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Effects of Soil Amendment on Early Growth of Moringa Oleifera in Nasarawa State, Nigeria

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Abstract:
*In recent times, Moring aoleifera has gained a lot of popularity due to recent discovery of its usefulness to mankind resulting in rapid interest in growing of plant either for local or export purposes. It is highly nutritious and medicinal plant with great agricultural industrial and domestic uses. One factor required for optimum yield of the crop is adequate nutrient in the soil and its proper management. This can be achieved through incorporation of organic matter into the soil to improve the nutrient status in a sustainable manner. Therefore, the objective of the study is to determine the effect of combined application of Biochar and NPK 15:15:15 on growth performance of Moringa oleifera. Data obtained were subjected to statistical analysis using the analysis of variance. Means that were significantly different were separated using the Least Significant Difference (L.S.D. The research revealed Significant different on Leaf Number, Plant Height, Stem Girth) of Moring growth parameters. On Plant Height, T_7 = (Biochar16tons/ha 6.4kg + NPK120gs + Urea: 13.5gs) (8WAP) show significant difference (0.049**) at 1% level of significant compared to T_3 andT_4 that received only biochar at the rate of 8tons/ha and 16tons/ha and T_0 (control) which received neither biochar nor NPK 15:15:15 + Urea having the lowest Plant height. Furthermore, the study showed that application of biochar to soil increased soil pH of acidic soil and reduced leaching of Organic Carbon, Organic Matter, Nitrogen, Sodium, Potassium and Cations Exchange Capacity (C.E.C) compared to non-amended treatments. It could be recommended that biochar can be used as soil amendments to improved soil quality and crop productivity such as Moringa oleifera in a variety of soil.*

Keywords: *Moringa, bio char, amendments, soil, Nigeria*

1. Introduction

In recent times, *Moring aoleifera* has gained a lot of popularity due to recent discovery of its usefulness to mankind resulting in rapid interest in growing of plant either for local or export purposes (Yang and Chang, 2006). One factor required for optimum yield of the crop is adequate nutrient in the soil and its proper management. This can be achieved through incorporation of organic matter into the soil to improve the nutrient status in a sustainable manner. Thus, the objective of the research is to determine the effect of combined application of Biochar, NPK 15:15:15 on growth performance of *Moringa oleifera.*

2. Materials and Methods

*Experimental Site***:** The study was carried out at the research farm of Faculty of Agriculture, Nasarawa state University Keffi. Shabu-Campus, Nasarawa State. The location is situated at Latitude 08^0 33N, Longitude 08^0 32E, with mean elevation of 181.53m above sea level (Jayeoba, 2013).

2.1. Experimental Design and Materials

Experimental Material: Moringa oleifera viable seed was used for the study and combined applications of biochar were used. Soil sample was collected before and after combined application of Biochar and NPK 15:15:15, air dried, and sieve through a 2mm mesh and prepared for soil analysis.

*Biochar Production***:** Biochar was made from rice husk; the rice husk material undergoes a process called pyrolysis (low oxygen burning) which resulted to arrangement of biomass' molecules, yielding black biochar.

Experimental Design/ Layout and Treatments: Experiments was lay out in randomized complete block design (RCBD) Comprising nine (9) treatments and (3) three replicates. The total experimental plot is 4 m^2 (2 m x 2 m). The planting distance was intra row 50 cm and inter row 30 cm.

Data Analysis: Data obtained were subjected to statistical analysis using the analysis of variance. Means that were significantly different were separated using the Least Significant Difference (L.S.D.)

3. Results

3.1. Soil Analysis before Combined Application of Biochar and NPK 15:15:15

Table 1 shows the effect of biochar on physical and chemical properties of soil before combined application of biochar and NPK 15:15:15. In the result, T_5 (8ton/ha 3.2kg + NPK 120gs + Urea 13.5gs) has the highest Organic Carbon, Organic Matter and Magnesium, (1.76, 3.01, and 2.70) respectively, Similarly T_5 (8ton/ha 3.2kg + NPK 120gs + Urea 13.5gs) has the highest in Cation Exchange Capacity (CEC), (6.95). While, T_1 (NPK 15:15:15: 120gs + Urea: 13.5gs has the highest percentage in clay (8.5).

Trts	pH in $CaCl_2$	Tarts O.C	% O.M	% mol/	%N mol/	P mol/	K mol/	Ca mol/	Mg mol	Na meg/1	E.A	CEC B.S	% sand	% silt	% clay	%	T.C	in H_2O
T_0	6.64	6.38	1.66	2.77	0.34	3.60	0.31	3.60	2.52	0.21	0.17	6.68	97	90.1	3.4	7.9	Sand	
T_1	6.65	6.48	1.66	3.01	0.35	3.60	0.30	3.40	2.60	0.20	0.17	6.55	97	86.9	2.4	8.5	Sand	
T_2	6.65	6.46	1.68	2.77	0.34	3.60	0.31	3.40	2.50	0.20	0.16	6.68	96	86.1	2.4	7.8	Sand	
T_3	6.63	6.49	1.74	2.99	0.35	3.68	0.33	3.67	2.67	0.21	0.17	6.87	98	90.8	1.4	7.8	Sand	
T_4	6.63	6.40	1.70	2.96	0.35	3.61	0.31	3.42	2.52	0.22	0.17	6.71	97	86.6	2.4	7.8	Sand	
T_5	6.84	6.51	1.76	3.01	0.35	3.66	0.33	3.70	2.70	0.22	0.17	6.96	98	88.8	3.4	8.0	Sand	
T_6	6.84	6.51	1.75	3.00	0.35	3.60	0.30	3.58	2.50	0.20	0.17	6.68	97	88.8	3.5	7.6	Sand	
T_7	6.83	6.50	1.56	2.65	0.35	3.61	0.30	3.58	2.52	0.22	0.13	6.55	98	90.5	3.5	8.5	Sand	
T_8	6.86	6.65	1.75	3.55	0.34	3.66	0.31	3.60	3.00	0.22	0.17	6.87	98	86.6	3.5	8.6	Sand	

Table 1: Physio-Chemical Properties of Soil before Combined Application of Biochar and NPK 15:15:15 Amendment

3.2. Soil Analysis after Combined Application of Biochar and NPK 15:15:15

Table 2 shows the effect of biochar on physical and chemical properties of soil after application of combined biochar and NPK 15:15:15. In the result, it shows that T_1 (NPK 15:15:15: 120gs + Urea: 13.5gs), has the highest Organic Carbon (3.13) whileT_3 (Biochar 8tons/ha 3.2 kg) has the highest percentage of sand (89.8%). Therefore, the higher in pH in water, K, and CEC are recommended for plant growth (7.16, 0.41, and 8.19), respectively. However, T_4 (Biochar 16tons/ha 6.4kg) has the highest recommended pH in $CaCl_2$ (6.30) respectively.

Trts	pH O.C	pH O.M	% mol/	% mol/	%N mol/	P mol/	K mol/	Ca mol/	Mg mol	Na meg/1	E.A	CEC B.S	% sand	% silt	% clay	%	T.C	H_2O	in $CaCl_2$	in
T_0	6.80	6.19	1.82	3.12	0.42	3.78	0.36	4.28	2.61	0.25	0.33	7.5	96	88.8	3.4	7.8	Sand			
T_1	6.67	5.74	1.82	3.13	0.35	3.56	0.32	3.89	2.32	0.21	0.33	6.74	93	87.8	3.4	8.8	Sand			
T_2	7.16	6.43	1.82	3.12	0.56	4.36	0.41	4.62	2.86	0.30	0.17	8.19	92	87.8	3.4	8.8	Sand			
T_3	6.79	6.01	1.80	3.09	0.42	3.76	0.35	4.11	2.59	0.24	0.33	7.29	92	89.8	3.4	6.8	Sand			
T_4	7.04	6.30	1.80	3.09	0.49	4.21	0.39	4.20	2.60	0.27	0.17	7.46	93	88.8	4.4	6.8	Sand			
T_5	6.37	5.54	1.80	3.09	0.35	3.16	0.30	3.21	2.10	0.20	0.33	5.81	94	87.8	5.4	6.8	Sand			
T_6	6.67	5.98	1.80	3.09	0.35	3.57	0.32	3.89	2.32	0.22	0.33	6.74	93	87.8	5.4	6.8	Sand			
T_7	6.72	6.01	1.82	3.12	0.42	3.73	0.33	3.96	2.46	0.23	0.33	6.98	93	88.8	3.4	8.8	Sand			
T_8	6.13	5.17	1.82	3.12	0.28	3.11	0.28	3.11	2.08	0.18	0.50	5.65	94	88.8	3.4	7.8	Sand			

Table: 2 Physio-Chemical Properties of Soil after Combined Application of Biochar and NPK 15:15:15 Amendment

3.3. Effect of Combined Application of Biochar and NPK 15:15:15 on Leaf Number of Moringa

Table 3 showed the effect of combined application of biochar and NPK 15:15:15 on the leaves number of Moringa in 3WAP. T_7 of (16tons/ha6.4kg+NPK120gs+Urea:13.5gs) produce significantly higher number of leaves (9.33) at 3WAP less than<1% (0.009***), Compare to T_0 it has lowest leaf number (6.33). Similarly, at 4WAP up to 10WAP T_8 (Biochar 8tons/ha 3.2kg + NPK 240+ Urea: 27gs) has the highest leaves number of moringa, (13.33, 16.00, 18.67, 19.33, 19.67, 20.33, 20.67), are produce significantly at both 1% and less than <1% at 8WAP and 9WAP. Compare to T_0 it has lowest leaf number from 4WAP to 10WAP (7.67, 8.33, 8.67, 9.00, 9.33, 10.00, 10.33).

Treatment	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP
T_0 Control	6.33^{a}	6.33^{c}	7.67^{c}	8.33^{c}	8.67^{c}	9.00^{c}	9.33^{c}	10.00^{c}	10.33^{c}
T_1 NPK 15:15:15: 120gs + Urea: 13.5gs	6.50^{a}	7.50^{bc}	8.50^{bc}	10.50^{bc}	11.50^{bc}	12.00^{bc}	12.00^{bc}	13.00^{bc}	13.50^{bc}
T_2 NPK 15:15:15: 240gs + Urea: 27gs	6.333^{a}	8.00^{ab}	9.00^{bc}	10.33^{bc}	10.67^{bc}	11.67^{bc}	12.33bc	12.67^{bc}	12.67^{bc}
T_3Biochar 8tons/ha 3.2kg	6.33^{a}	8.00^{ab}	9.67^{bc}	12.67^{ab}	12.67^{bc}	13.33^{bc}	14.33^{b}	15.33^{b}	16.33^{ab}
T_4Biochar 16tons/ha 6.4kg	6.00^{a}	8.33^{ab}	9.33^{bc}	10.33^{bc}	11.00^{bc}	12.00^{bc}	12.00^{bc}	13.00^{bc}	13.00^{bc}
T_5 B 8tons/ha 3.2kg +NPK 120gs+Urea:13.5gs	7.00^{a}	9.00^{ab}	9.67^{bc}	10.67^{bc}	12.00^{bc}	12.67^{bc}	13.00^{bc}	13.67^{bc}	14.00^{bc}
T_6 B 16tons/ha 6.4kg + NPK 240gs +Urea:27gs	6.33^{a}	7.67^{bc}	8.67^{bc}	11.00^{bc}	12.00^{bc}	12.67^{bc}	12.67^{bc}	13.00^{bc}	13.33^{bc}
T_7 B 16tons/ha 6.4kg +NPK120gs+Urea:13.5gs	7.00^{a}	9.33^{a}	11.67^{ab}	13.33^{ab}	14.33^{ab}	15.00^{b}	15.33^{bc}	16.00^{b}	16.67^{ab}
T_8 B 8tons/ha 3.2kg + NPK 240+ Urea: 27gs	6.33^{a}	7.67^{ab}	13.33^{a}	16.00^{a}	18.67^{a}	19.33^{a}	19.67^{a}	20.33^{a}	20.67^{a}
Mean	6.461	7.981	9.72	11.46	12.39	13.07	13.41	14.11	14.5
Significance	0.499^{NS}	0.009***	0.028**	0.034**	0.027**	0.016**	0.008***	0.004***	0.010**
SE±	0.116	0.15	0.343	0.451	0.555	0.524	0.494	0.462	0.526
	NS	SG	SG	SG	SG	SG	SG	SG	SG

Table: 3 Effect of Combined Application of Biochar and NPK 15:15:15 on Leaf Number of Moringa oleiferaLam.plant

B = Biochar
WAP =Week after planting
NS= Not significant
SG = Significant

3.4. Effect of Combined Application of Biochar and NPK 15:15:15 on Plant Height of Moringa

Table 4 showed the effect of combined application of biochar and NPK 15:15:15 on the height of Moringa. In T_7= (16tons/ha 6.4kg+NPK120gs+Urea:13.5gs) (60.67^{a}, 76.67^{a}) produced the tallest plants at both 8WAP and 9WAP. Therefore, $T_{5=}$ (Biochar 8tons/ha3.2kg+ NPK120gs+Urea: 13.5gs) ($86.33^{a)}$ produced the tallest plant at 10WAP. The experiment also showed that at 2WAP, 3WAP, 4WAP, 5WAP, 6WAP, and 7WAP there was no significant difference among the various treatments in the height of the plants. This result reveals that among the various treatment combinations used, T_7 has better performance on plant heights compared to other treatments.

Treatment	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP
T_0 Control	8.00^{a}	13.67^{a}	18.33^{b}	22.00^{a}	24.33^{b}	30.33^{b}	33.67^{c}	36.67^{c}	45.67^{c}
T_1 NPK 15:15:15: 120gs + Urea: 13.5gs	8.00^{a}	14.00^{a}	20.50^{ab}	27.00^{a}	31.50^{ab}	37.00^{b}	46.00^{abc}	52.50^{abc}	60.50^{abc}
T_2 NPK 15:15:15: 240gs + Urea: 27gs	11.33^{a}	17.67^{a}	22.00^{ab}	31.33^{a}	34.67^{ab}	46.33^{ab}	54.33^{abc}	69.00^{ab}	81.67^{a}
T_3Biochar 8tons/ha 3.2kg	12.33^{a}	18.67^{a}	23.00^{ab}	27.33^{a}	31.33^{ab}	48.00^{ab}	54.00^{abc}	68.33^{ab}	77.67^{ab}
T_4Biochar 16tons/ha 6.4kg	10.67^{a}	17.00^{a}	22.67^{ab}	26.00^{a}	32.00^{ab}	43.33^{ab}	51.67^{abc}	63.33^{abc}	75.33^{ab}
T_5B8tons/ha3.2kg+NPK120gs+Urea:13.5gs	11.00^{a}	16.33^{a}	23.33^{ab}	30.00^{a}	39.67^{ab}	51.00^{ab}	60.67^{ab}	75.67^{a}	86.33^{a}
T_6 B 16tons/ha6.4kg+NPK240gs+ Urea:27gs	8.00^{a}	12.00^{a}	18.00^{ab}	24.33^{a}	32.67^{ab}	31.00^{b}	36.33^{bc}	44.00^{bc}	50.00^{bc}
T_7B16tons/ha6.4kg+NPK120gs+Urea:13.5gs	13.33^{a}	21.00^{a}	26.00^{a}	30.00^{a}	43.67^{a}	60.67^{a}	69.33^{a}	76.67^{a}	79.33^{a}
T_8B 8tons/ha 3.2kg + NPK 240+ Urea: 27gs	10.33^{a}	19.00^{a}	24.67^{ab}	31.33^{a}	37.67^{ab}	51.67^{ab}	62.00^{a}	75.00^{a}	83.67^{a}
Mean	10.33	16.59	22.06	27.7	34.17	44.37	52	62.35	71.13
Significance	0.304 NS	0.427 NS	0.276 NS	0.299 NS	0.219 NS	0.069 NS	0.049**	0.025**	0.024**
SE±	0.570	0.943	0.781	0.967	1.546	2.239	2.500	2.838	2.923
	NS	NS	NS	NS	NS	NS	SG	SG	SG

Table: 4 Effect of Combined Application of Biochar and NPK 15:15:15 on Plant Height of Moringa oleiferaLam.plant

B = Biochar
WAP =Week after planting
NS= Not significant
SG = Significant

3.5. Effect of Combined Application of Biochar and NPK 15:15:15 on Stem Girth of Moringa

Table 5 showed the effect of combined application of biochar and NPK 15:15:15 on the Stem Girth of Moringa. The result showed that at 2, 5, 6, and 10WAP, (0.787, 0.433, 0.129, and 0.099), there was no significance difference at both 1% and 5% percent.

But 3,7, 8, 9 WAP there was significant difference (0.010**, 0.010**, 0.044**, 0.012**) at 1% level of significant.

However, it is also revealed that at (4WAP) T2 (NPK 15:15:15: 240gs + Urea: 27gs) has the highest Stem Girth (2.00cm) significant difference at less than <1% (0.000***), Compare to T0 Control it has the lowest Stem Girth (1.00cm).

Treatment	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP
T_0Control	0.67^{a}	0.33^{b}	1.00^{b}	1.00^{a}	1.67^{ab}	1.67^{c}	1.67^{b}	2.00^{c}	4.00^{bc}
T_1 NPK 15:15:15: 120gs + Urea: 13.5gs	1.00^{a}	1.00^{a}	1.00^{b}	2.00^{a}	2.00^{ab}	3.00^{abcd}	3.00^{ab}	4.00^{abc}	6.00^{ab}
T_2 NPK 15:15:15: 240gs + Urea: 27gs	0.67^{a}	1.00^{a}	2.00^{a}	2.00^{a}	2.67^{ab}	3.33^{abc}	3.67^{ab}	4.33^{ab}	5.00^{abc}
T_3Biochar 8tons/ha 3.2kg	1.00^{a}	1.00^{a}	1.00^{b}	2.00^{a}	2.33^{ab}	2.67^{bcd}	3.67^{ab}	4.33^{ab}	5.33^{abc}
T_4Biochar 16tons/ha 6.4kg	1.00^{a}	1.00^{a}	1.00^{b}	1.67^{a}	2.00^{ab}	3.33^{abc}	4.00^{a}	5.00^{a}	5.67^{abc}
T_5B8tons/ha3.2kg +NPK120gs+Urea: 13.5gs	1.00^{a}	1.00^{a}	1.00^{b}	1.67^{a}	2.67^{ab}	3.33^{abc}	4.00^{a}	5.00^{a}	6.00^{ab}
T_6 B16tons/ha6.4kg+ NPK240gs+Urea:27gs	1.00^{a}	1.00^{a}	1.00^{b}	6.67^{a}	1.33^{b}	2.00^{cd}	2.67^{ab}	2.67^{bc}	3.33^{a}
T_7B16tons/ha6.4kg+NPK120gs+Urea:13.5gs	0.67^{a}	1.00^{a}	1.33^{b}	2.33^{a}	2.67^{ab}	4.33^{a}	4.67^{a}	6.00^{a}	6.67^{a}
T_8B 8tons/ha 3.2kg + NPK 240+ Urea: 27gs	0.67^{a}	1.00^{a}	1.00^{b}	1.67^{a}	3.00^{a}	4.00^{ab}	4.67^{a}	5.33^{a}	6.33^{ab}
Mean	0.85	0.93	1.15	2.33	2.26	3.07	3.56	4.3	5.37
Significance	0.787 NS	0.010**	0.000***	0.433 NS	0.129 NS	0.010**	0.044**	0.012**	0.099 NS
SE±	0.078	0.039	0.039	0.554	0.136	0.152	0.203	0.228	0.260
	NS	SG	SG	NS	NS	SG	SG	SG	NS

Table 5: Effect of Biochar and NPK 15:15:15 on Stem Girth of Moringa oleiferaLam

B = Biochar
WAP =Week after planting
NS= Not significant
SG = Significant

4. Discussion

The research showed that application of biochar to soil increased soil pH of acidic soil and reduced leaching of Organic Carbon, Organic Matter, Nitrogen, Sodium, Potassium and Cations Exchange Capacity (C.E.C) compared to non-amended treatments. Blackwell *et al.* (2009) reported that biochar can be used as soil amendments to improved soil quality and crop productivity in a variety of soil. The research revealed Significant different on Leaf Number, Plant Height, Stem Girth) of Moring growth parameters. On Plant Height, T_7 = (Biochar16tons/ha6.4kg + NPK120gs + Urea: 13.5gs) (8WAP) was significantly difference (0.049**) at 1% level of significant compared to T_3 andT_4 that received only biochar at the rate of 8tons/ha and 16tons/ha and T_0 (control) which received neither biochar nor NPK 15:15:15 + Urea having the lowest Plant height in Moringa plant. Kalpana *et al.* (2012) revealed that biochar improves plant growth and reduce nutrient leaching in red clay loam and sandy loam. Abdullahi *et al.* (2013) also reported that the application of NPK fertilizer significantly ($P<0.05$) increased the vegetative growth of moringa.

Table 3 revealed that the T_5 (8ton/ha 3.2kg + NPK 120gs + Urea 13.5gs) has the highest Organic Carbon, Organic Matter and Magnesium, (1.76, 3.01, and 2.70) respectively, Similarly, T_5 (8ton/ha 3.2kg + NPK 120gs + Urea 13.5gs) has the highest in Cation Exchange Capacity (CEC), (6.95). While T_1 (NPK 15:15:15: 120gs + Urea: 13.5gs has the highest percentage in clay (8.5), T_8 (Biochar 8tons/ha 3.2kg + NPK 240+ Urea: 27gs) has the highest in pH in $CaCl_2$ of (6.65) which may induce danger of trace elements. (Agbede, 2009). In comparison with the treatments with low rate had a high rate of leaching as well as that of T_0 with no application.

The variation in the reduction of leaching in the biochar treatment may be due to the rate of application or could be attributed to the rate of immobilization and slow decomposition of the material by the soil micro-organisms in the soil. It is supported by Lehman *et al.,* (2003) that biochar is an Organic Matter which is resistant to decomposition. The result also shows a significant change in Cations Exchange Capacity (C.E.C) and pH of the soil presented in Table 5.

5. Summary, Conclusion and Recommendation

5.1. Summary

Moringa (*Moringa oleifera* Lam.) is said to be native to India, Pakistan and produced widely round the world, especially throughout the tropical belt. The result showed significant difference on growth parameters such as plant height, leaf number, leaf area and stem girth at all stage of development.

5.2. Conclusion and Recommendation

In the study, application of NPK 15:15:15 inorganic fertilizer and biochar significantly stimulated the growth of moringa seedlings, therefore biochar and NPK 15:15: can be used solely or complementarily to produce vigorous and healthy moringa. Incorporation of biochar into degraded soil impro**v**ed the soil nutrients status due to the fact the biochar inherently contains significant amount of plant nutrients (such as Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium respectively), it also prevents leaching of soil Organic Carbon, Organic Matter, Cartion Exchange Capacity (C.E.C), Base Saturation and soil Microbial activities.

It can therefore be recommended that combination of NPK and biochar at 16t ha^{-1} and 64kg ha^{-1} respectively is necessary for effective growth and development of Moringa.

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