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Effect of Biochar and Npk Fertilizer on Growth, Biomass Yield and Nutritional Quality of Kale (*Brassica Oleracea*) in a Derived Agro-Ecological Zone of Nigeria.

Oluwagbenga Dunsin[1], Christopher MuyiwaAboyeji[1], ArunaOlasebikanAdekiya [1], Morolake Omolola[1], Gideon Agbaje[1], and Anjorin Oluwaseun[1]

[1]Department of Crop & Soil Sciences, Landmark University, Omu-Aran, Kwara-State. Nigeria
Corresponding author's e-mail: dunsin.oluwagbenga@lmu.edu.ng

Abstract

A pot experiment was conducted at Landmark University Teaching and Research Farm Omu-aran, Kwarato evaluate the effect of kale to different levels of inorganic fertilizer and bio-activator in derived savanna.The investigated treatment (Kale) was subjected into five levels of NPK fertilizer viz: 0, 5, 10, 15 and 20 kg/m^{2}and 2 levels of biochar (0 and 200 t/ha). These were assigned randomly into four replicates and fitted into a 5 x 2 factorial experiment in a randomized complete block design. Data collected on the growth parameters, yield and quality attributes were analyzed using ANOVA.Plants were harvested at eight WAP. Number of leaf and plant height were measured weekly. After harvest, root length, fresh and dry weights were also determined.Results showed that treatment 6, biochar 200 t/ha + NPK 0 kg/m^2 (200, 0) has the tallest plant height at week 1, 3, 5 and 6 as well as yield parameters in root length, fresh and dry weights. Treatment 6 also gave the highest value amongst the minerals.Treatment 7, biochar 200 t/ha + NPK 5 kg/m^2 (200, 5) has the highest number of leaves at week 2, 4, and 6 after planting.Integration biochar 200 t/ha + NPK 10 kg/m^2 (200, 10) is recommended for cropping of kale in the guinea savanna zone of Nigeria.
***Keywords:** Kale, NPK Fertilizer, Biochar,Growth, Yield, Quality.*

INTRODUCTION

Vegetables are generally succulent parts of plants grown in gardens and consumed as a side dish with starchy staples. They are of special nutritional importance being sources of vitamins such as vitamin A precursors, Vitamin C, Vitamin K and ascorbic acid, minerals, dietary fibre, essential amino acids and to a lesser extent protein (Guarino, 1995).Several vegetable species abound in the world. Green leafy vegetables constitute an indispensable constituent of human diet in Africa generally and West Africa in particular (Chima and Igyor, 2007). Green leafy vegetables occupy an important place among the food crops as they provide adequate amounts of many vitamins and minerals for humans. They are rich sources of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorus (Fasuyi, 2006).

Kale a green leafy vegetable which belongs to the brassica family, along with other group of vegetables like cabbage, collards and brussels sprouts have recently attract a widespread attention due to their health promoting, sulphur-containing phytonutrients. Kale is a highly nutritious vegetable, rich in vitamins (Vitamin C and provitamin A), minerals, particularly iron, potassium, calcium and it can withstand drought and temperature of 10^o to 15^{o}C. (Fadigas*et al.*, 2010). Nowadays, kale attracted more attention due to its multifarious use and great nutritional value (Ahmad and Beigh, 2009). Its vegetable protein content (11.67%) is higher than that recorded by the USDA Nutrient Database for Standard Reference (Hall, 1998).Kale has a high nitrogen (N) requirement, so good nitrogen availability sustainable is a pre-requiste for economic yield. However, too much nitrogen can create problem. Plant supplied with an excess of nitrogen accumulate nitrate in their vacuoles (Onyango *et al*., 2012). It was reported that lack of some mineral components (phosphorus and potassium) in soil influenced the amount and quality of protein in vegetable (Eppendorfer and Soren 1996).

In tropical countries, high cost, scarcity, nutrient imbalance and soil acidity are problems associated with the use of inorganic fertilizer while bulkiness, low nutrient quality and late mineralization were the bottleneck to the sole use of organic manures for crop production (Uyovbisere and Elemo, 2000). Therefore there is need to identify and study cheap, locally sourced agricultural wastes that could enhance balance crop nutrition, improve nutrient availability and serve as liming material to control soil acidity in the production of leafy vegetables. An area of interest is the addition of bio-char to the soil, which can improve soil properties and have other environmental benefits (Glaser *et al.* (2002).

Biochar is the term given to pyrolyzed biomass (charcoal) when applied as a soil amendment intended to increase productivity or otherwise ameliorate soil properties (Lehmann *et al*., 2006). The potential of biochar to increase plant biomass and crop yields has been demonstrated in a number of tropical agricultural studies, with a recent meta-analysis of published studies finding that biochar treatments increased crop yields by an average of 10% with larger effects observed on acidic and coarse-textured soils, and at high addition rates (Jeffery *et al.,* 2011).
Kwara state has a huge potential of developing agriculture and absorb a sustainable fraction of the nation crop product deficit. Maximum yields are obtainable only when plant nutritional requirements and other basic production factors are met. The soils of Landmark University loses water fast, hence the need for the use of organic amendment to improve its water-holding capacity is inevitable. Recent reviews have highlighted the benefits of adding bio-char to agricultural soils for improvement of soil water-holding capacity (Laird *et al*., 2010). Thus experiment will evaluate the complementary use of NPK fertilizer with Biochar on the growth, yield and leaf quality Kale

MATERIALS AND METHOD

The study was conducted using pot experiment at Landmark University Teaching and Research Farm Omu-aran, Kwara State. The study area is located on latitude 8.1333N and longitude 5.1000S, with altitude of 506m above sea level of the Guinea Savannah zone of Nigeria. It has annual rainfall pattern which extends between the month of April and October with minimum 600mm-1500mm, with peak rain in May-June and September-October, while the dry season is between November and March.

Soil samples were collected from around the Teaching and Research Farm of Landmark University, Omu-Aran, Kwara State, sieved with 2-mm sieve to remove stones and debris. 5 kg of the sieved soils were weighed into a polybag perforated at the bottom to allow for air and water movement. The polybags were randomly placed laid out in open fieldfor unbiased application of treatments (amendments). The Vates Blue Curled Kale *(Brassica oleracea)* was purchased from Starke Ayres Ltd, Gauteng South Africa. The Biochar were collected from the Cafeteria Store of Landmark University and the NPK fertilizer were collected also from the Teaching and ResearchFarm of Landmark University, Omu-Aran, Kwara State, Nigeria.
The treatments consist of 5 levels of NPK fertilizer (0, 5, 10, 15 and 20 kg/m^2) and 2 levels of biochar (0 and 200 t/ha) subjected to various combination. A 5 x 2 treatments were layout in a factorial design experiment arranged in a Randomize Complete Block Design with four replications. Blue Vates Curled Kale (*Brassica oleracea*) was planted into the soil without applying any fertilizer. Three seeds per pot were sown directly into the soil of each pot.

Germination starts 4-5 days after planting. The plants were thinned to one plant per stand just before fertilizer application. Crop protection practices were carried out with spraying of karate at 2, 4 and 6 WAS against defoliating pests and weeding was done manually.
Data collection on the growth and yield began two weeks after planting subsequently on a weekly basis for two months. To evaluate growth rates, Plant height was measured with a meter ruler from the base to the tip of the main shoots and Number of leaves where recorded by counting the leaves. At harvest yield parameters collected includes leaf weight (fresh and dry) and root length.

After determination of fresh weight leaves, root and grains were dried in an oven at 60°C for 48 h. Dried samples were milled and ground for tissue analysisTotal P was determined by the Vanadomolybdate method, K and Ca were determined by flame photometry and Mg and Fe were determined by atomic absorption spectrophotometer. Total N was analyzed by the micro-Kjheldahl procedure and crude protein was obtained by multiplying the total N by a factor of 6.25. While Vitamin C was determined by method of Osborne and Voogt (1978).

Data collected were subjected to statistical analysis of variance (ANOVA) using SPSS 21. The treatment means were compared using the Duncan's multiple range test (DMRT) at p = 0.05 probability level.

RESULTS AND DISCUSSION

The result of biochar and NPK fertilizer solely and/or combination on kale plant height revealed there was significant differences (P< 0.05) amongst the treatment (Table 1). Treatment 6, has the highest plant height at week 1, 3, 5 and 6 after planting, followed by treatment 8 and compared to treatment 1(control) which has the lowest value in plant height.

Table 1: Effect of Biochar, NPK and Their Combination on Plant Height (Cm) of Kale

Treatment	Plant Height (cm) (WAP)					
	1	2	3	4	5	6
T1	1.90^{b}	2.35^{d}	4.80^{d}	7.10^{c}	11.00^{c}	14.00^{b}
T2	4.77^{a}	7.50^{a}	11.03^{ab}	13.93^{ab}	18.50^{ab}	21.10^{ab}
T3	1.78^{b}	2.33^{d}	5.50^{cd}	8.25^{bc}	14.00^{bc}	16.60^{ab}
T4	4.57^{a}	5.40^{bc}	8.67^{bc}	12.17^{bc}	16.00^{bc}	19.17^{ab}
T5	3.40^{ab}	5.25^{bc}	8.00^{bc}	13.25^{ab}	16.75^{bc}	19.25^{ab}
T6	4.80^{a}	6.00^{bc}	9.85^{ab}	15.00^{a}	20.50^{a}	22.00^{a}
T7	3.84^{ab}	5.55^{bc}	11.95^{a}	13.70_{ab}	18.00^{ab}	21.50^{a}
T8	4.73^{a}	6.55^{ab}	11.55^{a}	13.10^{bc}	18.50^{ab}	22.00^{a}
T9	2.90^{ab}	4.23^{c}	6.83^{c}	11.00^{bc}	13.73^{bc}	19.90^{a}
T10	3.60^{ab}	4.97^{bc}	9.33^{b}	11.47^{bc}	14.67^{bc}	18.57^{ab}

Means with the same letters in the same column are not significantly different at p>0.05.

Table 2. Shows that biochar and NPK fertilizer significantly (P< 0.05) affect the number of leaves amongst the treatment (Table 2). Treatment 7, has the highest number of leaves at week 2, 4, and 6 after planting, followed by treatment 6 and compared to treatment 1 (control) which has the lowest value in number of leaves.

Table 2: Effect of Biochar, NPK and Their Combination on Number of Leaves of Kale

Treatment	Number of Leaves Cultivation (WAP)					
	1	2	3	4	5	6
T1	2.00^{b}	3.00^{c}	5.00^{b}	6.33^{b}	8.00^{b}	10.00^{d}
T2	4.67^{a}	6.33^{ab}	9.00^{ab}	10.67^{ab}	14.00^{ab}	16.67^{b}
T3	2.67^{ab}	3.33^{bc}	5.00^{b}	6.67^{b}	8.33^{b}	11.00^{cd}
T4	3.67^{ab}	5.00^{b}	6.67^{ab}	8.33^{ab}	11.67^{ab}	14.67^{bc}
T5	3.67^{ab}	5.00^{b}	7.00^{ab}	9.33^{ab}	11.33^{ab}	13.00^{c}
T6	3.67^{ab}	7.00^{a}	8.67^{ab}	12.33^{ab}	17.67^{a}	19.67^{ab}
T7	4.00^{ab}	7.33^{a}	10.00^{a}	14.00^{a}	18.33^{a}	20.67^{a}
T8	4.33^{a}	6.67^{a}	8.67^{ab}	11.33^{ab}	15.67^{a}	17.67^{ab}
T9	3.00^{ab}	4.00^{bc}	5.33^{b}	8.33^{ab}	11.67^{ab}	15.33^{b}
T10	4.67^{a}	5.67^{b}	7.33^{ab}	9.67^{ab}	11.67^{ab}	14.33^{bc}

Means with the same letters in the same column are not significantly different at $p>0.05$.

Table 3 shows the effect of biochar and NPK on yield parameters of kale (root length, fresh weight and dry weight). There were significant differences ($P< 0.05$) amongst the treatment. Treatment 6 has the highest value of yield in root length, fresh weight and dry weight followed by treatment 8 respectively as compared to treatment 1 (control) which has the lowest value in the yield parameters.

Table 3: Effect of Biochar, NPK and Their Combination on the Root Length, Fresh and Dry weight of Kale.

Treatment	Yield	Weight	
	Root Length (CM)	Fresh	Dry
T1	6.85^{c}	15.89^{c}	1.59^{c}
T2	10.23^{b}	38.33^{ab}	5.20^{ab}
T3	7.60^{b}	27.81^{bc}	3.15^{bc}
T4	9.70^{b}	44.53^{ab}	6.33^{ab}
T5	8.00^{b}	34.62^{b}	4.74^{b}
T6	15.67^{a}	49.67^{a}	7.59^{a}
T7	10.05^{b}	41.65^{ab}	6.41^{ab}
T8	12.40^{ab}	45.02^{ab}	6.94^{a}
T9	8.83^{bc}	38.45^{ab}	5.34^{ab}
T10	10.60^{b}	31.74^{b}	4.66^{b}

Means with the same letters in the same column are not significantly different at $p>0.05$.

Mineral and Vitamin C Composition of Kale (*Brassica oleracea*)

The result of biochar and NPK fertilizer solely and/or combination on kale statistical composition revealed there was no significant differences amongst the treatment (Table 4). Treatment 6 has the highest value amongst the other treatments followed by treatment 8 in the composition of iron (Fe), Zinc (Zn), Potassium (K), Magnesium (Mg), Calcium (Ca), Phosphorus (P), Manganese (Mn) and Vitamin C compared to treatment 1 (control) which has the lowest value in the mineral composition.

Table 4: Effect of Biochar, NPK and Their Combination on Mineral and Vitamin C composition of Kale leave

Treatment	Minerals			Composition (mg/100 g)				
	Iron	Zinc	Potassium	Magnesium	Calcium	Phosphorus (ppm)	Manganese	Vitamin C
T1	0.23	0.379	16.15	0.16	2.4	33.64	0.15	4.8
T2	0.235	0.381	26.15	3.2	4.08	115.19	0.161	10.7
T3	0.24	0.38	22.56	1.28	5.12	121.01	0.16	6.6
T4	0.239	0.381	24.35	4.08	3.44	59.53	0.157	8.6
T5	0.234	0.382	21.53	3.2	2.88	113.43	0.156	11.5
T6	0.266	0.383	31.02	11.6	5.28	153.06	0.164	16.1
T7	0.247	0.381	28.46	6.64	4.56	92.65	0.16	12.1
T8	0.248	0.383	28.97	8.16	5.2	115.19	0.162	13
T9	0.244	0.381	25.38	5.52	4.4	114.67	0.158	11
T10	0.241	0.381	21.53	4.4	5.04	114.49	0.156	12.6

Proximate Composition of Kale (*Brassica olerecea)*

The proximate composition of kale was effected by biochar and NPK fertilizer solely and/or combination shown no significant differences amongst the treatments (Table 5). Treatment 6 had the highest value in the moisture (%), protein (%), ash (%), crude fibre (%) and fat (5) and followed by treatment 8 respectively compared to treatment 1 which has the lowest value in the proximate composition.

Table 5: Effect of Biochar, NPK and Their Combination onProximate composition of Kale (*Brassica olerecea)*

Treatment	Nutrient			Composition	
	Moisture (%)	Protein (%)	Ash (%)	Crude fibre (%)	Fat (%)
T1	8.69	10.25	5.51	4.26	2.15
T2	10.59	12.87	9.26	5.35	2.38
T3	10.75	13.01	7.48	6.18	2.83
T4	10.85	14.49	7.71	6.12	2.63
T5	11.59	16.07	9.13	7.67	2.48
T6	11.70	20.01	9.97	8.73	3.06
T7	11.01	10.40	6.42	5.95	2.31
T8	11.35	14.29	7.36	8.24	2.92
T9	11.32	16.28	8.89	6. 12	2.71
T10	11.18	14.89	8.13	5.97	2.83

NPK fertilizer application solely had no consistent significant effects on kale plant height at 1, 3, 5 and 6 weeks of growth. Consistent significant differences were however observed at 4 weeks of growth under biochar treatment solely and in combination with NPK fertilizer at different levels. At 6 weeks of growth, biochar treatment solely had tallest plants height than both solely NPK fertilizer and complementary application of biochar and NPK fertilizer. The highest kale number of leaves was recorded under complementary biochar 200 t/ha + NPK 5 kg/m^2 (200, 5). Although, there were no significant difference from that of biochar 200 t/ha + NPK 0 kg/m^2(200, 0) respectively. High value for root length, fresh and dry weights of kale were obtained by application of biochar 200 t/ha + NPK 0 kg/m2 (200, 0). This variation might be due to the improvement of soil water holding capacity Roe and Cornforth (2000). The application of biochar combined with NPK fertilizer also improved the yield of kale.

Kale was high in potassium (31.02 mg/100 g), magnesium (11.6 mg/100 g), phosphorus (153.06 ppm) and calcium (5.28 mg /100 g) based on the application of biochar 200 t/ha + NPK 0 kg/m2 (treatment 6). Kale was fairly low in zinc (2.16 mg/100 g), manganese (0.164 mg/100 g) and iron (0.266 mg/100 g) with the application of treatment 6, biochar 200 t/ha + NPK 0 kg/m2 which gave the highest value in this study.

Treatment 6 gave the highest value for vitamin C content (16.01 mg/100g) of kale recorded in this study was found to be lower than that (41 mg/100g) reported by Hall (1998). Ukam (2008) also recorded vitamin C values of *Gnetumafricanum* ("Afang") (113.20mg/100g), *Xanthosomasagitifolium*("AfiaNkukwo") (32.80 mg/100g), *Lasiantheraafricana*("Editan") (32.61mg/100g) and *Heinsiacrinita*("Atama") (22.95mg/100g).Though the result of this study showed lower vitamin C content of kale.

Biochar 200 t/ha + NPK 0 kg/m2 (200, 0) result revealed that kale has a high moisture content of 11.70%, 20.01% in protein, 9.97% in ash and 3.06% in fat.Treatment 6 also gave the highest value among other treatment in this study for crude fibre (8.73%) which was found to be lower that of some other Nigerian vegetables such as "Oha" (*Pterocarpussoyauxii*) 13.1%, "Nturukpa" (*Pterocarpussantalinoides*) 10.55%, "Okazi" (*Gnetumafricanum*) 24.6% (Ekumankama, 2008) but higher than that of *Telferiaoccidentalis*(2.3%) and *Piper guineense* (2.9%) (Mensah *et al.*, 2008). Kale has also been recognized as an excellent source of fibre, which is an important consideration for people who suffer from elevated cholesterol levels and in helping to cleanse the colon (Zhao *et al.*, 2007).

Kale can be grown better in soil amended with biochar but application rate should be considered. Kale plants grown in soil amended with biochar were shown a vigorous vegetative growth (plant height, root length, fresh and dry weights), high yield, improved mineral composition and high percentage in proximate composition comparing with application chemical fertilizer solely. Furthermore, kale produce with biochar products are expected to be healthy for human and may be more profitable than those from conventional production system. Further studies are needed to determine optimal rates of biochar for proper growth and production of kale.

Therefore due to the rising cost of fertilizer, integratingbiochar 200 t/ha + NPK 10 kg/m^2 (200, 10) is recommended for cropping of kale in the guinea savanna zone of Nigeria.

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