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# Influence of cocoa pod husk biochar fortified with different forms of NPK fertilizer on the growth and dry matter yield of Kola seedlings in Ibadan, Nigeria

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**Abstract**
A greenhouse trial was carried out at Cocoa Research Institute of Nigeria, Ibadan in 2013 to evaluate the influence of cocoa pod husk biochar (CPHB) fortified with NPK fertilizer formulations on the growth and dry matter yield of kola seedlings. The treatments consisted of a control, NPK (3g) + biochar (5g), NPK (Liquid – 3 mlslitre-$^{1}$ of water: T3) + biochar (5g), biochar (5g), NPK (solid-3g), NPK (liquid - 3mls litre-$^{1}$ of water). The six treatments were replicated three times in a completely randomized design (CRD) and data on growth of kola seedlings were taken for seven months. Results showed that all the fertilizers irrespective of rates of application and types of NPK formulations enhanced the growth parameters relative to control. CPHB in combination with NPK (Solid) significantly ($p < 0.05$) enhanced the height and stem diameter of kola seedlings at 1 month after planting (MAP) compared to CPH biochar amended with liquid NPK (T3) and CPH biochar alone. At 4 MAP, the influence of CPHB amended with NPK (solid) on kola seedlings significantly ($p < 0.05$) increased the plant height compared to CPH biochar and NPK liquid applied separately. The root dry matter yield (RDMY) was significantly ($p < 0.05$) enhanced by biochar applied solely compared to NPK (solid) applied alone. The positive influence of CPH biochar applied either solely or in combination with NPK fertilizers on the growth and dry matter yield of kola seedlings indicated that integrated use of CPH biochar along with inorganic fertilizers holds the ace for kola production and the soil fertility management in Nigeria.

**Keywords: Biochar, dry matter yield, growth, Kola seedlings, NPK fertilizer.**

## INTRODUCTION

Kola is a tropical African genus that belongs to the family Sterculiaceae and has long history in West Africa (Opeke, 2005). *Cola nitida and Cola acuminata* are the two major cultivated species in Nigeria and have both local and industrial uses (Quarcoo, 1974; Van Eijatteen, 1964). Despite the strong cultural importance of kola in West Africa, research interest on the crop has been very tardy. However, *C. nitida* had gained better attention in terms of research work in Nigeria compared with *C. acuminata* because of its greater economic importance.

Poor field survival and yield are major bane to Kola expansion and production in Nigeria (Oduwole, 2012; Ojo and Ehinmowo, 2010). Farmers do not open up new plantations for kola due to the problem of poor survival in the field. Most Kola farmers concentrate their efforts on the management of old plantations thus making the possibility of expanding the Kola hectarage in Nigeria to be very low. It is a known fact that the existing kola plantations in Nigeria are shrinking on annual basis due to urbanization, competition with other preferred crops of the farmers (Oduwole, 2012). Hence, there should be a deliberate effort at arresting this negative trend by the use of fertilizers (organic and inorganic) to enhance the growth of the crop.

The use of fertilizer on kola at seedling stage or fruiting stage has not received much research attention probably because previous attempts indicated that the crop did not show consistent response to fertilizer application (Ayodele, 1983). The response of kola to fertilizer application in terms of yield and growth had been very inconsistent and this makes kola research unattractive to most Scientists (Ayodele, 1983). However, the previous efforts were concentrated on the use of inorganic fertilizer such as NPK 15-15-15, urea, MOP and SSP. Over the years, little effort had been made on the use of organic fertilizer for kola cultivation. The use of organic fertilizers either as compost or biochar to promote the growth and productivity of kola can be encouraged.

Biochar is a carbon-rich product obtained when a biomass wood or crop residues is heated in a closed container with little or no oxygen (Lehmann and Joseph, 2009). Biochar is important for supplying organic materials for soil fertility improvement, adsorption of applied mineral fertilizers, converting them into organic form, stabilization of soil organic matter as Biochar is very stable in the soil and improves crop productivity.

In Cocoa Research Institute of Nigeria (CRIN), very few systematic fertilizer trials on kola have been conducted. Previous trials on fertilizers indicated that only potassium increased the yield of kola by 7.5%. However, Egbe *et al.* (1989) reported the results of a $2^3$ NPK factorial trial on ramets and showed that PK produced more pods than NPK, N, NP and NK applied alone. Ayodele (1983), reported that P, K, NK and PK treatments had higher average yields than the control on ramets. Afolami and Egbe, (1984) reported that N rather than increasing yield when used alone, it depressed yield. The use of P, K, NP, KP and NPK has also been reported to have no significant effect on yield while NK increased the yield of the nuts. Recent trials on the use of organic fertilizers by Ipinmoroti, *et al.* (2009) indicated positive responses of kola seedlings to organic fertilizer. The present effort will involve the use of different NPK fertilizers (solid and liquid) in combination with biochar made from cocoa pod husk on the growth and dry matter yield of kola seedlings in the greenhouse.

## MATERIALS AND METHODS

A greenhouse trial was carried out at Cocoa Research Institute of Nigeria, Ibadan in 2013 to evaluate the effect of CPH biochar amended with NPK fertilizer formulations on the growth and dry matter yield of kola seedlings in Ibadan, Southwestern Nigeria. The six treatments consisted of a control ($T_1$), Biochar (5g) +

NPK (3g) ($T_2$), Biochar (5g) + NPK (Liquid – 3 mlsL-[1] of water ($T_3$), Biochar (5g) ($T_4$), NPK Solid (3g) ($T_5$) and NPK Liquid (3 mlsl-[1] of water) ($T_6$). The NPK liquid fertilizer contains 20: 2: 4 + TE while the solid NPK fertilizer contains 15:15:15. The CPH Biochar contained 1.55, 0.58, 6.86, 1.42, 0.64, 3.28 and 12.78 % respectively for N, P, K, Ca, Mg, Na and organic C (Ogunlade *et al*. 2011). The six treatments were replicated three times in a completely randomized design (CRD) and data on growth of kola seedlings were taken for seven months. The kola nuts used for the trial were induced using incision method with very sharp blade and pre-germinated in the germinator for sixty days before they were transferred into five-litre plastic buckets filled with top soil (0 – 30 cm) collected from the old kola plots within the Institute The liquid NPK fertilizer was foliarly applied by spraying on kola leaves fortnightly while the solid fertilizer was applied in a ring form 5 cm away from the base of the seedlings. Watering was carried out thrice per week throughout the period of the trial.

The sub-samples of the soil were analyzed for both physical and chemical properties according to International Institute of Tropical Agriculture Manual (IITA, 1982). The soil samples were air-dried, ground and sieved using 2.0 mm mesh. Soil pH was measured in water (1:1). Particle size distribution was carried out using the hydrometer method; while organic carbon was determined using chromic acid method. The regular microkjehldal method was used to analyze for total nitrogen. Available P in the soil was determined using ascorbic acid method. The Cation Exchange Capacity (CEC) of the soil was determined by using pH 7.0 buffer solution of calcium ammonium acetate, while EDTA titration was used to measure $Ca^{2+}$, $Mg^{2+}$ and $K^{+}$.

Analysis of variance was performed on the number of leaves, number of branches, plant height, stem diameter and dry matter yield using a GenStat 8th Edition. Least Significant difference ($p<0.05$) was used to separate the means.

## RESULTS AND DISCUSSION

The physical properties of the soil indicated that the sand, silt and clay fractions were 694, 150 and 156 g/kg soil respectively (Table1). The soil is sandy loam. The clay + silt content of 306 g/kg soil were sufficient to hold enough water for sustainable kola plant growth and could guard against short duration drought (Ipinmoroti *et al.* 2009). The pH, organic carbon, total N and available P were 6.66, 1.81 g/kg, 0.65 g/kg and 8.87 mg/kg soil respectively. The exchangeable cations, $K^{+}$, $Ca^{2+}$ and $Mg^{2+}$ of the soil were 0.67, 2.1 and 2 cmol/kg soil respectively. The pH of the soil was adequate for kola production; however the soil was marginal in terms of the compositions N, P and K compositions (Egbe *et al*.1989).

CPH biochar amended with NPK (Solid) ($T_2$) significantly ($p < 0.05$) enhanced the height of kola seedlings at 1 Month After Planting (MAP) compared with CPH biochar combined with liquid NPK ($T_3$) and CPH biochar (Table 3). The significant increase in kola seedling height arising from CPH biochar fortified with NPK (solid) fertilizer relative to control at 1MAP was attributed to the combined beneficial effects of organic and NPK fertilizer which probably enhanced the mineralization of organic nutrients and subsequent availability of more nutrients. This is consistent with the earlier result of Akanbi *et al.* (2012) and Adeniyan and

Ojeniyi (2005) who recorded higher crop performance due to integrated application of organic manure and mineral fertilizer. NPK gave superior seedling height compared with CPH biochar combined with liquid NPK fertilizer ($T_3$). However, at 3, 5, 6 and 7 MAP, the influence of NPK fertilizer formulations and CPH biochar was not significant on the height of kola seedlings. This shows that the liquid fertilizer (NPK) gave comparable effect on the growth of kola seedlings with NPK solid. This may be due to its quick absorption by the kola seedlings than when applied in solid form.

At 4MAP, the influence of CPH biochar amended with NPK solid significantly ($p < 0.05$) increased the height of Kola seedlings compared to CPH biochar and NPK liquid applied separately. At 7MAP, the height of Kola seedling ranged from 59 to 73cm in CPHB amended with NPK liquid ($T_{3)}$ and NPK liquid alone ($T_{6)}$ respectively.

**Table 1: Physical and chemical characteristics of Onigambari-Ibadan soil**

| Soil Properties | Unit | Value |
|---|---|---|
| Physical | | |
| Sand | $gkg^{-1}$ | 694.00 |
| Silt | “ | 149.55 |
| Clay | “ | 156.45 |
| Textural class | | Sandy loam |
| Chemical | | |
| $pH(H_2O)$ 1:1 | - | 6.66 |
| Organic carbon | $gkg^{-1}$ | 1.81 |
| Total Nitrogen | “ | 0.65 |
| Available phosphorus | $mgkg^{-1}$ | 8.87 |
| Exch. Bases | | |
| $K^+$ | $cmolKg^{-1}$ | 0.67 |
| $Ca^{2+}$ | “ | 2.07 |
| $Mg^{2+}$ | “ | 2.01 |
| $Na^+$ | “ | 0.55 |
| Exch. Acidity | | |
| $Mn^{2+}$ | $mgkg^{-1}$ | 0.03 |
| $Al^{3+}$ | “ | 0.13 |
| $H^+$ | “ | 0.04 |
| ECEC | “ | 5.14 |
| Base saturation | % | 96.76 |

**Table 2: Height of Kola seedlings as affected by NPK fertilizer formulations and CPH biochar**

| Treatments | Plant height (cm) Months after planting | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Control | 28.50 | 31.00 | 40.90 | 47.70 | 48.60 | 52.40 | 67.20 |
| Biochar (5g) + NPK (Solid) | 36.20 | 42.00 | 47.90 | 57.20 | 55.70 | 59.00 | 70.50 |
| Biochar(5g)+NPK (Liquid) | 22.80 | 26.70 | 38.10 | 48.30 | 48.90 | 54.70 | 73.90 |
| Biochar (5g) | 22.70 | 30.50 | 37.00 | 41.20 | 44.90 | 45.50 | 60.50 |
| NPK (Solid) | 31.80 | 35.90 | 43.00 | 46.10 | 48.30 | 49.10 | 64.20 |
| NPK (Liquid) | 29.30 | 30.30 | 37.00 | 40.50 | 45.00 | 45.80 | 59.20 |
| LSD ($p<0.05$) | 11.64 | 13.58 | ns | 12.28 | ns | ns | ns |

CPH biochar amended with NPK solid ($T_2$) fertilizer significantly ($p < 0.05$) increased the stem diameter of Kola seedlings at 1 MAP compared with CPH biochar amended with NPK liquid ($T_3$) and CPHB alone ($T_4$). This observation was consistent with earlier findings of Ipinmoroti *et al*. (2006) in which organic fertilizer amended with NPK fertilizer enhanced the growth of maize. However, the stem diameter of Kola seedlings was not significantly ($p<0.05$) affected by CPH biochar when applied solely ($T_4$) or amended either with solid or liquid NPK fertilizer formulation.

At 7 MAP, the stem diameter of kola ranged from 0.93 to 1.19 cm in NPK liquid and the control ($T_1$) respectively. Fertilizer application seems to confer depressive effect on the stem diameter of kola seedlings at 7 MAP. This might be due to limited soil volume of five kilogrammes.

The effect of NPK (liquid) fertilizer ($T_6$) significantly ($p < 0.05$) promoted the number of leaves per kola seedling compared with Biochar amended with NPK liquid fertilizer ($T_3$) at 1 and 3 MAP respectively. However, at 2 and 4 MAP, NPK fertilizer formulation did not significantly affect the number of leaves of kola seedlings (Table 4). CPH biochar amended with liquid NPK ($T_3$) consistently gave the least values on the number of leaves per plant at 2 and 4 MAP. Similar trend was observed at 6 and 7 MAP. Conversely, at 5 MAP, the number of leaves of kola seedlings was significantly ($p < 0.05$) enhanced as a result of NPK liquid fertilizer ($T_6$) compared to CPH biochar amended with liquid NPK ($T_3$) and CPH biochar alone. At 7 MAP, the number of leaves ranged from 29 to 39 per plant in NPK liquid fertilizer ($T_6$) and CPH biochar alone ($T_4$).

**Table 3: Stem diameter of Kola seedlings as affected by NPK fertilizer formulations and CPH biochar**

| Treatments | Stem Diameter (cm) Months After planting | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Control | 0.50 | 0.52 | 0.59 | 0.68 | 0.78 | 0.82 | 1.19 |
| Biochar (5g) + NPK (Solid) | 0.52 | 0.55 | 0.65 | 0.76 | 0.83 | 0.87 | 1.16 |
| Biochar(5g)+NPK (Liquid) | 0.39 | 0.50 | 0.63 | 0.74 | 0.76 | 0.82 | 1.14 |
| Biochar (5g) | 0.41 | 0.53 | 0.56 | 0.64 | 0.73 | 0.73 | 1.11 |
| NPK (Solid) | 0.45 | 0.49 | 0.59 | 0.65 | 0.70 | 0.78 | 1.30 |
| NPK (Liquid | 0.47 | 0.58 | 0.56 | 0.64 | 0.69 | 0.74 | 0.93 |
| LSD ($p < 0.05$) | 0.09 | ns | ns | ns | ns | ns | ns |

The leaf area of kola seedlings was not significantly affected by the application of NPK fertilizer formulations and CPH biochar. At 7 MAP, the leaf area ranged from 101 to 142 $cm^2$ in NPK solid fertilizer ($T_5$) and CPH biochar amended with liquid fertilizer. CPH biochar amended with either liquid or solid NPK fertilizers tended to promote the leaf area of kola better than the control (Table 5). This observation is supported by Ayeni *et al*. (2012), Olaniyi and Oyelere (2012) in their works on comparative effects of organic, organo-mineral fertilizers and other fertilizer types on growth, yield, nutrient uptake of okra and fluted pumpkin respectively. The improvement in the kola plant vegetative parameters as influenced by the combination of biochar and NPK fertilizer types may be due to heightened microbial activities resulting from the mineralization of immobilized nutrients in the material and vegetative growth due to N application respectively, this is in agreement with Omar, (2013) who reported that combined application of organic and inorganic fertilizer increased the yield of maize more than either farm yard manure alone or NPK fertilizer alone. The leaf area of kola seedlings is in the order of NPK (liquid) + biochar >biochar > NPK+ biochar >NPK liquid > control>NPK (solid).

The number of branches of kola seedlings was not significantly affected by CPH Biochar amended with either solid or liquid NPK fertilizers at 1 to 6 MAP (Table 5). Kola seedlings did not branch profusely at young age but the number of branches ranged from 1 – 2 plant-$^1$. However, at 7 MAP, NPK solid ($T_5$) applied sole significantly ($p < 0.05$) promoted branching of Kola seedlings compared with other treatments combinations of NPK+ biochar, NPK (liquid)+biochar and biochar sole.

The leaf and stem dry matter yield of kola seedlings were not significantly affected by NPK formulations and CPH biochar at 7 MAP. The leaf dry matter yield (LDMY) ranged from 12 to 18g/plant in control ($T_1$) and biochar ($T_4$) while the stem dry matter yield (SDMY) ranged from 12 to 16g plant-$^1$ in NPK solid ($T_5$) and the control ($T_1$) respectively. However, the root dry matter yield (RDMY) was significantly ($p<0.05$) enhanced by Biochar applied solely to kola seedlings compared with

NPK (solid) applied alone. This result is consistent with the findings of Fagbenro *et al*. (2013) in which biochar improved the growth and dry matter yield of *Moringa oleifera* seedlings. This also agrees with the findings of Adejobi *et al*.(2015) that fresh and dry matter root weight of cocoa seedlings were significantly ($p<0.05$) enhanced by organic fertilizers of plant origin.

This might be due to the presence of some vital elements such as Ca, Mg, OC and other micronutrients which are present in the biochar and are required for good seedling growth but these however are absent in the NPK fertilizer.

**Table 4: Influence of NPK fertilizer formulations and CPH biochar on number of leaves (NL) of Kola seedlings**

| Treatments | Number of leaves<br>Months after planting<br>1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Control | 6.71 | 8.33 | 11.33 | 17.33 | 18.50 | 23.00 | 36.70 |
| Biochar (5g) + NPK (Solid) | 7.50 | 8.83 | 12.00 | 16.33 | 17.67 | 21.70 | 30.70 |
| Biochar(5g)+NPK (Liquid) | 3.67 | 5.33 | 9.67 | 11.83 | 15.33 | 21.00 | 35.00 |
| Biochar (5g) | 5.67 | 7.00 | 10.67 | 14.67 | 17.00 | 21.50 | 30.20 |
| NPK (Solid) | 8.33 | 9.17 | 15.17 | 16.50 | 20.20 | 23.30 | 39.20 |
| NPK (Liquid | 8.67 | 8.17 | 14.33 | 17.17 | 22.50 | 24.50 | 29.20 |
| LSD ($p < 0.05$) | 2.46 | ns | 4.25 | ns | 4.84 | ns | ns |

**Table 5: Influence of NPK fertilizer formulations and CPH biochar on leaf area ($cm^2$) (LA) of kola seedlings**

| Treatments | Leaf area ($cm^2$)<br>Months after planting<br>1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Control | 126.60 | 119.00 | 164.00 | 185.00 | 206.00 | 163.90 | 108.20 |
| Biochar (5g) + NPK (Solid) | 118.60 | 121.00 | 206.00 | 200.00 | 189.00 | 157.60 | 127.70 |
| Biochar(5g)+NPK (Liquid) | 142.70 | 136.00 | 300.00 | 282.00 | 267.00 | 204.90 | 142.40 |
| Biochar (5g) | 117.40 | 123.00 | 221.00 | 227.00 | 211.00 | 197.10 | 135.20 |
| NPK (Solid) | 125.00 | 119.00 | 157.00 | 168.00 | 153.00 | 142.60 | 101.60 |
| NPK (Liquid) | 97.60 | 133.00 | 177.00 | 213.00 | 148.00 | 122.20 | 119.70 |
| LSD ($p < 0.05$) | ns | ns | ns | ns | ns | ns | ns |

**Table 6: Influence of NPK fertilizer formulations and CPH biochar on number of branches (NB) of Kola seedlings**

| Treatments | Number of Branches Months after planting | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Control | 1.00 | 1.22 | 1.00 | 1.33 | 1.17 | 1.50 | 2.17 |
| Biochar (5g) + NPK (Solid) | 2.00 | 1.12 | 1.66 | 1.43 | 1.95 | 1.31 | 0.77 |
| Biochar(5g)+NPK (Liquid) | 2.50 | 1.12 | 1.33 | 1.08 | 2.23 | 0.84 | 1.33 |
| Biochar (5g) | 2.00 | 1.00 | 1.83 | 1.58 | 2.23 | 2.66 | 1.83 |
| NPK (Solid) | 2.50 | 1.12 | 2.46 | 1.83 | 2.23 | 1.41 | 3.61 |
| NPK (Liquid | 2.00 | 1.12 | 1.67 | 1.33 | 1.89 | 1.67 | 2.33 |
| LSD ($p < 0.05$) | ns | ns | ns | ns | ns | ns | 1.65 |

**Table 7: Effect of NPK fertilizer formulations and CPH biochar on Dry matter yield (g) of Kola seedlings**

| Treatments | Dry matter yield | | |
|---|---|---|---|
| | LDW (g) | SDW (g) | RDW (g) |
| Control | 12.50 | 15.80 | 12.83 |
| Biochar(5g)+ NPK (Solid) | 14.00 | 13.20 | 16.73 |
| Biochar(5g)+NPK ( liquid) | 16.40 | 15.20 | 17.69 |
| Biochar (5g) | 17.80 | 13.00 | 19.47 |
| NPK (Solid) | 11.80 | 11.90 | 10.14 |
| NPK (Liquid | 14.20 | 13.10 | 14.74 |
| LSD ($p<0.05$) | ns | ns | 7.23 |

LDW-leaf dry weight, SDW- stem dry weight, RDW- root dry weight

**Conclusion:**

The improved growth and drymatter yield of kola seedlings through the use of CPH biochar applied either solely or in combination with NPK (liquid) fertilizers provides alternative fertilizer options to farmers as a means of promoting kola productivity.

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