



Effect of Site-Specific Application of N and K Fertilizers on Cashew Growth and Yield in Ochaja, Kogi State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the Ochaja Substation of the Cocoa Research Institute in Ibadan, Nigeria. Ochaja is located in the guinea savanna zone of Nigeria. Plantation soil nutrient requirements were determined prior to applying the required fertilizers. The soil was deficient in nitrogen (N) and potassium (K), with values of 0.41 g/kg soil and 0.012 cmol/kg soil, respectively, at depths 0–40 cm. This value was used to calculate cashew fertilization rates of 54 kg N/ha and 84 kg K₂O/ha. Based on these values, four treatment combinations of two rates of nitrogen fertilizer and two rates of potassium fertilizer were formed and applied to young cashew trees on the field. Nitrogen fertilizer was applied at 0 and 54 kg N/ha while the Potassium was applied at 0 and 84 kg K/ha. Treatments were placed in a Randomized Complete Block Design (RCBD) with three replications, Cashew growth, nut yield and soil nutrient characteristics were measured. The first dose was applied in June while the second dose was applied in September of 2019 and 2020. Application of N fertilizer had a significant lowering effect on soil pH at both soil depths compared to the control and compared to N and K fertilizers applied together. Similarly, application of potassium-based fertilizer, with or without nitrogen fertilizer, slightly increased soil pH by 5.4%. Soil N had a significant effect ($P < 0.05$). Total N ranged from 0.5 g/kg to 0.7 g/kg soil for fertilizer

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treatments. N and K fertilizers did not significantly improve available soil phosphorus (P) across fertilization treatments. Exchangeable K in soil followed a similar trend with available P in different treatments. Yield of cashew nuts (280kg) improved significantly ($P < 0.05$) under application of sole nitrogen fertilizer and the control.

Keywords: Available phosphorus; exchangeable K; fertilization rates; treatment combinations.

1. INTRODUCTION

Cashew is an important commercial crop and has great potential as a source of foreign exchange earnings and industrial raw materials, and has the potential to become an important commercial tree in Nigeria. Due to its wide adaptability, cashews are often grown in very poor soils which have hampered their survival and establishment [1,2]. Cashew cultivation is subject to different limitations, both biotic and abiotic factors, especially in poor soils. The soil in which cashews are grown is of low or low fertility due to the misleading claim that cashews can survive in any soil, regardless of fertility. In most cashew plantations, fertilizer is not part of the production input system, so productivity is highly dependent on natural soil nutrients abundance [3,4]. As a result, the soil in which cashews are grown has been preserved by waste and other bounties of nature, and has not reached its full harvest potential. Fertilizers are rarely used in cashew production as an input to the production system, and when they are used, they are widely applied. This practice leads to over-fertilization in some areas and under-fertilization in others, or results in an unbalanced soil nutrient balance [5]. Fertilization is unavoidable to compensate for the depletion of soil nutrients during the annual harvest of apples and nuts. Site - specific fertilizer management (SSFM) improves nutrient use efficiency and yields higher returns on fertilizer investments [6,7]. At Ochaja Substation, the site under consideration is deficient in nitrogen and potassium, and for effective soil management, additional nitrogen and potassium-based fertilizers can increase productivity. Traditionally, among the few farmers who use fertilizers on their crops in Nigeria, the use of solid fertilizers containing the main nutrients nitrogen, phosphorus and potassium is common. The aim of this study therefore, was to evaluate the effects of N and K fertilizer applications and their effects on soil properties based on soil test values on cashew yield.

2. MATERIALS AND METHODS

Soil samples were randomly collected within the plantations area of Ochaja, and samples were

processed and analyzed for both physical and chemical properties using standard laboratory procedures using the IITA Laboratory Manual [8]. Calculated fertilizer rates are based on the result of analysis of soil samples from 0 to 40 cm depths. The result of the analysis indicated that the total nitrogen was 0.04 g/kg soil which is inadequate to sustain cashew as it requires 1g/kg soil and the available P was adequate while the exchangeable potassium was deficient having a value of 0.012 cmol/kg which is far below the critical limit of 0.12 cmol/kg soil. From these values, four treatment combinations of two rates of nitrogen fertilizer and two rates of potassium fertilizer were formed and applied to young cashew trees in the field. Nitrogen fertilizers were applied at 0 and 54 kg N/ha, potassium at 0 and 84 kg K/ha, treatments were placed in three replicate RCBDs, and crop morphological parameters, nut yield and soil nutrient characteristics were measured. The fertilizers were applied in two splits application. The first dose was applied in June, 2020 while the second dose was applied in September of 2020. Early plant growth parameters were used to form the basis for evaluating the effects of fertilizer treatments. Collected data were subjected to ANOVA and means separated using LSD with 5% probability.

3. RESULTS AND DISCUSSION

3.1 Results of Pre – Cropping Soil Analysis

The pre-cropping soil properties indicated that the soil was sandy loam, with average values for sand, silt, and clay of 888, 20, and 92 g/kg soil, respectively (Table 1). The pH was slightly acidic and very close to neutral averaging 6.7, and organic carbon (OC) was low averaging 0.82 g/kg soil. Block B OC was higher than Block A OC. Total nitrogen in soil was 0.41 g/kg soil, which is below the critical value of 1 g/kg soil. A deficiency of 0.6 g/kg soil required 54 kg N for optimal production, whereas the average available P was 5.28 mg/kg soil. This value exceeds the level required by cashews for optimal productivity. The mean potassium value

was 0.012 cmol/kg soil. A deficit of 0.108 cmol/kg requires 84 kg/ha. Exchangeable calcium ranged from 1.26 to 2.26 cmol/kg at soil depths of 0 to 40 cm, with an average of 1.68 cmol/kg. The exchangeable Mg ranged from 0.25 – 0.35 cmol/kg soil with an average of 0.29 cmol/kg soil.

3.2 Effects of Urea and Potassium Fertilizer on the Soil pH

Table 2 revealed the influence of Nitrogen and Potassium fertilizers on some soil chemical properties at Ochaja cashew plot. The Soil pH of the two soil depths (0 - 20 and 20 - 40 cm) was significantly ($P < 0.05$) affected by the application of nitrogen and potassium fertilizers. The Urea (N) fertilizer application had a significant depressive effect on soil pH at both soil depths compared to the control and the plots where urea (N) and K fertilizers were applied in combination.

3.3 Influence of N and K Fertilizer Application on Soil N

The control (T1) and plots that received K fertilizer recorded a significantly ($P < 0.05$) higher N value of 0.07 g/kg soil compared to where urea (N) fertilizers (T2 and T4) were applied. The differences were significantly ($P < 0.05$) different among the treatments. However, the control plot and those that were treated with sole potassium (K) fertilizer recorded similar effect on the amount of N content in the soil. The amount of N in each of the plot number under consideration are in the following descending order: T1 and T3 > T2 and T4 at 0 to 20 cm depths, At depths 20 to 40 cm,, the plots that received combined application of Urea and Potassium fertilizers recorded the highest N values (0.04 g/kg soil) relative to the rest. The mean differences of N values across the treatments were not different significantly ($P < 0.05$) from one another. This may be due to the properties of urea fertilizers that lower soil pH, as observed by Agbede [9] and Adejumo [10]. Similarly, application of N and K fertilizers significantly ($P < 0.05$) affected total soil N at soil depths of 0-20 cm. However, the effect was not significant for soil depths of 20- 40 cm, notably, total soil N appeared lower at urea - applied sites than in controls (no fertilizer). A high sand content in the soil may be the reason for the low retention of the applied N. Similarly, Sandy textured soils generally have limited nutrient holding capacity. Nitrogen is prone to leaching in sandy soil as water flows through the more porous structure [11]. This observation contradicted the observations of Adejumo, [10]

that application of urea fertilizer increased the total soil N.

3.4 Effects of Urea and Potassium Fertilizer Application on soil Phosphorus

The application of Urea and potassium fertilizers significantly depressed the amount of available phosphorus in the soil irrespective of the depths. The plots without fertilizer application recorded the highest soil available P relative to the other plots with fertilizer addition. Similar trend was observed at both depths (0 – 20 & 20 – 40 cm) with the control plots recording the mean values of 11.17 and 10.35 mg/kg soil respectively (Table 2). The mean differences were significant. The order of significance in descending order is as follows: Control (T1) > T2 > T4 > T3 at 0 – 20 cm depths while at the lower depths (20 – 40 cm) Control (T1) > T4 > T2 > T3.

3.5 Influence of Application of Urea and Potassium Fertilizer on Soil K

Similar trend was observed in the amount of exchangeable K in the soil arising from the effects of applied K and Urea fertilizers. The control plot recorded the highest mean K values of 0.16cmol/kg relative to the plots where Urea and K fertilizers were applied irrespective of whether the fertilizers were applied sole or in combination. T2 and T3 recorded similar effects and values 0.14 cmol/kg soil respectively at 0 - 20cm depths (Table 2), these values were significantly ($P < 0.05$) higher than T4 at the same depth. At 20 - 40cm depth, T2 produced a significantly ($P < 0.05$) higher K in the soil compared to the rest, T1 and T2 were not statistically different from each other but were both higher significantly when compared with T3.

3.6 Influence of Application of Urea (N) and Potassium (K) Fertilizers on Raw Cashew Nuts

Application of N fertilizer (Urea) promoted cashew growth, which was reflected in an increase in cashew nut yield. The Cashew nut yield was significantly ($P < 0.05$) improved by nitrogen and potassium fertilizers (Fig. 1). In particular, N fertilizer application significantly ($P < 0.05$) increased cashew nuts yield (280 kg) compared to the control (100 kg). Relative to other fertilizer type, Cashew plots that were treated with sole Urea fertilizer (T2) positively enhanced the vegetative and the reproductive growth of cashew thus increased the yield of raw nuts.

Table 1. Initial soil physical and chemical properties of the cashew plot

Block	Soil Depth (cm)	Sand g/kg soil	Silt g/kg soil	Clay g/kg soil	pH	O.C g/kg	Total N g/kg	Ava.P Mg/kg	Exch K ⁺ Cmol/kg	Exch Ca ²⁺ Cmol/kg	Exch Mg ²⁺ Cmol/kg	CEC Cmol/kg	Base saturation (%)
A	0-20	885.20	22.80	92.00	6.7	0.78	0.07	5.03	0.012	2.26	0.35	2.78	95.83
A	20-40	895.20	12.80	92.00	6.8	0.66	0.02	5.20	0.011	1.73	0.29	2.18	95.05
B	0-20	895.20	12.80	92.00	6.6	0.97	0.05	5.35	0.012	1.26	0.27	1.70	92.81
B	20-40	875.20	32.80	92.00	6.7	0.86	0.02	5.55	0.012	1.34	0.25	1.15	91.62
Mean (x)		887.70	20.30	92.00	6.7	0.82	0.04	5.28	0.012	1.65	0.29	1.95	93.83

Table 2. Influence of Nitrogen and Potassium fertilizers on some soil chemical properties at Ochaja cashew plot

Treatment	pH (H ₂ O)		Total N (g/kg)		Available P (mg/kg)		Exchangeable K (cmol/kg)	
	0 - 20cm	20 - 40cm	0 - 20cm	20 - 40cm	0 - 20cm	20 - 40cm	0 - 20cm	20 - 40cm
N ₀ K ₀ -T1(Control)	5.13	4.94	0.07	0.03	11.17	10.35	0.16	0.10
N ₁ K ₀ -T2	5.77	4.77	0.05	0.03	10.22	9.74	0.14	0.11
N ₀ K ₁ -T3	5.27	5.17	0.07	0.03	7.39	8.98	0.14	0.09
N ₁ K ₁ -T4	5.54	5.37	0.05	0.04	9.37	10.32	0.13	0.10
LSD (P<0.05)	0.19	0.20	0.01	0.02	0.72	0.60	0.01	0.01

Legend: N₀K₀-T1 (Control); N₁K₀-T2, N₀K₁-T3, N₁K₁-T4

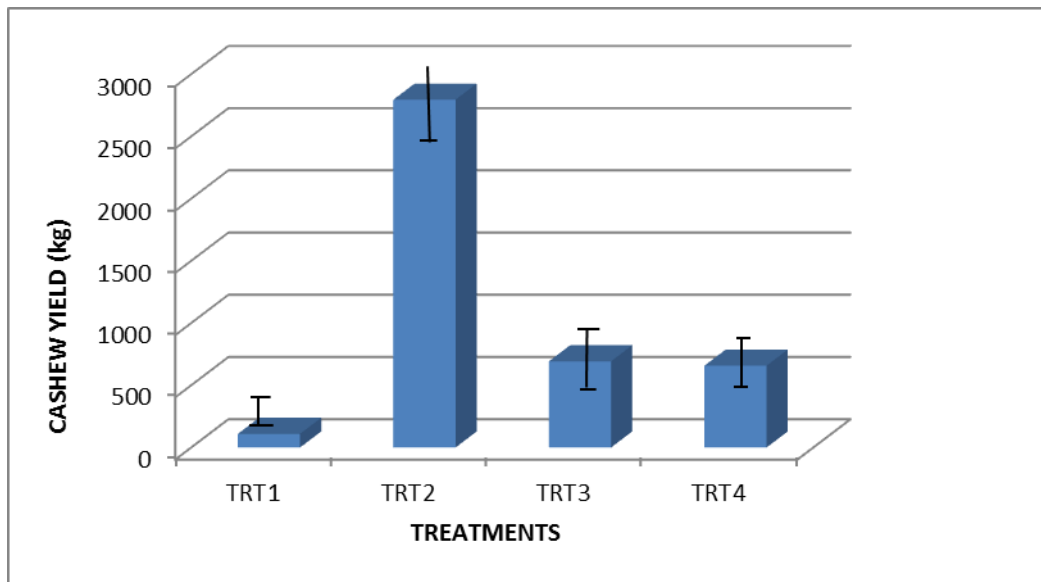


Fig. 1. Effects of Nitrogen and Potassium based fertilizer on raw cashew yield (kg)

This observation is consistent with the result obtained by Adejumo, [10]; Babu et al., [12] and Habibu et al., [13] who reported that, application of N P K fertilizer significantly enhanced the yield of Cashew nuts relative to the control. In a separate study on nitrogen and potassium application effects on productivity, profitability and nutrient use efficiency of irrigated wheat (*Triticum aestivum* L.), Sandeep et al., [14] revealed that wheat productivity, plant growth and yield attributes, nutrients uptake and use efficiency increased significantly ($P < 0.05$) with N - fertilizer application, although there were no significant interaction effects of N and K.

4. CONCLUSION

Arising from the results of the study, it could be concluded that application of N – based fertilizer inform of urea significantly enhanced yield performance of the Cashew in the study area. However, fertilization based on the result of soil test and the needs of the site yields optimal results in terms of efficiency of fertilizer use, yielding better crop yields compared to blanket application of fertilizers without relying on the inherent nutrients of the soil. Potassium (K) and nitrogen (N) are two vital nutrients that create greater benefits working together than alone. However, higher nitrogen fertilization resulted in higher crop yields and higher nitrogen accumulation. It is also beneficial when SSFM is used in combination with other soil management techniques such as integrated soil fertility management and conservation agriculture (CA).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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