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Growth response of cashew seedlings to applied organic fertilizers of animal and plant origin on a degraded soil in Ibadan, South-West, Nigeria

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Abstracts

A greenhouse experiment was conducted at Cocoa Research Institute of Nigeria (CRIN), Ibadan to compare the response of cashew seedlings to organic fertilizers of both animal and plant origin for six months. The treatments which consisted of control (CTRL) and four organic fertilizers materials namely cocoa pod husk ash (CPHA); kola pod husk ash (KPHA); poultry dung manure (PDM) and cow dung manure (CDM) were applied to supply 10kgN/ha respectively and laid out in a completely randomized design (CRD) in three replications. Result indicated that all the fertilizer materials irrespective of sources consistently and significantly (p> 0.05) increased all the growth parameters considered. Fresh and dry matter yield of the cashew plants were also improved significantly relative to control. The total dry matter yield (TDMY) of cashew seedlings as increased by PDM, CPHA, CDM, and KPHA were 62.07; 56.21; 44.1 and 38.08% respectively. Similarly, the percentage increases in plant height ranged between 5.99 – 36.66%. It could therefore be concluded that optimal and sustainable growth performance of cashew seedlings can be attained by the use of organic fertilizer materials especially those of PDM and CPHA rather than total dependence on costly and scarce chemical fertilizers.

Keywords: Cashew, organic fertilizers, soil and plant origin.

INTRODUCTION

Cashew is a prime tree crop of economic importance in Nigeria where more than 65% of the farming families who are small holder farmers depends on the crop as a major source of income (CBN, 2005; Aikpokpodion, *et al*., 2009). As an important commodity crop with great potentials as foreign exchange earner and source of industrial raw materials with the prospect of becoming a major commercial tree crop in Nigeria, cashew production in Nigeria has been bedeviled by a number of problems ranging from years of abandonments due to poor apple and nut pricing, urbanization, conversion of cashew field to other profitable agricultural uses (arable farming, poultry keeping e. t. c) and poor soil. Although, cashew grows very well on wide range of soils irrespective of their textural, structural and fertility status, its survival and establishment however is often affected by poor soils (Topper, 2001). It has been reported that cashew requires fertile soils and needs soil fertility amendment like other tree crops in order to produce nuts and apples economically. It has also been confirmed that most soils found to support cashew production in Edo, Delta, Ondo and Oyo states were formed from igneous and metamorphic rocks of basement complex, Imo, Anambra, Enugu and Abia soils were found to be of false bedded sandstones origin and from sedimentary rocks derived from sand stones and shales in Ogun and parts of Edo states. These soils have been confirmed to be highly leached and low in exchangeable bases; N, P, water holding capacity and organic matter. Hence, most of the essential nutrients found in them are below the critical level (Egbe and Chude, 1987). Moreover, cashew farmers in Nigeria are economically incapable to afford the application of inorganic fertilizers coupled with its negative effects on the environment. Therefore, there is

the need to adopt agricultural practices that will ensure sustainable cashew production through the application of organically formulated material that will enhanced organic carbon build up in crop plant. In Nigeria, the quest to optimally increased crop yield with fertilizer use has not been attained as a result of lack of adequate fertilizer recommendation because fertilizer usage are mostly based on blanket application, while soil testing programme does not take into account the amount of nutrient being fixed by the soils (Ogunlade, et. al., 2011). The present study therefore, sought to assess growth response of Cashew seedlings to applied organic fertilizers of both animal and plant origin on a depleted soil in Ibadan.

MATERIALS AND METHODS

The experiment was carried out at the greenhouse of the Cocoa Research Institute of Nigeria, Ibadan in the Southwestern belt of Nigeria agro- ecological Zone during the crop growing season of 2010/2011. Prior to the commencement of the experiment, surface soil samples (0 – 20 cm) were taken from the old and abandoned plantation site at Zone six within the Institute estate. The site had not received any form of fertilizer addition since establishment of the plantation forty – eight years ago. The soil samples were air dried, sieved through a 2mm sieve and analyzed for selected physical and chemical properties.

Particles size distribution was determined by the hydrometer method (Udo and Ogunwale, 1986) using sodium hexameta- phosphate as the dispersing agent. Soil pH was determined potentio-metrically in distilled water at soil to water ratio 2:1. Exchangeable bases (K, Ca, Na and Mg) were extracted with neutral normal NH_4OAC. Potassium and Sodium in the extract were determined by flame photometry while Ca and Mg were read by atomic absorption spectrophotometer (AAS). Exchangeable acidity was determined by titration of normal KCL extract against 0.05 Na $(OH)_2$ to a pink end point using Phenolphthalein as indicator (Mclean, 1967). Available P was determined using Bray-1 method. Total N was determined by regular Micro – Kjeldahl method while organic matter was determined using the wet Oxidation method. The Cocoa Pod Husk ash (CPHA), Cow dung manure (CDM), Poultry Dung manure (PDM) and Kola Pod Husk ash (KPHA) used for the experiment were sourced from the farmers farm and CRIN Fermentry section respectively. The organic materials were dried, milled, sieved and analyzed using Standard procedures for the following properties: Total P, total N, OC, K, Ca, Mg, Mn and Cu.

Top soil (0 – 20 cm) collected from the old moribund cashew plot, were air dried, sieved, thoroughly mixed and filled into twenty- four pieces of 10 litres plastic pots. Each of the pot was filled with 10kg top soil. The pots were watered to field capacity and arranged on a raised platform in the greenhouse. Two Indian Mandras cashew nuts were planted per pot. Thinning was carried out six weeks after sprouting to one seedling per pot. Watering was done twice per week throughout the experiment.

Treatment Application

There were five (5) treatments altogether namely CDM, PDM, CPHA, KPHA and Control (no application). Equivalent quantity of each of the materials respectively were weighed to supply 10kgN/ha and applied to each of the pots six weeks after sprouting. The experiment was arranged in a completely randomized design (CRD) with three replications. Agronomic parameters measured includes: number of leaves and branches per plant, plant height (cm), stem diameter (mm) and leaf area (cm^2) respectively. Data were collected monthly on these parameters for six months. Hand weeding was done at three weeks after sowing and repeated at 6,9,12,15,18,21 and 24 weeks after sowing respectively. At 24th weeks after sowing, the seedlings were carefully uprooted, root washed and separated into parts, parameters such as root length (cm), shoot length (cm), number of leaves, stem diameter (mm), number of branches per plant and leaf area (cm^2) were also measured. Dry matter weights (g/plant) of leaves, stem and root were also measured after drying in the oven to a constant weight at 70^oC.

Statistical Analysis

The data obtained were analyzed using analysis of variance (ANOVA) and the significant means differences were separated by Duncan Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSION

Some physical and chemical properties of the soil used for the experiment are presented in Table 1. The soil is acidic (pH 5.75) and deficient in N contents. The values for available P, K and Ca fall below the required value for sustainable and optimum cashew production since they are lower than the critical level determined for cashew in Nigeria (Egbe, *et al.,* 1989). The low organic carbon contents coupled with the deficiency of essential macro – nutrient elements of the soil suggest that the soil will require the use of soil amendments for better crop performance. Incorporation of organic fertilizers inform of CPHA, KPHA, PDM and CDM however will help increase the pH value of the soil and nutrient addition capacity of the soil since they are rich in both micro and macro nutrient elements (Table 1). The nutrient compo-

Table 1. Properties of Soil and organic materials used for the experiment.

Properties	Soil sample	CPHA	KPHA	PDM	CDM
Chemical properties					
Organic Carbon (gkg^{-1})	26.71	0.10	0.07	0.30	0.13
Total Nitrogen (gkg^{-1})	0.62	0.09	0.04	O.30	0.13
Available phosphorus ($mgkg^{-1}$)	2.95	0.50	0.41	0.16	0.06
Exchangeable bases ($cmolkg^{-1}$)					
Potassium (K^1)	0.10	0.52	0.61	0.18	0.08
Calcium (Ca^{21})	0.47	1.24	0.28	0.36	0.16
Magnesium (Mg^{21})	0.76	0.18	0.01	0.05	0.04
Sodium (Na^1)	0.42	0.31	0.30	-	-
Manganese (Mn)	0.03	0.36	0.08	30.47	32.46
Exchangeable acidity ($cmolkg^{-1}$)					
Aluminum ($A1^+$)	0.22	-	-	-	-
Hydrogen (H^+)	0.10	-	-	-	-
ECEC					
Base saturation (%)					
pH (H_2O) 2: 1	5.75	7.41	7.32	-	-
Physical properties (gkg^{-1})					
Sand	612.02	-	-	-	-
Silt	128.43	-	-	-	-
Clay	159.55	-	-	-	-
Textural Class	**SCL**				

CPHA= Cocoa pod husk ash, KPHA = Kola pod husk ash; PDM = Poultry dung manure; CDM = Cow dung manure; SCL = Sandy clay loam

sition of CPHA, KPHA, PDM and CDM respectively as presented in Table 1 indicated that the value of K presence in the CPHA and KPHA is higher than that of PDM and CDM respectively but lower in N contents relative to N contents in PDM and CDM. PDM is the most concentrated in terms of nutrients among the fertilizer materials used (both plant and animal origin). This is in agreement with the observation of Yayock and Awoniyi, (1974) who reported that poultry manure is the most concentrated among the animal manures in terms of nutrients and so can be a suitable alternative to the chemical fertilizer. The low N contents recorded for CPHA and KPHA respectively is as a result of burning during which complete oxidation and volatilization occurred and resulted to loss of N as oxides (gasses) with decomposition of phosphates, oxides and carbonates of cations, hence its valuable liming quality. This result corroborates the findings the findings of Fredrick, (2004); Ajayi, *et al.,* (2007a; 2007b). The amount of N, P, Ca, Mg and Mn contents of CPHA were higher respectively comparing to KPHA.

The higher P, K, Ca and pH for CPHA and KPHA compare with CDM and PDM agreed with the fact that plant derived ash including those of cocoa and kola pod husk increased the P, K, Ca, Mg, soil pH and yield of vegetables, rice, millet and maize (Owolabi et al., 2003).

The effects of fertilizer materials on the plant height (cm) and stem diameter (mm) of cashew seedlings are presented in Table 2. The organic fertilizer materials (CPHA, KPHA, PDM and CDM) significantly increased ($p > 0.05$) the plant height and stem diameter relative to control throughout the period of growth. PDM however, recorded the highest values for both plant height and stem diameter respectively compared to other fertilizers (irrespective of sources). This is closely followed by CDM, CPHA and KPHA in descending order (PDM > CDM> CPHA > KPHA > CTRL). The percentage increases in plant heights of cashew seedlings at harvest (6 months after application) ranged from 5.99 – 36.66%. Similarly, all the fertilizer materials slightly increased stem diameters of cashew seedlings with poultry manure recording the highest value while the least was noted with the control. At 3^{rd}, 4^{th} and 5^{th} months after treatment application, there were no significant effects of CPHA, KPHA, CDM and PDM on the stem diameter of Cashew seedlings although; there were slight increases due to the treatment effects. PDM significantly increased the stem diameter at 6th months after application relative to other treatments, the effects of CPHA, KPHA and CDM were comparable but significantly($p> 0.05$) higher than the control which recorded the least values throughout the period of the study.

Table 2. Effects of organic fertilizers application on plant height and stem diameter of cashew seedlings.

Treatments ($kgNha^{-1}$)	Plant height (cm)							Stem diameter (mm)					
	Months after application						% increase in height at 6 months.	Months after application					
	1	2	3	4	5	6		1	2	3	4	5	6
CTRL	16.50^{d}	26.7^{d}	30.70^{e}	32.69^{e}	34.60^{e}	40.10^{e}		0.4^{c}	0.5^{c}	0.6^{b}	0.7^{b}	0.8^{b}	0.9^{c}
CPHA	22.70^{c}	31.40^{bc}	36.60^{c}	39.80^{c}	42.10^{c}	44.20^{c}	10.22	0.5^{b}	0.6^{b}	0.8^{a}	0.9^{a}	1.0^{a}	1.1^{b}
KPHA	25.90^{b}	28.20^{c}	33.90^{d}	36.00^{d}	39.10^{d}	42.50^{d}	5.99	0.6^{a}	0.7^{a}	0.8^{a}	0.9^{a}	1.0^{a}	1.1^{b}
CDM	26.20^{b}	32.60^{b}	38.80^{b}	43.00^{b}	46.10^{b}	49.00^{b}	22.20	0.6^{a}	0.7^{a}	0.8^{a}	0.9^{a}	1.0^{a}	1.1^{b}
PDM	28.80^{a}	35.60^{a}	40.90^{a}	48.60^{a}	51.50^{a}	54.80^{a}	36.66	0.6^{a}	0.7^{a}	0.8^{a}	0.9^{a}	1.0^{a}	1.3^{a}

CTRL= Control; CPHA= Cocoa pod hush ash; KPHA= Kola pod husk ash; CDM= Cow dung manure; PDM= Poultry dung manure.

Table 3. Effects of organic manures application on numbers of Leaves of cashew seedlings.

Treatments	Number of leaves per plant						Number of branches per plant		
	Months after application						Months after application		
	1	2	3	4	5	6	2	4	6
CTRL	9.00^{d}	14.00^{e}	20.00^{e}	$26,00^{e}$	28.00^{e}	31.00^{d}	4.00b	5.00b	6.00bc
CPHA	14.33^{ab}	23.33^{b}	30.00^{b}	39.00^{b}	41.00^{b}	39.00^{b}	6.00a	7.00a	9.00a
KPHA	12.50^{d}	18.00^{d}	26.00^{d}	28.00^{d}	32.33^{d}	31.50^{d}	5.00ab	6.00ab	6.00bc
CDM	13.00^{c}	20.00^{c}	28.40^{bc}	36.00^{c}	39.30^{c}	35.33^{c}	5.00ab	6.00ab	6.00bc
PDM	15.01^{a}	25.50^{a}	35.00^{a}	42.00^{a}	45.00^{a}	44.00^{a}	6.00a	7.00a	7.00b

CTRL= Control; CPHA= Cocoa pod hush ash; KPHA= Kola pod husk ash; CDM= Cow dung manure; PDM= Poultry dung manure.

The application of CPHA, KPHA, PDM and CDM also had a positive effects on the number of leaf formation of the cashew seedlings in the greenhouse with organic manure of animal origin having the highest foliage formation, thismight be as a results of higher N contents of the material (Table1) which has contributed immensely to leaf development compare to control and other fertilizer materials. At 1^{st}, 2^{nd} and 3^{rd} months of treatment imposition, PDM and CPHA recorded significantly ($p > 0.05$) higher number of leaves per plant compare to both KPHA and CDM with PDM having the highest of leaves per plant. These were followed by respectively by CDM and KPHA in ascending order (Table 3). Similar pattern were followed by for the 4^{th}, 5^{th} and 6^{th} month of treatment application. This observation is in agreement with the findings of Adejobi *et al.,* (2011) which showed that, organic manures increased the plant height, number of leaves, stem diameter, number of branches, leaf area, root length e. t. c.

The data on leaf area (cm^2) and number of branches are shown in Table 4. The use of organic materials as fertilizer positively and significantly at 5% level of probability enhanced leaf area of cashew leaves. PDM gave the highest leaf area values in the first, second fourth, fifth and sixth months of treatments addition while CPHA on the other hand recorded the highest values for the leaf area at the third month. The differences recorded are significantly different relative to control. Similar trend was observed for the number of branches per plant. Control had the least number of branches formation per plant while the highest number of branches formation was found with CPHA. The values recorded for the KPHA (6.0) and CDM (6.0) were comparable and not different significantly ($p > 0.05$) from one and other.

The results of the root length (cm) and fresh weight (g/plant) of cashew seedlings as affected by organic fertilizer materials is presented in Table 5. Root length and fresh weight of cashew plants were increased by the fertilizer materials used compared to the control. Relative to the control and other fertilizer treatments, PDM recorded a significant effects on the root length of cashew, this is followed distantly by CPHA; the least root length was observed with control. CDM gave the highest fresh leaf and root weight while the least weight was

Table 4. Leaf area and number of branches of cashew seedlings as influenced by organic manure application

Treatments	Months after treatments imposition					
	1	2	3	4	5	6
CTRL	72.6^{d}	79.6^{e}	83.9^{e}	108.9^{d}	111.4^{e}	118.0^{e}
CPHA	81.7^{c}	86.9^{d}	117.9^{a}	127.8^{b}	141.8^{b}	150.3^{b}
KPHA	85.3^{b}	90.4^{c}	98.6^{d}	101.4^{e}	117.3^{d}	123.1^{d}
CDM	88.6^{ab}	93.1^{b}	102.8^{c}	116.5^{c}	123.3^{c}	130.4^{c}
PDM	90.1^{a}	95.4^{a}	115.5^{b}	136.5^{a}	181.2^{a}	190.3^{a}

CTRL= Control; CPHA= Cocoa pod hush ash; KPHA= Kola pod husk ash; CDM= Cow dung manure; PDM= Poultry dung manure.

Table 5. Effects of organic fertilizers application on the root length (cm), fresh weight of leaf, stem and root (g/plant) of cashew seedling

Organic materials (kgNha^{-1})	RL	FRW	FLW	FSW	TFW
CONTROL	20.60e	8.60d	10.60d	14.80d	34.00e
CPHA	47.10b	12.40ab	17.90c	20.50a	50.90b
KPHA	35.60c	11.90c	18.80b	18.60c	49.30c
CDM	32.20d	12.80a	20.60a	14.70de	47.70d
PDM	54.80a	11.60cd	20.50ab	20.20b	52.6 0a

RL = Root length; FLW = Fresh leaf weight; FSW= Fresh stem weight; FRW = Fresh root weight; TDMY = Total dry matter yield; CPHA= Cocoa pod hush ash; KPHA= Kola pod husk ash; CDM= Cow dung manure; PDM= Poultry dung manure.

Table 6. Effects of organic fertilizer materials on dry matter weight (g/plant) of cashew seedlings

Organic materials (kgNha^{-1})	LDW	SDW	RDW	TDMY	% increase TDMY
CTRL	7.410c	7.40c	6.70b	21.51c	
CPHA	11.90b	12.30a	9.30a	33.50ab	56.21
KPHA	10.80bc	10.20b	8.60ab	29.60bc	38.08
CDM	11.40b	10.60b	8.90a	30.90b	44.12
PDM	13.30a	12.70a	8.60ab	34.60a	62.07

CTRL= Control; CPHA= Cocoa pod hush ash; KPHA= Kola pod husk ash; CDM= Cow dung manure; PDM= Poultry dung manure; LDW= Leaf dry matter yield; SDW=Stem dry matter yield; RDW= Root dry matter yield; TDWY = Total dry matter yield.

recorded for the control. On the contrary, the fresh weight of cashew stem was significantly increased by CPHA relative to control and others. PDM gave the highest total fresh weight (TFW) of cashew seedlings relative to other fertilizer materials. This might have been as result of increased microbial activities that led to increased mineralization of organic matter from the natural source in the soil and availability of nutrients in the soil for the plant use hence, increased dry matter accumulation. The highest total fresh matter accumulation due to PDM addition could have also been due to the fact that PDM is capable of supplying nutrients to the soil to correct deficiencies especially of N as indicated in the previous study by Bhogal et al., (1997) and Saviozzi, et al., (1997).

Dry matter yield of cashew seedlings as influenced by different types of organic wastes materials is presented in Table 6. Dry matter accumulation of cashew is positively and significantly improved by organic addition. PDM and CPHA significantly ($p > 0.05$) increased leaf and stem dry matter yield relative to control and other organic materials. The effects of PDM on dry matter accumulation of cashew are either higher than or comparable to CPHA. CPHA and CDM produced a significantly higher effect on dry root weight of cashew seedlings compare to control, KPHA and PDM respectively. Generally, all the fertilizer materials irrespective of sources increased total dry matter yield value, PDM gave the highest total dry matter yield value (34.60 g/plant) in cashew relative to other treatments considered. This is followed closely by CPHA (33.50g/plant) while control (21.51g/plant) and KPHA (29.60g/plant) produced the least effect on the dry matter yield. The total dry matter yields of cashew seedlings were increased by PDM, CPHA, CDM and KPHA by 62.07, 56.21, 44.12 and 38.08% respectively. These

increases are attributable to the facts that organic manure (plant and animal materials) are good sources of both macro and micro nutrients which encourage better seedlings growth. This results is consistent with the earlier works of Adeniyan and Ojeniyi (2005); Moyin – Jesu (2007) and Ipimoroti and Akanbi, (2012) who reported that organic manure improved the growth performance and increased significantly crop yield and dry matter accumulation respectively.

CONCLUSION

It is evident from this present study that application of organic manure of both plant and animal origin significantly enhanced cashew seedling performance and increased dry matter accumulation and could therefore be recommended for cashew growers.

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