**EFFECTS OF BIOCHAR ON THE GROWTH OF MAIZE (*Zea mays*) IN MUBI NORTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE, NIGERIA**

# COVER PAGE

**BY**

**UTOR BENJAMIN**

**(SA/CP/HND/23/002)**

**SEPTEMBER, 2025**

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**UTOR BENJAMIN**

**(SA/CP/HND/23/002)**

**BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL TECHNOLOGY FEDERAL POLYTECHNIC MUBI IN PARTIAL FULFILMENT**

**FOR THE REQUIREMENTS OF THE AWARD OF HIGHER NATIONAL**

**DIPLOMA IN CROP PRODUCTION TECHNOLOGY**

**SEPTEMBER, 2025**

# DECLARATION

I Utor Benjamin with registration number SA/CP/HND/23/002 declare that this project “Effects of Biochar on the Growth of Maize (*Zea* *mays*) in Mubi North Local Government Area of Adamawa State Nigeria” Federal Polytechnic, Mubi under the supervision of Malam Zakari Yusuf, information derived from literature have been duly acknowledged in the text and a list of references provided. No part of this project was previously presented for the award of any Higher National Diploma (HND) at any institution.

…………..…………......................... ……..………….....

UTOR BENJAMIN Date

# DEDICATION

I dedicated this research work to my lovely parents for all their care, support and encouragement throughout my study.

# APPROVAL PAGE

This project entitled “Effect of Biochar on the Growth of Maize (*Zea* *mays*) in Mubi North Local Government Area of Adamawa State Nigeria” meets the regulation governing the award of Higher National Diploma (HND) in Crop Production Technology, Federal Polytechnic, Mubi and is approved for its contribution to knowledge and literary presentation.

…………..…………..... ……..………….....

Mallam Zakari Yusuf Date

(Supervisor)

…………..…………..... ……..………….....

Dr. Musa Benjamin Vimtim Date

(Head of Department)

…………..…………..... ……..………….....

External Examiner Date

# ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty for his blessing and sparing my life up to this point, may he take all praise, honour, glory and adoration. I am highly grateful to my supervisor Mallam Zakari Yusuf for his tireless effort in ensuring the success and completion of this research work. I also acknowledge the Head of Department Dr. Musa Benjamin Vimtim, the project coordinator Mallam Mohammed Isa and the entire staff of Agricultural Technology Department for their guidance during this experimental work. I also want to appreciate my lovely parents for their love and care and for giving me the opportunity to be trained and achieve my dreams. Finally, I appreciate the efforts of my uncles and aunties, for their encouragement and support throughout the course of my study and also my friends and relatives, course mates and all well-wishers. I love you all, may the Almighty God bless you abundantly, Amen.

# ABSTRACT

*The field experiment was carried out at the Research and Demonstration Farm, Department of Agricultural Technology, Federal Polytechnic Mubi, Adamawa State to evaluate the effects of biochar application on the growth of maize in 2025 cropping season. The treatment comprised of four application rates of biochar: 0 kg/ha (control), 100 kg/ha, 150 kg/ha, and 200 kg/ha and replicated three times using Randomized Complete Block Design (RCBD). Data were collected on plant height, number of leaves, leaf length (cm), stem girth (mm), days to first tasseling and slicking and days to 50% tasseling and silking. The data collected were subjected to analysis of variance (ANOVA). The treatment means that showed significance were separated using Least Significant Difference (LSD) at 0.05 level of probability. The results obtained from this study revealed that there was no significant difference (P ≥ 0.05) on parameters measured in 3 WAS, except days to first tasseling and days to first silking, while at 6 and 9 WAS there were significant differences (P ≤ 0.05). Application of 200 kg/ha of biochar gave more significant effects than other treatments. Based on the findings, this study can be concluded that biochar application had a significant effect on the growth of maize. Therefore, application of 200 kg/ha of biochar is recommended for maize production in the study area, since it is found to be promising. However, further research needs to be carried out to validate these findings.*

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# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the Study

Maize requires human intervention for its propagation. The kernels of its naturally propagating teosinte ancestor fall off the cob on their own, while those of domesticated maize do not (Benz, 2001). All maize arose from a single domestication in southern Mexico about 9,000 years ago. Maize spread from this region to the lowlands and over the Americas along two major paths (Matsuoka *et al.,* 2002). The centre of domestication was most likely the Balsas River Valley of South-Central Mexico (Piperno, 2011). Maize reached highland Ecuador at least 8,000 years ago (Pagan-Jimenez *et al.,* 2016). The earliest maize plant grew a single, small ear per plant (Davidson, 2014). The Olmec and Maya cultivated maize in numerous varieties throughout Mesoamerica; they cooked, ground, and processed it through nixtamalization for various foods.

Maize spread to the rest of the world because of its ability to grow in diverse climates. It was cultivated in Spain just a few decades after Columbus’s voyages and then spread to Italy, West Africa, the Philippines, and elsewhere (Earle, 2012; Salazar, 2016). When maize was introduced into Western farming systems, it was welcomed for its productivity.

Biochar is charcoal obtained from biomass meant to be incorporated into the soil (Lemann *et al.,* 2006). In the past years, biochar grew into one of the great promises to improve soil fertility and in addition, to migrate climate change through carbon sequestration (Roberts *et al.,* 2010; Biederman and Harpole, 2013). Biochar has received particular interest for improving the inherently poor soils in the humid tropics, where large amount of fallow vegetation from shifting cultivation at present usually burned could be used to feedstock for charring (FAOSTAT, 2016). However, although considerable research on biochar in recent years has yielded promising results, these are in consistent and the mechanisms leading to better soil fertility and higher yields are not yet well understood (Shackley *et al.,* 2009; Jeffery *et al.,* 2011). The use of biochar has a good impact on the availability of water, improving soil nutrients that help increase plant growth. Biochar implementation can increase the growth of maize hybrid especially in the addition of crop height and nutrients absorption in the soil (Verdiana *et al.,* 2017). Some studies show an interaction between biochar and fertilizer at the fresh weight of maize hybrid, this is because the provision of biochar is able to increase the quality and quantity of soil so that it affects plant growth (Praing *et al.,* 2018).

Biochar a multifunctional porous material with a small particle size, high surface area, low bulk density, high absorption capacity, and abundant carbon content, has attracted much attention because of its great potential on improving soil physiochemical properties (Khalili *et al.,* 2020; Obia *et al.,* 2021; Hale *et al.,* 2021; Tian *et al.,* 2021). Several studies have addressed the positive effects of biochar treatment on soil physiochemical properties, crop growth and yield and water and fertilizer use efficiency (Lychuk *et al.,* 2015; Li *et al.,* 2018); Danso *et al.,* 2019; Shahzad *et al.,* 2019; Zhang *et al.,* 2020). Additionally, for deficit irrigation, biochar addition/application to agricultural soils is effective in enhancing soil fertility, maize yield, water use efficiency and economic return under low rainfall conditions in Akure, Nigeria (Faloye *et al.,* 2019). For continual biochar application under limited irrigation in arid and semi-arid regions, previous studies have reported improvement in crop yield, water productivity and fertilizer use efficiency through the use of straw biochar (Faloye *et al.,* 2019); Danso et al., 2019; Khalili *et al.,* 2020). It has been previously shown that a single application of 30+/ha of biochar in the first year was beneficial for an increase in crop yield and soil organic matter under the rainfall mulching (Yang *et al.,* 2020).

## 1.2 Statement of the Problem

Maize is an important food crop cultivated throughout the world for food to man and feds to livestock animals. However, despite the number of farmers engaging the cultivation and production of maize there is still low production efficiency/output. This could largely be attributed to poor soils, climate conditions, inadequate fertilizer, inadequate farm inputs, lack of improved variety of seeds and government policies on agriculture. However, many farmers do not follow appropriate cultural practices especially as regards improving and maintaining soil fertility so this study seeks to examine the effects of biochar on the growth and yield of maize in Mubi North Local Government Area.

## 1.3 Objectives of the Study

The main objectives of this study is to assess the effects of biochar on the growth of maize, while the specific objectives are to:

1. Determine the effects of different application rates of biochar on the growth of maize.
2. Determine the best application rate(s) of biochar on the growth of maize.

## 1.4 Significance of the Study

This study would provide agricultural practitioners with information on the effect of biochar application on the growth yield of maize so as to boast agricultural production.

## 1.5 Scope of the Study

The study was limited to Mubi North LGA and maize variety on the effects of biochar application on growth of maize (*Zea mays*) in 2025 cropping season.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 History and Origin of Maize

Maize requires human intervention for its propagation. The kernels of its naturally – propagating teosinte ancestor fall off the cob on their own, while those of domesticated maize do not (Benz, 2001). All maize arose from a single domestication in southern Mexico about 9,000 years ago, the oldest surviving maize types are those of the Meximan highlands and maiz spread from this region to the lowlands and lower the Americans along two major paths (Matsuoka *et al.,* 2002). The center of domestication was most likely the balsas river valley of southcentral Mexico (Piperno, 2011). Maize reached highland Ecuador at least 8,000 years ago (pagan-Jimenez *et al.,* 2016). It reached lower central America by 7600 years ago and the valleys of the Colombian Andes between 7,000 and 6,000 years ago (Piperno, 2011). The earliest maize plants grew a single, small ear per plant (Davidson, 2014). The Olmec and Maya cultivated maize in numerous varieties throughout Mesoamerica; they cooked, ground and processed it through mixtamalization (Roney, 2009). By 3000 years ago, maize was central to Olmec culture including their calendar, language and Myths (Fussell, 1999). Maize is the domesticated variant of the four species of teosintes, which are its crop wild relatives (Whipple *et al.,* 2011). The teosinte origin theory was proposed by the Russian botanist Nikolai Ivanovich Vavilov in 1931 and the American Noble prize winner George Beadle in 1932 (Wilkes, 2004). In the late 1930s, Paul Mangelsdorf suggested that the domesticated maize was the result of a hybridization event between an unknown wild maize and a species of Tripsacum a related genus (Wilkes, 2004). Maize pollen dated to 7,300 years ago from San Andres, Tabasco has been found on the Caribbean coast (Ranere *et al.,* 2009). A primitive corn was being grown in Southern Mexicon Central America and Northern South America 7,000 years ago. Archaeological remains of early maize wars forund at Guila Naquitz cave in the Oaxaca valley are 6,250 years old, the oldest ears from caves near Tehuacan, Puebla are 5,450 years old (Roney, 2009).

## 2.2 Botanical Description

Maize is a tall annual grass with a single stem ranging in height from 1.2 – 4m (4 – 13ft) (Solaimalai *et al.,* 2020). The long narrow leaves arise from the nodes or joints, alternately on opposite sides on the stalk (Solaimalai *et al.,* 2020). Maize is Monoecious, with separate male and female flowers on the same plant at the top of the stem is the tassel, an inflorescence of male flowers and their anthers release pollen which is dispersed by wind (FAO, 2018). Like other pollen, it is an allergen but most of it falls within a few meters of the tassel and the risk is largely restricted to farm workers (Oldenburg *et al.,* 2011). The female inflorescence some way down the stem from the tassel is first seen as a silk, a bundle of soft tabular hairs one for the carpel in each female flower which develops into an ear or corn cob enveloped by multiple leafy layers or husks (Solaimalai *et al.,* 2020). The ear leaf is the leaf most closely associated with a particular developing ear. This leaf and those above it contribute over three quarters of the carbohydrate (starch), that fills the grain (integrated crop management, 2021). The grains are usually yellow or white in modern varieties, other varieties have orange, red, brown blue, purple or black grains. They are arranged in 8 to 31 rows around the cob; there can be up to 1200 grains on a large cob (Davidson, 2014). Yellow maize derive their colour form carotenoids; red maize are coloured by anthocyanins and phlobaphenes; and orange and green varietis may contain combination of these pigments (Chatham *et al.,* 2019).

## 2.3 Pest and Diseases

Many pest and diseases can affect maize growth and development, including invertebrates, weeds and pathogens (Muller and Pope, 2009). Maize is susceptible to a large number of fungal bacterial and viral plant diseases (Wise, 2024). Those of economic importance include diseases of the leaf, smuts, ear rats and stalk rots (Adkins, 2018). Northern corn leaf blight damages maize throughout its range, whereas banded leaf and sheath blight is a problem in Asia (Juroszek and Von, 2013). Some fungal diseases of maize produce potentially dangerous mycotoxins such as aflatoxin (Ostry *et al.,* 2015). Another serious pests is the fall army worm (*Spodoptera frugiperda*). The maize weevil (*Sitophilus zemais*) is a serious pest of stored grain (pest web, 2011). The northern armyworm, oriented armyworm or rice ear cutting caterpillar (*Mythimna separata*) is also or a major pest of maize (Thakur *et al.,* 1987). Nematodes too are pests of maize crop. It is likely that every maize plant harbours some nematodes parasites and populations of pratylenchid lesion nematodes in the roots can be enormous and its effects is stunting of growth and sometimes of whole fields especially when there is also water stress and poor control of weeds (Norton, 1983).

## 2.4 Soil and climatic requirements

The maize crop is grown in climates ranging from temperate to tropic during the period when moan daily temperatures are above 15oC and frost free (Akande *et al.,* 2007). Adaptability of varieties in different climates varies widely, successful cultivation markedly depends on the right choice of varieties so that the length of growing period of the crop matches the length of the growing season and the purpose for which the crop is grown (Akande, 2005; Vasanthi and Kumarawamy, 2000). When mean daily temperatures during the growing season are grwter than 20oC, early grain varieties take 80 – 110 days and medium varieties 110 – 140 days to mature (Bahrani *et al.,* 2007). The maize crop thrives in warm climates with temperature above 15oC, requiring well-drained, fertile and loamy soils with good aeration and drainage and a pH range between 5.8 – 6.8 (Feng and Vin, 2009). While the crop can tolerate drought, it requires sufficient rainfall, especially during flowering and grain filling periods. Maize requires adequate levels of Nitrogen (N), Phosphorus (P), and Potassium (K) as well as other essential elements and nutrients (Rasool *et al.,* 2008). It is sensitive to water logging, so well-drained soils are essential, especially during flowering and yield formation (Sakurai and Kolchtar, 2005). The crop does not do well in compacted, muddy and clayey soils, as well as areas with tress, shaded regions and ant hills (Nagassa *et al.,* 2005).

## 2.5 Weed Control

Weed management is a severe issue in forage crop production and weeds play a large piece in fodder maize production. World wide yield losses in maize due to weeds are estimated to be around 37% (kumawat *et al.,* 2019). Farmers usually give prime attention and importance to few cultural practices and neglect other factors like weed control (Tanisha et al., 2022). Maize crop are infested with a variety of weeds and subjected to intense weed competition, resulting in huge losses (Verma *et al.,* 2022). Weeds are a major problem in rainy season crops due to favourable growth conditions, primarily wide spacing and initial slow growth, frequent rains, causing huge losses ranging from 28 to 100% (Shukla *et al.,* 2022; Sahu *et al.,* 2022). Herbicides control measure is one of the ways to get higher productivity with lower cost involvement. However, continuous use of these herbicides causes shift in weed flora and development of resistance to herbicides (Verma *et al.,* 2022; Patel *et al.,* 2023). Herbicides are used to retain weed-free conditions during the early stage of growth either by cultural or mechanical means or through pre-planting, pre-emergence and post-emergence applications (Sahu *et al*., 2022; Shiv *et al.,* 2023). Pre-emergence or early post-emergence atrazine application followed by inter cultivation has been shown to be quite successful in Kharif maize (Heap, 2019). Farmers sometimes fail to apply atrazine as a pre-emergence spray due to excessive soil moisture as a result of exceptional rains. In such cases, applying a post-emergence herbicide may be viable option (Kumawat *et al.,* 2021).

## 2.6 Effects of biochar application on Maize

To minimize the effects of the climate change to agricultural soils and crop production, biochar has been introduced since last two decades (Laird, 2008; Lehman and Joseph, 2009). When biochar is applied to the soil, its health is improved in terms of increased water retention, sorption capacity, nutrients availability, plant growth, carbon sequestration and less leaching (Laird, 2008). Biochar made from different sources and at different temperatures have different chemical composition (Lehman *et al.,* 2011). Most of the oxygen and hydrogen present in organic matters are lost when subjected to pyrolysis (FAO, 2016). On the other hand, biochar is much more stable carbon content than original organic matter (Keiluweit, 2010). By using biochar as soil amendment, CO2 (carbon monoxide) emission can be reduced in atmosphere, which helps in mitigating global warming (Lehman, 2007). Biochar contain almost all plant nutrients needed to support the growth and yield of maize but their concentration may vary depending on the type of parent material used beside oxygen, all other nutrients are retained in biochar after pyrolysis (Chan and Xu, 2009).

Chan *et al.* (2007) observed that plant nutrient uptake and availability of elements such as phosphorus, potassium and calcium are typically increased while free aluminum is decreased in solution in biochar amended soils. Biochar at the rates of 20 and 40 t/ha with nitrogenous fertilization on maize showed 5.8% and 7.3% increase in yield respectively, while with the same rates of biochar when nitrogen is added, an increase of 8.8% and 12.1% respectively was observed (Zhang *et al.,* 2011).

## 2.7 Utilization/Importance of Maize

Maize and cornmeal (ground dried maize) constitute a staple food in many regions of the world (Davidson, 2014). Maize is used to produce the food ingredients corn starch (Merriam, 2016). Mize starch can be hydrolyzed and enzymatically treated to produce high fructose corn syrup, a sweetener (European Starch Association, 2013). Maize may be fermented and distilled to produce bourbon whiskey, corn is extracted from the germ of the grain as well (Kiniry, 2013).

Although maize naturally contains niacin an important nutrient, it is not bioavailable without the process of nixtamalization. The Maya people used nixtamal meal to make porridges and tamales (Pilcher, 2012). Maize is also a major source of animal feed, as a grain crop the dried kernels are used as feeds for animals (Adkins et al., 2020). When the whole maize plant (grain plus stalks and leaves) is used for fodder, it is usually chopped and made into silage as this is more digestible and more palatable to ruminants than the dried form (Heuze *et al.,* 2017). In the tropics, maize is harvested year round and fed as green forage to the animals (Heuze *et al.,* 2017). Baled cornstalks offer an alternative to hay for animal feed, alongside direct grazing of maize grown for this purpose (Bale cornstalks, 2023). Starch form maize can be made into plastics, fabrics, adhesives and many other chemical products (Corn Refiners Association, 2013). Corn steep liquor a plentiful water byproduct of maize wet milling process is used in the biochemical industry and research as a culture medium to grow microorganisms (Liggett and Koffler, 2021).

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Location of the Study Area

Field experiment was carried out at the teaching and research farm Department of Agricultural Technology, Federal Polytechnic, Mubi, Adamawa State during the 2025 rainy season to determine the effect of biochar application on the growth and yield of maize crop. Mubi is in the Northern guinea savannah of Nigeria situated between latitude 10o10 and 10o30 North of the equator and between longitude 13o10 and 13o30 East of Greenwich meridian and at an altitude of 696 meters above mean sea level (Adebayo & Tekwa, 2010).

## 3.2 Source of Seed

The seeds were bought from the main market in Mubi.

## 3.3 Treatment and experimental design

The experimental design was laid out in a Randomized Complete Block Design (RCBD), the treatments consisted of four different rates of biochar fertilizer (0kg/ha (control), 100kg/ha, 150kg/ha and 200kg/ha) respectively. All treatment replicated three times accordingly each with a control. The treatment comprised of four different rates of biochar fertilizer; 0kg/ha (control), 100kg/ha, 150kg/ha, and 200kg/ha laid out in a Randomized Complete Block Design (RCBD), replicated three times. The total land area was 32m x 11m = 352m2 and each plot was 3m x 6m = 18m2.

11m

T1

T4

T3

T4

T3

T2

T2

T1

T3

3m

6m

REP III

REP II

REP I

T2

T1

T4

.

1m

32m

Figure 1: Field layout of the experiment

**Key:**

**Rep I -** means replication 1

**Rep II -** means replication 2

**Rep III -** means replication 3

**T1** - 0 kg/ha (control)

**T2** - 100kg/ha

**T3** - 150kg/ha

**T4** - 200kg/ha

## 3.4 Cultural Practices

***3.4.1 Land preparation***

The land was cleared manually using hoe, cutlass and then ploughed using tractor. The area was marked out into plots replicated in a Randomized Complete Block Design (RCBD).

***3.4.2 Sowing***

The sowing was done in June when rainfall is well established and two seeds were placed by hole in a depth of 1.5 – 2.0cm.

***3.4.3 Thinning***

The thinning operation was done at two weeks after sowing (2WAS) and excess seedlings were removed.

***3.4.4 Spacing***

The spacing was done at 75cm x 50cm inter and intra spacing

***3.4.5 Weeding***

Weeding was done at three to four weeks after sowing and when necessary to keep the experimental plots free from weed competition.

***3.4.6 Fertilizer Application (Biochar)***

The application of biochar was done at different rates of 0kg/ha (control), 100kg/ha, 150kg/ha and 200kg/ha respectively.

## 3.5 Collection of Data

***3.5.1 Plant Height (cm)***

The plant height was measured using a meter rule from the base to the tip (top) of the plant at 3, 6 and 9 weeks after sowing and the average mean recorded.

***3.5.2 Number of leaves***

This was done by counting the leaves manually on the randomly selected 5 plants at 3, 6 and 9 weeks after sowing and the average mean recorded.

***3.5.3 Stem girth (mm)***

Was taken at 3, 6 and 9 weeks after sowing (WAS) with the help of a digital vernier caliper and their average computed and recorded.

***3.5.4 Days to First Silking and 50% Silking***

This was done by observing the time when the crop produced its first and 50% silk and the mean average recorded.

***3.5.5 Days to First Tasseling and 50% Tasseling***

This was done first by visual observation when the crop plant produces its first and 50% tasseling and the mean average recorded.

***3.5.6 Length of leaves***

This was done by measuring the leaves of maize using a metre rule and mean recorded.

## 3.6 Data Analysis

Data collected were subjected to analysis of variance (ANOVA), using SAS (2020) version and treatment means was separated using Least Significant Difference (LSD) at 0.05 level of probability.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 Effects of Biochar on Plant Height (cm) of Maize

The effects of biochar on plant height of maize at 3, 6, and 9 weeks after sowing (WAS) is presented in Table 1. The result indicated that biochar application had no significant difference (P ≥ 0.05) on plant height of maize at 3 WAS. There was significant difference (P ≤ 0.05) in plant height at 6 WAS and highly significant difference (P ≤ 0.01) on plant height at 9 WAS.

The highest biochar application was at application of 2.5 kg/ha of biochar at 3, 6, and 9 WAS which produced the highest plant height (41.7 cm, 88.1 cm and 120.0 cm) respectively, followed by the application of 1.5 t/ha of biochar which at 3, 6 and 9 WAS recorded the plant height of 42.9 cm, 84.1 cm and 119.0 cm respectively. While the control plot produced the least plant height (19.0 cm, 55.6 cm and 100.9 cm) at 3, 6 and 9 WAS.

The non-significant effect of biochar on plant height at 3 WAS might be attributed to the early stages of biochar application, because at this stage the plant could not fully utilize the amount of nutrient by the biochar. This result is in agreement with Adkins *et al.* (2020) who reported that application of biochar by maize seedling had no significant effect.

The significant differences in plant height due to biochar application at 6 and 9 WAS could be attributed to the increased in the number of applications of biochar which might result to variation in plant height, because the higher rates might have more plant nutrients which might have resulted to increase in plant height. This result is in agreement with the findings of Ibrahim *et al.* (2021) who found that application of biochar promote maize growth. This is also supported by Kuzyokove *et al.* (2014) who reported that application of biochar in the soil helps to improve plant nutrient utilization and hereby promote plant growth.

## 4.2 Effect of Biochar on Number of Leaves per Plant

The response of number of leaves per plant to biochar application is also presented in Table 1. Application of biochar had no significant variation (P ≥ 0.05) on number of leaves per plant at 3 WAS while there was significant effect (P ≤ 0.05) at 6 WAS and highly significant difference (P ≤ 0.01) at 9 WAS. Application of 200 kg/ha of biochar produced the maximum number of leaves per plant (5.10, 13.00 and 13.62) respectively, at 3, 6, and 9 WAS. Followed by application of 100 kg/ha of biochar which gave a number of leaves of 4.91, 12.91 and 13.21 at 3, 6 and 9 WAS. Furthermore, application of 100 kg/ha of biochar gave a number of leaves of 5.02, 11.90 and 17.00 at 3, 6 and 9 WAS respectively, while the least number of leaves was observed in control (10.12, 11.12, 13.12 respectively).

The non-significant number of leaves at 3 WAS might be due to low dissolution of biochar in the soil which might have led to low release of nutrients to the plant for vegetative growth. The significant differences in number of leaves at 6 and 9 WAS due to biochar application could be attributed to increase in the rates of biochar application that contained more plant nutrients. The more nutrients were released, the more the growth and the more the number of leaves. The result of this study is similar to work of Richardson *et al.* (2009) who reported that biochar application in the soil changes the physical properties of the soil which improves plant growth. This was also supported by Kuzyokove *et al.* (2014).

**Table 1: Effects of Biochar on Plant Height (cm) and Number of Leaves of Maize in 2025 Cropping Season.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment (kg/ha)** | **PH3WAS** | **PH6WAS** | **PH9WAS** | **NL3WAS** | **NL6WAS** | **NL9WAS** |
| 0 | 49.01 | 85.60d | 100.92d | 5.00 | 10.12d | 15.55d |
| 100 | 49.00 | 91.45b | 105.66c | 5.02 | 11.90c | 17.00c |
| 150 | 48.99 | 94.45b | 112.01b | 4.98 | 11.81b | 20.11b |
| 200 | 49.04 | 110.67a | 120.00a | 5.10 | 13.02a | 25.62a |
| LOS | NS | \* | \*\* | NS | \* | \*\* |
| LSD | 0.11 | 0.34 | 0.54 | 0.10 | 0.34 | 0.54 |

a,b,c,d Means in the same row bearing different superscript is significantly P≤ 0.05 different, LOS=Level of Significance, LSD=Least Significant Difference, \*\* Significant P≤ 0.001, PH = Plant Height, NL = Number of leaves.

## 4.3 Effect of Biochar on Leaf Length of Maize

Table 2 presents the effect of biochar on leaf length of maize. The result showed that biochar application had no significant effect (P ≥ 0.05) on leaf length per plant at 3 WAS while there were significant differences (P ≤ 0.05) on biochar application on leaf length at 6 and 9 WAS. Application of 200 kg/ha of biochar gave the highest maize plant leaf length (68.12 cm and 133.99 cm) respectively at 6 and 9 WAS while application of biochar at 150 kg/ha at 6 and 9 WAS produced the following leaf length (64.03 cm and 129.80 cm respectively). Similarly, application of 100 kg/ha of biochar gave the leaf length of 63.14 cm and 120.44 cm. The least leaf length was recorded in the control plots (61.94 cm of biochar and 115.80 cm respectively). The significant effects in leaf length per plant at 6 and 9 WAS could be attributed to increasing rates of biochar application because the more the rate of application, the more the nutrients that might be utilized by the plant to produce longer leaves. The result of this study agrees with the report of Natalia *et al.* (2014) who reported that application of biochar to corn plant produced maximum and longer leaves.

## 4.4 Effects of Biochar Application on Stem Girth (mm) of Maize

The effects of biochar application on stem girth at 3, 6 and 9 WAS is also presented in Table 2. Biochar application had no significant difference (P ≥ 0.05) on stem girth at 3 WAS while there were significant differences (P ≤ 0.05) at 6 and 9 WAS. Application of 200 kg/ha of biochar at 6 and 9 WAS produced the thickest stem girth (26.33 mm and 32.50 mm), followed by application of 150 kg/ha of biochar at 6 and 9 WAS respectively with mean values of 26.10 mm and 33.01 mm respectively. Similarly, application of 100 kg/ha of biochar at 6 and 9 WAS recorded stem girth of 24.81 mm and 29.51 mm respectively while the control gave the smaller stem girth (20.10 mm and 27.42 mm respectively).

The significant effects of biochar application at 6 and 9 WAS may be due to the available nutrients present in the higher rates that might have resulted to wider stem girth. This result is in line with the findings of Oguntunde *et al.* (2008) that application of charcoal in the soil increases the vegetative growth of plants.

**Table 2: Effects of Biochar on Leaf Length (cm) and Stem Girth of Maize in 2025 Cropping Season.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment (kg)** | **LL 3WAS** | **LL 6WAS** | **LL 9WAS** | **SG 3WAS** | **SG 6WAS** | **SG 9WAS** |
| 0 | 33.40 | 60.11d | 115.30d | 18.03 | 20.10c | 27.42d |
| 100 | 32.94 | 63.44c | 120.44c | 18.00 | 24.81b | 29.51c |
| 150 | 33.00 | 64.03b | 122.00b | 17.99 | 26.00a | 33.44b |
| 200 | 32.99 | 68.12a | 123.99a | 18.10 | 26.33a | 34.99a |
| LOS | NS | \* | \* | NS | \* | \* |
| LSD | 0.11 | 1.43 | 0.88 | 0.10 | 1.12 | 0.99 |

a,b,c,d Means in the same row bearing different superscript is significantly P≤ 0.05 different, LOS=Level of Significance, LSD=Least Significant Difference, \* Significant P ≤ 0.001, LL = Leaf Length, SG = Stem Girth.

## 4.5 Effect of Biochar Application on Days to First and 50% Tasseling of Maize

Table 3 shows the effects of biochar application on days to first and 50% tasseling of maize. The results revealed that biochar application had no significant effect (P ≥ 0.05) on days to first tasseling, while there was significant difference (P ≤ 0.05) on days to 50% tasseling. Application of 150 kg/ha of biochar recorded the least days to first and 50% tasseling (60.89 and 62.01), while the control (0 kg/ha) recorded the maximum days to first and 50% tasseling (61.23 and 65.00 respectively).

The non-significant effect on days to first tasseling might be due to physiological maturity of the plant. Once the plant reaches its physiological maturity, with or without biochar application, the tassel will manifest, as reported by Oguntunde *et al.* (2008). The significant effect of biochar application on days to 50% tasseling could be attributed to the higher rate of biochar application which might gave contained more plant nutrients that resulted to early tasseling. The result of this study is in line with the work of Kuzyakove *et al.* (2014) who reported that application of biochar to maize plant facilitates days to tasseling.

## 4.6 Effects of Biochar Application on Days to First and 50% Silking

The effect of biochar application on days to first and 50% silking is presented in Table 3. The result indicated that there was no significant variation (P ≥ 0.05) of biochar application on days to first silking and significant variation on days to 50% silking (P ≤ 0.05). Application of 200 kg/ha of biochar produced the least days to 50% silking (72.67), while the control (0 kg/ha) recorded the highest days to 50% silking (77.43). The non-significant effect of biochar application on days to first silking might be due to the growth maturity of the plant, which might have caused the plant to have silk at the same period. The significant variation of the biochar application could be related to the high rate of application of biochar that resulted in increased nutrients, which might have resulted in the decreased number of days to 50% silking. This result is in agreement with the work of Natalia *et al.* (2014) who reported that application of biochar to plant leads to early maturity of the plant.

**Table 3: Effects of Biochar on Days to First Tasseling, 50% Tasseling, Days to First Silking and Days to 50% Silking of Maize in 2025 Cropping Season.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment (kg)** | **Days to First Tasseling** | **50% Tasseling** | **Days to First Silking** | **50% Silking** |
| 0 | 61.23 | 65.00a | 70.10 | 77.43a |
| 100 | 62.00 | 65.10b | 70.03 | 76.94b |
| 150 | 61.99 | 63.12c | 69.44 | 73.50c |
| 200 | 60.89 | 62.01d | 69.00 | 72.67d |
| LOS | NS | \* | NS | \* |
| LSD | 0.10 | 1.66 | 0.12 | 1.65 |

a,b,c,d Means in the same row bearing different superscript is significantly P≤ 0.05 different, LOS=Level of Significance, LSD=Least Significant Difference, \* Significant P≤ 0.001.

# CHAPTER FIVE

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Summary

The field experiment was carried out at the Research and Demonstration Farm, Department of Agricultural Technology, Federal Polytechnic, Mubi, Adamawa State during 2025 cropping season to assess the effects of biochar application on the growth of maize. The treatments consisted of four biochar application rates: 0 kg/ha (control), 100 kg/ha, 150 kg/ha and 200 kg/ha, which were replicated three times using Randomized Complete Block Design (RCBD). The data were collected on plant height at 3, 6 and 9 WAS, number of leaves at 3, 6, 9 WAS, leaf length at 3, 6 and 9 WAS, stem girth at 3, 6 and 9 WAS, days to first and 50% tasseling, and days to first and 50% silking. The data were subjected to analysis of variance (ANOVA), and significant differences were separated using least significant difference (LSD) at 0.05 level of probability.

The results of this study revealed that there was no significant difference (P ≥ 0.05) in plant height at 3 WAS, but there was significant effect (P ≤ 0.05) on plant height at 6 and 9 WAS. Similarly, there were significant effects (P ≤ 0.05) in number of leaves, leaf length, stem girth, days to 50% tasseling and silking.

The results from this research work indicated that application of 200 kg/ha of biochar produced the maximum plant height, number of leaves, leaf length, stem girth, minimum number of days to first and 50% tasseling and silking, while the control (0 kg/ha) recorded the least.

## 5.2 Conclusion

Application of 200 kg/ha of biochar recorded the significant effects in most of the parameters measured. It is therefore concluded that application of 200 kg/ha of biochar gave the best performance.

## 5.3 Recommendations

This project work recommends the application of 200 kg/ha of biochar to promote the growth and yield of maize, hence should be adopted by the farmers in the study area.

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