INFLUENCE OF BIOCHAR AND NPK FERTILIZER ON THE GROWTH AND YIELD OF AMARANTHS (AMARANTHUSVIRIDIS L.)

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ABSTRACT

An experiment was conducted at Unguwar kudu garden, Dutsin-Ma from the month of February to April 2023 to study the combined influence biochar and NPK performance of vegetable amaranths. Biochar used in the experiment was produced using pit method with a limited supply of oxygen. The experiment consisted of three levels of biochar at 5t/ha,2.5t/ha and 0t/ha along with three levels of NPK fertilizer at 100%, 50% and %0 of the recommended dosage which were laid in factorial Randomized Complete Block Design(RCBD), the absolute control experiment consisted 0ton/ha biochar and 0% recommended dose of NPK. Biochar produced from plant materials resulted in higher performance and yield (p<0.0500. Yield of amaranths was significantly higher with the application of 2.5t/ha of biochar and 50% recommended dose of NPK fertilizer (p<0.050). As such the combined application 2.5toh/ha and 50% recommended dose of NPK fertilizer is recommended for enhanced and economic production of vegetable amaranth in the study area.

KEYWORDS

Biochar, NPK, pit method, oxygen, performance and plant materials.

1. INTRODUCTION

Africa represents a major block of the globe where malnutrition and poor living standard across the spectrum of the population is conspicuous and most intractable (UNICEF 2019; FAO 2018). Ninety per cent (90%) of children from Africa do not meet the minimum criteria for acceptable diet and 60% fall below the expected minimum meal frequency (Rickards 2019). Infant malnutrition in the African region is a serious treat and global health problem because of its consequential effects on childhood mortality, morbidity, impaired intellectual development and risk of diseases that can reduce the efficiency of adulthood working capacity (WHO 2013; Akombi*et al.,* 2017). In low- and middle income countries, child malnutrition contributes to about 45% of under-five year children mortality and this portends great danger to Africa growth and development. One third of child deaths in Africa are attributable largely to protein energy malnutrition and micronutrient deficiencies (Luchuo*et al.*, 2013, Branca*et al.*, 2020) which can be solved by exploring underutilized nutritious crop species of Africa origin. Nations in Africa need to proactively think and plan to address these problems in order to have an adulthood future that is productive (Coulibaly*et al.,* 2016). Consequently, there is a need for a policy framework and strategic roadmap that could reduce poverty and child malnutrition which is prevalent in most developing countries of Africa. The African continent is blessed with a rich diversity of food crops, most of which have received little or no attention in terms of research and development of policy frame works that can promote their effective commercial and industrial utilization. Grain amaranth (*Amaranthus spp.*) is one of such neglected and underutilized species. It is an indigenous leafy vegetable of Africa that has great inherent health promoting components good for human applications and uses (Kwenin, Wolli, and Dzomeku 2011; Zhu, 2020). The grain amaranth is a promising underutilized food crop because it can grow in a wide range of weather conditions. It is a drought tolerant crop with inherent strong market and industrial potentials which are yet to be fully tapped (Akin-Idowu*et al.,* 2017). Amaranth has the ability to grow and adapt in extremely harsh weather conditions (Olufolaji, Odeleye, and Ojo 2010). It can be successfully cultivated for leaf or grain in many regions and seasons where other crops cannot thrive (Mlakar*et al.,* 2009; Ebert, Wu, and Wang 2011; Grundya*et al.,* 2020).

Contrary to popular belief, Chemical fertilizers(NPK) often harm the plants. Phosphorus, for example, damages the essential relationship between a plant and its mycorrhizal fungi. NPK fertilizers compromise trees' root systems, block the uptake of micronutrients, encourage attack from harmful pests, and cause a host of other issues for plants. They also pollute waterways (leaf & limb).

At the very least, food crops produced using chemical fertilizers may not be as nutritious as they should be. This is because chemical fertilizers trade fast growth for health in plants, resulting in crops that have less nutritional value. Plants will grow on little more than NPK, but they will be missing or developing less of essential nutrients such as calcium, zinc, and iron. This can have a small but cumulative effect on the health of people that consume them (Apr 2018).

Constraints to amaranths production in Katsina state and Dutsinma local government in particular include the use of organic manure such as bio char. Bio char application can significantly affect N_2O and CH_4 emissions (Clough et al. 2010; Gaunt and Lehmann, Sevilla*et al.*, 2011; Wang *et al.*, 2011). Bio char application significantly decreased N_2O emissions, but increased total CH_4 emissions in a rice paddy (Zhang *et al.,* 2010). Woodchip bio char suppressed N_2O emissions and ambient CH_4 oxidation in laboratory incubation.

There is paucity of research information on the Agronomy of the vegetable crop. In areas where the crop is being grown, farmers lack some basic research information on the use of bio char and other important agronomic practices for better growth and yield of amaranths.

Based on the uses of amaranths to the economic growth and human health coupled with paucity of research information on the Agronomy of the crop, the present study was conceived to investigate the influence of combined application of biochar and NPK fertilizer on theperformance of vegetable amaranths.

2. MATERIALS AND METHODS

2.1. Experimental Site

Field experiments was conducted in dry season from February to April 2023, at Dutsin-Ma local government area, Unguwar kudu (12°26'35.59"N, 7°29'11. 97"E) in Sudan savanna ecological zone of Nigeria.

2.2. Treatments and Experimental Design

The experiment consisted of two different factors, and total number of Nine treatments, starting with Biochar and NPK at the rate of 0kg as control, 2.5t/ha of Biochar, 5t/ha of Biochar, 1/2kg NKP/ha, 2.5t/ha of Biochar +1/2kg of NPK/ha, 5t/ha of Biochar + 1/2kg NKP/ha, 1kg of NPK/ha, 2.5t/ha of Biochar + 1kg of NPK/ha, and 5t/ha of Biochar + 1kg of NPK/ha, and the treatments were replicated three times, these were factorially combined and laid out in Randomized Complete Block Design (RCBD).

2.3. Soil Sampling

Before the establishment of trial, a composite sample was collected from surface to 30 cm using auger. After six weeks from the establishment of the trial. These samples were air-dried, gently crushed and sieved through a 2 mm sieve mesh and stored in an air tight container prior to soil analysis.

2.4. Soil Analysis

The pH of the soil was determined in soil : water of 1:2.5 using glass electrode pH meter as described in Estefan et al.,(2013). Soil EC was determined in soil: water ratio of 1:5 soil : water as described by Estefan et al., (2013); Bower and Wilcox, (1965) and then converted to EC_e by using Slavich conversion factor (Slavich and Petterson, 1993). Soil Organic Carbon (SOC) was determined using Walkley-Black wet oxidation method (Walkley and Black, 1934). Soil organic matter (SOM) was calculated by using a multiplier of 1.724. Neutrally buffered ammonium acetate was used in the extraction of exchangeable bases. Ca^{2+} and Mg^{2+} were read using Atomic Absorption Spectrophotometer (Buck Scientific Model 210 VGP), while Na^+ and K^+ were read using flame photometer (Jenway PFP 7) as described in Anderson and Ingram (1993). Exchangeable acidity was extracted using IM KCl solution and determined by titration with NaOH as described in Anderson and Ingram (1993). Cation Exchange Capacity was determined by summation method as described by Chapman (1965). Total nitrogen was determined using Micro Kjeldahl method as described in IITA (1979) and Bremmer (1996). The soil available phosphorus was extracted using Bray 1 method(Bray & Kurtz, 1945) and determined using Blue method (Drummond and Maher, 1995; Murphy and Riley, 1962). Micronutrients were extracted using 0.1M HCl and read using Atomic Absorption Spectrophotometer (Buck Scientific Model 210 VGP), (Estefan et al., 2013; IITA, 1979).

2.5. Production of Biochar

The Bio char used was produced from a grinded and well dried maize stover in a fabricated pyrolysis Kiln in the Department of soil science Federal University Dutsin-Ma as described by (Lehmann, 2007) prior to addition to the experimental plots.

2.6. Biochar Analysis

Portions of the portion of the biochar was taken, sieved using 2mm sieve and preserved for analysis. The parameters analysed were:

The pH and EC of the bio char and compost were determined using amendment : water ratio of 1:10 as described by McLaughlin (2010) and USDA (2010) respectively. Total Nitrogen was determined using micro Kjeldahl method as described in Bremmer (1996) and IITA (1979). Total carbon in both of the amendments was determined by ignition method as described by Shuttle (1995). Available phosphorus was extracted using Bray 1 method extractant(Bray and Kurtz, 1945) and then read using spectrophotometer (22PC MODEL) at a wavelength of 860nm (Murphy and Riley, 1962). Exchangeable bases were extracted using NH_4Ac saturation method as described in Anderson and Ingram (1993) Ca^{2+} and Mg^{2+} were determined using AAS(BUCK SCIENTIFIC 210 MODEL) while Na^+ and K^+ were determined using flame photometer (JENWAY PFP 7) as described by Anderson and Ingram (1993). Exchangeable acidity was extracted using IM KCl and then determined by titration with NaOH as described by Anderson and Ingram (1993). The Effective Cation Exchange Capacity was determined by summation method as described by Chapman, (1965).

2.7. Agronomic Practices

2.7.1. Land preparation: The land was prepared manually using hoe and cutlass, in order to make fine beds for suitable growth of the amaranth plant, and also the land was marked out into plots. The gross plot size was 2m×2m.

2.7.2. Application of Biochar: Biochar was applied 2weeks before the establishment of the trial

2.7.3. Sowing: The seed was sown in different plots. The plants required a spacing of 15cm within the row and 20cm between rows, (15×20cm), using seed rates at 2 peak tins. Local variety of amaranth was used.

2.7.4. Irrigation: Water was applied more frequently during the early part of the growing period. Adequate irrigation was carried out. Local Irrigation was adopted; irrigation water was applied at the intervals of two days to prevent soil moisture loses.

2.7.5. Weeding: weed control was achieved manually using hoe at 1 week after sowing, to keep the plots weed free. Total of 2weeding were carried out.

2.7.6. Application of NPK fertilizer: NPK fertilizer was applied at the specified plots at 1week after sowing.

2.7.7. Thinning: The purpose of thinning in amaranth was to maintain the proper density of the crop, maintain spacing and to rouge off-types and diseased plants. The crop was thinned to two plants per stand.

2.7.8. Tagging: This task was conducted immediately after Thinning in order to identify the plants that were used in recording of observations.

2.7.9. Harvesting: Harvesting was carried out at six weeks after sowing after sowing (WAS) in order to measure the yield of the amaranths plant.

2.8. Growth Parameters

Recording of observations was carried out at 3,4,5 and 6 weeks after sowing (WAS) on the following growth and yield parameters.

2.8.1. Plant height: four plants were randomly tagged/plot. The heights of the tagged plants were measured in centimeters from the ground level to the tip of the plants using meter rule.

2.8.2. Number of leaves/plant: This was taken by counting the total number of leaves from the tagged plants.

2.8.3. Leaf area: The length and width were measured using meter rule.

2.8.4. Total dry weight: The weight of the dried plant was separately taken from the cut border line plants at 4,5 and 6 weeks after sowing. Both the leaves and the stems were dried at temperature of 70°C.

2.8.5. Stem diameter: The diameter of the stem was measured using meter rule from the tagged plants, and the mean was determined.

2.8.6. Fresh plant weight: This was taken by measuring the weight of a fresh plant shoot.

2.9. Statistical analysis

Analysis of variance was carried out to determine if there is significance difference between means of the data obtained from the experiment was carried out using R Software (3.4.3) edition. Means of the treatment were separated Duncan Multiple Ranking Technique DMRT (Duncan 1955)

3. Results and Discussion

3.1. Characteristics of the Experimental Soil

Table 1 shows the chemical characteristics of the soils of the experimental site. The soil has mean pH of 6.83, This indicates that the soil is neutral and falls within the optimum range for the growth of the experimental crop as described by Havlin et al., (2012) which is similar to the findings of Abdulkadir et al., (2020), Dawaki et al., (2019), Abdulkadir et al., (2022) and Sufiyanu et al., (2022). The EC_e with a mean 0.92dS/m, shows that it is non-saline based on FAO rating (FAO, 1999). The total organic carbon of the studied soil was 0.36%. The total Nitrogen of the studied soil was 0.14%. Its available Phosphorus was found to have mean of 3.24mg/kg. The soil contains low Organic Carbon, Available Phosphorus and the Total Nitrogen based on ESU rating (Esu, 2010). The exchangeable bases of the experimental site were found to be 1.24cmol/kg K, 0.12cmol/kg Na, 2.30cmol/kg Ca and 0.58cmol/kg Mg. The mean ECEC ranges between 4.24cmol/kg. The soil has a medium content of Calcium and Sodium with a high content of Magnesium and Potassium, the Effective Cation Exchange Capacity (ECEC) of the soil rated medium (Esu, 2010).

Table 1: Chemical characteristics of the pre amendment application soil

Soil property	Values
pH	6.83
EC (dSm^{-1})	0.92
TN (%)	0.14
OC (%)	0.36
K ($cmolkg^{-1}$)	1.24
Na ($cmolkg^{-1}$)	0.12
Mg ($cmolkg^{-1}$)	0.58
Ca ($cmolkg^{-1}$)	2.30
EA ($cmolkg^{-1}$)	0.17
ECEC ($cmolkg^{-1}$)	4.24
Av. P ($mgkg^{-1}$)	3.24

EC= Electrical Conductivity, TN = Total Nitrogen, OC = Organic Carbon, ECEC =Effective Cation Exchange Capacity, EA = Exchangeable acidity, and Av. P = Available Phosphorus

3.2. Characterization of the Biochar Used in the Experiment

Table 2 shows the chemical characteristics of the biochar used in the experiment. It shows that the pH of the biochar used was 7.54. The EC (1:5) of the bio char was 0.43dS/m. The Total Nitrogen of the biochar was 1.1%. The biochar was found to have available phosphorus of 36.44. The bio char contains 1.39cmol/kg Ca, 1.39cmol/kg Mg, 0.08cmol/kg Na and 3.81cmol/kg K. The respective Effective Cation Exchange Capacity of the biochar was 10.47cmol/kg and 7.18cmol/kg.

Table 2: Chemical characteristics of the biochar used

Property	BIOCHAR
pH	7.54
EC (dSm^{-1})	0.43
TN (%)	1.1
OC (%)	64.8
K ($cmolkg^{-1}$)	3.81
Na ($cmolkg^{-1}$)	0.08
Mg ($cmolkg^{-1}$)	1.64
Ca ($cmolkg^{-1}$)	2.24
EA ($cmolkg^{-1}$)	0.51
ECEC ($cmolkg^{-1}$)	8.28
Av. P ($mgkg^{-1}$)	36.44
C:N ratio	58.91

EC= Electrical Conductivity, TN = Total Nitrogen, OC = Organic Carbon, ECEC =Effective Cation Exchange Capacity, EA = Exchangeable acidity, and Av. P = Available Phosphorus

3.3. Influence of Biochar and NPK Fertilizer on the Height (cm) of Vegetable Amaranth

Table 1 shows the effect of varying rates of biochar and NPK fertilizer on plant height of amaranths at 3,4,5 and 6 weeks after sowing. 5t of bio char per hectare significantly produced the tallest plants compared to other treatments. At 3 weeks after sowing (WAS) 5t of bio char produced the tallest plants with the value of (50.77a) which had a significant difference among the means, and then followed by 1/2kg of NPK per hectare (47.29a), while the least in performance or the shortest plants at 3 weeks after sowing (WAS) were 0t of bio char (32.28c) and 0kg of NPK (39.56c) per hectare as control.

At 4 weeks after sowing (WAS), 5t/ha of bio char produced the best performing plants in term of height with the value of (54.00a), and then followed by 2.5t/ha of bio char (52.56a), while 0t/ha of bio char (37.11b) and 0kg/ha of NPK fertilizer (45.33b) produced the shortest plants, it was observed that there were no significant differences among the means when compared. At 5 weeks after sowing (WAS), 5t/ha of bio char (65.30a) produced the tallest plants, followed by 2.5t/ha of bio char (61.86a), while 1kg/ha of NPK (57.67ab) showed similarity between 5t/ha of bio char and control (0t/ha of bio char and 0kg/ha of NPK), 0t/ha of bio char produced shortest plants. There was a significant difference among the means in plant height at 5 weeks after sowing. At 6 weeks after sowing (WAS), 5t/ha of bio char (72.88a) produced the tallest plants, while 0t/ha of bio char (59.73c) produced the shortest plants. It was observed that at 6 weeks after sowing (WAS) there was no significant differences among the means, meaning that they were statistically similar.

Table 1: Plant height (cm) of vegetable amaranths as affected by Biochar and NPK fertilizer

Plant height	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
NPK 0kg/ha NPK	39.56c	45.33b	56.48b	65.58a
1/2kg/ha NPK	47.29a	51.78a	61.59a	68.53a
1kg/ha NPK	42.70b	46.56b	57.67ab	67.53a
BIOCHAR RATE 0T/ha BIOCHAR	32.28c	37.11b	48.58b	59.73c
2.5T/ha BIOCHAR	46.50b	52.56a	61.86a	69.03b
5T/ha BIOCHAR	50.77a	54.00a	65.30a	72.88a
SED	0.351	1.603	1.854	1.752
INTERACTIONS	**	NS	**	NS

Key: **= significant, NS= not significant.

3.4. Influence of Biochar and NPK Fertilizer on the Number of Leaves of Vegetable Amaranth

Table 2 shows the influence of bio char and NPK fertilizer on number of leaves of vegetable amaranths at 3,4,5 and 6 weeks after sowing (WAS). 5t/ha of bio char insignificantly produced the highest number of leaves per plants compared to other treatments. At 3 weeks after sowing (WAS) 5t of bio char produced the highest number of leaves per plant with the value of (15.22a), and then followed by 1/2kg of NPK per hectare (14.11a), while 1kg/ha of NPK had similarities between 5t/ha of bio char (15.22a) and 0t/ha (11.33b), 0t/ha of bio char (11.33b) and 0kg/ha of

NPK (12.67b) produced less number of leaves at 3 weeks of sowing (WAS), there was no significant differences among the means, meaning that they were statistically similar.

At 4 weeks after sowing (WAS), 5t of bio char produced the highest number of leaves per plant with the value of (22.33a), and then followed by 0kg of NPK per hectare (21.00a), while 1kg/ha of NPK had similarities between 5t/ha of bio char (22.33a) and 1/2kg/ha of NPK (19.78b), 0t/ha of bio char (19.11b) produced less number of leaves at 4 weeks after sowing (WAS), there was no significant differences among the means, meaning that they were statistically similar. At 5 weeks after sowing (WAS), 5t/ha of bio char produced the highest number of leaves per plant with the value of (24.78a), and then followed by 2.5t/ha of bio char (23.78a), while 0t/ha of bio char (18. 56b) produced less number of leaves at 5 weeks after sowing (WAS), there was no significant differences among the means. At 6 weeks after sowing (WAS), 2.5t/ha of bio char produced the highest number of leaves per plant with the value of (32.33a), and then followed by 5t/ha of bio char (28.78a), while 0t/ha of bio char (21.67b) produced less number of leaves at 6 weeks after sowing (WAS), it was observed that there were no significant differences among the means.

Table 2: Number of leaves of vegetable amaranths as affected by Biochar and NPK fertilizer

NO of Leaves	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
NPK 0%%NPK	12.67b	21.00a	21.56a	28.67a
50% NPK	14.11a	19.78b	23.67a	26.11a
100% NPK	13.78ab	20.22ab	21.89a	28.00a
BIOCHAR RATE 0T/ha BIOCHAR	11.33b	19.11b	18.56b	21.67b
2.5T/ha BIOCHAR	14.00a	19.56b	23.78a	32.33a
5T/ha BIOCHAR	15.22a	22.33a	24.78a	28.78a
SED	0.592	0.891	2.307	2.77
INTERACTION	**NS**	**NS**	**NS**	**NS**

Key: **= significant, NS= not significant.

3.5. Influence of Biochar and NPK Fertilizer on the Leaf Area (cm^2) f Vegetable Amaranth

Table 3 shows the influence of bio char and NPK fertilizer on leaf area of vegetable amaranths at 3,4,5 and 6 weeks after sowing (WAS). There was no significant influence of biochar and NPK fertilizer in both weeks. At 3 weeks after sowing (WAS), 5t/ha of bio char (50.62a) resulted largest leaf area, while 0t/ha of bio char (28.39b) resulted in smallest leaf area when compared with others. At 4 weeks after sowing (WAS), 5t/ha of bio char (73.63a) resulted largest leaf area, and 0t/ha of bio char (56.14b) resulted in smallest leaf area. At 5 weeks after sowing (WAS), 5t/ha of bio char (80.84a) produced the largest leaf area, while 0t/ha of bio char (66.39b) resulted in smallest leaf area. At 6 weeks after sowing (WAS), 2.5t/ha of bio char (165.0a) resulted in the largest leaf area among the treatments, while 0t/ha of bio char (95.8b) resulted in the lowest leaf area compared to other treatments.

Table 3: Leaf area (cm) of vegetable amaranths as affected by Biochar and NPK fertilizer.

Leaf Area	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
NPK	42.42a	62.74a	74.4b	109.2b
0% NPK				
50%NPK	42.29a	65.93a	75.1ab	154.4a
100%NPK	42.42a	67.16a	73.7b	161.3a
BIOCHAR RATE	28.39b	56.14b	66.39b	95.8b
OT/ha BIOCHAR				
2.5T/ha BIOCHAR	38.64b	66.07ab	75.95 ab	165.0a
5T/ha BIOCHAR	50.62a	73.63a	80.84a	164.1a
SED	5.47	5.71	4.72	17.46
INTERACTIONS	**NS**	**NS**	**NS**	**NS**

Key: **= significant, NS= not significant.

3.6. Influence of Biochar and NPK Fertilizer on the Plant Dry Weight (g) of Vegetable Amaranth

Data on plant dry weight at various treatments at 3,4,5 and 6 weeks after sowing (WAS) as affected by bio char and NPK fertilizer on vegetable amaranths was presented on table 4. There was significant difference in plant dry weight at 6 weeks after sowing (WAS). At 3 weeks after sowing (WAS), 5t/ha of bio char (9.000a) produced heaviest plants compared to other treatments, followed by 1/2kg of NPK per hectare (8.333a), while 0t/ha of bio char (4.111c) and 0kg of NPK per hectare (5.111c) produced the lowest plants, statistically it showed no significant difference among the means.

At 4 weeks after sowing (WAS), 5t/ha of bio char (15.22a) produced the heaviest plants, followed by 1kg of NPK per hectare (15.11a), while 1/2kg of NPK per hectare produced the lowest plants (14.11a), statistically it resulted in no significant difference among the means, meaning that they were statistically similar. At 5 weeks after sowing (WAS), 5t/ha of bio char (31.11a) resulted the heaviest plants, while 0t/ha of bio char (22.00b), produced the smallest plants among the treatment means, the result showed that there was no significant difference among the means. At 6 weeks after sowing (WAS), 5t/ha of bio char (40.11a) resulted in the heaviest plants, followed by 1kg/ha of NPK fertilizer (37.22a), while 0t/ha of bio char (26.33c) and 0kg/ha of NPK (30.67c) produced the lowest plants among the treatments, the result showed that there was significant difference among the m

Table 4: Plant dry weight (g) of vegetable amaranths as affected by Biochar and NPK fertilizer.

Dry Weight	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
NPK	5.111c	14.89a	24.78a	30.67c
0%NPK				
50%NPK	6.889b	14.11a	28.22a	34.56b
100%NPK	8.333a	15.11a	28.22a	37.22a
BIOCHAR RATE	4.111c	14.33a	22.00b	26.33c
0T/ha BIOCHAR				
2.5T/ha BIOCHAR	7.222b	14.56a	28.11a	36.00b
5T/ha BIOCHAR	9.000a	15.22a	31.11a	40.11a
SED	0.509	1.293	1.819	1.016
INTERACTION	**NS**	**NS**	**NS**	**

Key: **= significant, NS= not significant.

3.7. Influence of Biochar and NPK Fertilizer on the Stem Diameter (cm) of Vegetable Amaranth

Table 5 shows the effects of varying rates of biochar and NPK fertilizer on stem diameter of vegetable amaranths at 3,4,5 and 6 weeks after sowing (WAS). The result showed that 5t/ha of bio char produced the largest stem while 0t/ha of bio char 0kg/ha of NPK fertilizer resulted in the lowest stem diameter. Statistically there was no significant difference among the means.

Table 5: Stem diameter (cm) of vegetable amaranths as affected by Biochar and NPK fertilizer.

Stem diameter	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
NPK 0%NPK	0.9444a	1.156a	1.466b	1.711a
50% NPK	0.9889a	1.189a	1.488a	1.778a
100%NPK	0.9667 a	1.167a	1.543a	1.811a
BIOCHAR RATE 0T/ha BIOCHAR	0.8778b	1.089b	1.522a	1.600b
2.5T/ha BIOCHAR	0.9556b	1.089b	1.499a	1.844a
5T/ha BIOCHAR	1.0667a	1.267a	1.587a	1.856a
SED	0.0481	0.0464	0.0511	0.0585
INTERACTION	**NS**	**NS**	**NS**	**NS**

Key: **= significant, NS= not significant.

Plant weight (g)

Table 6 shows the influence of bio char and NPK fertilizer on the growth performance of amaranths on plant weight at 3,4,5 and 6 weeks after sowing (WAS). There was significant interaction in plant weight at 3 weeks after sowing (WAS).

At 3 weeks after sowing (WAS), 5t/ha of bio char (102.67a) produced the heaviest plants, while 0t/ha of bio char (72. 22b) and 0kg/ha of NPK (80.11b) produced the lowest plants among the means, the result showed that there was significant difference among the means.

At 4 weeks after sowing (WAS), 5t/ha of bio char (153.8a) produced the heaviest plants, while 0t/ha of bio char (100.8c) produced the lowest plants, and the result showed that there was no significant difference among the means. At 5 weeks after sowing (WAS), 5t/ha of bio char (193.9a) produced the heaviest plants, while 0t/ha of bio char (157. 8b) produced the lowest plants, statistically it showed no significant difference among the means. At 6 weeks after sowing (WAS), 5t/ha of bio char (326. 7a) produced the heaviest plants, while 0t/ha of bio char (269. 9b) produced smallest plants among the treatments, the result showed that there was no significant interaction.

Table 6: Plant weight (g) of vegetable amaranths as affected by Biochar and NPK fertilizer.

Plant weight	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
NPK	80.11b	115.3b	174.4a	302.7ab
0% NPK				
50% NPK	96.78a	130.2ab	181.2a	303.3ab
100%NPK	98.67a	143.9a	164.6a	303.1ab
BIOCHAR RATE	72.22b	100.8c	157.8b	269.9b
0T/ha BIOCHAR				
2.5T/ha BIOCHAR	100.67a	134.9b	168.6ab	312.6a
5T/ha BIOCHAR	102.67a	153.8a	193.9a	326.7a
SED	3.98	8.55	14.61	19.33
INTERACTION	**	**NS**	**NS**	**NS**

Key: **= significant, NS= not significant.

3.8. Influence on Interaction of Biochar and NPK Fertilizer on the Performance of Amaranths

Table 7 shows the influence of interaction between bio char and NPK fertilizer on the growth performance of amaranths at 3 weeks after sowing (WAS), the result showed that 5t/ha of bio char and 1/2kg of NPK fertilizer per hectare (53.17a) produced the highest performance, followed by 2.5t/ha and 1/2kg of NPK per hectare (51.67b), 5t/ha of bio char (51.43b) while 1kg/ha of NPK and 0t/ha of bio char produced shortest plants, statistically there was significant difference among the means ($p<0.05$).

Table 7: Plant height of vegetable amaranths as affected by interaction between Biochar andNPK fertilizer at 3 WAS.

Interaction on plant (cm) height at 3 WAS	**0T/ha BIOCHAR**	**2.5T/ha BIOCHAR**	**5T/ha BIOCHAR**
0% NPK	30.40e	36.83d	51.43b
50% NPK	37.03d	51.67b	53.17a
100%NPK	29.40e	51.00b	47.70c
SED		**0.351**	

Key: T= ton, SED= standard error of difference.

Table 8 shows the influence of interaction between Biochar and NPK fertilizer on the growth performance of amaranths at 6 weeks after sowing (WAS), 5t/ha of bio char and 1/2kg of NPK per hectare (68.60a) produced the tallest plants, while 2.5t/ha of bio char and 1kg/ha of NPK(65.93ab), 2.5t/ha of bio char and 1/2kg of NPK(65.03ab) per hectare showed similarity, and 1kg/ha of NPK fertilizer produced the shortest plants.

Table 8: Plant height (cm) of vegetable amaranths as affected by interaction between Biochar andNPK fertilizer at 6 WAS.

Interaction on plant height at 6 WAS	**0T/ha BIOCHAR**	**2.5T/ha BIOCHAR**	**5T/ha BIOCHAR**
0% NPK	48.50de	54.60cd	66.33ab
50% NPK	51.13de	65.03ab	68.60a
100% NPK	46.10e	65.93ab	60.97bc
SED		**1.854**	

Key: T=ton, SED= standard error of difference.

Table 9 shows the effects of interaction between bio char and NPK fertilizer on the growth performance of amaranths on plant dry weight at 6 weeks after sowing (WAS), 5t/ha of bio char and 1kg/ha of NPK fertilizer (43.67a) resulted in heaviest plants, followed by 5t/ha of bio char and 0kg/ha of NPK (40.33ab) which showed similarity between 5t/ha of bio char + 1kg/ha of NPK and 2.5t/ha of bio char + 1kg/ha of NPK fertilizer, while 0t/ha of bio char and 0kg/ha of NPK (16.33e) resulted in lowest plant weight.

Table 9: Plant dry weight (g) of vegetable amaranths as affected by interaction between Biochar andNPK fertilizer at 6 WAS.

Interactions on plant dry weight at 6 WAS	**0T/ha BIOCHAR**	**2.5T/ha BIOCHAR**	**5T/ha BIOCHAR**
0kg/ha NPK	16.33e	35.33c	40.33ab
1/2kg/ha NPK	31.33d	36.00c	36.33bc
1kg/ha NPK	31.33d	36.67b	43.67a
SED		**1.016**	

Key: T= ton, SED= standard error of difference

Table 10 shows the influence of interaction between bio char and NPK fertilizer on the growth performance of amaranths on plant weight at 3 weeks after sowing (WAS), 2.5t/ha of bio char and 1kg/ha of NPK fertilizer (117. 67a) produced the heaviest plants, followed by 5t/ha of bio char and 1/2 NPK fertilizer (114.67b) while 0t/ha of bio char and 0kg/ha of NPK fertilizer produced the lowest plants.

Table 10: Plant weight (g) of vegetable amaranths as affected by Biochar and NPK fertilizer at 3WAS.

Interaction on plant weight at 3 WAS	**0T/ha BIOCHAR**	**2.5T/ha BIOCHAR**	**5T/ha BIOCHAR**
0kg/ha NPK	62.67f	85.00d	92.67cd
1/2kg/ha NPK	76.33e	99.33c	114.67b
1kg/ha NPK	77.67e	117.67a	100.67bc
SED		**3.98**	

Key: T= ton, SED= standard error of difference.

Influence of bio char and NPK fertilizer on the growth performance of amaranths.

The growth performance of amaranth was significantly higher using Biochar at the rate of 5t/ha in (table 1) compared to NPK fertilizer in both 1kg/ha and 1/2kg/ha. Use of NPK fertilizer showed no significant variation in the growth performance of amaranth (table 1). Ammu, *et., al*

2017, reported that all the Biochar treatments produced more or similar yield. This showed the long term benefits of biochar in crop performance.

Based on the growth and yield performance of amaranth, there was no significant difference on number of leaves among the biochar and NPK interaction in (table 2), while Tenenbaum 2009, reported that combination of bio char and fertilizer showed a 60% increase over fertilizer alone. Leaf area and stem diameter showed no significant differences in all cases. (Mohammed D. 2016) reported that there was significant difference between stem girth of amaranths with respect to Nitrogen fertilizer.

It also has been hypothesized that the long term effect of bio char on nutrients availability was due to an increase in surface oxidation and cation exchange capacity (Liang et al., 2017). Biochar produced best performance and yield of amaranths at the rate of 5t/ha.

Influence of interaction between biochar and NPK fertilizer on the growth performance ofamaranths.

Combination of bio char and NPK fertilizer showed an increase of about 60% then when is applied alone on amaranths (Tenenbaum 2009). From the result obtained, 2.5t/ha of bio char in combination with 1/2kg per hectare of NPK resulted in 100% growth and yield performance of amaranths.

Limitations of the study

i. The research was conducted in the Sudan savannah agro-ecological zone of Nigeria, as such the research needs to be conducted in other agricultural zone.
ii. The research was only conducted during dry season; this does not take into consideration the effect of rainfall.

4. CONCLUSION

From the results obtained from this study, it can be concluded that application of biochar at the rate of 5t/ha gave significant influence on plant height, dry weight and fresh shoot yield of amaranths. Large quantity of NPK fertilizer obtained harm our plants. Thus the best rate of NPK seems to be 1/2kg/ha while biochar at the rate of 5t/ha.

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