August 2019 to study the effect of organic manure and inorganic fertilizer on growth and yield of maize. The materials and methods of this experiment are presented in this chapter under the following headings:

3.1 Experimental site

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level. The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh (Appendix-I).

3.2 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year. The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991). The weather data during the study period at the experimental site including maximum and minimum temperature, total rainfall and relative humidity were shown in Appendix-II.

3.3 Soil

The soil of experimental field was general soil type and shallow red brown terrace soils under Tejgaon series. The selected plot was higher than the flood level and sufficient sunshine was available having availability of irrigation and drainage system during the experimental period. The experimental plot was a high land. The top soil was characterized by silty clay in texture, olive- gray whitish with common fine to medium distinct dark whitish brown mottles was seen on the top soil and the soil had pH- 5.6 and organic carbon- 0.45%. The experimental area was flat and medium high topography with available easy irrigation and drainage system.

The initial soil status of the experimental field from 0-15 cm depth has shown in Appendix III.

3.4 Details of the experiment

3.4.1 Treatments

The experiment consisted of 11 treatments as mentioned below:

T_0 = Control (without fertilizer)

T_1 = Recommended dose of chemical fertilizer (RDCF)

T_2 = Cowdung + RDCF

T_3 = Cowdung + 50% of RDCF

T_4 = Cowdung + 75% of RDCF

T_5¬ = Vermicompost + RDCF

T_6 = Vermicompost + 50% of RDCF

T_7 = Vermicompost + 75% of RDCF

T_8 = Poultry litter + RDCF

T_9 = Poultry litter + 50% of RDCF

T_{10} = Poultry litter + 75% of RDCF

Recommended doses of organic manure and chemical fertilizers have been presented in section 3.5.3.

3.4.2 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of unit plots were 33. The size of unit plot was 3 m × 1.8 m. The spacing 60 cm × 25 cm was used under present study. The final layout of the experimental plots has shown in Appendix-IV.

3.5 Experimental procedure

3.5.1 Seed collection

Seeds of SAU hybrid vhutta 1 were collected from Sher-e-Bangla Agricultural University farm.

3.5.2 Land preparation

The land of the experimental field was first opened on March 11, 2019 with a power tiller. Then it was exposed under the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to make a good tilth, which was necessary to get better plant stand and yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The soil was treated with Furadan 5G @ 20 kg ha^{-1} when the plot was finally ploughed to protect the young plant from the attack of cut worm.

3.5.3 Fertilizers

Urea, TSP, MOP, Gypsum and Boric acid were applied @ 550, 250, 200, 175 and 6 kg ha^{-1}, respectively. All the inorganic fertilizer was applied as per treatment (mention in 3.4.1) except urea fertilizer. In case of urea fertilizer it's applied in 3 instalments. 1/3 at final land preparation stage, 1/3 at vegetative stage and finally 1/3 at flower initiation stage respectively following krishi projukti hatboi (2019) recommendation. The rates of cow dung, vermicompost and poultry litter were 10, 5, 5 ton ha^{-1} respectively, which was applied 7 days before final land preparation.

3.5.4 Seed treatment

Seeds were treated with Provex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease.

3.5.5 Seed sowing

Healthy and uniform sized maize seeds were collected. Seed of maize were sown in lines each having a line to line distance of 60 cm and plant to plant distance of 25 cm having 3 seeds $hole^{-1}$ under direct sowing in the well-prepared plot at a depth of 3-4 cm on March 21, 2019 for easy emergence.

3.6 Intercultural operations

3.6.1 Ridging of soil

To reduce the lodging of maize plant the soil was uplifted to near the base as ridge at 30 DAS.

3.6.2 Removal of weeds

It was required to keep the crop free from weeds and to keep the soil loose for proper aeration and for proper growth and development of maize plant. First weeding was done two weeks after emergence. Another weeding was done before 2^{nd} top dressing of urea.

3.6.3 Thinning and gap filling

Seeds were emerged at 6^{th} and 7^{th} days after sowing. After emergence of seedling, gap filling was completed within 15 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 10 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 5 days after first thinning keeping one healthy seedling in each hill.

3.6.4 Irrigation and drainage

First irrigation was given on 20 April, 2019 which was 30 days after sowing. Second irrigation was given on 5 June, 2019 which was 75 days after sowing. Top dressing of fertilizers was followed by irrigation for proper utilization of fertilizers. Drainage was made to drained out excess water.

3.6.5 Control of insects and diseases

All possible phyto-sanitary measures were adopted to keep plant healthy. Dursban @ 7.5 litre ha^{-1} was drenched on both sides of ridges at 25 DAS to control the cutworm. Dimecron 100 EC @ 2% and Admire 200 SL @ 0.5% were applied at 35 DAS to control leaf folder and roller.

3.6.6 Harvest and post-harvest operation

The crops were harvested when the cover of husk was completely dried and black coloration was found in the grain base. The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. The inner two lines were harvested for recording grain yield and stover yield. Harvesting was done on 1 July, 2019. The harvested products were taken on the threshing floor and it was dried for about 3-4 days.

3.7 Collection of data

Data were collected on the following parameters-

3.7.1 Crop growth parameter

- Plant height (cm) at 30, 60, 90 days after sowing (DAS) and at harvest
- Dry weight plant^{-1} (g) at 30, 60, 90 DAS and at harvest
- SPAD value at 30 and 60 DAS.

3.7.2 Yield contributing characters

- Cob length (cm)
- Cob diameter (cm)
- Tassel length (cm)
- Number of rows cob^{-1}
- Number of grains row^{-1}
- Number of seeds cob^{-1}
- Cob to tassel height (cm)
- Weight of 100 grains (g)

3.7.3 Yield and harvest index

- Grain yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest Index

3.8 Procedure of sampling and data collection for growth parameters

3.8.1 Plant height

At different stages of crop growth (30, 60, 90 DAS and at harvest), the height of three randomly selected plants from the inner rows of every plot was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm. Plant height data was taken from the same plants in all sampling date.

3.8.2 Dry weight plant^{-1}

From each plot 3 plants were uprooted randomly. Then the stem, leaves and roots were separated. The shoot sample (stem and leaves) was sliced into very thin pieces and put into envelop and placed in oven maintaining 65^{0}C for 72 hours. Then the shoot sample was transferred into desiccators and allowed to cool down at room temperature. Then weight of the sample was taken. It was done at 30, 60, 90 DAS and at harvest.

3.8.3 SPAD value

At different stages of crop growth (30, 60 DAS), the SPAD value of three randomly selected plants from the inner rows of every plot was measured from the leaf surface of the plant. The SPAD value was taken from the same plants in all sampling date.

3.9 Procedure of data collection for yield and yield components

3.9.1 Cob length

Five cobs from each plot were selected randomly and the length of cob was measured by measuring tap and then the average result was recorded. Cob length was measured in centimeter from the base to the tip of the ear for five cobs and averages them to get length per cob.

3.9.2 Cob diameter

Five cobs from each plot were selected randomly and the diameter of cob was measured by slide calipers and then the average result was recorded. Cob diameter was measured in centimeter

3.9.3 Tassel length

Five tassels from each plot were selected randomly and the length of tassel was measured by measuring tap and then the average result was recorded. Tassel length was measured in centimeter.

3.9.4 Number of rows cob^{-1}

Five cobs from each plot were selected randomly and the number of rows was counted and then the average result was recorded.

3.9.5 Number of grains rows^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted in each row and then the average result was recorded.

3.9.6 Number of grains cob^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted in each cob and then the average result was recorded.

3.9.7 Weight of 100 grains

From the seed stock of each plot 100 seeds were counted and the weight was measured by an electrical balance. It was recorded in gram.

3.9.8 Grain yield

After removing the grain from the cob grain yield was calculated. Grain yield was calculated from cleaned and well dried grains collected from the plant of inner two row of each plot and expressed as t ha^{-1}. Finally grain yield was adjusted at 14% moisture.

3.9.9 Stover yield

After removing the grains from the cob various parts of the plants without grain part was weighted and well dried stover were collected from each plot were taken and converted into hectare and were expressed in t ha^{-1}.

3.9.10 Biological yield

Grain yield along with stover yield was regarded as biological yield and calculated with the following formula:

Biological yield (t ha^{-1}) = grain weight (t ha^{-1}) + stover yield (t ha^{-1})

3.9.11 Harvest index

Harvest index indicates the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic Yield (Grain weight)}}{\text{Biological Yield (Biological weight)}} \times 100$$

3.10 Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10 software. The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The data on different growth, yield contributing characters and yield were recorded to find out the effect of organic manure and inorganic fertilizer on growth and yield of maize.

The results have been presented and discussed and possible explanation has been given under the following headings:

4.1. Growth parameters

4.1.1. Plant height

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. From this experiment, result revealed that there was significant effect of organic manure and inorganic fertilizer on plant height of maize (Table 1 and Appendix V). The highest plant height (97.40, 236.60, 261.10 and 268.43cm at 30, 60, 90 DAS and, at harvest, respectively was observed from T_8 treatment, which was statistically similar with T_{10} treatment followed by T_5 treatment. The lowest plant height (68.2, 177.94, 195.80 and 202.90 cm at 30, 60, 90 DAS and at harvest, respectively) was observed from the T_0 treatment which was statistically similar with T_3 treatment. The result obtained from the present study was similar with the findings of Toungos (2019).

Table 1. Effect of organic manure and inorganic fertilizer on plant height of maize cv SAU hybrid Vhutta 1

Treatment	Plant height at			
	30 DAS	60 DAS	90 DAS	harvest
T_0	68.200 f	177.94 d	195.80 e	202.90 f
T_1	82.700 b-d	206.66 bc	237.40 c	241.60 cd
T_2	84.200 bc	209.56 b	239.60 bc	242.78 cd
T_3	75.100 ef	190.64 cd	217.67 d	218.30 ef
T_4	78.200 c-e	203.74 bc	228.80 cd	232.10 de
T_5	94.600 a	233.40 a	257.60 ab	260.70 a-c
T_6	77.200 de	200.64 bc	225.35 cd	228.50 de
T_7	86.100 b	210.86 b	240.50 bc	245.26 b-d
T_8	97.400 a	236.60 a	261.10 a	268.43 a
T_9	80.500 b-e	204.44 bc	230.90 cd	233.93 de
T_{10}	96.800 a	235.60 a	258.30 ab	263.60 ab
LSD $_{(0.05)}$	6.9034	17.126	19.173	19.495
CV(%)	5.84	5.79	5.78	5.77

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly.

Here, T_0 = Control, T_1 = RDCF, T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

4.1.2 SPAD value

From this experiment, result revealed that there was significant effect of organic manure and inorganic fertilizer on SPAD value of maize (Table 2 and Appendix VII). The experiment result revealed that the highest SPAD value (53.240 and 62.865 at 30 and 60 DAS, respectively) was observed from T_8 treatment, which was statistically similar with T_{10} treatment followed by T_5 treatment at 30 and 60 DAS, respectively and at T_7 treatment at 30 DAS Whereas, the lowest SPAD value (31.62 and 32.400 at 30 and 60 DAS, respectively) was observed from the T_0 treatment.

Table 2. Effect of organic manure and inorganic fertilizer on SPAD Value of maize cv SAU hybrid Vhutta 1

Treatment	SPAD value at	
	30 DAS	60 DAS
T_0	31.620 h	32.400 e
T_1	45.490 c-f	46.580 cd
T_2	47.510 b-e	48.280 c
T_3	39.180 g	40.832 d
T_4	41.930 e-g	43.810 cd
T_5	50.930 a-c	60.291 ab
T_6	40.090 fg	41.540 d
T_7	47.700 a-d	54.890 b
T_8	53.240 a	62.865 a
T_9	43.060 d-g	45.570 cd
T_{10}	51.960 ab	62.260 a
LSD $_{(0.05)}$	5.6626	6.2849
CV(%)	7.42	7.53

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly.

Here, T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

4.1.3 Dry weight plant^{-1}

From this experiment, result revealed that there was significant effect of organic manure and inorganic fertilizer on dry matter weight of maize (Table 3 and Appendix VI). It can be inferred from the table that maximum dry matter weight (15.730, 145.77, 288.53 and 296.60 g at 30, 60, 90 DAS and at harvest, respectively was observed from T_8 treatment, which was statistically similar with T_{10} treatment followed by T_5 treatment at 30, 60, 90 DAS and at harvest, respectively. Statistically similar result was also observed from T_7 treatment at 30 DAS and at harvest, respectively. Whereas, minimum dry matter weight (7.950, 70.90, 164.61 and 173.49 g at 30, 60, 90 DAS and at harvest, respectively) was observed from T_0 treatment which was statistically similar with T_3 treatment at 60 DAS. Athar *et al.* (2012) also found similar result of dry weight plant^{-1} which supports the present finding.

Table 3. Effect of organic manure and inorganic fertilizer on dry weight plant^{-1} of maize cv SAU hybrid Vhutta 1

Treatment	Dry weight plant^{-1} (g) at			
	30 DAS	**60 DAS**	**90 DAS**	**harvest**
T_0	7.950 g	70.90 f	164.61 f	173.49 e
T_1	12.670 cd	119.62 cd	250.32 cd	269.87 ab
T_2	13.310 c	121.92 cd	251.70 b-d	273.38 ab
T_3	9.800 f	80.45 ef	198.91 e	211.45 d
T_4	11.300 d-f	94.04 e	238.27 cd	229.72 cd
T_5	14.980 ab	133.41 a-c	282.29 ab	289.40 a
T_6	10.350 ef	92.63 e	221.83 de	218.63 cd
T_7	13.680 bc	128.92 bc	265.80 a-c	283.54 a
T_8	15.730 a	145.77 a	288.53 a	296.60 a
T_9	11.670 de	110.54 d	242.09 cd	246.53 bc
T_{10}	15.530 a	140.76 ab	283.17 ab	292.73 a
LSD $_{(0.05)}$	1.6297	14.771	31.652	32.614
CV(%)	7.68	7.70	7.61	7.56

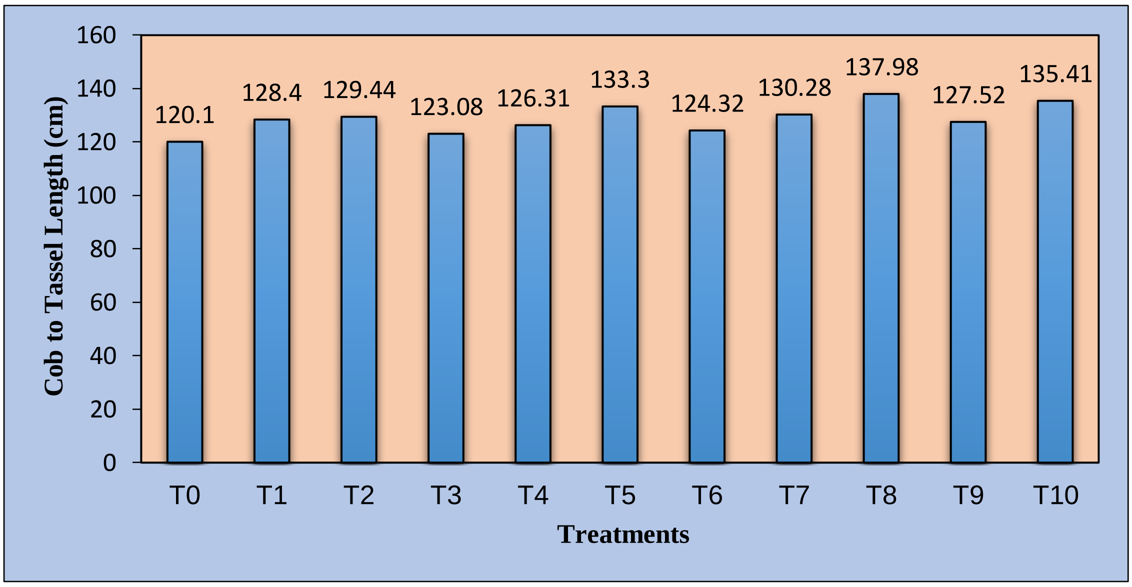
In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly.

Here, T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

4.2. Yield contributing characters

4.2.1 Cob to tassel length

Organic manure and inorganic fertilizer showed non-significant effect on cob to tassel length of maize (Figure 1). However, it was found that maximum cob to tassel length (137.98 cm) was observed from T_8 treatment. Whereas minimum cob to tassel length (120.10 cm) was observed from T_0 treatment.

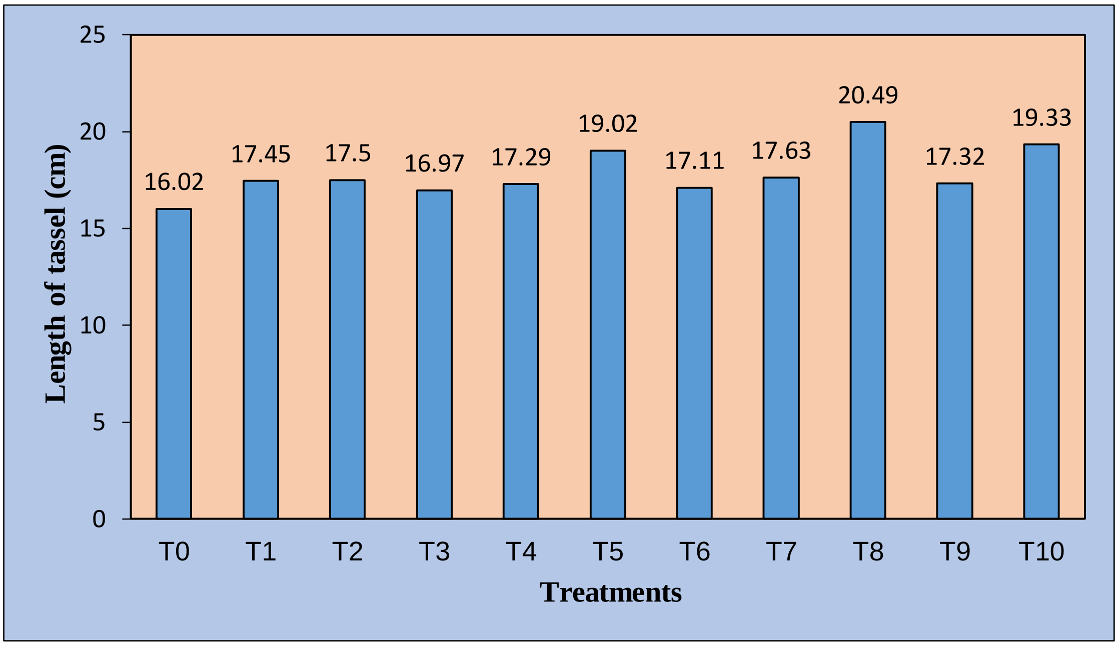


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 1. Effect of organic manure and inorganic fertilizer on cob to tassel length of maize $LSD_{(0.05)}$=NS.

4.2.2 Length of tassel

Organic manure and inorganic fertilizer showed significant effect on tassel length of maize (Figure 2). The result revealed that maximum tassel length (20.490 cm) was observed from T_8 treatment, which was statistically similar with T_{10} treatment followed by T_5 treatment. Whereas minimum tassel length (16.020 cm) was observed from T_0 treatment which was statistically similar with T_3 treatment and then followed by T_6, T_9, T_4, T_1, and T_2 treatments.

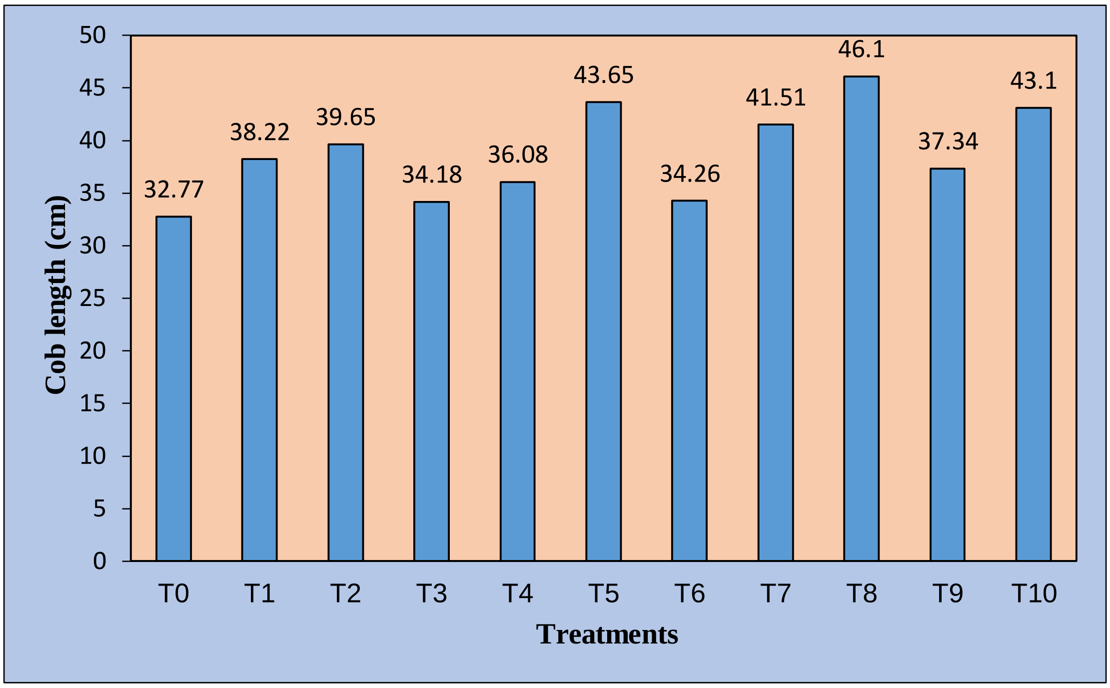


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 2. Effect of organic manure and inorganic fertilizer on tassel length of maize ($LSD_{(0.05)}$= 1.5935).

4.2.3 Cob length

Organic manure and inorganic fertilizer showed significant effect on cob length of maize (Figure 3). The experiment result revealed that maximum cob length (46.10 cm) was observed from T_8 treatment, which was statistically similar with T_{10} treatment followed by $T_{5,}$ $T_{7,}$ and $T_{2,}$ treatment. Whereas minimum cob length (32.77 cm) was observed from T_0 treatment which was statistically similar with T_3 treatment which was also followed by $T_{6,}$ $T_{4,}$ $T_{9,}$ and $T_{1,}$ treatments. Woldesenbet and Haileyesus (2016) found similar result of cob length which supported the present study.

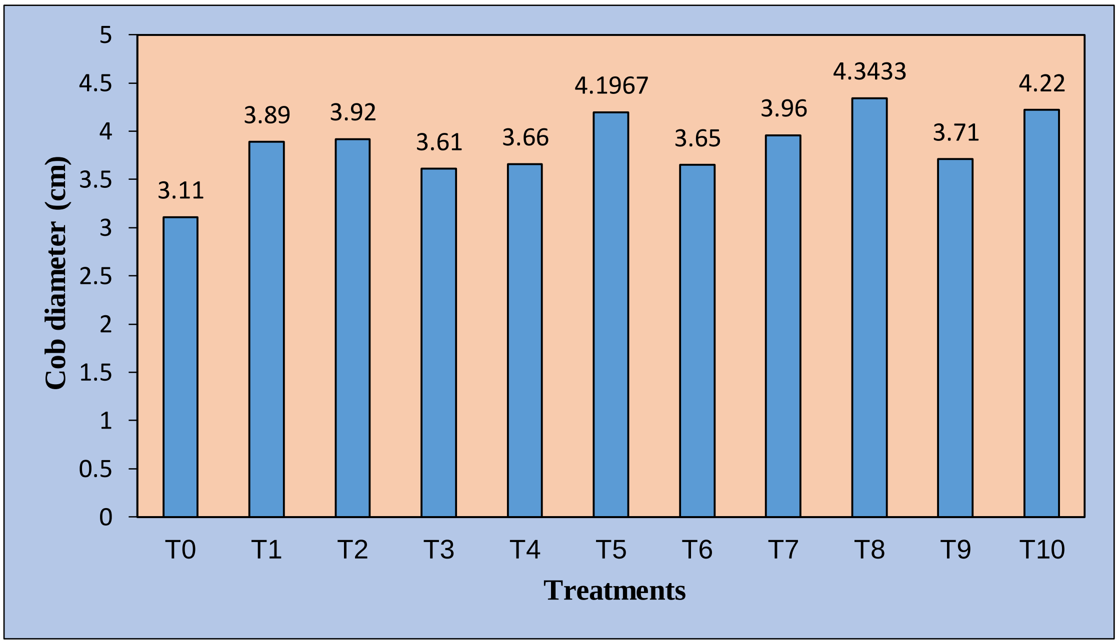


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 3. Effect of organic manure and inorganic fertilizer on cob length of maize ($LSD_{(0.05)}$= 6.8913).

4.2.4 Cob diameter

Organic manure and inorganic fertilizer showed significant effect on cob diameter (cm) of maize (Figure 4). The figure shows that maximum cob diameter (4.34 cm) was observed from T_8 treatment which was statistically similar with all others treatment except T_0, T_3, T_6 and T_4 treatment. Whereas minimum cob diameter (3.11 cm) was observed from T_0 treatment which was statistically similar with T_3, T_6 and T_4 treatment.

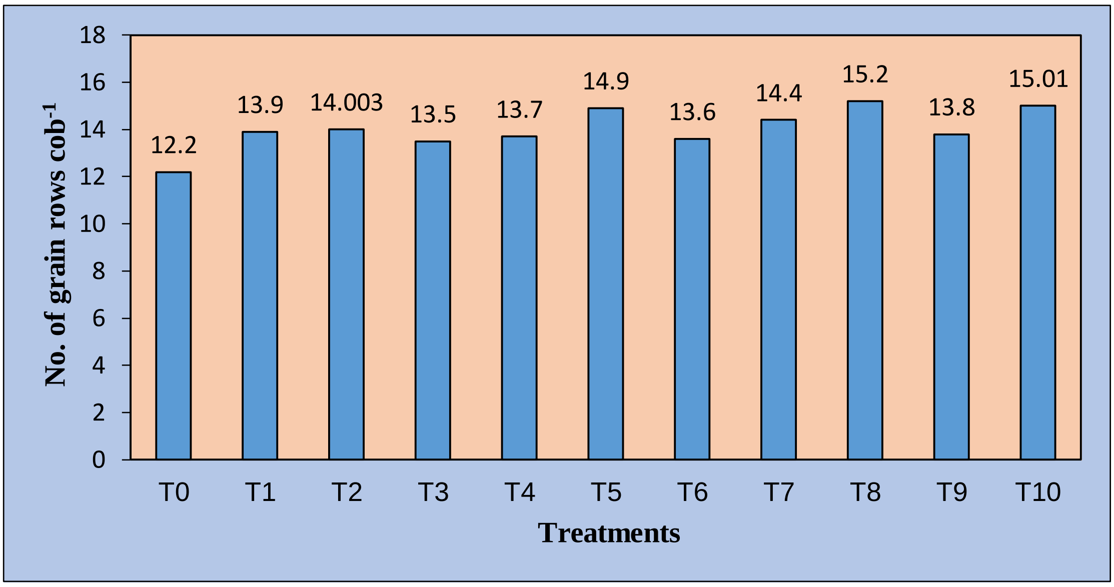


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 4. Effect of organic manure and inorganic fertilizer on cob diameter of maize ($LSD_{(0.05)}$= 0.6640).

4.2.5 Number of grain rows cob^{-1}

Organic manure and inorganic fertilizer showed significant effect on number of grain rows cob^{-1} of maize (Figure 5). It can be inferred from the table that the maximum number of grain rows cob^{-1} (15.20) was observed from T_8 treatment which was statistically similar with T_{10}, T_5, T_7 and T_2 treatment. Whereas minimum number of grain rows cob^{-1} (12.2) was observed from T_0 treatment.

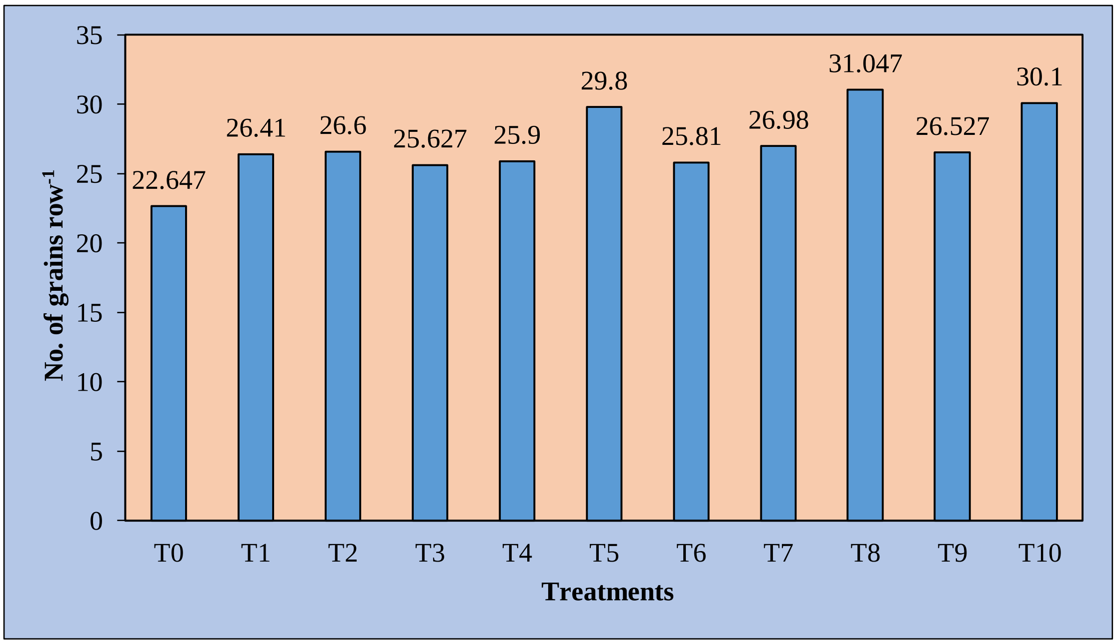


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 5. Effect of organic manure and inorganic fertilizer on number of grain rows cob^{-1} of maize ($LSD_{(0.05)}$= 1.2013).

4.2.6 Number of grains row^{-1}

Organic manure and inorganic fertilizer showed significant effect on number of grains row^{-1} of maize (Figure 6). The experiment result revealed that the highest number of grains row^{-1} (31.05) was observed from T_8 treatment which was statistically similar with T_{10} and T_5 treatment (30.10 and 29.80, respectively). Whereas, minimum number of grains row^{-1} (22.65) was observed from T_0 treatment.

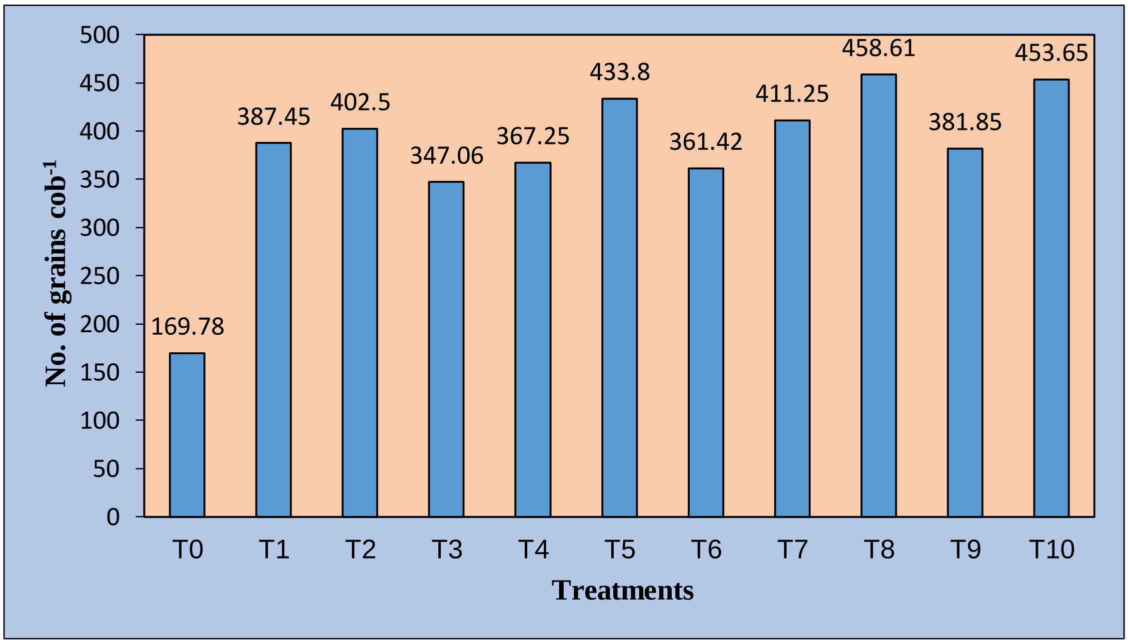


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 6. Effect of organic manure and inorganic fertilizer on number of grains row^{-1} of maize (LSD $_{(0.05)}$ = 2.3255).

4.2.7 Number of grains cob^{-1}

Significant variation was observed on grains cob^{-1} of maize due to the effect of organic manure and inorganic fertilizer (Figure 7). The experimental result revealed that the maximum number of grains cob^{-1} (458.61) was observed from T_8 treatment which was statistically similar with T_{10} treatment. On the other hand, minimum number of grains cob^{-1} (169.78) was observed from T_0 treatment.

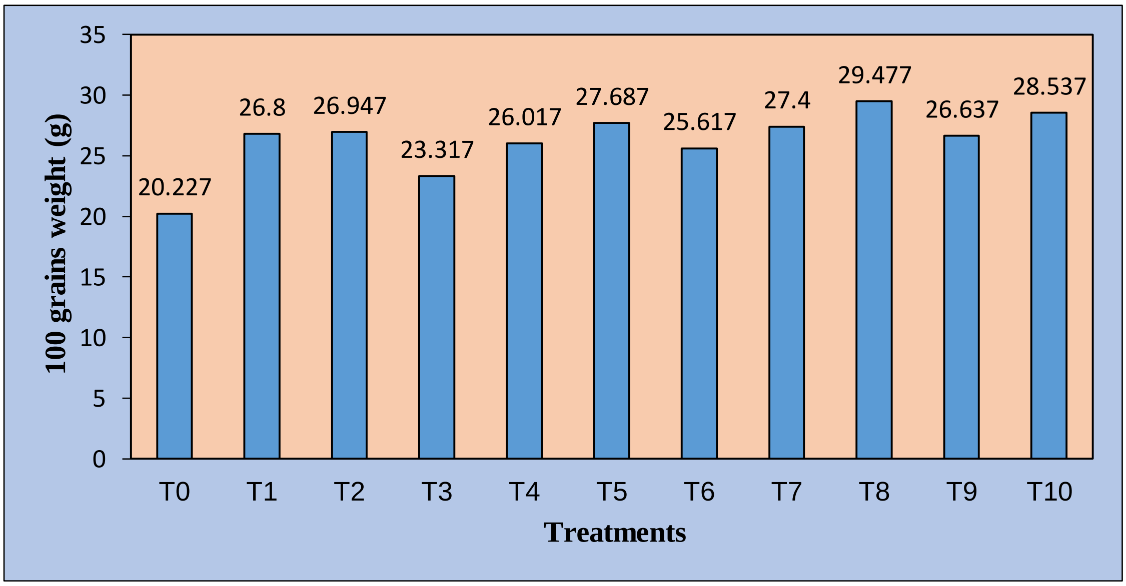


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 7. Effect of organic manure and inorganic fertilizer on number of grains cob^{-1} of maize (LSD $_{(0.05)}$ = 34.171).

4.2.8 100 grains weight

Significant variation was observed on 100 grains weight of maize due to the effect of organic manure and inorganic fertilizer (Figure 8). The figure indicated that the highest 100 grains weight (29.48 g) was observed from T_8 treatment which was statistically similar with T_{10} treatment followed by T_5 and T_7 treatment. On the other hand, the lowest 100 grains weight (20.23 g) was observed from T_0 treatment.



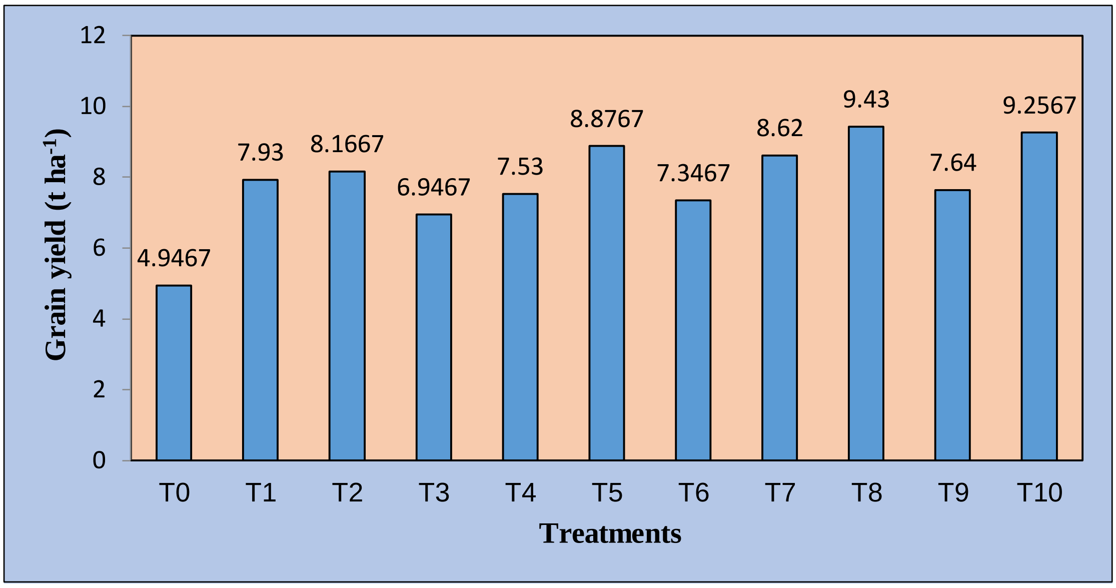
T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 8. Effect of organic manure and inorganic fertilizer on 100 grains weight of maize (LSD $_{(0.05)}$ = 2.2582).

4.3. Yield characters

4.3.1 Grain yield

Significant variation was observed on grain yield (t ha^{-1}) of maize due to the effect of organic manure and inorganic fertilizer (Figure 9). The result revealed that the highest grain yield (9.43 t ha^{-1}) was observed from T_8 treatment which was statistically similar with T_{10} treatment followed by T_5 and T_7 treatment. Whereas, the lowest grain yield (4.95 t ha^{-1}) was observed from T_0 treatment. It can be inferred from the data that treatment T_8, T_{10}, T_5 and T_7 showed 90.51%, 87.07%, 79.39% and 74.14% higher yield over control (T_0) treatment.

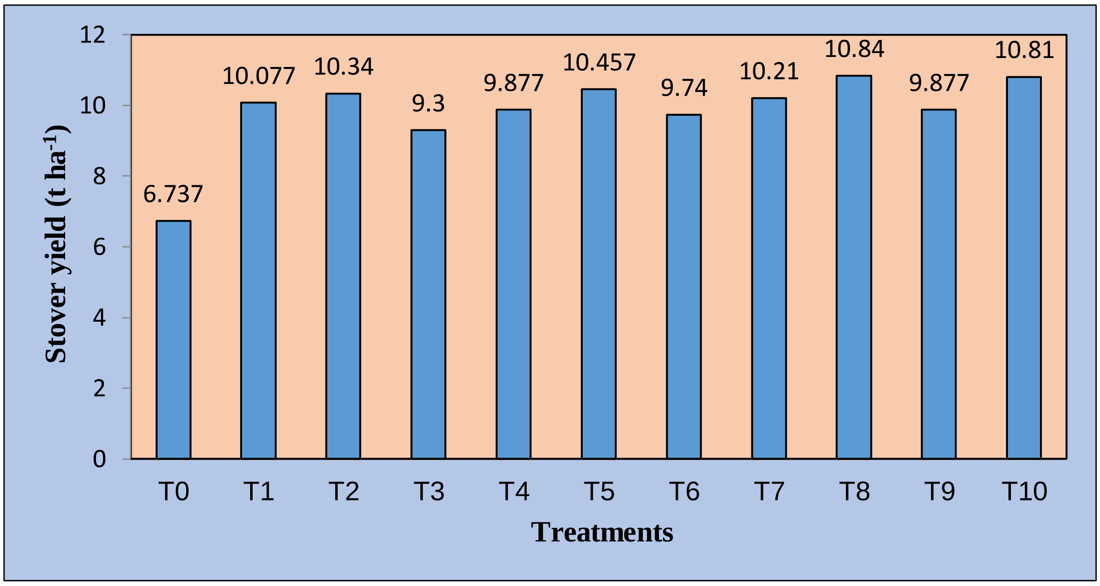


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 9. Effect of organic manure and inorganic fertilizer on grain yield of maize (LSD $_{(0.05)}$ = 1.1982).

4.3.2 Stover yield

There are significant variation observed on stover yield (t ha^{-1}) of maize due to the effect of organic manure and inorganic fertilizer (Figure 10). The figure indicates that the highest stover yield (10.84 t ha^{-1}) was observed from T_8 treatment which was statistically similar with all others treatment except T_0 and T_3 treatment. On the other hand, the lowest stover yield (6.74 t ha^{-1}) was observed from T_0 treatment.

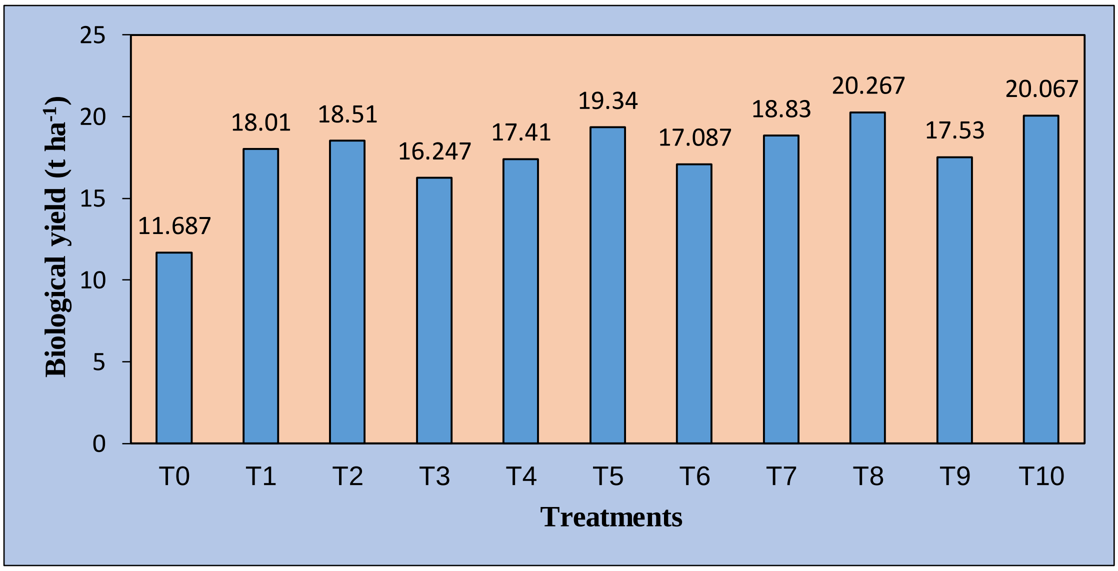


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 10. Effect of organic manure and inorganic fertilizer on stover yield of maize ($LSD_{(0.05)}$= 1.4812).

4.3.3 Biological yield

Organic manure and inorganic fertilizer showed significant effect on biological yield of maize (Figure 11). The experimental result revealed that the highest biological yield (20.27 t ha^{-1}) was observed from T_8 treatment which was statistically similar with T_{10}, T_5, T_7, T_2 and T_1 treatments and whereas, the lowest biological yield (11.69 t ha^{-1}) was observed from T_0 treatment.

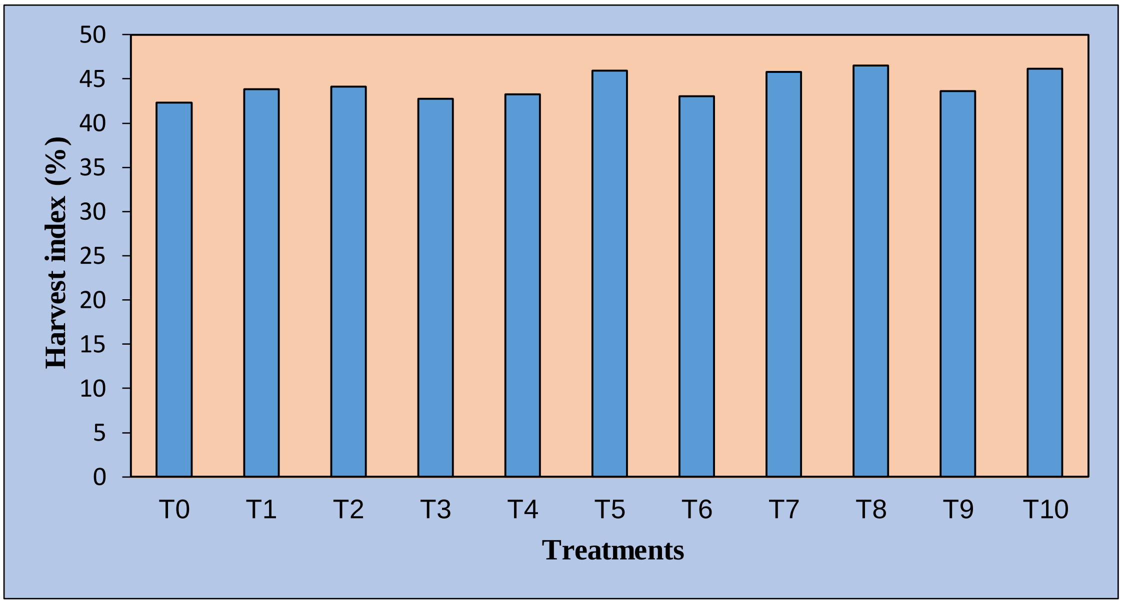


T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 11. Effect of organic manure and inorganic fertilizer on biological yield of maize (LSD $_{(0.05)}$ = 2.6792).

4.3.4 Harvest index (%)

Organic manure and inorganic fertilizer showed non significant effect on harvest index of maize (Figure 12). Numerically the highest harvest index (46.52 %) was observed from T_8 treatment. Whereas, the lowest harvest index (42.34 %) was observed from T_0 treatment



T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Figure 12. Effect of organic manure and inorganic fertilizer on harvest index (%) of maize (LSD $_{(0.05)}$ = NS)

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was carried out at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during March 2019 to August 2019 to investigate the effect of organic manure and inorganic fertilizers on growth and yield of maize. 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, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of single factor and followed a Randomized Complete Block Design (RCBD) with three replications. There were 11 treatments: T_0 = Control, T_1 = Recommended Dose of Fertilizers (RDCF), T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF and T_{10} = Poultry litter + 75% of RDCF. There were 11 treatments. The total numbers of unit plots were 33. The size of unit plot was 5.40 m^2 (3.0 m × 1.8 m). Urea: 550 kg ha^{-1}, TSP: 250 kg ha^{-1}, MoP: 200kg ha^{-1}, Gypsum: 175 kg ha^{-1}, Boric acid: 6 kg ha^{-1} and cowdung: 10 ton ha^{-1} was applied at final land preparation except urea fertilizer. In case of urea fertilizer, it is applied in 3 instalments. They are: 1/3 at final land preparation stage, 1/3 at vegetative stage and finally 1/3 at flower initiation stage respectively following krishi projukti hatboi (2019) recommendation. Data on different growth stage, yield contributing characters and yield were recorded to find out the suitable nutrient management for the highest yield of maize.

Different growth, yield and yield contributing characters were significantly influenced by different fertilizers management treatments. The experimental result revealed that the highest plant height (97.40, 236.60 , 261.10 and 268.43cm at 30, 60, 90 DAS and at harvest respectively), SPAD value (53.240 and 62.865 at 30, 60 DAS respectively), dry matter weight (15.730, 145.77, 288.53 and 296.60 at 30, 60, 90 DAS and at harvest respectively), cob to tassel length (137.98 cm), tassel length (20.490 cm), cob length (46.10 cm), cob diameter (4.3433 cm), number of grain rows cob^{-1} (15.203), number of grains row^{-1} (31.047), number of grains cob^{-1} (458.61), 100 grains weight (29.477 g), grain yield (9.430 t ha^{-1}), stover yield (10.84 t ha^{-1}), biological yield (20.267 t ha^{-1}) and finally harvest index (46.52 %) were observed from T_8 treatment. Whereas lowest plant height (68.2, 177.94, 195.80 and 202.90 cm at 30, 60, 90 DAS and at harvest respectively), SPAD value (31.62 and 32.400 at 30 and 60 DAS respectively), dry matter weight (7.950, 70.90, 164.61 and 173.49 (g) at 30, 60, 90 DAS and at harvest respectively), cob to tassel length (120.10 cm), tassel length (16.020 cm), cob length (32.77 cm), cob diameter (3.11 cm), number of grain rows cob^{-1} (12.2), number of grains row^{-1} (22.647), number of grains cob^{-1} (169.78), 100 grains weight (20.227 g), grain yield (4.9467 t ha^{-1}), stover yield (6.737 t ha^{-1}), biological yield (11.687 t ha^{-1}) and harvest index (42.337 %) were observed from T_0 treatment.

From the result of the experiment it may be observed that the treatment T_8 (Poultry litter + RDCF), T_{10} (Poultry litter + 75% of RDCF), T_5 (Vermicompost + RDCF) and T_7 (Vermicompost + 75% of RDCF) performed best in respect of grain yield production along with some yield contributing parameters. So, farmer may be used T_{10} or T_7 treatments for achieving higher yield of maize in AEZ-28.

However, to reach a specific conclusion and recommendation, more research work taking more combination of organic manure and inorganic fertilizer in different Agro-ecological zones of Bangladesh.

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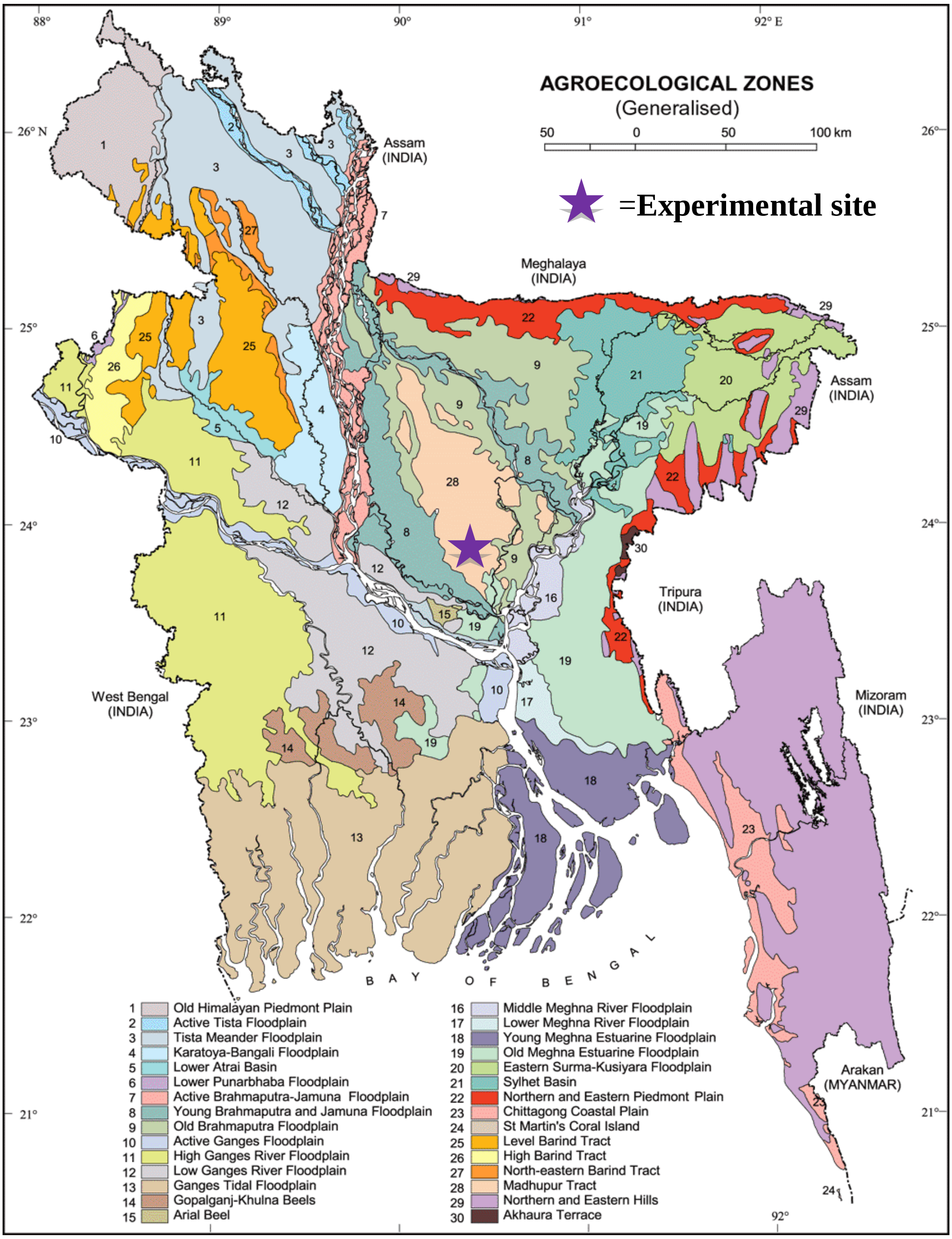
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

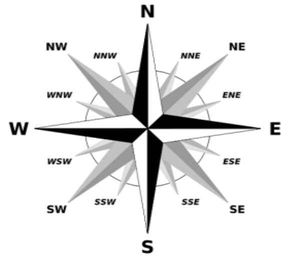
Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

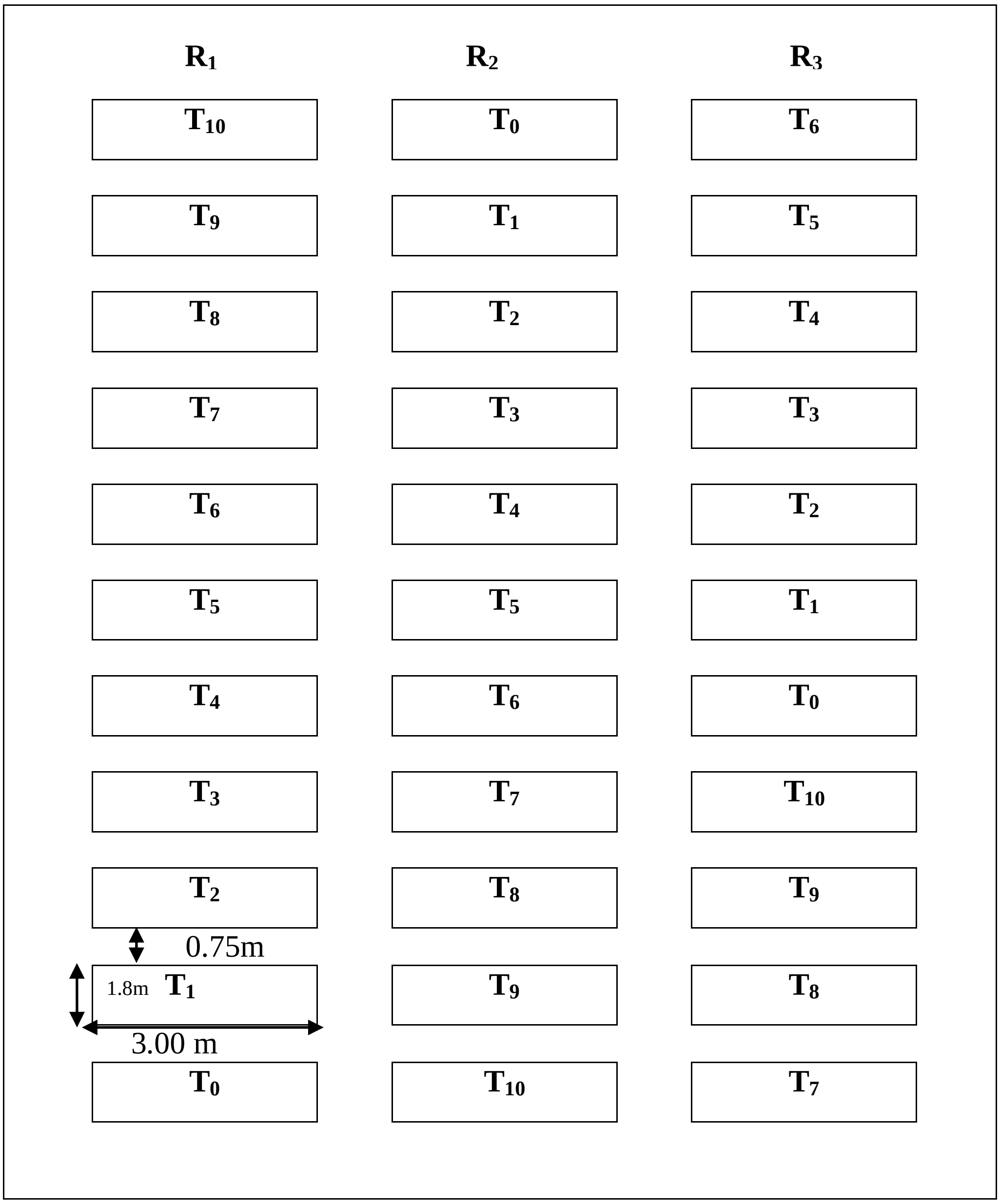
B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Source: SRTI, Farmgate, Dhaka, Bangladesh

Appendix III. Layout of the experimental field





LEGEND

R= Replication, T_0 = Control, T_1 = RDCF , T_2 = Cowdung + RDCF, T_3 = Cowdung + 50% of RDCF, T_4 = Cowdung + 75% of RDCF, T_5 = Vermicompost + RDCF, T_6 = Vermicompost + 50% of RDCF, T_7 = Vermicompost + 75% of RDCF, T_8 = Poultry litter + RDCF, T_9 = Poultry litter + 50% of RDCF, T_{10} = Poultry litter + 75% of RDCF

Appendix IV: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March, 2019 to August, 2019

Year	Month	Air Temperature (°C)			Relative Humidity (%)	Total Rainfall (mm)	Sunshine (Hour)
		Max	Min	Mean			
2019	March	34	24	30	44	57.6	301.5
	April	37	28	33	54	225.1	294
	May	39	29	35	61	259.3	294.5
	June	36	29	33	67	273.6	226.5
	July	34	28	31	74	380.6	194
	August	34	27	31	73	254.8	203.5

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka.

Appendix V: Analysis of variance of the data on plant height of maize as influenced by organic manure and inorganic fertilizer

Source	Df	Mean square of plant height at			
		30DAS	60DAS	90DAS	Harvest
Replication (R)	2	615.661	3875.09	4882.92	5055.84
Treatment (T)	10	264.619**	1044.88**	1131.46**	1173.04**
Error	20	16.429	101.11	126.73	131.01
Total	32				

** Significant at 1% level of probability
*Significant at 5% level of probability
NS: Non significant

Appendix VI: Analysis of variance of the data on dry matter weight of maize as influenced by organic manure and inorganic fertilizer

Source	Df	Mean square of dry matter weight at			
		30DAS	60DAS	90DAS	Harvest
Replication (R)	2	8.5254	705.86	3256.73	3548.53
Treatment (T)	10	18.7680**	1874.64**	4326.17**	4874.97**
Error	20	0.9155	75.21	345.36	366.68
Total	32				

** Significant at 1% level of probability
*Significant at 5% level of probability
NS: Non significant

Appendix VII: Analysis of variance of the data on SPAD value weight of maize as influenced by organic manure and inorganic fertilizer

Source	Df	Mean square of SPAD value at	
		30DAS	60DAS
Replication (R)	2	114.306	137.985
Treatment (T)	10	124.515**	291.972**
Error	20	11.054	13.617
Total	32		

** Significant at 1% level of probability
*Significant at 5% level of probability
NS: Non significant

Appendix VIII. Analysis of variance of the data on yield contributing characters of maize as influenced by organic manure and inorganic fertilizer

Source	Df	Mean square of			
		Cob to tassel length (cm)	Length of tassel	Cob length	Cob diameter (cm)
Replication (R)	2	1406.33	26.3772	3.8480	0.11683
Treatment (T)	10	86.18^{NS}	4.8362**	57.4656**	0.36581*
Error	20	41.97	0.8754	16.3712	0.15197
Total	32				

** Significant at 1% level of probability
*Significant at 5% level of probability
NS: Non significant

Appendix IX: Analysis of variance of the data on yield contributing characters of maize as influenced by organic manure and inorganic fertilizer

		Mean square of			
		(No). Row cob^{-1}	(No). Grains row^{-1}	(No). Grains Cob^{-1}	100 grains weight (g)
Source	**Df**				
Replication (R)	2	62.3700	16.7170	12436.2	58.8250
Treatment (T)	10	17.4006**	2.1651**	18546.8**	19.5908**
Error	20	1.8642	0.4975	402.5	1.7579
Total	32				

** Significant at 1% level of probability
*Significant at 5% level of probability
NS: Non significant

Appendix X: Analysis of variance of the data on yield characters of maize as influenced by organic manure and inorganic fertilizer

		Mean square of			
		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Source	**Df**				
Replication (R)	2	2.03261	3.17532	10.2930	65.6905
Treatment (T)	10	4.75903**	3.80970**	16.6985**	6.8203^{NS}
Error	20	0.49493	0.75627	2.4744	15.0321
Total	32				

** Significant at 1% level of probability
*Significant at 5% level of probability
NS: Non significant

Plates

Plate 1. Field view of the experimental plant immediately after germination

Plate 2. Field view of maize plot at vegetative stage.

Plate 3. Researcher working on the field at vegetative stage

Plate 4. Spraying insecticide in the field

Plate 5 a. Field view with signboard at matured stage

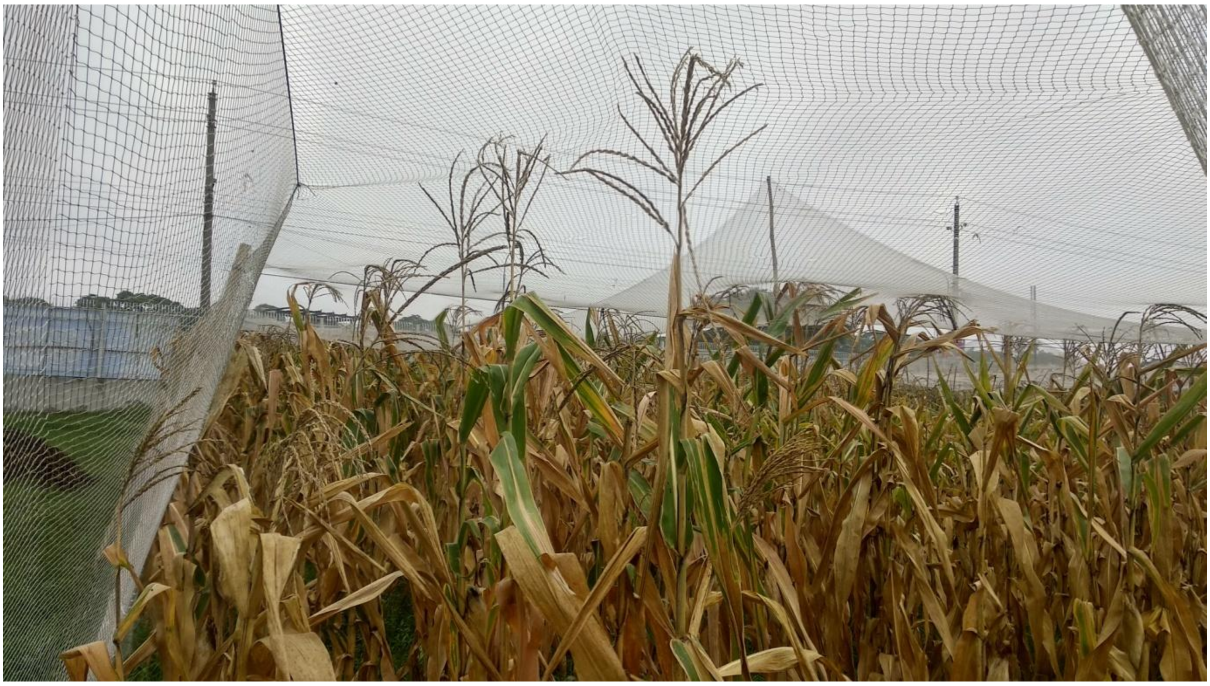


Plate 5 b. Field view of the plot at matured stage

Plate 6 a. Comparative view of maize cob in different treatment

Plate 6 b. Researcher working on post harvest data