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Comparison of Organic Nutrient Sources with NPK for Cashew Seedlings Growth towards Organic Cashew Farming in Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author RRI designed the Experiment, while authors RRI and OSOA carried out the field experimentation, data collection and analysis, literature review and write-up. Both authors read and approved the final manuscript.

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ABSTRACT

As a preliminary effort to commence organic cashew farming in Nigeria, a study to assess the growth performance of cashew seedlings was conducted in two consecutive trials using four organic nutrient sources namely cow dung, poultry droppings, cocoa pod husk and kola pod husk compared with NPK (15:15:15) and control - without fertilizer. The trial was conducted in the greenhouse at Cocoa Research Institute of Nigeria, Ibadan, in a completely randomized design with 4 replications. Data on agronomy parameters and dry matter yield after 6-months of planting were taken and statistically analyzed using ANOVA and significant mean differences were separated by LSD at $p<0.05$. Cashew seedling growth performance was significantly ($p<0.05$) influenced by fertilizer application over the control in both trial periods. The plant root growth was significantly ($p<0.05$) better with organic nutrient sources compared to NPK. Cashew seedlings leaf, stem and root dry matter yield values were least in control treated plants and highest for poultry droppings. Similar trend but with higher values of 7.7-23.5% were obtained at the 2nd trial than for 1st trial for the fertilizer treated cashew seedlings, while it was reduced by 6.56% for the control. On the overall, the fertilizer treated cashew seedlings had significantly ($p<0.05$) higher dry

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matter yield of 60.4 - 117.4% compared with the control plants. The organic fertilizers were superior to NPK while the organic fertilizers of animal origin were superior to those of plant origin.

Keywords: Cashew production; economic impact; nutrient deficiency; organic farming; soil productivity.

1. INTRODUCTION

Cashew (*Anacardium occidentale*) cultivation in Nigeria dated back to 19th century. It is grown primarily for the nuts and the pseudo-apple, which could be processed for the juice (Pseudo apple juice). It is also useful for the kennel oil (CNSL) while the tree is a good plant for erosion control [1]. Nigeria is the 3rd largest producer and supplies 660,000mt/year of cashew to the world market [2,3]. Unfortunately, the production level has recently been on the decrease due to several factors of which soil fertility is germane [4].

With the present situation of non availability of virgin forests for new plantation establishments as well as expansion of existing plantations, farmers majorly depends on available farm lands that are under arable cultivation for years. As a result, the farm lands are inherently low in their fertility status with organic C, Total N, available P and exchangeable K range of 1.89-2.87%, 0.65-0.91%, 6.47-8.87mg/kg soil and 0.34-0.67cmol/kg soil respectively [5]. It has been reported that most cultivated soils in Nigeria are of low fertility status, low activity clays, low organic matter contents and of low CEC. Therefore, there is the need for nutrient supply by way of fertilizer application to make the soils productive optimally [6,7].

All crops, cashew inclusive, require the supply of basic nutrients for optimal growth performance and production on a sustainable basis. Inorganic fertilizers for this purpose are scarce, costly and have several side effects on soils, water bodies, the environment and human health [8,9]. Several farm wastes have been assessed for their potentials as organic fertilizers in improving soil fertility status and crop productivity. The classes of crops that have been evaluated for their productivity level under the utilization of organic wastes as nutrient sources cut across arable, vegetables and tree crops [10,11]. Common amongst the farm wastes are poultry droppings, slurry, cow dung, cassava peels, plantain peels, brewery wastes, cocoa husks, kola husks, corn while the inorganic fertilizers were applied in 2 equal split doses, first at planting and 3 months stubbles and palm bunch wastes for supply of nutrients for coffee, cassava, maize, cashew and vegetables [12,13,4,14,5]. The use of organic fertilizers have been reported to have long and lasting effects on soil physical, chemical and biological properties [15] through improvement on the soil organic matter content, better access to water, nutrients, reduced acidity and improved soil biological activities which are advantageous to soil and plant relationships [16].

Organic cashew production involves, amongst other certification prerequisites, the avoidance of the usage of convectional inorganic fertilizers for soil fertility management. This study assessed the utilization of some basic common farm wastes and their usage as nutrient sources compared to NPK (15:15:15) for the growth performance and dry matter yield of cashew seedlings on soil previously under arable cultivation for several years without fertilizer usage.

2. MATERIALS AND METHODS

The experiment was conducted in the greenhouse of Cocoa Research Institute of Nigeria, Ibadan between April 2011 and May 2012. Top soil at 0-30 cm depth was collected from an arable plot with no history of fertilizer application for over fifteen years. The soil was air dried, sieved through 10 mm sieve and potted into 24 plastic pots of 10 liter size at 10 kg soil/pot. Cocoa pod husk (CPH), Kola pod husk (KPH), cow dung and poultry droppings were fermented for 21 days [17] and analysed for their nutrient contents. The fermented materials and NPK (15:15:15) were used separately to supply equivalent of 10kg N ha^{-1} and the control - no fertilizer for the growth of cashew seedlings. The plastic pots filled with soil were tagged in 4 replicates against each treatment and arranged randomly on the greenhouse bench in a completely randomized design (CRD). The potted soils were watered to 70% field capacity and cashew nuts were planted at 2 nuts pot^{-1} and thinned to one seedling pot^{-1} after one month of planting. The manures were applied at planting; after planting. Watering was continued twice weekly, while hand weeding was bi-monthly.

The seedlings' height was measured from the plant-soil base to the shoot tip, by use of meter rule (cm), girth at the plant-soil base level by use of venier caliper (cm), number of leaves and branches by visual count and leaf area by use of leaf area meter. These were carried out immediately after thinning and continued monthly to 6 months after planting (MAP). The cashew seedlings were uprooted 6 MAP, the root lenght taken, sectioned into the root, leaf and stem and oven dried at 70℃ to constant weight and dry matter yield (DMY) determined. The soil particles attached to the roots were rinsed with deionised water. The procedure was repeated for the second trial using the same potted soils but without fertilizer application. The resultant growth parameter and the DMY values were statistically analyzed by analysis of variance (ANOVA) at $P<0.05$ and the mean differences were separated using Least Significant Difference (LSD) at 5% level.

The soil total N was determined by the micro-kjeldahl method and the available P by Bray 1 method [18], the cations were extracted with 1N NH_4OAC at pH 7 and the Ca and Mg contents were read using the atomic absorption spectrophotometer (AAS), while the K was determined by the use of flame photometer. The organic carbon (OC) was determined by wet dichromate oxidation method [19]. The composed cow dung, poultry droppings, cocoa and kola pod husks were digested using nitric-perchloric-sulphuric acid mixture [20]. The N content was determined by micro-kjeldah approach and P by vernadomolybdate colorimetry. The K was determined by flame photometer, while Ca and Mg were read through the AAS.

3. RESULTS

The soil organic carbon of 10.2g/kg soil, which was below the 30.0g/kg soil suitable for tree crop like cashew [21], suggests the need to increase the soil organic matter (SOM) content in order to allow for optimal and sustainable cashew cropping on the soil. The soil N and P contents were below their critical values. However, the K, Ca and Mg contents were all above the soil critical values required for cashew crop (Table 1). The nutrient contents of the organic fertilizers (Table 1) showed that poultry dropping was higher in N and P compared to cocoa husk, kola husk and cow dung, while cocoa pod husk followed by kola pod husk were higher in K compared to the poultry dropping and cow dung.The organic fertilizer materials contained Ca and Mg in addition to the N, P and K, which were lacking in NPK (15:15:15).

The cashew seedlings growth parameters obtained showed that plant height ranged from 34.50-54.30 cm, the value was highest for the control and least for NPK treatment, while values for the organic fertilizer treated cashew plants clustered between 46.00-53.00 cm, with significant ($p<0.05$) treatment mean differences. However, the plant girth was not in trend with plant height values because the value was least for the control while it was highest for the kola pod husk treated plants (Table 2). The number of branches of the cashew seedlings ranged from 0.50-5.50 with the least value recorded for the control plants. The number of leaf was highest for cashew seedlings that were applied cow dung manure, while it was least for the control plants. However, the leaf area value was highest for the cashew plants treated with kola pod husk manure, with mean value of 2773.07cm^2 $plant^{-1}$ (Table 2).

The differences in mean values were significant at $p<0.05$. The root length ranged from 29.50-44.00 cm however, the values were similar for the cow dung and kola pod husk treated plants, while it was the same for poultry droppings and cocoa pod husk and least for the control and followed by NPK treatment.

Table 1. Some soil properties and nutrient contents of fertilizer materials used

Properties	Soil	Soil critical	CDG	PDG	CPH	KPH	NPK
			←	%		→	
N (g/kg)	0.87	1.00	1.29	2.92	0.95	2.13	15
Organic C (gl/kg)	10.2	30.0	38.4	26.2	24.3	22.1	-
P (mg/kg)	2.47	3.70	0.65	1.48	0.29	0.90	15
K (cmol/kg)	3.98	0.12	0.80	1.85	4.30	2.55	15
Ca (cmol/kg)	52.0	0.80	1.60	3.60	0.70	2.98	-
Mg (cmol/kg)	1.10	0.08	0.40	0.50	0.35	0.48	-

CDG= Cow dung, PDG = Poultry dropping, CPH = Cocoa pod husk, KPH = Kola pod husk

The growth parameters at the 2nd trial showed that cashew seedling height ranged from 29.50-49.50 cm, while it was least for the control plants and highest for kola pod husk treated plants (Table 3). The plant girth was similarly least for the control plants with value of 0.93cm, while it ranged from 0.95-1.15cm for the fertilizer treated plants. The mean differences were significant at $p<0.05$. The plant number of branches was highest for cocoa pod husk treated plants which was followed by those of poultry droppings and least for kola pod husk applied cashew seedlings. The number of leaves was least for the control plants, while it was highest for the cocoa pod husk plants. The leaf area was however highest for seedling with poultry droppings application and was followed by that for cocoa pod husk and least for control. The plant root length was similarly shortest for the control plants with mean value of 25.70cm as against 54.00 cm for kola pod husk treated plants.

The cashew leaf dry matter yield values (g/plant) at the 1st trial (Table 4) showed that poultry droppings usage resulted to 9.94g plant^{-1} and this was followed by cow dung manure, while cocoa pod husk, kola pod husk and NPK had close range values, while it was least for the control. The stem and root dry weight values generally followed the same trend as obtained for the leaf dry weight.

The total dry matter yield (TDMY) was highest under poultry droppings treatment which was closely followed by those of cow dung and least for the control plants. Similar trend obtained at the 1st trial was maintained at the 2nd trial. The mean differences were significantly different at $p<0.05$ at both trial periods. On the overall, the combined total dry matter yield obtained due to the various treatments followed the order poultry droppings (PDG) > cow dung (CDG) > cocoa pod husk (CPH) > kola pod husk (KPH) > NPK > control (CTR) (Fig. 1).

Table 2. Growth parameters and root length of cashew seedlings at 1st trial in 2011

Treatments	Height (cm)	Girth (cm)	Number of Leaf	Number of Branch	Leaf area (cm2)	Root length (cm)
Control	54.30	0.95	21.30	0.50	1486.74	29.50
Cow dung	46.00	1.05	34.50	1.50	2524.88	41.80
Poultry dropping	53.00	1.05	26.60	0.50	2604.14	44.00
NPK (15:15:15)	34.50	1.02	24.50	4.00	2174.12	31.00
Cocoa pod husk	50.50	1.05	23.00	1.00	2600.64	44.00
Kola pod husk	48.00	1.15	25.00	5.50	2773.07	42.00
LSD (5%)	2.07	0.05	3.31	1.82	150.02	5.41

LSD = Least significant difference

Table 3. Growth parameters and root length of cashew seedlings at 2nd trial in 2012

Treatments	Height (cm)	Girth (cm)	Number of leaf	Number of branch	Leaf area (cm2)	Root length (cm)
Control	29.50	0.93	28.50	2.00	945.23	25.70
Cow dung	38.20	1.10	38.00	4.00	2352.80	45.10
Poultry dropping	37.70	1.15	32.50	4.00	3639.64	53.00
NPK (15:15:15)	34.00	0.95	26.00	2.50	1967.88	31.50
Cocoa pod husk	42.00	1.08	44.50	4.50	3381.84	42.40
Kola pod husk	49.50	1.15	33.50	1.50	2798.24	54.00
LSD (5%)	3.41	0.03	6.13	1.22	22.59	6.18

LSD = Least significant difference

Table 4. Dry matter yield of cashew seedlings (g/plant) at 1st and 2nd cropping

Treatments	Leaf	Stem	Root	TDMY	Leaf	Stem	Root	TDMY
	1st cropping (2011)				2nd cropping (2012)			
Control	4.48	3.80	3.46	11.74	3.40	4.40	3.17	10.97
Cow dung	8.15	8.01	6.13	22.29	8.90	9.30	6.30	24.50
Poultry dropping	9.94	8.55	5.28	23.77	10.30	9.70	5.60	25.60
NPK (15:15:15)	6.67	6.00	4.17	16.83	7.80	7.10	4.70	19.60
Cocoa pod husk	6.37	6.13	4.99	17.49	8.00	7.60	5.90	21.80
Kola pod husk	6.07	5.83	5.80	17.00	7.70	7.20	5.60	21.67
LSD (5%)	1.45	1.22	0.83	1.62	1.25	1.81	0.66	2.11

** TDMY = Total Dry Matter Yield, LSD = Least significant difference*

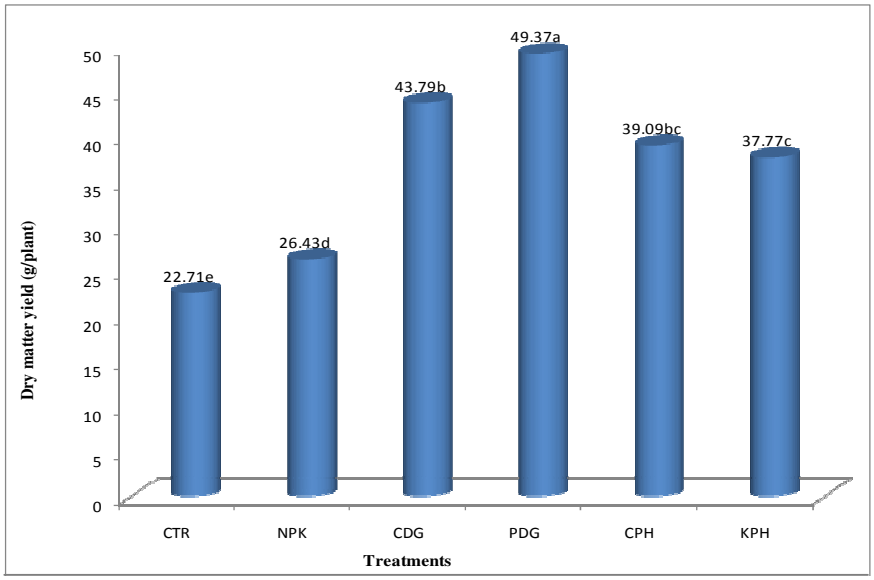

Fig. 1. Cumulative dry matter yield of cashew seedlings at frist and second trials
**Mean values in the Fig. 1 with the same letter are not significantly difference*

4. DISCUSSION

The cashew seedlings had better growth and total dry matter yield performance when fertilizers were used relative to the control treatment at both the 1st and 2nd trial periods. This points out that the potential of the soil to support optimal growth performance of cashew seedlings and the eventual production of cashew nuts and pseudo-apples could be enhanced through judicious use of the fertilizers. The response of the soil to the applied fertilizers indicated that the soil is inherently low of some basic nutrients that were essential for better growth performance of the cashew seedlings. The soil N, organic C and P contents of 0.87g/kg soil, 10.2g/kg soil and 2.47mg/kg soil were generally lower compared to their critical values of 1.00g/kg soil, 30.0g/kg soil and 3.70mg/kg soil respectively [21].

In Nigeria, insufficiency in food production and supply has been ascribed to poor crop yield due mainly to unfavourable soil conditions [22]. This is true in that a large proportion (70%) of the soils in Nigeria are made up of low activity clay soils, with low CEC [5] and cannotnaturally support crop production on a continuous basis [11]. This trend was generally reflected in this study in that all the fertilizer treated cashew plants outperformed the control plants. However, the organic nutrient sources were superior to the NPK (15:15:15) for better performance of the cashew seedlings. The cashew plant root growth was significantly ($p<0.05$) enhanced with the use of the organic fertilizers compared to the inorganic fertilizer probably due to balanced nutrient supply to the plants from the organic fertilizers in terms of N, P and K, in addition to Ca and Mg which are not available in NPK (15:15:15). Organic nutrient sources are noted for gradual nutrient release unlike the fast nutrient release by inorganic fertilizers which may be lost and become unavailable to the plants [4] The better root development resulting from balanced nutrient supply by the organic fertilizers must have led to better plant establishment with more access to soil water, nutrients and better anchorage than the NPK treated cashew plants [23,24].

The poultry dropping application (PDG) gave higher growth and dry matter yield values compared to other organic fertilizer materials. This must have resulted from its higher N and P contents compared to cocoa husk, kola husk and cow dung. This may be in addition to the low C/N ratio of 8.97 for the PDG relative to 10.38, 25.58 and 29.76 for kola pod husk, cocoa pod husk and cow dung respectively. The low C/N ration must hasten nutrient release than could be for the other organic materials.

When the 1st and 2nd trials results were compared, fertilizer treatments gave increased residual effect of 7.70-27.5% on cashew seedlings dry matter yield, while the control

decreased by 6.56 %. It has been reported that organic fertilizers has great potentials for residual effects on crop performance compared to inorganic fertilizers [25]. This indicated that the frequency of usage of NPK for cashew plants would be higher if sustainable optimal cashew performance is expected. The resultant effect of this would be higher cost of labour for fertilizer application, which is a major problem to small-scale farmers in Nigeria [26], drudgery on personnel due to high frequency of contact with fertilizer, increased soil acidity as a result of increased level of acid radicals in the soil medium [27], high propensity for soil water and water pollution [9] and general soil degradation [22].

Further increase in the total dry matter yield of the cashew seedlings due to the organic fertilizers implies that the organic fertilizers could have long lasting effects on the soil physical, chemical and biological properties [15] thereby improving the soil organic matter content, better access to water, nutrients, reduced acidity and improved soil biological activities that were advantageous to the soil and plant relationships [16]. Cashew is a permanent tree crop with long production period, fertilizers that would be able to act positively longer in the soil would be advantageous for its sustainable production performance. This is because, increasing yield per unit area requires high yielding varieties and good soil conditions [22].

5. CONCLUSION

The study therefore showed that for better starting up and establishment of organic cashew farms for enhanced cashew seedling establishment and growth performance; good plant access to soil nutrients for eventual optimal performance of cashew plants, judicious use of organic fertilizers would suffice. However, organic manures of animal origin were outstanding compared to those of plant origin.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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