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Research Article

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Comparative Studies on the Effects of Organic and Inorganic Fertilizers on Growth factors, Dry matter yield and Phosphorus (P)-Uptake of Cashew Nut Seedlings

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Abstract A greenhouse study was carried out at Cocoa Research Institute of Nigeria (CRIN), Ibadan to investigate growth factors, dry matter yield and P-uptake of cashew seedlings of different nut sizes using organo-mineral and inorganic fertilizers. The fertilizers were applied at rates of 0, 10, 20 ton/ha and 0, 10, 20kg N/ha for seven treatments using a completely randomized block design.

The results showed that for PCA (Organo fertilizer (fortified with Urea)), an increase in level of fertilization led to an increase for all the parameters measured having the most significant effect on plant height whereas for PCB (Organo fertilizer (non-fortified)) an increase in level of fertilization generally led to a reduction in growth factors except for P-uptake. An increase in fertilizer application for the Inorganic fertilizer (NPK) gave marginal increases in the growth factors measured although this increase is not proportional to the amount of fertilizer used. All the values were found not significantly different (at P>0.05) compared with the control measurement values for jumbo nut sizes of cashew seedlings. It can be deduced that optimal results for the parameters measured would be obtained at 20 t/ha PCA and 10t/ha PCB for jumbo nut sizes.

For small nut sizes, application of PCA, PCB and NPK fertilizers did not significantly affect the measured parameters. However, PCB at 20ton/ha had the highest P-uptake (30.12mg/kg) and this was found significantly different (at P>0.05) amongst other treatments for small nut sizes.

Thus, PCA and PCB applied at 10 and 20ton/ha could be used to enhance the growth and P-uptake of cashew seedlings and would serve as viable alternatives to mineral fertilizers.

Keywords Cashew nut, Organo-mineral, Inorganic fertilizer, P-uptake, Dry matter yield

Introduction

Cashew (Anarcadium occidentale Linn) is a tropical and sub-tropical evergreen tree. The plant is native to tropical central and South America most notably North Eastern Brazil from where Portuguese explorers introduced it into Nigeria in the 15th century [1-2]. Nigeria is the 2nd largest producer of cashew nuts in the world and is blessed with seven diverse agro-ecologies. Aliu and Hammed [3] have shown that cashew can only be economically cultivated in woodland-tall-grass savannah and rainforest ecologies. It is an export crop and is produced in 27 states in Nigeria cutting across several agro-ecological zones in Nigeria. The total land under cashew tree cultivation in Nigeria increased from about 40,000ha in 1995 to about 320,000ha in 2006, and total cashew nut production has been on a steady increase from 30,000 metric tonnes in 1990 to 636,000 metric tonnes in 2006 [4-5]. With the introduction of inorganic fertilizers, farmers quickly adopted its use probably due to its being easy to handle and relatively low cost due to subsidies by the government. However, the removal of subsidies on fertilizers and its attendant higher cost

could not be met by farmers [6] leading to a fall in output. This necessitated research into cheaper methods of enhancing growth (fertilization) for the crop.

Soil productivity and its sustainability have been major constraints of tropical agriculture. Continuous use of inorganic fertilizers has been found to only increase yield for a period of time ultimately decreasing base saturation resulting in soil acidification and a drop in soil pH [7-8]. This has led to an intensification of research into organic fertilizers. Akanbi *et al* [9] reported that the use of organic fertilizers improved productivity in tropical soils and led to an increase in organic matter content of the soil more than what obtains for inorganic fertilizers. This investigation was carried out to evaluate growth factors, dry matter yield and P-uptake of cashew seedlings of different nut sizes using organic and inorganic fertilizers.

Materials and Methods

The experiment was conducted in the greenhouse of Cocoa Research Institute of Nigeria. Top soils were collected at the CRIN cashew research centre at 0-30cm depth. The soil samples were air –dried for two weeks and sieved using 2mm sieve before analyses of physical and chemical properties. Forty –two plastic buckets each were filled with 5kg soil. Two viable cashew nuts (jumbo and small sizes) were planted in each plastic bucket containing 5kg of top soil. Two organic fertilizers (A–fortified with urea and B–non fortified) were collected from Pace-setter Organo-mineral fertilizers plant, Bodija, Ibadan. Organo-mineral fertilizer (OMF- A) and Organo-mineral fertilizer (OMF- B) – referred to as PCA and PCB respectively- were applied at 0, 10,20ton/ha while NPK was applied at (0, 10, 20 kgN/ha). All treatments were replicated four times and arranged in a completely randomised design (CRD) using two cashew nuts sizes (Jumbo and Small). The pots were watered twice weekly to 70% field capacity. Data on the following growth parameters: plant height, girth, number of leaves, branches and leaf area were taken on monthly basis. Destructive sampling was done six months after planting (MAP). The plant samples were separated into sections - leaf, stem and root. The fresh samples were washed, enveloped and oven dried at 70 ^{o}C to constant weight. Dry matter yield (DMY) was determined. Data collected was subjected to analysis of variance (ANOVA) and mean differences separation by LSD (5%). The total Nitrogen, N, was determined by the micro-kjeldahl method and the available Phosphorus, P, by Bray-1 method [10]. The exchange cations were extracted with NH_4OAC at pH 7.0; Ca, and Mg were read using Atomic Absorption Spectrophotometery (AAS) while Potassium, K, was determined by flame photometry. The organic carbon was determined by wet dichromate oxidation method.

Results and Discussion

Soil Analyses

Soil used contained 685g/kg sand, 150g/kg silt and 165g/kg clay. Soil was Sandy loam in texture. Clay and silt content of 315g/kg soil were sufficient to hold enough water for sustainable cashew plant growth and guard against short durations of drought as reported by Egbe *et al* [11].

Table 1: Physical and Chemical properties of the soil used

Soil Parameter	Value	Critical level[10]
pH	6.2	
Sand (g/kg)	685	
Silt (g/kg)	150	
Clay (g/kg)	165	
Total N (g/kg)	0.82	10.0
Avail P (mg/kg)	9.68	
Mg (cmol/kg)	0.96	0.97
Ca (cmol/kg)	0.37	3.0
Organic carbon (g/kg)	0.2	1.05
K (cmol/kg)	0.1	0.4

The pH value of 6.2 obtained is suitable for cashew production. An organic carbon content of 0.2 g/kg was found below the critical level of 1.05g/kg ideal for cashew production [6]. The soil N content of 0.82g/kg was also below the critical level of 10.0g/kg required for optimal cashew growth. The soil P and Mg were found to be adequate. The soil was found to be low in exchangeable K and Ca levels (Table 1) compared to critical levels of 0.40cmol/kg and 3.0cmol/kg for soil suitable for cashew cultivation in Nigeria. Table 2 shows the nutrient content of the fertilizers used for the study.

Table 2: Nutrients content of fertilizers used

Properties	Pacesetter Grade A	Pacesetter Grade B	NPK
N (%)	2.55	1.46	15
P (mg/kg)	1.10	1.03	15
K (cmol/kg)	0.68	0.60	15
Ca (cmol/kg)	0.36	0.36	
Mg (cmol/kg)	0.11	0.11	-

Table 3 shows the effect of fertilizer use on growth parameters, Dry matter yield and P-uptake for jumbo nut sizes. It shows that treatment with Organo-mineral fertilizer pacesetter B (PCB) had the highest plant height (45.20cm) at 10t/ha while Organo-mineral fertilizer pacesetter A had the highest plant height (44.92cm) at 20t/ha compared to other treatments. The results are not significantly different at P>0.05.

For small nut sizes (table 4), NPK had a plant height value of 26,08cm at 10kgN/ha, Organo-mineral fertilizer grade A had 25.00cm while Organo-mineral B and control had values of 24.70cm and 23.30cm at 10ton/ha. These values were also found not to be statistically insignificant.

Plant height of Jumbo nuts was higher in comparison to small nut sizes of cashew seedlings due mainly to the mineralization of organic matter in Pacesetter B. For stem diameter, NPK at 20kgN/ha had the highest stem diameter (0.70mm) followed by the organo-mineral fertilizer grade B (0.68mm) at 20t/ha. All the values are not significantly different at P>0.05 for jumbo nut sizes. The stem diameter for small nut sizes was 0.59mm in control and organo-mineral fertilizer grade A at 10t/ha. It, however, is reduced with PCA at 20t/ha (0.45mm) and PCB at 10t/ha and 20t/ha (0.44mm). NPK gave slightly higher values at 10kgN/ha (0.50mm) and 20kgN/ha (0.54mm). The values were found not to be significantly different.

The treatment with NPK at 20kgN/ha had the highest value for leaf area of 131.90cm^2 while PCB had 128.90cm^2 at 10t/ha. PCA at 10t/ha had the least value compared to the control.

The dry matter yield (DMY) of NPK at 20kgN/ha gave the highest dry matter weight of 0.70g/pot. This is comparable to values of 0.68g/pot (PCB at 20t/ha), 0.67g/pot (PCA at 20t/ha), 0.65g/pot (PCB at 10t/ha). The other treatments gave values close to control (0.54g/pot). However, there is no significant difference between all these values at P>0.05. Little variations were found for the small nut sizes but still gave no significant differences statistically.

For jumbo nut sizes, PCA at 20t/ha (24) and PCB at 10t/ha (21) had the highest value of number of leaves with NPK (10kgN/ha) (20), PCB at 20t/ha (18) were comparable to control (17). These values were not statistically different. The same trend was observed for the small nut sizes.

The control had a P-uptake of 4.82 mg/kg with only PCA at 20t/ha (6.65mg/kg) and PCB at 20t/ha (5.0mg/kg) resulting in higher P-uptake value for jumbo sized nuts. For small nut sizes, the control value of 4.05mg/kg is surpassed by all treatments especially PCB at 20t/ha (30.12mg/kg) and NPK at 20kgN/ha (15.73 mg/kg). While the results for jumbo sized nuts were found not to be significantly different, those for small sized nuts are.

Table 3: Effect treatments on growth parameter, DMY and P-uptake of jumbo nut sizes cashew seedlings of fertilizer

Treatment	Rate of application	Height	Stem diameter	Leaf area	No of Leaves	DMY	P-uptake
Control	0	27.64	0.54	100.51	17	11.60	4.82
PCA	10	28.25	0.53	93.20	15	8.20	4.53
PCB	10	45.20	0.65	128.90	21	14.30	1.99

NPK	10	33.00	0.59	108.40	16	10.63	3.53
PCA	20	44.92	0.67	113.70	24	13.23	6.65
PCB	20	37.83	0.68	112.0	18	13.33	5.0
NPK	20	33.40	0.70	131.90	20	18.96	3.59
LSD (P>0.05)		NS	NS	2.996	NS	NS	NS

Similarly, the effect of fertilizer treatment on growth parameters, DMY and P-uptake of small nut sizes of cashew seedlings (table 4) showed that the plant height of the treatment that received NPK at 10t/ha was 26.08cm followed by PCA at 10ton/ha was 25.00cm while PCB at 20ton/ha showed the least growth in height of 20.0cm. These values were also found not to be significantly different at P>0.05. For small sized nuts, treatments had no significant effect on stem diameter. Also, PCA at 10ton/ha application resulted in the highest number of leaves followed by PCA at 20ton/ha while application of NPK at 20ton/ha showed the lowest value. This may be as a result of depletion of nutrients needed by the leaves of the plant.

For dry matter yield (DMY) PCA at 10ton/ha (12.40g/plant) had the highest value which implies that cashew seedling that received PCA at 10ton/ha performed better than other treatment in terms of growth, while the PCB at 10ton/ha had lowest value of dry matter yield. Also, PCB at 20ton/ha had the highest P-uptake (30.12mg/kg) and this was found to be significantly different at P>0.05 from all other treatments.

Jumbo nuts have more food reserve than small nuts which could be utilized for initial growth before relying on the nutrients contained in the soil. These is similar to earlier findings of Adebola *et al*. [12] in which jumbo nuts gave better growth parameters than smaller and medium nut sizes. The better performance of the cashew plants resulting from the application of the organic fertilizers over inorganic fertilizer is important in view of the move towards organic cashew food production. Organic manures used as fertilizer were noted to be slow but steady in their nutrient release pattern [13].

Table 4: Effect of fertilizer treatment on growth parameters, DMY and P-uptake of small nut sizes cashew seedlings

Treatment	Rate of application	Height	Stem diameter	Leaf area	No of Leaves	DMY	P-uptake
Control	0	23.20	0.59	68.57	15	8.10	4.05
PCA	10	25.0	0.59	99.40	17	12.40	5.41
PCB	10	24.70	0.44	78.03	13	6.40	3.82
NPK	10	26.08	0.50	91.62	14	7.60	24.0
PCA	20	23.33	0.45	79.0	16	7.30	5.0
PCB	20	20.0	0.44	72.0	15	7.23	30.12
NPK	20	24.84	0.54	94.06	11	7.40	15.73
LSD (P>0.05)		NS	NS	NS	NS	NS	3.28

Conclusion

The results indicate that organo-mineral pacesetter grade B (PCB) at 10ton/ha and PCA at 20ton/ha gave the highest plant height (45.20cm and 44.92cm) in jumbo nuts compared to small nuts. It had plant height of 26.08cm and 25.0cm at PCA 10t/ha and NPK 10kgN/ha respectively. Application of NPK 15:15:15 at 20kgN/ha for jumbo nuts sizes gave highest value of leaf area (131.90cm^2). There is also a significant increase in dry matter yield and number of leaves of the jumbo cashew seedlings compared to small nut sizes. The small nut sizes had the highest P-uptake of 30.12mg/kg at PCB 20t/ha. It therefore indicates that optimal and economic cashew production on the soil could be obtained only if fertilizer application is properly managed. PCA at 10, 20 ton/ha and PCB at 10ton/ha could therefore be used to enhance the growth and P-uptake of cashew seedlings.

The results indicate that organo-mineral fertilizers performed better than inorganic fertilizers and this may be due to favourable nutrient mineralization of these fertilizers as a result of the influence of the mineral component on the organic fraction [14]. Therefore, due to the present high cost and scarcity of chemical fertilizers in Nigeria, organic fertilizers could be used to replace inorganic fertilizers as alternative sources of nutrients for better cashew plant

performance. In addition the organo-mineral pacesetter grade fertilizers are available, cheaper and environmentally friendly.

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