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

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CERTIFICATE

This is to certify that the thesis entitled, "**INFLUENCE OF ORGANIC AND INORGANIC FERTILIZER MANAGEMENT ON GROWTH AND YIELD OF MAIZE**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **RUBAYA BINTE REZAUL,** Registration no. **20-11081** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Date:

Place: Dhaka, Bangladesh

Dr. Md. Abdullahil Baque
Professor
Supervisor

Dedicated to

My

Beloved Parents

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The Author

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Abstract

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm SAU, Dhaka during the period from December 2020 to April 2021 in Rabi season to study influence of organic and inorganic nutrient management on growth and yield of maize. The experiment consisted of two factors followed by split plot design with three replications. Factor A: Variety viz (2); V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype). Factor B: Fertilizer application rate viz (6); T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF and T_6= 100% Biochar + 100% RDF. Data was taken during growth and harvest. The experimental results revealed that different varieties, fertilizer dose and their combination significantly influenced the growth, yield contributing characteristics and yield of hybrid maize. In case of different hybrid variety, the V_2 [Pioneer 3355 (Maize genotype)] recorded the highest grain yield (12.035 t ha^{-1}), stover yield (14.248 t ha^{-1}), biological yield (25.986 t ha^{-1}) and harvest index (45.143%) comparable to the other variety. In case of different fertilizer doses the highest grain yield (12.542 t ha^{-1}), stover yield (14.982 t ha^{-1}), biological yield (27.532 t ha^{-1}) and harvest index (45.573%) were observed in T_6 (100% RDF + 100% Biochar) treatment comparable to other treatments. In case of combined effect, the V_2T_6 treatment combination had the highest grain yield (12.827 t ha^{-1}) followed by V_1T_6 (11.957 t ha^{-1}) treatment combination. Hence, it was concluded that growing hybrid maize with the use of 100% Biochar and 100% of the recommended fertilizer dose will improve the yields of both Pioneer 3355 (Maize genotype) and SAU-984 (Advance line) but Pioneer 3355 (Maize genotype) will provide more production than SAU-984 (Advance line).

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ABBREVIATIONS

Full word	Abbreviations
Agriculture	Agric.
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Biology	Biol.
Biotechnology	Biotechnol.
Botany	Bot.
Cultivar	Cv.
Dry weight	DW
Editors	Eds.
Emulsifiable concentrate	EC
Entomology	Entomol.
Environments	Environ.
Food and Agriculture Organization	FAO
Fresh weight	FW
International	Intl.
Journal	J.
Least Significant Difference	LSD
Liter	L
Triple super phosphate	TSP
Science	Sci.
Soil Resource Development Institute	SRDI
Technology	Technol.
Serial	Sl.

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L., also commonly known as corn**)** was domesticated more than 9,000 years ago in southern Mexico/Meso America (Kennett *et al*., 2020), following the earlier domestication some 10,000 years ago of wheat in the Fertile Crescent of the Near East and rice in the Yangtze Valley, China (Awika, 2011). Despite maize's somewhat later domestication and relative isolation till the European settlement in the Americas, maize has quickly disseminated across the globe since then and has become the leading global staple cereal in terms of annual production exceeding 1 billion metric tons (Lara & Saldivar, 2019). Among the cereal crops, maize is one of the most important crops in the world and used as food for human beings and feed for animals and poultry. The yielding ability of maize is on higher side than other cereals and therefore named as "Queen of Cereals". Maize is cultivated in different countries with total area of 197 million hectares, production of 1.2 billion tonnes (FAOSTAT, 2021). After rice and wheat, maize is the most significant cereal crop in Bangladesh. Together, the three big global staple cereals – wheat, rice, maize – comprise a major component of the human diet, accounting for an estimated 42 percent of the world's food calories and 37 percent of protein intake (FAOSTAT, 2021; Erenstein *et al*., 2022). Among them maize may have nutritional benefits like; 100 grams of mature maize seeds include 7.3 grams of dietary fiber, 0.64 grams of sugar, 9.42 grams of protein, and 365 kcal of energy (Wikifarmer, 2022). Maize promotes bone and renal health, controls heart rhythm, prevents constipation, and lowers stomach acidity. Maize also lowers LDL cholesterol and protects against cardiovascular problems, diabetes, and hypertension. Thus, maize provides a variety of health advantages that aid in reducing malnutrition among the people of the nation.

Huge sum of money are spent on importing maize seeds and products in order to meet the demand. In Bangladesh, maize will increasingly be consumed as food for humans, animal feed, and poultry feed across all market sectors.

Additionally, maize has a promising future in Bangladesh because the country's average annual weather is favorable for maize cultivation. Here in Bangladesh, it often grows year-round and exhibits potential productivity. In Bangladesh, corn yields have recently grown astronomically. In terms of yield, maize has surpassed wheat (2.60 t ha^{-1}) and boro rice (3.90 t ha^{-1}) to take the top spot among the cereals. There are two kinds of maize in respect of grain color: yellow and white. Worldwide, the yellow maize is mainly used as fodder while the white ones are consumed as human food. The currently grown maize in this country is yellow type, which is mainly adapted importing genetic materials from CIMMYT. Again, although there are some indigenous local maize in the south east hills those have also not improved for having higher yields (Ullah *et al*., 2016). Maize currently grown in Bangladesh is of yellow type and is used in the feed industry.

One of the main obstacles to maize's low productivity is the insufficient and imbalanced usage of key nutrients. Due to its higher productivity, it is widely known that maize is a heavy feeder for both nutrients and soil moisture.

Due to its extensive growth, maize has a significant demand for fertilizers, particularly those containing nitrogen. Nitrogen is a crucial component of enzymes, protoplasm, and chlorophyll (Kaur *et al*., 2020). Additionally, it controls how potassium and phosphorus are used. It is a crucial element for improved vegetative development and increasing wheat production. Knowing the ideal nitrogen application dosage is crucial in order to maximize advantages without sacrificing a greater crop yield. Reduced yield potentials may arise from inadequate N availability during the first three to six weeks following planting. Its demand and utilization are steadily rising day by day (Kaur *et al*., 2020). High crop yields are produced when phosphorus is applied as fertilizer in a balanced ratio with other crucial nutrients like nitrogen and potassium. This also ensures that farmers will make more money. Potassium (K), the most prevalent cation in plants and a vital element for plant growth and development, accounts for up to 3-5% of a plant's total dry weight.

Organic fertilizers are readily available mineral sources that have a modest concentration of vital minerals for plants. Among the organic sources one is Biochar. The process of heating biomass (wood, manure, crop residues, solid waste, etc.) with little to no oxygen in a furnace that has been particularly built to capture all emissions, gases, and oils for later use as energy results in biochar, which is fine-grained charcoal. More than 2,500 years of agricultural use have led to the widespread adoption of biochar as a safe, long-lasting soil additive in modern agriculture and horticulture. The ability of biochar to draw in and hold water, nutrients, phosphorus, and agrochemicals is superior then that of any other organic soil material. The plants are healthier, and less fertilizer leaches into the groundwater and washes off into surface waters. Since biochar is largely inert, it stays in the soil much longer than any other organic soil additive. In contrast to typical fertilizers and soil conditioners, biochar lasts 100 to 1000 years, so its advantages of nutrient and water retention and total soil porosity continue to work.

Utilizing biochar, a porous, carbon-rich product made from agricultural biomass through pyrolysis, may help sustainably reduce nutrient losses. Plant biomasses are subjected to a 350°–500°C range of thermochemical conversion in the absence of oxygen.

By acting as an amendment, the soil enhances the physical, chemical, and biological characteristics of the soil and addresses numerous soil-related problems (Singh *et al.*, 2012). Unlike other types of organic matter, biochar is stable in soils and has longer-lasting positive benefits. Biochar is distinct from other organic materials like on-farm common leaf litter, compost, or manures in that it maintains the majority of the applied nutrients and makes them available to growing plants (Schulz *et al.*, 2013). After harvest, extra agricultural wastes that gathered in the field might be used to prepare biochar.

The many forms of biochar in combination with organic inorganic fertilizers considerably increase nutrient availability (Lehmann *et al*., 2006; Silber *et al*., 2010), crop yield (Graber *et al*., 2010). The liming impact of biochar on acid soils increases soil microbial diversity and function while also boosting cation exchange capacity and crop water availability (Anderson *et al*. 2011).

Sandy soils, which have less surface area than other soil types, benefit from the addition of biochar because it increases their ability to hold water.

The surface area of biochar causes a higher amount of soil moisture to be retained and made available for crop absorption (Fang *et al*., 2014).

Objectives

i. To find out the better performing variety of hybrid maize
ii. To find out the suitable fertilizer dose for hybrid maize production
iii. To explore the interaction effect of variety and nutrient management of hybrid maize

CHAPTER II

REVIEW OF LITERATURE

In this section, an attempt was made to collect and study relevant information available about studying influence of organic and inorganic nutrient management on growth and yield of maize in order to gather knowledge useful in carrying out the current piece of work.

2.1 Effect of biochar on nutrients retention and availability

In 2009 DeLuca *et al*. found that Biochar produced at temperatures higher than 300°C resulted in a large increase in accessible P content and no change in the total P content of soil. Increasing phosphorous availability arose from the oxidation of Al and Fe in soils with biochar and their combination, which liberated the fixed P in the soil.

According to Jha *et al*. (2010) the use of biochar significantly reduced the leaching of N, Ca, and Mg. When biochar was applied to soils that were both chromium-polluted and unpolluted, the amount of total and organic C and N in the soil rose. Biochar made from 10 t ha^{-1} of maize stalks resulted in higher levels of organic carbon and total nitrogen in the soils. This resulted from the higher levels of carbon and nitrogen present in the maize stalk (Nigussie *et al*., 2012).

In 2013 Masto *et al*. said that biochar offers significant advantages such as enhancing soil fertility, structure, water-holding capacity, organic carbon content, and biological activity, all of which contribute to greater crop yield. Given that it performs tasks that FYM and other composts do, it also functions as a better substitute for other organic manures.

Srinivasarao *et al*. (2014) investigated that the long-term effects of biochar on soil quality and crop performance using a single application of several biochars made from maize, castor, and sugarcane. In rainfed alfisols, cotton and pigeon pea stalk were added at varying rates to maize (DHM 117), and it was discovered that the addition of RDF and FYM to residual maize stalk biochar at a rate of 4 t ha^{-1} increased the amount of soil available nitrogen (175.6 kg ha^{-1}), phosphorus (22.5 kg ha^{-1}), potassium (328.0 kg ha^{-1}), and organic carbon in the soil (15.1 g kg^{-1}).

According to Laghari *et al*. (2016), biochar absorbs moisture and holds onto nutrients in the soil, reducing the need for inorganic fertilizer and protecting crops from the effects of drought. The biomass used and the preparation temperature have an impact on the properties of the biochar material formed by the pyrolysis process.

According to Pandian *et al*. (2016) the soil accessible nitrogen content in biochar-incorporated soil ranged from 158 to 178 kg ha^{-1}. Biochar from redgram stalks and corn 5 t ha of biochar per stalk. In comparison to the control, the applied soil had 25% more soil-available nitrogen and phosphorus. The soil that had been treated with cotton and redgram stalk biochar at a rate of 5 t ha^{-1} had the greatest levels of K that could be found.

2.2 Effect of Organic (biochar) on nutrient use efficiency

In 2008 Gaskin *et al*. found that, biochar can minimize the amount of fertilizer needed when combined with fertilizers because it prevents applied nutrients from seeping into the ground. Implementation of Biochar @ 5 t ha^{-1} reduced the need for fertilizer by 7%. Application of biochar had an effect on severely deteriorated acidic or nutrient-poor soils.

Biochar offers significant advantages such as enhancing soil fertility, structure, water-holding capacity, organic carbon content, and biological activity, all of which contribute to greater crop yield. Given that it performs tasks that FYM and other composts do, it also functions as a better substitute for other organic manures (Masto *et al*., 2013)

Sohi *et al*. discovered in 2010 that biochar has an impact on crop output by directly altering the chemistry of the soil, by offering chemically active areas, composition. Better root development, nutrient and water retention, and acquisition are the results of changing the dynamics of soil nutrients through soil responses or by altering the physical characteristics of the soil.

Peng *et al*. (2012) suggested that, applying biochar in addition to fertilizers promotes better crop establishment and growth than applying chemical fertilizers alone. When the chemical fertilizers are applied alone the chemical nutrients are not that absorbable by the crop roots. Biochar makes great efforts to make those nutrients available for the crop roots. And the plants absorb those nutrients and grow well.

Widowati *et al*. (2014) found that, adding biochar reduced the need for N fertilizer and enhanced soil organic carbon. Excess nitrogen is not good for plants so it's necessary to reduce the amount of excess nitrogen from the soil. It can cause acidity otherwise.

When biochar was added to fertilizer, Alburquerque *et al*. (2014) reported improved fertilizer usage efficiency. Effective uptake of plant nutrients takes place when biochar is applied to the soil. Plants become healthy by uptaking the nurients.

Deb *et al*. (2016) obtained the results that biochar increased nutrient availability by retaining more nutrients in the soil. Leaching losses were negligible due to the sorption of nitrates and phosphates.

2.3 Effect of Organic (Biochar) and inorganic fertilizer on plant growth characteristics

2.3.1 Germination

According to Van Zwieten *et al*. (2010), applying biochar made from paper mill waste at a rate of 10 t ha^{-1} improved wheat germination. Wheat seeds can take proper moisture from soil to germinate in presence of paper mill waste made biochar. It takes less time to germinate and makes healthy seedlings also.

Application of maize stover biochar resulted in significantly better germination rates and seedling emergence in rice and maize crops, according to Kamara *et al*. (2015). Biochar makes the nutrients in the soil more available for rice roots to be uptaken. So when biochar is applied during the land preparation it started its working with the soil. And more nutrients became available as a result the rice and maize seeds had uptaken more and fast germination happend.

Prosopis biochar's impact on germination was examined by Rajalakshmi *et al*. (2015) using green gram, rice, and cotton with doses ranging from 10 to 30 t ha^{-1}. The seedlings in the petridish had increased root length and germination, according to the data.

Agegnehu *et al*. (2016) hypothesized that the beneficial effects of biochar on maize germination were caused by changes in the soil's physical properties and thermal dynamics. Which was the result of biochar's black color, potential water availability, and hormonal impacts.

According to Ramzani *et al*. (2017), adding biochar to low fertility soils at a rate of 5 to 10 t ha^{-1} enhanced wheat germination rates, shoot length, shoot dry weight, and shoot fresh weight. Garden pea treated with lantana biochar had a maximum germination percentage of 96.02 percent and a germination index of 24.03 percent (Berihun *et al*., 2017).

2.3.2 Plant growth parameters

Kamara *et al*., (2015) claimed that rice straw biochar had a substantial impact on the growth of the rice plants, and increased plant height was seen in biochar-treated plots compared to controls. Biochar makes the nutrients in the soil more available for rice roots to be uptaken. So when biochar is applied during the land preparation it started its working with the soil. And more nutrients became available as a result the rice plants had uptaken more and grew more.

According to Satyabhan *et al*., (2018), the combination application of 100% RDF + PSB resulted in noticeably higher yields of cob and green fodder than other treatments. Green cob yield was highest with the administration of treatment 100% RDF + PSB, whereas higher plant growth (plant height and stem girth) and green fodder production were seen with the application of 150% RDF + PSB (Phosphate Solubilizing Bacteria). Higher net yields were obtained for treatment 100% RDF + PSB than for the other treatments (97466.66 ha^{-1}) and B: C. (2.77).

Higher plant height was documented by Pandian *et al*., (2016) in Redgram stem biochar was applied to a peanut crop at a rate of 5 t ha^{-1}. and the control plot showed shorter plants. In soil treated with biochar, the height of beans, fenugreek, and mint was measured to be 36 cm, 12 cm, and 20 cm, respectively. These values are correspondingly 55%, 62%, and 35% higher than those of the control plot (Kalyani, 2016).

A field experiment was carried out by Spandana (2012) at the Agricultural Research Institute in Hyderabad in the kharif season of 2009 to examine how the maize hybrid responded to different plant densities and nitrogen levels. The findings showed that an increase in nitrogen treatment from 120 to 240 kg ha^{-1} caused growth features such plant height, leaf area index (LAI), and dry matter accumulation to rise.

Wisnubroto *et al*., (2017) reported that, 45 days after rice was planted, plant height in non-biochar plots was only 29.3 cm, while plant height of 40.3 cm was found in plots where biochar had been applied.

Singh *et al*., (2012) carried out a field experiment to investigate the effects of crop geometry at Wadura, Jammu and Kashmir, during the wet seasons of 2007 and 2008, and nitrogen levels (0, 30, 60, 90, 120, and 150 Kg N ha^{-1}) on the growth of maize. In comparison to applications of 0, 30, 60, 90, and 150 kg N ha^{-1}, they found that an application of 120 kg N ha^{-1} considerably resulted in the maximum plant height, leaf area, and number of leaves per plant.

2.3.3 Chlorophyll in leaves

Agegnehu *et al*., (2015) observed a significant increase in leaf chlorophyll content when biochar was sprayed along using fertilizer and compost in corn. When organic amendments were applied and nutrients and water were made available over time, the amount of chlorophyll in the leaves increased with the age of the plant.

2.3.4 Dry matter production

According to Yeboah *et al*., (2009) application of 3 t ha^{-1} biochar coupled with 120 kg N ha^{-1}, resulted in greater shoot dry weight in maize as a result of increased biochar nutrient retention. For the sandy loam soil, the shoot dry weight varied between 41 and 45 g pot-l, while for the silt loam soil, it varied between 28 and 35 g pot-l.

Revell *et al*. (2012) observed that, adding cow manure biochar at 15 and 20 t ha^{-1} enhanced maize dry matter yield by 150 and 98 percent, respectively, as compared to untreated plots.

Agegnehu *et al.* (2017) conducted research and found that, adding organic amendments and biochar boosted the amount of chlorophyll in the leaves. Resulting in the encouragement of healthy plant production.

According to Pandian *et al*. (2016) biochar subsequently increased crop biomass and grain output. Treatment of maize and redgram stalk biochar at a rate of 5 t ha^{-1} produced groundnuts with longer roots measuring 12.5 cm and 351 g, respectively, which were 36% and 45% higher than the control. Additionally, the redgram stalk biochar @ 5 t ha1 treated plots had the highest dry matter accumulation (2202 kg ha^{-1}) and pod yield (1661 kg ha^{-1}), which increased by 24 and 29% over control, respectively.

In 2017 Berihun *et al*. found that, adding Lantana biochar to an area of land enhanced its fresh shoot and root biomass by a significant amount, which improved dry matter output.

Wisnubroto *et al*. (2017) observed that, using nitrogen-enriched biochar dramatically enhanced rice dry biomass from 43.2 g pot^{-1} to 69.4 g pot^{-1}. As biochar is a carbon rich element it helps in reserving more mass in the plants and gain more weight. So biochar can be a good amendment to the plants in field as well as pots.

2.4 Effect of Organic (biochar) and inorganic fertilizer on crop yield parameters and yield

According to Purakayastha *et al*. (2015), applying wheat straw biochar at 1.9 t ha^{-1} together with the advised dose of 180:80:80 NPK fertilizers ha^{-1} considerably boosted the production of maize and was superior to control.

According to the report of CRIDA (2012) the highest pigeonpea grain yield of 1685 kg ha^{-1} was recorded with alternate year application of cotton stalk biochar @ 3 t ha^{-1} along with fertilizers. Castor stalk biochar application @ 6.0 t ha^{-1} either every year or alternate year with recommended dose of fertilizers gave marginally higher yield than other treatments

Suppadit *et al*. (2012) studied the effect of biochar on soybean yield attributes and yield in pot experiment using sandy soil and observed significant yield increase with 98.4 g biochar application per pot.

Liu *et al*. (2013) reviewed biochar effect on productivity of different crops (from 59 pot experiments and 57 field experiments from 21 countries) and stated that the increase in crop productivity was on an average of 11 per cent. Under field conditions, application of biochar at less than 30t ha^{-1} was advantageous and increase in crop productivity varied with crops i.e., 30 per cent in legumes, 29 per cent in vegetables, 14 per cent in grasses, 8 per cent in corn, 11 per cent in wheat and 7 per cent in rice.

Srinivasarao *et al*. (2013) found that the maize grain yield in biochar treated plots was significantly higher than control plots. Further, higher nitrogen use efficiency of 91.0 kg $grain^{-1}$ kg N was recorded with application of biochar @ 6.0 t ha^{-1} + RDF followed by biochar @ 3.0 t ha^{-1} + RDF with N use efficiency of 52 kg grain kg^{-1} N.

Van Vinh *et al*. (2015) inferred that in comparison with NPK applied plots, rice yields were increased by 5.9-22.3 per cent in biochar treated plots and by 26.3- 34.2 per cent in compost mixed with 5 per cent biochar. In case of vegetables, biochar application increased the yield by 4.7-25.5 per cent compared to normal cultivation practices.

Coumaravel *et al*. (2015) concluded that under Integrated Plant Nutrition System (IPNS), application of biochar @ 10 t ha^{-1} along with RDF of 250:75:75 kg ha^{-1} + FYM @ 12.5 t ha^{-1} and *Azospirillum* @ 2 kg ha^{-1} had recorded significantly higher yield and NPK uptake with sustained soil fertility.

Gebremedhin *et al*. (2015) opined that grain and straw yields of wheat were significantly increased by 15.7 per cent and 16.5 per cent, respectively in plots applied with biochar and fertilizers of 100 kg urea +100 kg DAP + 4 ton biochar ha^{-1} over the control plot which received only inorganic fertilizers.

Gokila and Baskar (2015) stated that application of biochar @ 5 t ha^{-1} with RDF and bio-fertilizer recorded the highest 100 grain weight (38.9 g), cob length (23.5 cm) and cob weight (310 g) over other treatments and control in maize crop. The higher grain and stover yield of 8100 and 12150 kg ha^{-1}, respectively were also recorded in the same treatment.

Deb *et al*. (2016) indicated that biochar applied along with Phosphorus Solublizing Mycorrhizae (PSM) recorded significant mean crop yield for jute, rice, radish, and tomato in India and for radish in Thailand. Further, biochar alone applied plot shown less beneficial effect on crop productivity.

Wisnubroto *et al*. (2017) claimed that rice planted in nitrogen enriched biochar soil yielded a higher grain yield of 49.3 g pot^{-1} compared to that of planted on non-biochar treated soil of 27.2 g pot^{-1}.

2.5 Impact of Organic (biochar) and inorganic fertilizer on growth, yield and quality of maize

Major *et al*. (2010) indicated that biochar application had no significant effect on maize yield in the first year but increased maize yields during the next 3 years by 28–140 per cent.

Zhu *et al*. (2017) reported that biochar + NPK amendment of a red soil increased maize total biomass up to 2.7–3.5 and 1.5–1.6 times compared to that of NPK only and biochar only amendments, respectively.

Zhang *et al*. (2017) observed that, maize yield was increased to the tune of 11.9 per cent and 35.4 per cent in balanced fertilization system with wheat straw biochar @ 20 t ha^{-1} over control during two years of study period (2011 and 2012) in calcareous inceptisol soils of China.

Sarkhot *et al*. (2013) found that as Nutrient Enriched Biochar (NEB) having high surface area, it adsorbed the nutrients of NH_4^+, NO_3^-, K^+, Ca^{2+}, Zn^{2+} and reduced losses and this offered great mechanisms for developing slow-release fertilizer by using biochar which in turns improved nutrient use efficiency and increased the crop yield.

Eazhilkrishna *et al*. (2017) pointed out that application of 125% through NEB recorded higher grain yield of 5677 kg ha^{-1} and stover yield of 9504 kg ha^{-1} maize over the control. The nutrient uptake was also higher in same treatment compared to control.

CHAPTER III

METHODS AND MATERIALS

This part presents a concise depiction about the duration of the experimental period, site description, climatic state of the area, harvest or planting materials that are being utilized in the test, treatments, design, crop growing procedure, intercultural activities, data collection and statistical analyses.

3.1 Experimental period

The experiment was conducted during the period from December 2020 to April 2021 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The experiment was directed at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar Agargaon Dhaka, Bangladesh. The experimental site is topographically situated at 23°77′ N scope and 90°33′ E longitude at an elevation of 8.6 meter above ocean level (Anon., 2004).

3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988a). 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 (Anon., 1988b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I. (Banglapedia, 2014)

3.3 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Weather data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka.

3.4 Soil

The soil of the experimental pots belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6 (Anon., 1989). The land was above flood level and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-III (Biswas *et al*., 2019).

3.5 Planting materials

Two varieties called SAU-984 (Advance line) and Pioneer 3355 (Maize genotype)of hybrid maize have been used as planting material for the present study which were collected from Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.6 Description of the variety

Two varieties called SAU-984 (Advance line) (V_1) and Pioneer 3355 (Maize genotype)(V_2) of hybrid maize have been used as planting material for the present study. These variety was recommended for Rabi and Kharif season. The feature of this varieties is presented in next page:

3.7 Experimental details

Land preparation Date:	19 October 2020
Seed Sowing Date:	20 October 2020
Germination Date:	According to the treatment requirement
Fertilizer application	According to the treatment requirement all the fertilizers were applied at 19 October 2020 during final land preparation except total urea
Flowering date:	24 December 2020
Harvesting Date:	20 February 2021

3.8 Experimental Factors

There were two sets of factors in the experiment. The factors were varieties and fertilizer application rate. Those are shown below:

Factor A: Genotype viz (2).

V_1= SAU-984 (Advance line)

V_2= Pioneer 3355

Factor B: Fertilizer application rate viz (6).

T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid)

T_2= 100% Biochar

T_3= 100% Biochar + 50% RDF

T_4= 100% Biochar + 75% RDF

T_5= 50% Biochar + 50% RDF

T_6= 100% Biochar + 100% RDF

3.9 Experimental design

The experiment was laid out in the Split plot design with three replications. The field was divided into 3 blocks to represent 3 replications (R_1, R_2, R_3) of each variety (V_1 and V_2). Total 36-unit plots were made for the experiment with 6 treatments. The size of each unit plot was 4.5 m^2 (3 m × 1.50 m). Distance maintained between replication and plots were 0.60 m and 0.30 m. Layout of the experimental field was presented in Appendix IV.

3.10 Detail of experimental preparation

3.10.1 Preparation of experimental land

The land was opened with the help of a tractor drawn disc harrow on (13 December 2020) and then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on (13 December 2020) according to experimental specification. Individual plots were cleaned and finally the 36 plots were prepared.

3.10.2 Fertilizer application

Cow dung 7 t ha^{-1} was used on the total land before final land preparation. Among the 36 plots 30 plots were prepared with biochar application. A total of Biochar 4 t ha^{-1} Biochar was applied and among the 30 plots 24 were provided with 100% and 6 was provided with 50% of biochar. The 100% RDF for this experiment was at the rate of 74-110-100-75-3-5-6 kg ha^{-1} of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate, boric acid and magnesium sulphate for the availability nitrogen, phosphate, potash, sulphur, zinc, boron and magnesium of respectively. In the 36 plots, 6 were provided with only 100% RDF, 6 with 50% RDF combining with 100% biochar, 6 with 75% RDF combining with 100%, 6 with 50% RDF combining with 50% biochar, 6 with 100% RDF combining with 100%

biochar and the remaining 6 had no RDF% only 100% Biochar was applied on them. The whole amounts of fertilizers were applied as basal doses except Urea. Only one third Urea was applied as basal doses and the rest amount was applied in three installments.

3.10.3 Seed sowing and germination

The maize seeds were sown in lines having 2 seeds hole^{-1} under direct sowing in the well-prepared plot on 14 December 2020 after 8 days that means on 22.12.20 germination was started.

3.10.4 Intercultural operations

After raising seedlings, various intercultural operations such as irrigation, weeding, gap filling and thinning, drainage, pest and disease control etc. were accomplished for better growth and development of the maize seedlings.

3.10.5 Gap filling and thinning

Gap filling was done at 12th day after sowing to maintain uniform plant population. Thinning was done two weeks after the sowing in order to maintain required plant density in each plot. By pulling out the excess seedlings in each spot, one seedling retained at each spot to maintain optimum plant population per plot.

3.10.6 Weed management

To check the weed growth, two inter cultivations were done during fourth and sixth week after sowing with the help of blade hoe and two hand weeding were carried out at 25 and 45 days after sowing.

3.10.7 Water management

Protective irrigation was provided to the crop depending upon the soil moisture content and prevailing weather conditions during the period of experiment. Five irrigations were given for the entire crop growth to avoid moisture stress.

3.10.8 Earthing up

Earthing up was done at 30 DAS along with secondhand weeding and top dressed with urea and Mop. It helped to give the better anchorage and favorable environment for root growth and development. It also helped to loosen the soil, to reduce the bulk density and to increase the water holding capacity of the soil.

3.10.9 Plant protection measure

Plant protection measures was adopted wherever they found necessary during the crop growth period. Chloropyriphos 55EC 5ml L^{-1} was sprayed against the control of stem borer.

3.10.10 Harvesting

The crop was harvested after attaining the physiological maturity at 90 days after sowing from all the plots. Harvesting was done on 24 April 2021. The cobs were picked up when ears were of full size, had tight husk and somewhat dried silks. At this stage, kernels were fully developed and exuded a milky liquid when punctured. The crop was harvested at milky stage by removing the cobs from the plot in the net plot area. The green fodder is obtained after harvest of the produce and the fresh cob yield, green fodder is worked out for t ha^{-1}.

3.10.11 Crop sampling

After 20, 40, 60, 80 days and at harvesting period 5 plants was cutting from the soil base which was selected for crop sampling for taking various parameters data of the plant.

3.11 Data collection

The data were recorded on the following parameters:

A. Crop growth characters:

i. Plant height (cm)

B. Yield and yield contributing characters

ii. Cob length plant^{-1} (cm)

iii. Cob height from ground (cm)

iv. Cob diameter plant^{-1} (cm)

v. Number of grains cob^{-1} (no.)

vi. Total seed weight with straw cob^{-1} (g)

vii. Total seed weight without straw cob^{-1}(g) or the grain weight cob^{-1} (g)

viii. Unfilled space of the cob (cm).

ix. Harvest Index

x. Yield (t ha^{-1})

3.12 Procedure of recording data

A brief outline on data recording procedure followed during the study is given below:

i. Plant height

The plant height was measured at 20, 40, 60, 80 days after sowing (DAS) and at maturity stage from the base to the base of the youngest fully opened top leaf until tassel emergence, afterwards plant height was measured from the base of the plant to the collar of flag leaf and expressed in centimeter (cm).

ii. Cob length plant^{-1}

At harvest, length of the cob of selected plants was taken from the base to tip of the cob with the help of meter scale. Thereafter mean cob length was worked out and represented in centimeter (cm).

iii. Cob height from ground (cm)

Five plants were randomly selected per plot and the height of the cob from ground was taken. Then average result was recorded in cm.

iv. Cob diameter plant^{-1}

Five cobs were randomly selected per plot and the diameter was taken from each cob. Then average result was recorded in cm.

v. Number of grains cob^{-1}

The numbers of grains per cob was measured from the base to tip of the ear collected from five randomly selected cobs of each plot and finally average result was recorded.

vi. Total seed weight with straw cob^{-1} (g)

Total seed weight with straw was taken by selecting five cobs per plot. The weight was measured by an electrical balance. It was recorded in gram.

vii. Total seed weight without straw cob^{-1}(g) or Grain weight cob^{-1}

After removing the grain from each cob the straw was taken out. And the seeds were taken to measure. Total seed weight per cob was then measured in grams by using an electrical balance.

viii. Unfilled space of the cob (cm)

Five cobs per plot were collected and the unfilled space on the cobs was calculated in centimeters.

ix. Harvest Index (%)

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

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

3.13 Statistical data 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

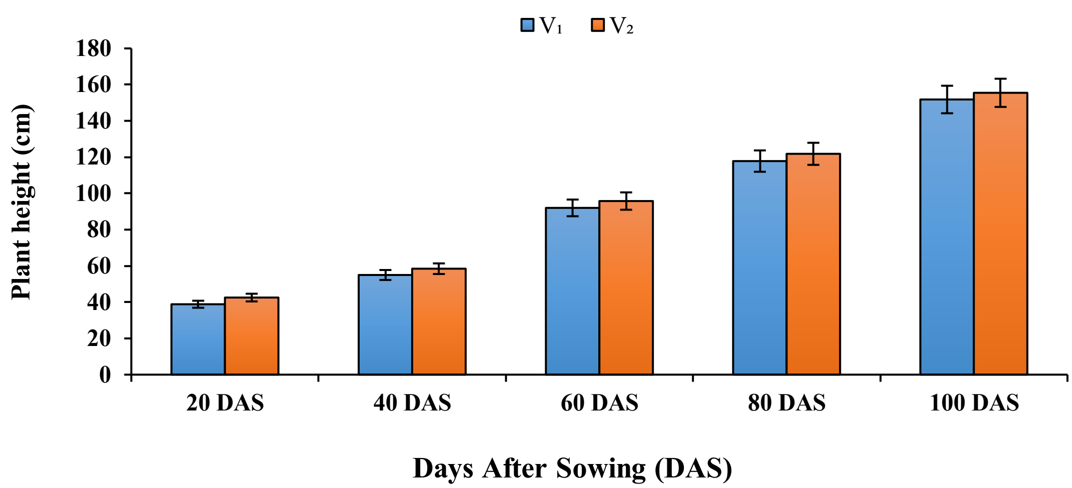
RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to studying influence of organic and inorganic nutrient management on growth and yield of maize. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Plant growth parameter

4.1.1 Plant height

Effect of different hybrid varieties

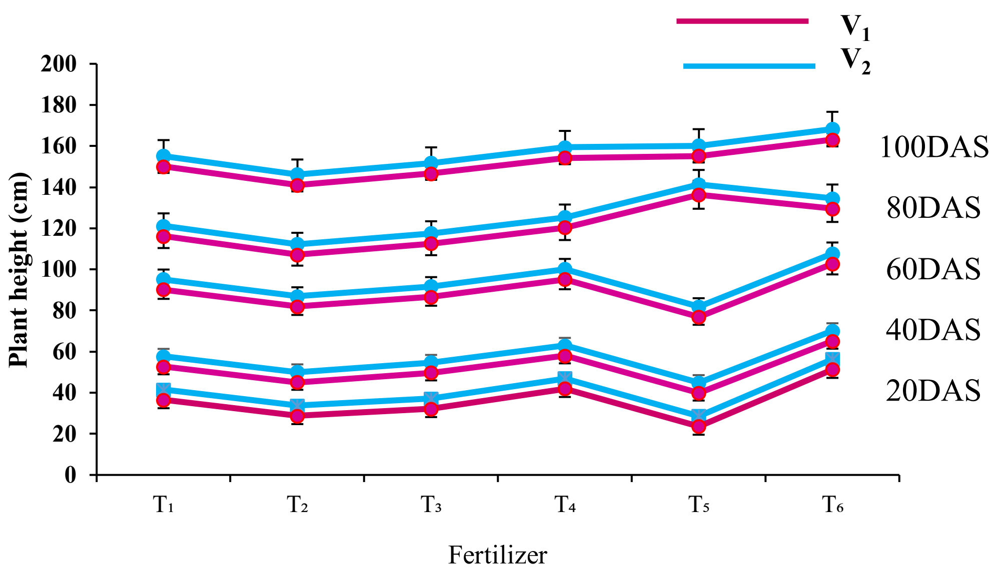


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 1. Effect of two varieties on plant height of hybrid maize at different DAS (LSD $_{(0.05)}$ =0.9224, 1.629, 1.7404, 1.801 and 1.3392cm at 20, 40, 60, 80 and 100 DAS respectively)

Plant height is an essential character of the vegetative stage of the crop plant and indirectly impacts on yield of crop plants. Different varieties of hybrid maize significantly influenced the plant height at different days after sowing (DAS). It was seen that height increased more and more with the age of the crop up to harvest. The plant height reached the highest value at maturity that is 100 DAS (Figure 1). Experimental result revealed that the highest plant height (42.539, 58.461, 95.783, 121.84 and 155.5cm) at 20, 40, 60, 80 and 100 DAS respectively was observed in V_2 (Pioneer 3355) and the lowest plant height (38.844, 54.989, 92.006, 117.83 and 151.82cm) at 20, 40, 60, 80 and 100 DAS respectively was observed in V_1 [SAU-984 (Advance line)]. The two varieties are statistically similar in growth character to each other as they are both hybrid varieties. And among them V_2 gives higher growth then V_1.

Effect of Biochar and inorganic fertilizer



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF

Figure 2. Effect of different fertilizer treatments on plant height of hybrid maize varieties at different DAS (LSD $_{(0.05)}$ = 0.6597, 1.4349, 1.6328, 1.6552, 1.764cm at 20, 40, 60, 80 and 100 DAS respectively)

Different fertilizer treatment showed significant effect on plant height of hybrid maize varieties at different days after sowing (Figure 2). Experimental result showed that the highest plant height at 20, 40, 60, 80 and 100 DAS respectively was observed in T_6 (100% Biochar + 100% RDF) treatment in case of both variety V_1 and V_2. While the lowest plant height at 20, 40, 60, 80 and 100 DAS respectively was observed in T_5 (50% Biochar + 50% RDF) treatment in case of both variety V_1 and V_2. In general height was increasing as the amount of biochar combining with the recommended dose of fertilizer was increased. And when the biochar was applied alone it could not work as much as it worked with RDF. As biochar works as a nutrient availability maintainer, when it was applied with the RDF it made the nutrients coming from RDF more available along with its' own nutrients for plant uptake. And the plants grew higher. But in T_5 treatment when the biochar was half (50%) in amount along with the half (50%) of RDF it was half in ratio of T_6. Nutrients were available but not enough for plant to grow appropriately. Whereas in T_2 treatment 100% biochar alone showed better performance than T_5. According to Ramzani *et al*. (2017), adding biochar to low fertility soils along with RDF at a rate of 5 to 10 t ha^{-1} enhanced cereal shoot length.

Combined effect of varieties and different fertilizer treatments on plant height

Combined effect of varieties and different fertilizer treatments, significantly influenced plant height of hybrid maize varieties at different DAS (Table 1). Experimental result revealed that the highest plant height (60.567, 72.000, 109.27, 136.23 and 170.00 cm) was observed in V_2T_6 treatment combination at 20, 40, 60, 80 and 100 DAS respectively which was statistically similar with V_1T_6 (68.200, 106.10 and 132.17cm) at 40, 60 and 80 DAS; with V_2T_4 (128.53 and 161.83 cm) at 80 and 100 DAS respectively. While the lowest plant height (28.067, 43.567, 80.30, 106.30 and 139.73 cm) at 20, 40, 60, 80 and 100DAS respectively was observed in V_1T_5 treatment combination, which was statistically similar with V_2T_5 (29.100, 46.167, 83.43 and 109.33cm) at 20, 40, 60 and 80 DAS and with V_1T_2 (33.167 and 48.200 cm) at 20 and 40 DAS respectively.

Table 1. Combined effect of varieties and different fertilizer treatment on plant height of hybrid maize at different DAS

Treatment Combination	Plant Height				
	20DAS	40DAS	60DAS	80DAS	100DAS
V_1T_1	38.767e	56.033e	93.33e	119.57e	153.73e
V_1T_2	33.167h	48.200gh	85.17g	110.23g	143.83g
V_1T_3	36.867f	53.233f	89.43f	115.70f	150.20f
V_1T_4	44.300d	60.700d	97.70d	123.00d	156.93d
V_1T_5	28.067hi	43.567hi	80.30h	106.30hi	139.73h
V_1T_6	51.900b	68.200ab	106.10ab	132.17ab	166.47b
V_2T_1	44.200cd	59.233de	96.97de	122.80d	156.53d
V_2T_2	34.367g	52.000f	88.70f	114.83f	148.43f
V_2T_3	37.400f	56.133e	93.87e	119.33e	153.33e
V_2T_4	49.600bc	65.233bc	102.47c	128.53a-c	161.83ab
V_2T_5	29.100hi	46.167f-h	83.43gh	109.33gh	142.87g
V_2T_6	60.567a	72.000a	109.27a	136.23a	170.00a
LSD $_{(0.05)}$	1.1828	2.4435	2.4088	2.5690	2.7402
CV (%)	1.35	2.10	1.44	1.15	0.95

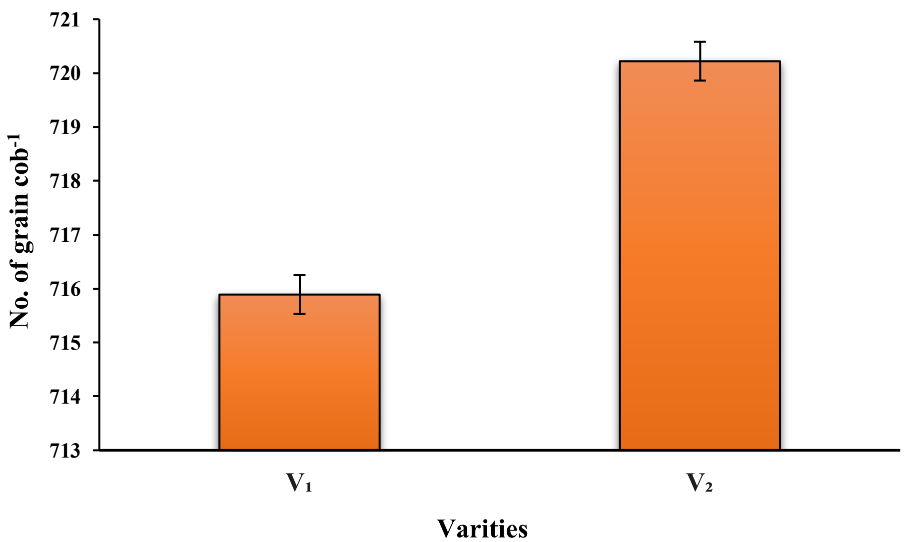
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355; T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF

4.2 Effect on yield contributing characters

4.2.1 Effect on no of grain cob^{-1}

Effect of different hybrid varieties

The number of grains cob^{-1} of hybrid maize is an important parameter. Here the two hybrid varieties showed two different results. The experiment's findings revealed that the V_2 variety had the highest number of grains cob^{-1} (720.22). As a result the V_1 variety had the lowest number of grains cob^{-1} (715.89) both are statistically similar to each other.

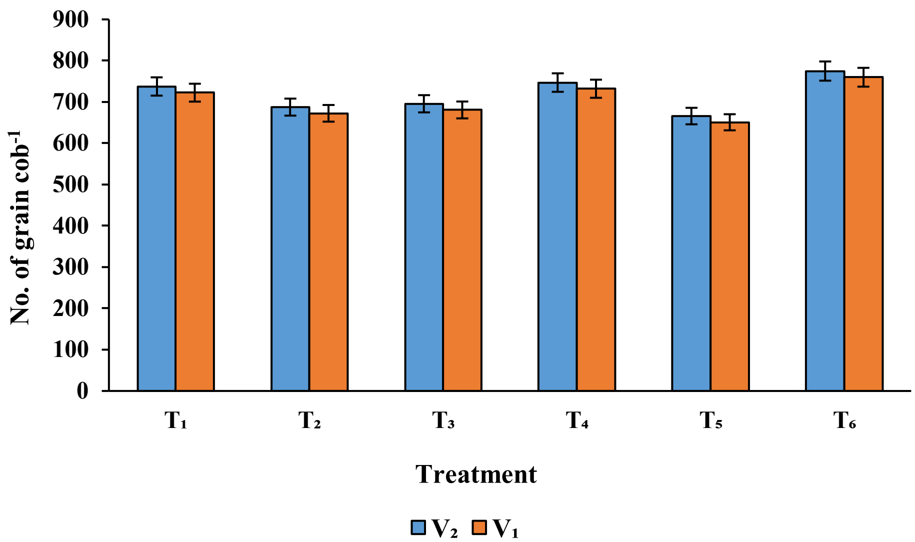


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 3. Effect of two varieties on no. of grain cob^{-1} of hybrid maize (LSD $_{(0.05)}$ =2.1908)

Effect of Biochar and inorganic fertilizer

Different fertilizer treatments had shown significant effect in respect of number of grains cob^{-1} of hybrid maize (Figure 4). The experimental findings revealed that the T_6 treatment had the highest number of grains cob^{-1} in case of both V_1 and V_2. However, the T_5 treatment's had the lowest number of grains cob^{-1}. Rahman *et al.* (2021) concluded that in respect of the effect of 100% RDF with 10ton (100%) biochar showed the highest number of grain per cob compared to other treatments.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 4. Effect of different fertilizer treatments on no. of grain cob^{-1} of hybrid maize varieties (LSD $_{(0.05)}$ = 0.8421)

Combined effect of varieties and different fertilizer treatments

The number of grains cob^{-1} of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and hybrid varieties (Table 2). The experimental results revealed that V_2T_6 treatment combination had the highest number of grains cob^{-1} (777.67). While V_1T_5 treatment combination had the lowest number of grains cob^{-1} (663.33).

Table 2. Combined effect of varieties and different fertilizer treatment on no. of grain cob^{-1}, 1000 seed weight (g), cob weight plant^{-1} (g), cob diameter plant^{-1} (cm) of hybrid maize

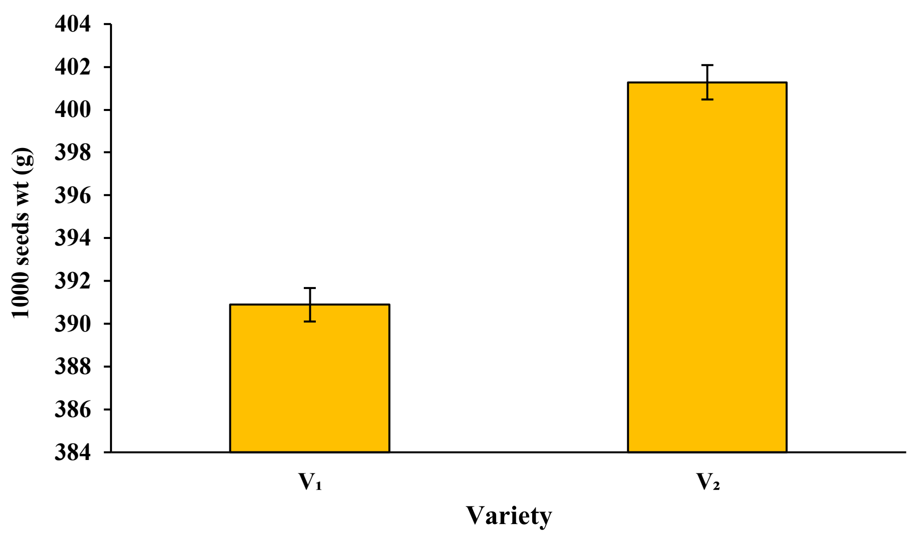
Treatment combination	No. of grain per cob	1000 seed weight (g)	Cob weight plant^{-1} (g)	Cob diameter plant^{-1} (cm)
V_1T_1	735.67f	407.33f	250.33e	15.633fg
V_1T_2	686.00j	344.67jh	226.33h	15.067h
V_1T_3	693.67h	387.00gh	233.67g	15.433gh
V_1T_4	744.67d	426.33cd	255.33cd	15.967d-f
V_1T_5	663.33kl	337.33l	218.33j	14.500i
V_1T_6	772.00ab	442.67a	270.00b	16.333c-e
V_2T_1	739.33ef	418.33e	252.67d	16.800c
V_2T_2	689.00i	351.33i	232.33g	16.200de
V_2T_3	697.67g	398.00h	240. 33f	16.433cd
V_2T_4	749.33bc	439.33bc	258.67c	17.233b
V_2T_5	668.33k	347.00	223.33i	15.867e-g
V_2T_6	777.67a	453.67a	273.67a	17.633a
CV (%)	0.10	0.11	0.38	1.42
$LSD_{(0.05)}$	2.3086	1.4186	1.5749	0.4883

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355; T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF

4.2.2 Effect on 1000 seeds weight

Effect of different hybrid varieties

Hybrid maize varieties had shown significant effect in respect of 1000 grain weight of hybrid maize (Figure 5). The results of the experiment showed that the V_2 variety had the highest weight of 1000 seeds weight (401.28 g). However the V_1 variety, had the lowest weight in 1000 seeds weight (390.89 g). As both are hybrid varieties they are showing comparable results. But in the comparison V_2 better then V_1 in case of 1000 seeds weight. V_2 gives better results in this aspect.

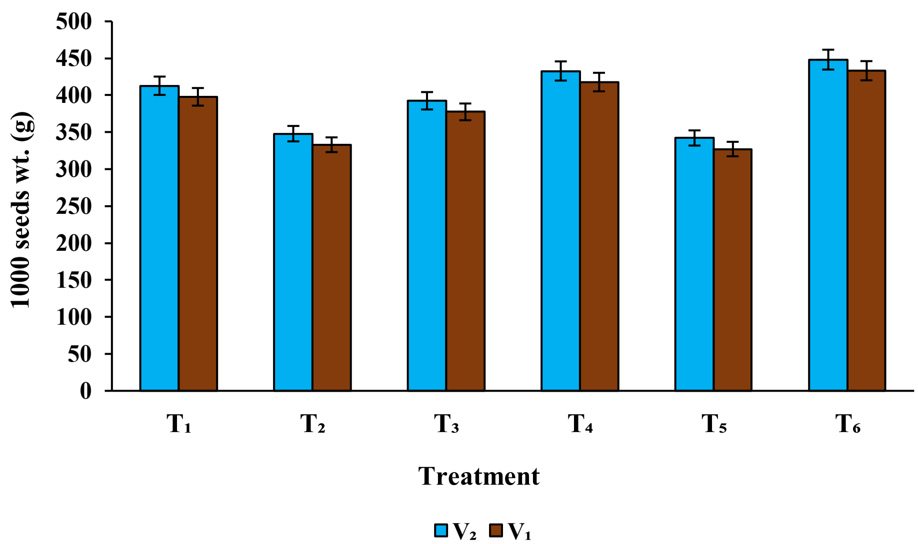


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 5. Effect of two varieties on 1000 seeds weight of hybrid maize (LSD $_{(0.05)}$ =1.3309)

Effect of Biochar and inorganic fertilizer

The various fertilizer application rates had shown significant effect in respect of 1000 seeds weight of hybrid maize (Figure 6). The results of the experiment showed that the T_6 treatment had the highest weight of 1000 seeds weight in case of both V_1 and V_2. However the T_5 treatment, had the lowest weight in 1000 seeds weight. 1000 seeds weight of maize increased with increased rates of fertilizer dose might be due to the fact that application of increased fertilizer dose to the maize plants maintained greenness of leaves for longer period which in turn helped in greater dry matter accumulation and this might have contributed much as a major source for the development of sink and thereby improved the 1000 grains weight of hybrid maize. Rahman *et al.* (2021) also concluded that in respect of the effect of 100% RDF with 10ton (100%) biochar showed the highest 1000 grain weight compared to other treatments.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 6. Effect of different fertilizer treatments on 1000 seeds weight of hybrid maize varieties (LSD $_{(0.05)}$ = 0.5460)

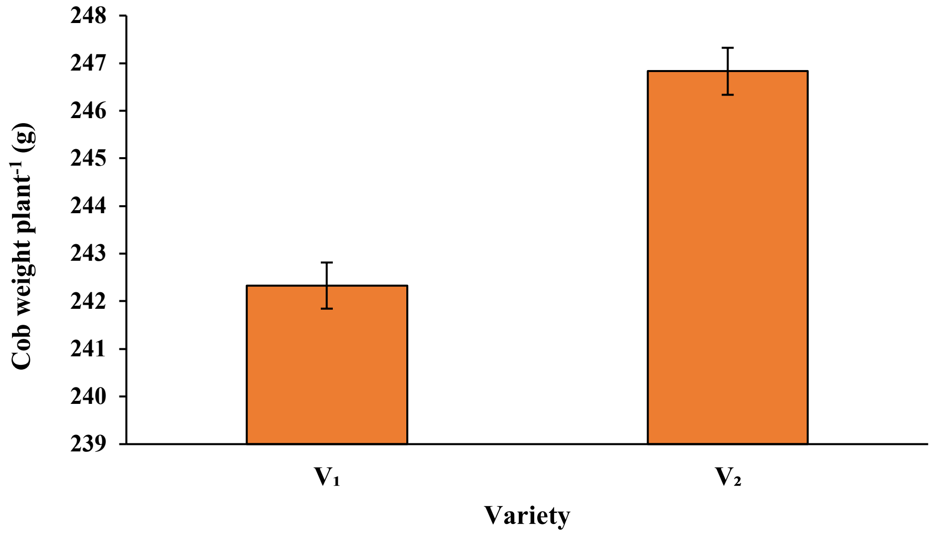
Combined effect of varieties and different fertilizer treatments

The 1000 seeds weight (g) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and hybrid varieties (Table 2). According to the experimental findings, the V_2T_6 treatment combination had the highest 1000 seeds of hybrid maize (453.67 g), which was statistically similar to the V_1T_6 treatment combination (442.67 g). The lowest 1000 seeds of white maize (337.33 g) was recorded by the V_1T_5 treatment combination**.**

4.2.3 Cobs weight plant^{-1}

Effect of different hybrid varieties

Hybrid maize varieties had shown significant effect in respect of cobs weight plant^{-1} of hybrid maize (Figure 7). The results of the experiment showed that the V_2 variety had the highest weight of cob per plant (246.83 g). However the V_1 variety, had the lowest weight of cob per plant (242.33 g). As both are hybrid varieties they were showing comparable results. But in the comparison V_2 performed better then V_1 in case of cob weight plant^{-1}. V_2 gives better results in this aspect as V_2 utilized the nutrients more than V_1 and gave more grain filling in the cobs.



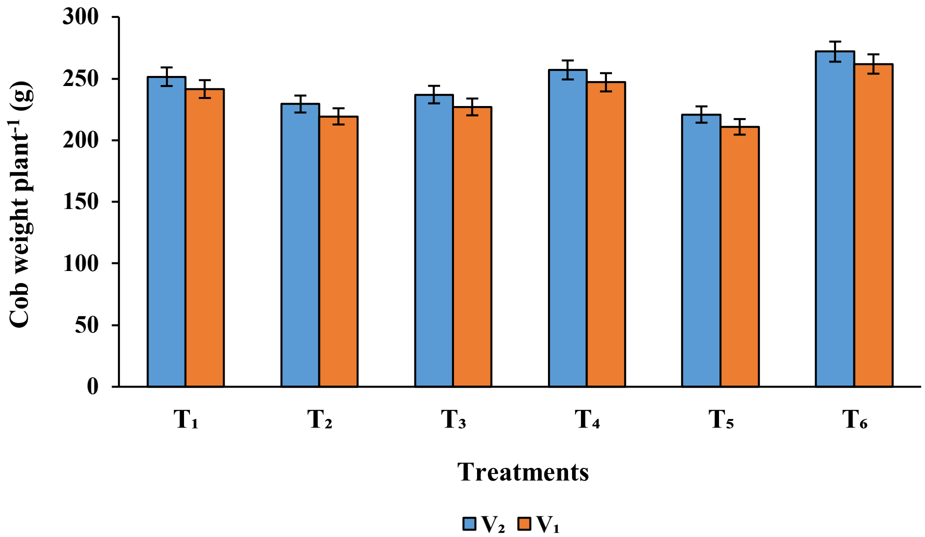
Here, V_1= SAU-984 (Advance line)) and V_2= Pioneer 3355 (Maize genotype)

Figure 7. Effect of two varieties on cobs weight plant^{-1} (g) of hybrid maize

(LSD $_{(0.05)}$ =0.7171)

Effect of Biochar and inorganic fertilizer

The different rate of fertilizer treatment significantly affected cobs weight plant^{-1} (g) in hybrid maize (Figure 8). Experimental result revealed that the highest cob weight was found in T_6 treatment which was followed by T_4 treatment in case of V_1 and V_2. Whereas the lowest cob weight was found in T_5 treatment. The differences of cobs weight plant^{-1} might be due to sufficient supply of nitrogen to the crop because nitrogen being an essential constituent of plant tissue is involved in cell division and cell elongation. In treatment T_6 sufficient nitrogen was supplied by RDF and Biochar so in T_6 treatment the cob weight was highest. Gokila and Baskar (2015) also stated that application of biochar @ 5 t ha^{-1} with RDF and bio-fertilizer recorded the highest cob weight (310 g) over other treatments and control in maize crop.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 8. Effect of different fertilizer treatments on cobs weight plant^{-1} (g) of hybrid maize varieties (LSD $_{(0.05)}$ = 1.1212)

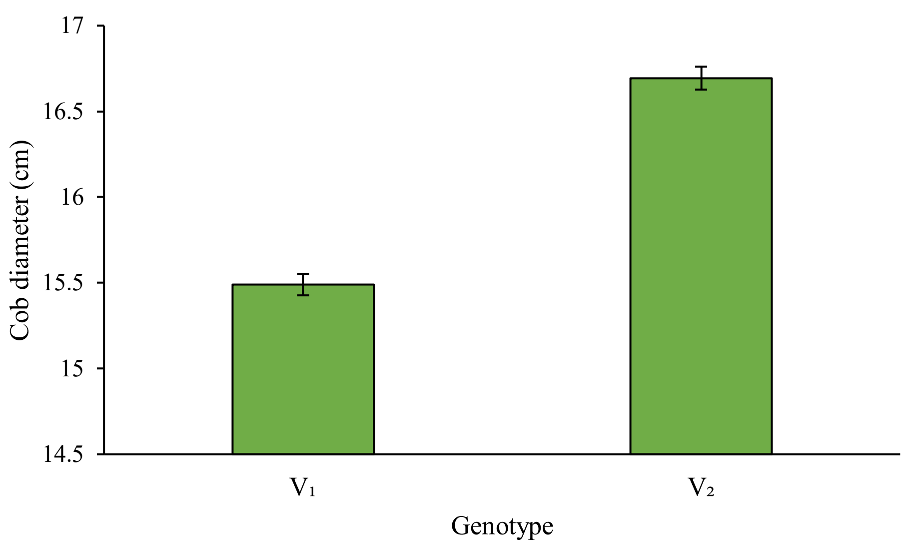
Combined effect of varieties and different fertilizer treatments

The cobs weight plant^{-1} of hybrid maize had significantly changed because of the combined effects of fertilizer treatment and varieties (Table 2). The experimental results revealed that V_2T_6 combination had the highest cobs weight plant^{-1} (273.67 g). While V_1T_5 treatment combination had the lowest cobs weight plant^{-1} (218.33 g). That means the V_2 variety showed the highest cobs weight in combination with 100% biochar and 100% RDF.

4.2.4 Diameter

Effect of different hybrid varieties

Hybrid maize varieties had shown significant effect on cob diameter plant^{-1} of hybrid maize (Figure 9). The results of the experiment showed that the V_2 variety had the highest cob diameter. However the V_1 variety, had the lowest cob diameter. As both are hybrid varieties they were showing comparable results. But in the comparison V_2 performed better then V_1 in case of cob diameter plant^{-1}. V_2 gives better results in this aspect as V_2 utilized the nutrients more than V_1 and put a wider diameter for itself in the cobs.

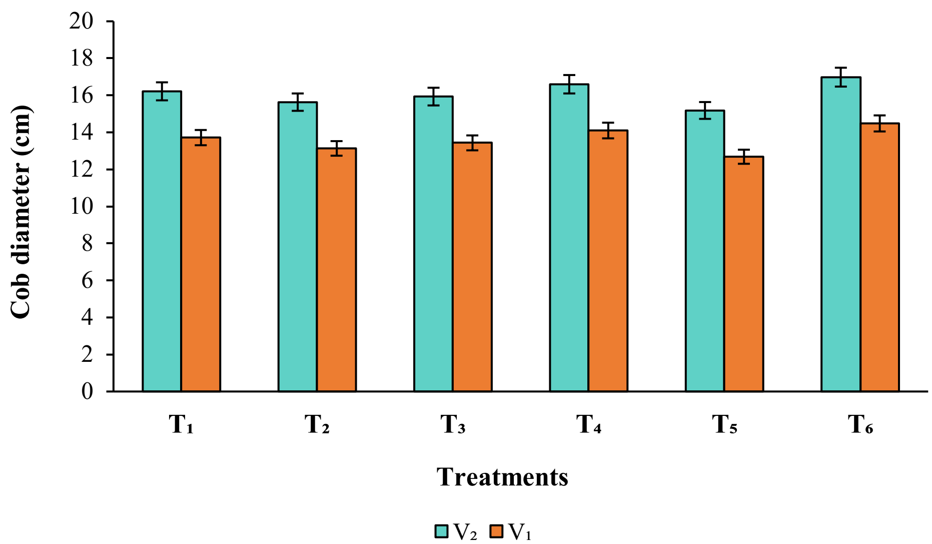


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 9. Effect of two varieties on cob diameter plant^{-1} (cm) of hybrid maize (LSD $_{(0.05)}$ =0.3757)

Effect of biochar and inorganic fertilizer

The different rate of fertilizer treatment significantly affected cob diameter plant^{-1} (cm) in hybrid maize (Figure 10). Experimental result revealed that the highest cob diameter in case of V_1 and V_2 was found in T_6 treatment which was followed by to T_4 treatment. Whereas the lowest cob diameter was found in T_5 treatment. Rahman *et al*. (2021) again concluded that in respect of the effect of 100% RDF with 10ton (100%) biochar showed the highest cob diameter compared to other treatments.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 10. Effect of different fertilizer treatments on cob diameter plant^{-1} (cm) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.2761)

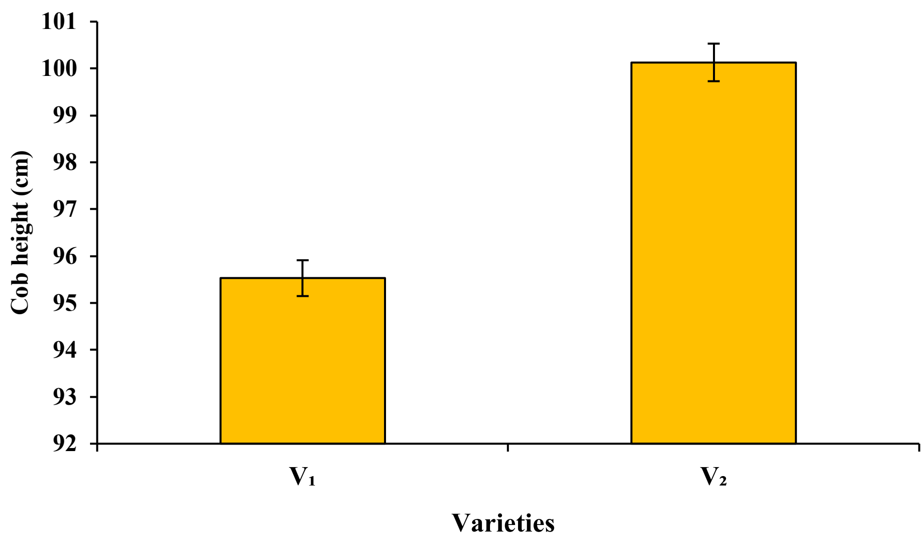
Combined effect of varieties and different fertilizer treatments

The cob diameter plant^{-1} (cm) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and varieties (Table 2). The experimental results revealed that V_2T_6 treatment combination had the highest cob diameter plant^{-1} (17.633 cm). While V_1T_5 treatment combination had the lowest cob diameter plant^{-1} (14.500 cm). That means the V_2 variety showed the highest cob diameter in combination with 100% biochar and 100% RDF.

4.2.5 Cob height from ground (cm)

Effect of different hybrid varieties

Hybrid maize varieties had shown significant effect in respect of cob height from ground of hybrid maize (Figure 11). The results of the experiment showed that the V_2 variety had the highest height of the cob from ground level (100.13 cm). However the V_1 variety, had the lowest height of cob from ground level (95.53 cm). As both are hybrid varieties they were showing comparable results. But in the comparison V_2 performed better then V_1 in case of cob height from ground. V_2 gives better results in this aspect.

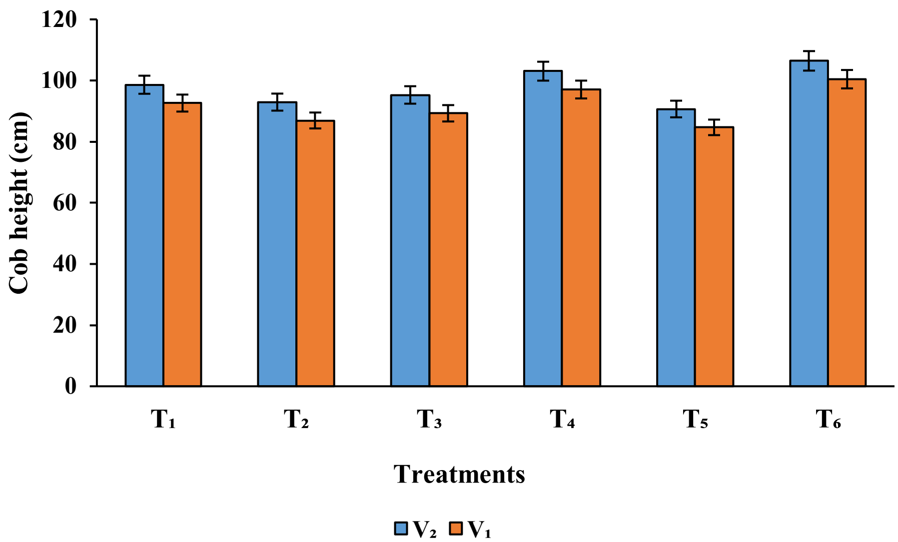


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 11. Effect of two varieties on cob height from ground (cm) of hybrid maize (LSD $_{(0.05)}$ =1.9685)

Effect of Biochar and inorganic fertilizer

The various fertilizer application rates had shown significant effect in respect of cob height from ground (cm) of hybrid maize (Figure 12). The results of the experiment showed that the T_6 treatment had the highest height of cob in case of V_1 and V_2 from the ground level. However the T_5 treatment, had the lowest height of cob from the ground level. Cob height from ground of hybrid maize increased with increased rates of fertilizer dose might be due to the fact that application of increased fertilizer dose to the maize plants resulted in fast growth of plant towards the sun and thereby improved the cob height of hybrid maize.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 12. Effect of different fertilizer treatments on cob height from ground (cm) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.6028)

Combined effect of varieties and different fertilizer treatments

The cob height from ground (cm) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and hybrid varieties (Table 3). According to the experimental findings, the V_2T_6 treatment combination had the highest cob height (109.60 cm), which was statistically similar to the V_1T_6 treatment combination (105.67 cm). The lowest cob height from ground of hybrid maize (88.77 cm) was recorded by the V_1T_5 treatment combination which was statistically similar to V_1T_2 treatment combination (91.07 cm). That means the V_2 variety showed better response to fertilizer doses then V_1 in case of its cob height from ground, when the fertilizer dose was 100% RDF with 100% biochar V_2 showed the best performance.

Table 3. Combined effect of varieties and different fertilizer treatment on cob height from ground (cm), cob length (cm) and unfilled space of cob (cm) of hybrid maize

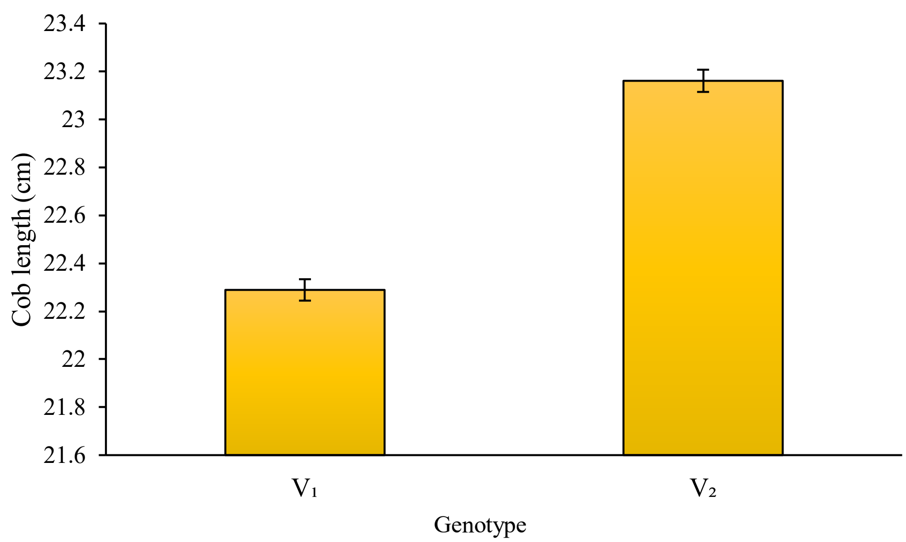
Treatment combination	Cob height from ground (cm)	Cob length (cm)	Unfilled space of cob (cm)
V_1T_1	96.33ef	22.70ef	2.13fg
V_1T_2	91.07i	20.96ij	2.70c
V_1T_3	93.33gh	21.73gh	2.36e
V_1T_4	100.43cd	23.66cd	2.00h
V_1T_5	88.77ij	19.33k	2.96a
V_1T_6	105.67ab	25.33b	1.80ij
V_2T_1	100.90d	23.20de	2.03gh
V_2T_2	94.80fg	21.43hi	2.53d
V_2T_3	97.23de	22.40fg	2.20f
V_2T_4	103.25c	24.47bc	1.83i
V_2T_5	92.60hi	20.26jk	2.83b
V_2T_6	109.60a	27.20a	1.70j
CV (%)	0.51	1.23	1.44
$LSD_{(0.05)}$	2.0174	0.9532	0.1094

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355; T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF

4.2.6 Cob length

Effect of different hybrid varieties

Hybrid maize varieties had shown significant effect in respect of cob length of hybrid maize (Figure 13). The results of the experiment showed that the V_2 variety had the highest length of the cob from in plants (23.161 cm). However the V_1 variety, had the lowest length of cob from in plants (22.289 cm). As both are hybrid varieties they were showing comparable results. But in the comparison V_2 performed better then V_1 in case of cob length. V_2 gives better results in this aspect as V_2 utilized the nutrients more than V_1 and gave a bigger length to the cobs.



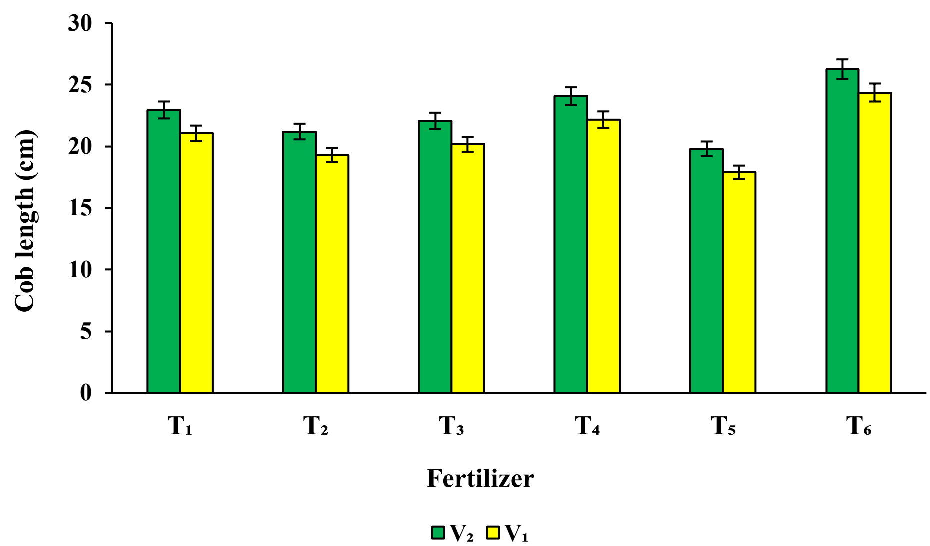
Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 13. Effect of two varieties on cob length (cm) of hybrid maize

(LSD $_{(0.05)}$ =0.9093)

Effect of Biochar and inorganic fertilizer

The different rate of fertilizer treatment significantly affected the cob length plant^{-1} of hybrid maize (Figure 14). Experimental result revealed that the highest cob length plant^{-1} was found in T_6 treatment in case of V_1 and V_2 which was comparable to T_4 treatment. Whereas the lowest cob length plant^{-1} was found in T_5 treatment. This might be due to an increase in cell elongation and more vegetative growth attributed to crop requirements of the additional fertilizer nutrients (*i.e.* NPK and biochar) for its normal physiological growth. On the other hand, the shortest cob length in the lower fertilized plots might have been due to the low level of those essential nutrients in the soil for crop requirements. Gokila and Baskar (2015) stated that application of biochar @ 5 t ha^{-1} which is 100% in ratio of RDF with RDF (100%) and bio-fertilizer recorded the highest cob length.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 14. Effect of different fertilizer treatments on cob length (cm) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.3379)

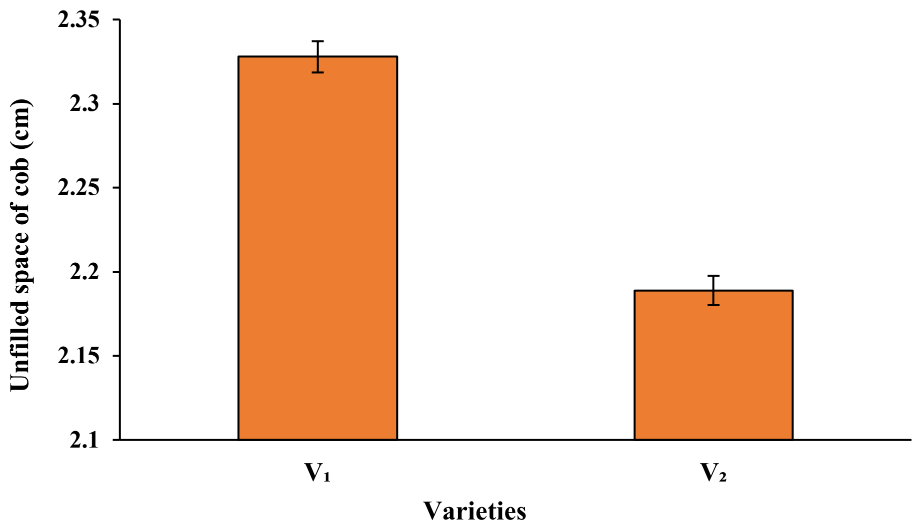
Combined effect of varieties and different fertilizer treatments

The cob length (cm) per plant of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and hybrid varieties (Table 3). According to the experimental findings, the V_2T_6 treatment combination had the highest cob length (27.200 cm), followed by V_1T_6 treatment combination (25.333 cm) which was statistically similar to the V_2T_4 (24.467 cm) treatment combination. The lowest cob length of hybrid maize (19.333 cm) was recorded by the V_1T_5 treatment combination which was statistically similar to V_2T_5 treatment combination (20.267 cm). That means the V_2 variety showed better response to fertilizer doses then V_1 in case of its cob height from ground, when the fertilizer dose was 100% RDF with 100% biochar V_2 showed the best performance.

4.2.7 Unfilled space of cob

Effect of different hybrid varieties

Hybrid maize varieties had shown significant effect in respect of only unfilled space of cob of hybrid maize (Figure 15). The results of the experiment showed that the V_1 variety had the highest length of the unfilled space in cobs (2.3278 cm). However the V_2 variety, had the lowest length of the unfilled space in cobs (2.1889 cm). As both are hybrid varieties they were showing comparable results. But in the comparison V_2 performed better then V_1 in case only unfilled space of cob. V_2 gives better results in this aspect as V_2 utilized the nutrients more than V_1 and gave more filling in the cobs with grains.



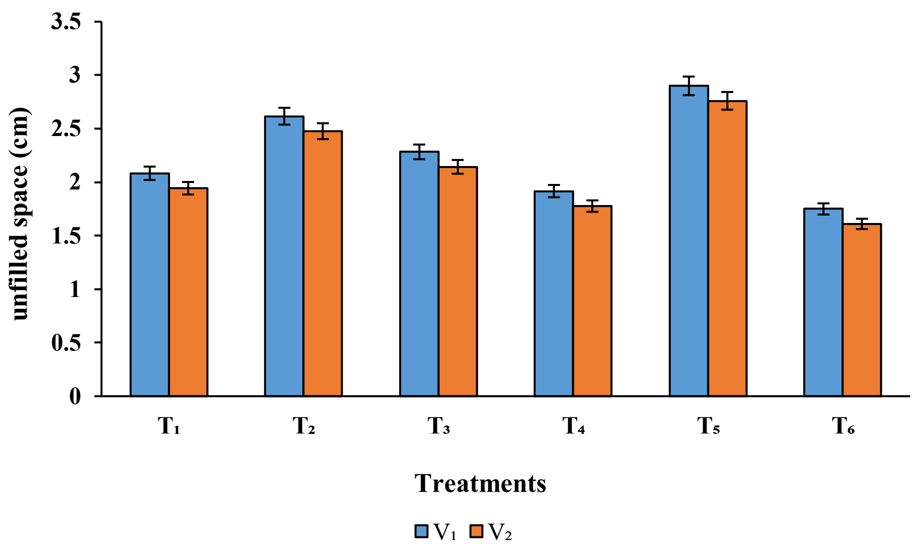
Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 15. Effect of two varieties on unfilled space of cob of hybrid maize

(LSD $_{(0.05)}$ =0.1042)

Effect of Biochar and inorganic fertilizer

The different rate of fertilizer treatment significantly affected the only unfilled space of cob in hybrid maize (Figure 16). Experimental result revealed that the highest length of unfilled space in the cob was found in T_5 treatment in case of both varieties which was followed by to T_2 treatment. Whereas the lowest length of unfilled space in the cob was found in T_6 treatment. This might be due to lack of nutrient acceptance. In T_5 treatment RDF was provided 50% also biochar was provided 50% which was not enough to supply adequate nutrient to plants. So as the amount of nutrient was in short when the grain was forming plants could not perform it perfectly. In the other treatments we found it giving better results than this. And in T_6 treatment the amount of nutrient was on peak for plants to uptake that resulted in reducing unfilled space of cob.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 16. Effect of different fertilizer treatments on unfilled space of cob (cm) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.0391)

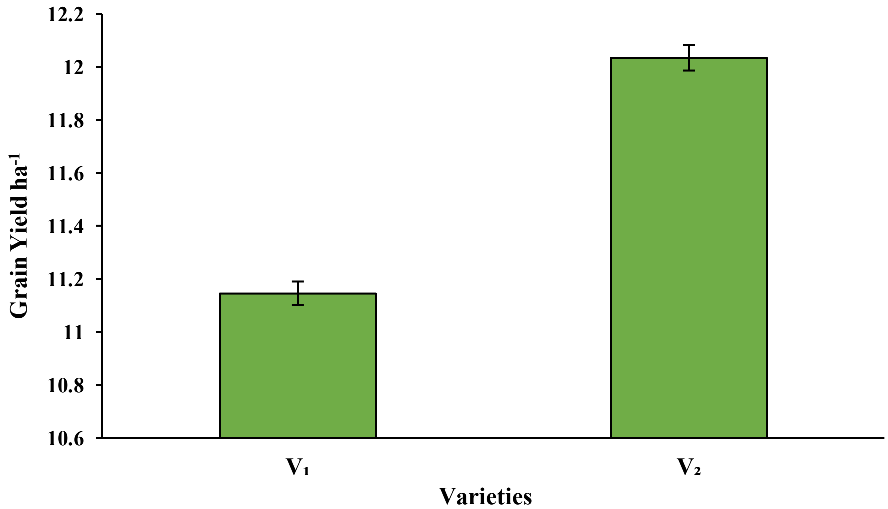
Combined effect of varieties and different fertilizer treatments

The only unfilled space of cob (cm) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and hybrid varieties (Table 3). According to the experimental findings, the V_1T_5 treatment combination had the highest length of unfilled space of cob (2.9667 cm), followed by V_2T_5 treatment combination (2.8333 cm). The lowest length of unfilled space of cob of hybrid maize (1.7000 cm) was recorded by the V_2T_6 treatment combination which was statistically similar to V_1T_6 treatment combination (1.8000 cm). That means the V_2 variety showed better response to fertilizer doses then V_1 in case of its only unfilled space of cob, when the fertilizer dose was 100% RDF with 100% biochar V_2 showed the best performance by filling most of its space with grains.

4.2.8 Grain yield ha^{-1}

Effect of different hybrid varieties

In this experiment result revealed that the V_2 variety recorded the highest grain yield (12.035 t ha^{-1}) that means V_1 variety had the lowest grain yield (11.146 t ha^{-1}). The result confirmed that V_2 is the highest grain producing variety among the two hybrids. It is more productive to use in all aspect.



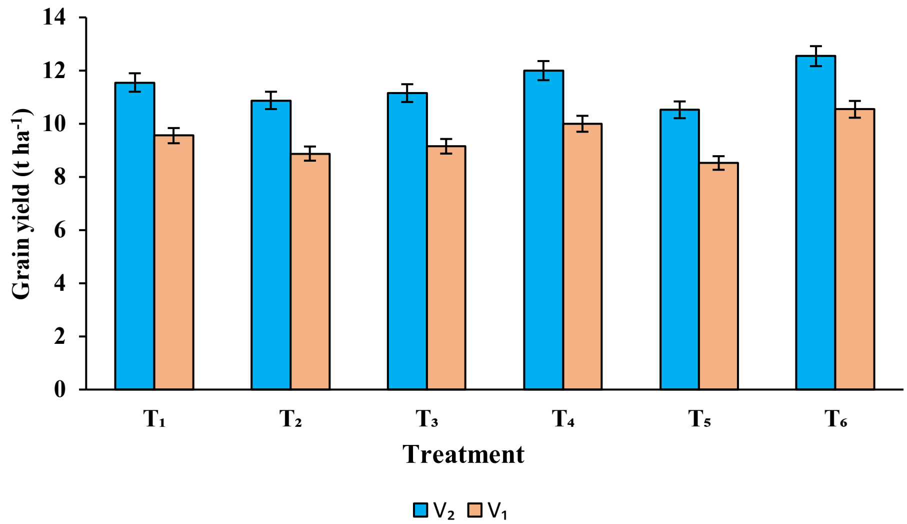
Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 17. Effect of two varieties on grain yield (t ha^{-1}) of hybrid maize (LSD $_{(0.05)}$ =0.4976)

Effect of Biochar and inorganic fertilizer

Due to different doses of fertilizer application, grain yield of hybrid maize was significantly influenced (Figure 18). In this experiment result revealed that the effect of T_6 treatment recorded the highest grain yield on V_1 and V_2. While T_5 treatment had the lowest grain yield. The result confirmed that higher levels of fertilizers enhanced grain yield on account of higher leaf area and leaf area duration that lead to more radiation interception, photosynthetic efficiency, growth rate and therefore grain number and grain weight per cob. Madhavi *et al*. (2017) found that 100%

Recommended dose of NPK along with biochar at 7.5 t ha^{-1} (100%) and humic acid at 30 kg ha^{-1} was significant in increasing seed yield.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 18. Effect of different fertilizer treatments on grain yield (t ha-1) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.0754)

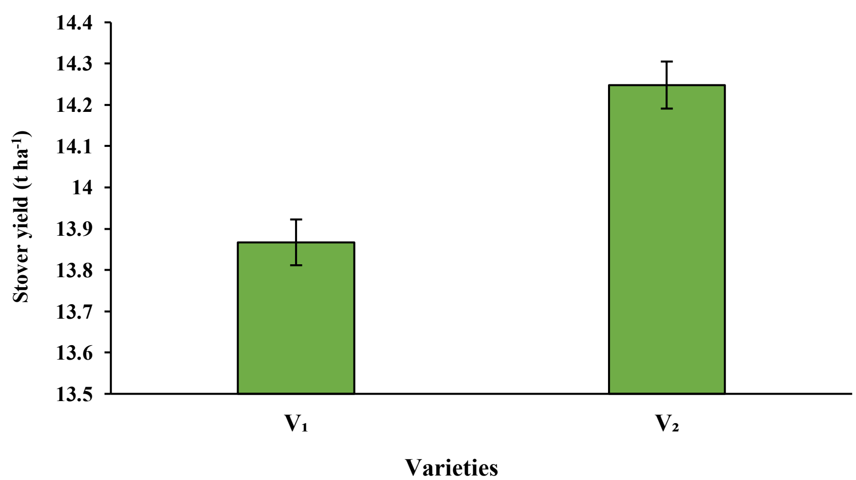
Combined effect of varieties and different fertilizer treatments

The grain yield (t ha^{-1}) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and varieties (Table 4). According to the experimental findings, the V_2T_6 treatment combination had the highest grain yield of hybrid maize (12.827 t ha^{-1}). Lowest grain yield of hybrid maize (10.133 t ha^{-1}) was recorded by the V_1T_5 treatment combination. That means the hybrid maize variety V_2 gives the highest grain production when 100% biochar is applied along with 100% RDF. Due to this fertilizer application leaf area was increased for better growth and plant performed more photosynthesis and gave higher yield production. The variety V_2 is better than V_1 variety.

4.2.9 Stover yield

Effect of different hybrid varieties

In this experiment result revealed that the V_2 variety recorded the highest Stover yield (14.248 t ha^{-1}) that means V_1 variety had lowest grain yield (13.867 t ha^{-1}). The result confirmed that V_2 is the highest stover producing variety among the two hybrids. It is more productive to use in all aspect.

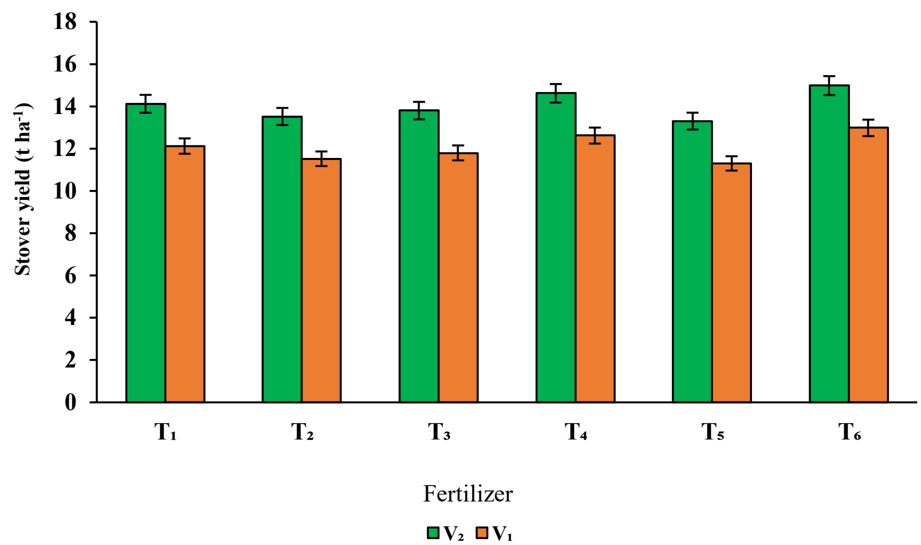


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 19. Effect of two varieties on stover yield (t ha^{-1}) of hybrid maize (LSD $_{(0.05)}$ = 0.0329)

Effect of Biochar and inorganic fertilizer

Due to different doses of fertilizer application, stover yield of hybrid maize was significantly influenced (Figure 20). In this experiment result revealed that the effect of T_6 treatment recorded the highest stover yield on V_1 and V_2. While T_5 treatment had the lowest stover yield. This might be due to the favorable soil condition created by increased fertilizer treatment in T_6 resulting in better root development thereby enabling plants to uptake more moisture and nutrients to produce high LAI meaning bigger assimilatory system and hence more dry matter production leading to higher stover yield. Srinivasarao *et al*. (2014) recorded that the higher grain and stover yield were also obtained in the same treatment.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 20. Effect of different fertilizer treatments on stover yield (t ha^{-1}) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.0404)

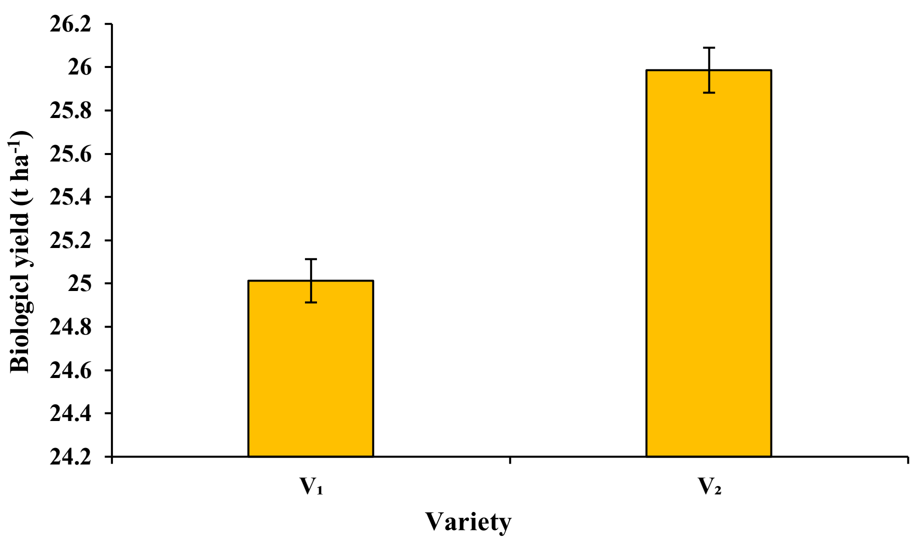
Combined effect of varieties and different fertilizer treatments

The Stover yield (t ha^{-1}) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and varieties (Table 4). According to the experimental findings, the V_2T_6 treatment combination had the highest stover yield of hybrid maize (15.007 t ha^{-1}). The lowest Stover yield of hybrid maize (12.963 t ha^{-1}) was recorded by the V_1T_5 treatment combination. That means the hybrid maize variety V_2 gives the highest Stover production when 100% biochar is applied along with 100% RDF. Due to this fertilizer application leaf area was increased for better growth and plant performed more photosynthesis and more dry matter accumulation that resulted in higher stover yield production. The variety V_2 is better than V_1 variety.

4.2.10 Biological Yield

Effect of different hybrid variety

In this experiment result revealed that the V_2 variety recorded the highest biological yield (25.986 t ha^{-1}) that means V_1 variety had lowest grain yield (24.996 t ha^{-1}). The result confirmed that V_2 is the highest biological yield producing variety among the two hybrids. It is more productive to use in all aspect.

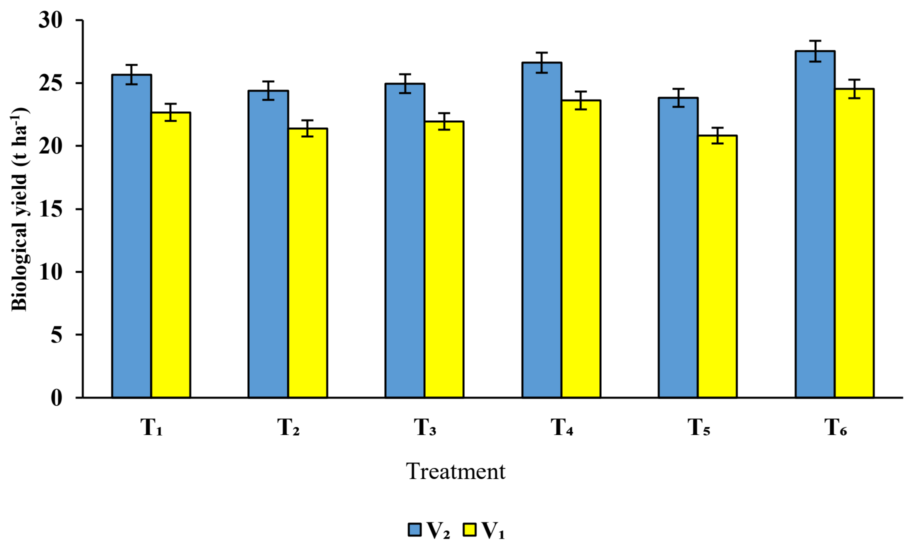


Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 21. Effect of two varieties on biological yield (t ha^{-1}) of hybrid maize (LSD $_{(0.05)}$ =0.5158)

Effect of Biochar and inorganic fertilizer

Due to different doses of fertilizer application, biological yield of hybrid maize was significantly influenced (Figure 22). In this experiment result revealed that the T_6 treatment recorded the highest biological yield on V_1 and V_2. While T_5 treatment had the lowest biological yield. The substantial increased in biological yield due to greater fertilizer doses may be attributable to the plant's favorable effect on absorbing additional nutrition, which ultimately influenced growth features such as increased dry matter accumulation per plant and its subsequent translocation towards sink. Gaire *et al.* (2020), reported that in each increase in fertilizer amount results in a different biological yield.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 22. Effect of different fertilizer treatments on biological yield (t ha^{-1}) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.0874)

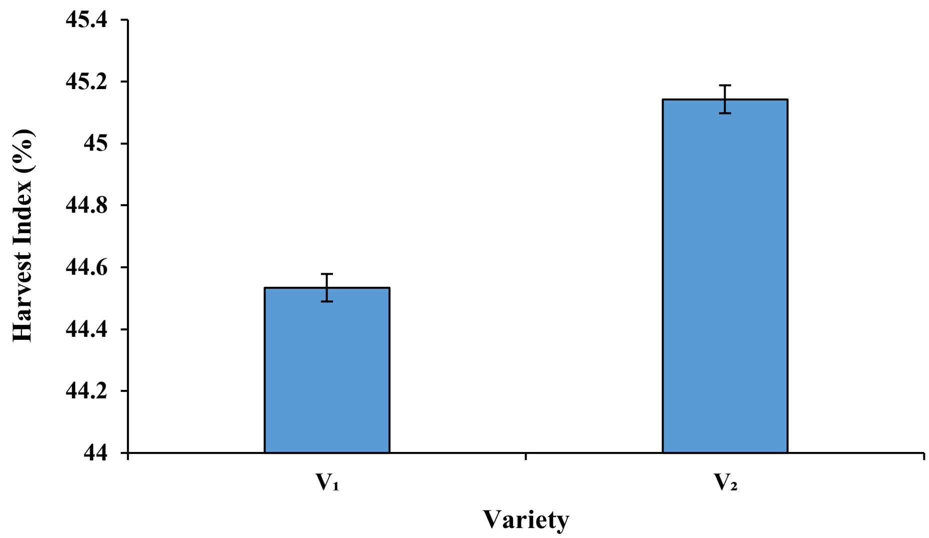
Combined effect of varieties and different fertilizer treatments

The biological yield (t ha^{-1}**)** of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and varieties (Table 4). According to the experimental findings, the V_2T_6 treatment combination had the highest biological yield of hybrid maize (27.850 t ha^{-1}). The lowest biological yield of hybrid maize (24.553 t ha^{-1}) was recorded by the V_1T_5 treatment combination. That means the hybrid maize variety V_2 gives the highest biological yield production when 100% biochar is applied along with 100% RDF. Due to this fertilizer application leaf area was increased for better growth and plant performed more photosynthesis and more dry matter accumulation and grain production that resulted in higher biological yield production. The variety V_2 is better than V_1 variety.

4.2.11 Harvest Index (%)

Effect of different hybrid varieties

The harvest index (%) of hybrid maize was significantly influenced by different varieties. In this experiment result revealed that the V_2 variety recorded the highest harvest index (45.143%) that means V_1 variety had the lowest harvest index (44.534%). The result confirmed that V_2 has the highest harvest index showing variety among the two hybrids. It is more productive to use in all aspects.



Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

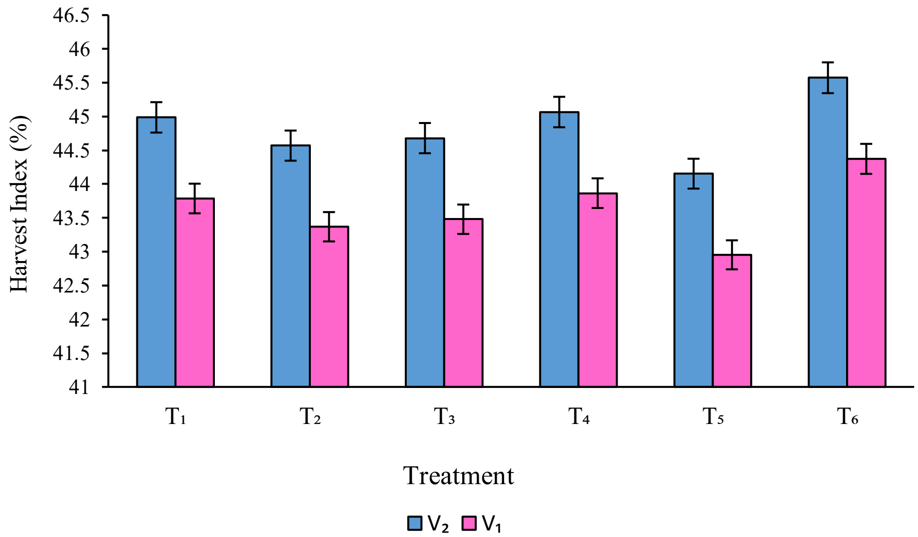
Figure 23. Effect of two varieties on harvest index (%) of hybrid maize

(LSD $_{(0.05)}$ =1.1355)

Effect of Biochar and inorganic fertilizer

Due to different doses of fertilizer application, harvest index (%) of hybrid maize was significantly influenced (Figure 24). In this experiment result revealed that the T_6 treatment recorded the highest harvest index on V_1 and V_2. While T_5 treatment had the lowest harvest index. Scientific fertilizer application is a key tool for increasing crop growth, conserving the environment, and ensuring agricultural sustainability. Plant fresh and dry weight, which reflect plant biomass accumulation to some extent, are key measures of growth vigor. Fertilizer (biochar and chemical fertilizer) application enhanced NPK availability in the root zone, resulting in greater nutrient uptake by the plant, resulting in increased grain and biological yield, which influences crop harvest index. The result was similar with the findings of

Raman and Suganya (2018) who reported that the harvest index were favorably influenced with increased fertilizer application.



Here, T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF; V_1= SAU-984 (Advance line) and V_2= Pioneer 3355 (Maize genotype)

Figure 24. Effect of different fertilizer treatments on harvest index (%) of hybrid maize varieties (LSD $_{(0.05)}$ = 0.1906)

Combined effect of varieties and different fertilizer treatments

The harvest index (%) of hybrid maize had significantly changed as a result of the combined effects of fertilizer treatment and varieties (Table 4). According to the experimental findings, the V_2T_6 treatment combination had the highest harvest index of hybrid maize (46.113%). The lowest of hybrid maize (43.863%) was recorded by the V_1T_5 treatment combination. A vital instrument for boosting crop development, protecting the environment, and guaranteeing agricultural sustainability is the application of fertilizer scientifically. Key indicators of growth vigor include plant fresh and dry weight, which indicate plant biomass increase to some extent. The application of fertilizer (biochar and chemical fertilizer) improved

NPK availability in the root zone, increasing plant nutrient uptake and increasing grain and biological yield, which affects crop harvest index. So the increased fertilizer treatment T_6 affected the varieties more positively and V_2 responded better than V_1 to it.

Table 4. Combined effect of varieties and different fertilizer treatment on grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) of hybrid maize

Treatment combination	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
V_1T_1	11.337ef	14.010e	25.347de	44.794f
V_1T_2	10.573j	13.177h	23.750g	44.445i
V_1T_3	10.873hi	13.617g	24.490f	44.504fg
V_1T_4	11.703d	14.477c	26.180c	44.719c
V_1T_5	10.133k	12.963i	24.553f	43.863j
V_1T_6	11.957c	14.957a	27.213b	45.438b
V_2T_1	11.767cd	14.233d	26.000c	45.034d
V_2T_2	11.18g	13.867f	25.047e	44.634h
V_2T_3	11.430e	13.983e	25.413d	44.973e
V_2T_4	12.293b	14.760b	27.053b	45.254bc
V_2T_5	10.913h	13.64g	23.097h	44.387i
V_2T_6	12.827a	15.007a	27.850a	46.113a
CV (%)	0.55	0.24	0.28	0.35
$LSD_{(0.05)}$	0.4979	0.0595	0.5165	1.1371

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1= SAU-984 (Advance line) and V_2= Pioneer 3355; T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF, T_6= 100% Biochar + 100% RDF

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm SAU, Dhaka during the period from December 2020 to April 2021 in *Rabi* season to studying influence of organic and inorganic nutrient management on growth and yield of maize. The experiment was consisted of two factors and followed split plot design with three replications. Factor A: Varieties viz (2); V_1= SAU-984 (Advance line) & V_2= Pioneer 3355. Factor B: Fertilizer application rate viz (6); T_1= 100% RDF (Urea+ TSP+ MoP+ Gypsum+ ZnS+ Boric Acid), T_2= 100% Biochar, T_3= 100% Biochar + 50% RDF, T_4= 100% Biochar + 75% RDF, T_5= 50% Biochar + 50% RDF & T_6= 100% Biochar + 100% RDF. The experimental results revealed that different varieties, fertilizer dose and their combination significantly influenced the growth, yield contributing characteristics and yield of hybrid maize.

In case of different varieties, the highest plant height (42.539, 58.461, 95.783, 121.84 and 155.5 cm) at 20, 40, 60, 80 and 100 DAS was observed for V_2 respectively. However in case of yield contributing characteristics and yield this variety (V_2) also recorded the highest height of the cob from ground level (100.13 cm), cob length plant^{-1} ((23.161 cm), cob circumference plant^{-1} ((16.694 cm), cob weight plant^{-1} (246.83 g), number of grains cob^{-1} (720.22), 1000 grain weight (401.28 g), grain yield (12.035 t ha^{-1}), stover yield (14.248t ha^{-1}), biological yield (25.986 tha^{-1}) and harvest (45.143%) comparable to other treatments. Also it showed the lowest length of the unfilled space in cobs (2.1889 cm). However the lowest yield contributing characterizes and yield *viz,* height of cob from ground level (95.53 cm), cob length plant^{-1} (22.289 cm), cob circumference plant^{-1} (15.489 cm), cob weight plant^{-1} (242.33 g), number of grains cob^{-1} (715.89), 1000 grain weight (390.89 g), grain yield (11.146 t ha^{-1}), stover yield (13.867 t ha^{-1}), biological yield (24.996 t ha^{-1}) and harvest (44.534%) were observed in V_1. Also it showed the highest length of the unfilled space in cobs (2.3278 cm).

In case of different fertilizer doses, the highest plant height (56.233, 70.1, 107.68, 134.2 and 168.23 cm) at 20, 40, 60, 80 and 100 DAS was observed for T_6 respectively. However in case of yield contributing characteristics and yield this treatment (T_6) also recorded the highest height of the cob from ground level (106.43 cm), cob length $plant^{-1}$ (26.267 cm), cob circumference $plant^{-1}$ (16.983cm), cob weight $plant^{-1}$ (271.83 g), number of grains cob^{-1} (774.83), 1000 grain weight (448.17 g), grain yield (12.542 t ha^{-1}), stover yield (14.982t ha^{-1}), biological yield (27.532t ha^{-1}) and harvest (45.573%) comparable to other treatments. Also it showed the lowest length of the unfilled space in cobs (1.75cm). However the lowest yield contributing characterizes and yield viz, height of cob from ground level (90.68cm), cob length $plant^{-1}$ (19.8cm), cob circumference $plant^{-1}$ (15.183cm), cob weight $plant^{-1}$ (220.83 g), number of grains cob^{-1} (665.83), 1000 grain weight (342.17 g), grain yield (10.523 t ha^{-1}), stover yield (13.302t ha^{-1}), biological yield (23.825 t ha^{-1}) and harvest (44.154%) were observed in T_5 treatment. Also it showed the highest length of the unfilled space in cobs (2.9cm).

In case of combination, the highest plant height (60.567, 72.000, 109.27, 136.23 and 170.00cm) at 20, 40, 60, 80 and 100 DAS was observed for V_2T_6 respectively. However in case of yield contributing characteristics and yield this combination (V_2T_6) also recorded the highest height of the cob from ground level (109.60cm), cob length $plant^{-1}$ (27.200 cm), cob circumference $plant^{-1}$ (17.633 cm), cob weight $plant^{-1}$ (273.67g), number of grains cob^{-1} (777.67), 1000 grain weight (453.67 g), grain yield (12.827 t ha^{-1}), stover yield (15.007 t ha^{-1}), biological yield (27.85t ha^{-1}) and harvest (46.113%) comparable to other treatments. Also it showed the lowest length of the unfilled space in cobs (1.7000 cm). However the lowest yield contributing characterizes and yield viz, height of cob from ground level (105.67 cm), cob length $plant^{-1}$ (19.333 cm), cob circumference $plant^{-1}$ (14.500 cm), cob weight plant^{-1}(218.33 g), number of grains cob^{-1} (663.33), 1000 grain weight (442.67 g), grain yield (10.133 t ha^{-1}), stover yield (12.963 t ha^{-1}), biological yield (24.553 t ha^{-1}) and harvest (43.863%) were observed in V_1T_5 treatment. Also it showed the highest length of the unfilled space in cobs (2.9667cm).

Conclusions

Based on the above findings, our experimental results revealed that, different hybrid variety, different fertilizer doses and their combination significantly influenced the growth, yield contributing characteristics and yield of hybrid maize.

i. In case of different hybrid variety, the V_2 [Pioneer 3355 (Maize genotype)] recorded the highest height of the cob from ground level (100.13 cm), cob length plant^{-1} ((23.161 cm), cob circumference plant^{-1} ((16.694 cm), cob weight plant^{-1} (246.83 g), number of grains cob^{-1} (720.22), 1000 grain weight (401.28 g), grain yield (12.035 t ha^{-1}), stover yield (14.248t ha^{-1}), biological yield (25.986t ha^{-1}) and harvest index (45.143%) comparable to the other variety. Also it showed the lowest length of the unfilled space in cobs (2.1889 cm).
ii. In case of different fertilizer doses the highest grain yield (12.542 t ha^{-1}), stover yield (14.982t ha^{-1}), biological yield (27.532t ha^{-1}) and harvest (45.573%) were observed in T_6 (100% RDF + 100% Biochar) treatment comparable to other treatments.
iii. In case of combined effect, the V_2T_6 treatment combination had the highest grain yield (12.827 t ha^{-1}) followed by V_1T_6 (11.957 t ha^{-1}) treatment combination.

Therefore, it was indicated that cultivation of hybrid maize through application of 100% biochar and 100% recommended dose of fertilizer along with Pioneer 3355 (Maize genotype) variety (V_2T_6) would enhance better yield production of hybrid maize. Because as biochar works as an activator for the nutrients provided, so in amount of 100% RDF 100% biochar makes more available nutrient for plant uptake then other doses in this experiment.

Recommendations

- Studies of similar nature could be carried out in different Agro Ecological Zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

CHAPTER VI

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CHAPTER VII

APPENDICES

Appendix I. Map showing the experimental location under study

★ =Experimental location

Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
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**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

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

Appendix III. Monthly meteorological information during the period from December 2020 to April 2021

Year	Month	Air temperature (^0C)		Relative humidity (%)	Average rainfall (mm)
		Maximum	Minimum		
2020	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00
2021	January	25.5	13.1	41	00
	February	25.9	14	34	7.7

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data of plant height of hybrid maize at different DAS

Source	DF	Mean square of plant height (cm) at				
		20 DAS	40 DAS	60 DAS	80 DAS	100DAS
Replication (R)	2	48.236	97.241	106.674*	89.448	77.726
Variety (V)	1	122.840*	108.507*	128.444*	145.203*	122.103*
Error	2	0.414	1.577	0.872	1.290	1.472
Fertilizer Treatment (T)	5	586.279*	488.824*	513.809*	535.782*	552.377*
V×T	5	16.086*	0.751	0.683	1.311	1.118
Error	20	0.300	1.420	1.838	1.889	2.146

Ns: Non significant
*: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data of cob length and cob circumference of hybrid maize at harvest

Source	DF	Mean square of	
		Cob length (cm)	Cob circumference (cm)
Replication (R)	2	9.5275*	11.2558*
Variety (V)	1	6.8469*	13.0803*
Error	2	0.4019	0.0686
Fertilizer Treatment (T)	5	30.8505*	2.5552
V×T	5	0.4029	0.0263
Error	20	0.0787	0.0526

Ns: Non significant
*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of cob height from ground and only unfilled space of cob of hybrid maize at harvest

Source	DF	Mean square of	
		Cob height from Ground (cm)	Only unfilled space of cob (cm)
Replication (R)	2	50.661*	0.15750
Variety (V)	1	190.624*	0.17361
Error	2	1.884	0.00528
Fertilizer Treatment (T)	5	219.969*	1.13583*
V×T	5	1.585	0.00161
Error	20	0.251	0.00106

Ns: Non significant
*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of cob weight plant^{-1} number of grains cob^{-1} and 1000 grains weight of hybrid maize at harvest

Source	DF	Mean square of		
		Cob weight plant^{-1}	Number of grains cob^{-1}	1000 grains weight
Replication (R)	2	42.75	80.8	91.1
Variety (V)	1	182.25*	169.0*	971.4*
Error	2	0.25	2.3	0.9
Fertilizer Treatment (T)	5	2158.45*	10322.0*	11490.8*
V×T	5	4.18	1.4	6.7
Error	20	0.87	0.5	0.2

Ns: Non significant
*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of on grain, stover, biological yield and harvest index of hybrid maize at harvest

Source	DF	Mean square of			
		Grain yield	Stover yield	Biological yield	Harvest index
Replication (R)	2	1.09944	0.00511	1.2673	4.81832
Variety (V)	1	3.12111*	1.31103	8.5264*	3.34179*
Error	2	0.12039	0.00052	0.1293	0.62683
Fertilizer Treatment (T)	5	3.33436*	2.51693*	11.6695*	1.41541*
V×T	5	0.01904	0.09812	0.1699	0.14274
Error	20	0.00392	0.00113	0.0053	0.02505

Ns: Non significant
*: Significant at 0.05 level of probability

Appendix IX. Several plates of the experimental field

Figure 25. Land preparation of the experimental field

Figure 26. Biochar application

Figure 27. Seed sowing

Figure 28. Tagging

Figure 29. Irrigation

Figure 30. Field banner

Figure 31. Growth and development of plant

Figure 32. Data collection for plant height

Figure 33. Harvested cobs

Figure 34. Collection of yield data