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Studies on the production of tigernut (*Cyperus esculentus L.*) in Southeastern Nigeria, I: Effect of seven complementary fertilizer treatments on growth and yield of tigernut in pot

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Abstract:

Tigernuts have so many food and medicinal potentials as it contains some amount of vitamins, minerals and phytochemicals. Despite the food and health benefits associated with this tuber, its production in southern Nigeria is at an abysmal level probably due to lack of knowledge for its production or utility. This experiment was conducted at the University of Nigeria Teaching and Research Farm to evaluate the effect of seven complementary fertilizer treatments on the growth and yield of tigernut. The experiment is an attempt to develop appropriate agronomic practice that will assure regular cultivation culture. The experimental design was a completely randomized design with seven fertilizer treatments and replicated 10 times. Treatments were NPK 15:15:15 (300 kg/ha), NPK 20:10:10 (300 kg/ha), poultry manure, PM, (5 t/ha), NPK 15:15:15 (150 kg/ha) + 3 t/ha PM, NPK 20:10:10 (150 kg/ha) + 3 t/ha PM, K-nitrate (100 kg/ha) + Ca-nitrate (100 kg/ha) + 2.5 t/ha PM and control (No fertilizer application). Fertilizer treatments significantly ($p < 0.05$) influenced growth and yield parameters except fresh weight of leaves, length of longest root and weight of seed planted. Significantly ($p < 0.05$) superior values of growth and yield parameters were obtained in plants grown with NPK 15:15:15 (300 kg/ha), followed closely by the application of NPK 20:10:10 at 150 kg/ha plus 3 t/ha PM. This study recommends application of NPK 15:15:15 (300 kg/ha) or the combined application of organic and inorganic fertilizer (NPK 20:10:10 at 150 kg/ha plus 3 t/ha PM) to boost the yield and growth of tigernut.

Keywords: Growth, Yield, Fertilizer treatment, Tigernut tubers.

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INTRODUCTION

Tigernut or the chufa nut is a crop of early domestication belonging to the family *Cyperaceae*. The plant is inaccurately referred to as a nut but has a spherical rhizome, which terminates as tuber serving as main means of reproduction, although it produces viable seeds. The storage root which is the tuber, popularly known as 'aki Hausa' in Igbo is produced and consumed fresh as a snack, processed or as a part of medicinal preparations (Lowe and Whitwell, 2000; Deatra, 1999; HBR 2005).

Tigernut can be grown annually or perennially, characterized by its vibrant green-yellow basal leaves and solitary stems emerging from a tuber (Bryson and DeFelice, 2009). The seed are the

means of dispersal, they are typically in a dormant state when shed, but the dormancy can be broken by exposure to moist storage at 10^{o}C (Holm et al., 1977). Nutritionally, the tubers are the economic or most important part of the plant because they consist of some amount of digestible carbohydrates, protein, fiber and oil (Zhang et al., 1996). Tigernuts have so many food and medicinal potentials as it contains some amount of vitamins, minerals and phytochemicals. Despite the health benefits associated with this tuber, it is still underutilized probably due to lack of knowledge of its health benefits.

Effective fertilization is a fundamental aspect of nutrient management strategies, carrying significant importance in crop production. It acts as a crucial means to enhance both crop yield and efficient utilization of nutrients (Yousaf et al., 2017; Seleimann *et al.,* 2021). Tigernuts can grow well in soils with low to moderate fertility, since they are not heavy feeders. However, proper fertilization is required for increased productivity and quality. During the process of plant growth, it is necessary for the plant to receive essential nutrients to ensure its optimal development. Adding fertilizers to soil ensures the plant receives the essential nutrient required (Naresh, 2019; Tang et al., 2015).

Plant nutrient uptake and responses to fertilization differs throughout the growth stages of the crop, hence adequate nutrient is required. Therefore, the objective of this study was to determine the effect of different complementary fertilizers on the growth and yield of tigernuts in a pot experiment.

MATERIALS AND METHODS

Experimental Site: The experiment was conducted in the Department of Crop Science, University of Nigeria, Nsukka, Enugu State between August and December 2022. Seeds were sourced from Jos and soaked in lukewarm water for a period of 24hrs before planting. Flotation test was carried out and only viable seeds were selected using this method. Seeds were planted in a seed tray and thereafter transplanted to a poly-pot.

The experiment was a completely randomized design with seven-fertilizer treatment and ten replications. The treatments were NPK 15:15:15 at 300kg/ha, NPK 20:10:10 at 300kg/ha, poultry manure 5t/ha, NPK 15:15:15 at 150kg/ha + 3t/ha poultry manure, NPK 20:10:10 at 150kg/ha + 3t/ha poultry manure and potassium nitrate (KNO_3) at 100kg/ha + calcium nitrate ($Ca(NO_2)_3$) at 100kg/ha + 2.5t/ha poultry manure and control (No fertilizer). Choice of complementary fertilizer treatments was based on long-term experiential (> 25 years) and empirical fertilizer studies on several horticultural crops in this region. Parameters measured included number of days to seedling emergence, number of shoots, number of leaves, number of tillers, leaf length, fresh weight of leaves, number of tubers, below ground biomass, whole plant biomass weight, weight of tubers produced and weight of seed planted. Data measured were subjected to Analysis of variance (ANOVA) using the procedures outlined for Completely Randomized Design (CRD) using Genstat12.0. Significant treatment means were determined using Fischer's Least Significance Difference (F-LSD) at 5% probability level.

RESULTS

The percentage of clay, silt and sand in the soil sample analyzed was 22%, 11% and 35% respectively (Table 1). The analysis showed that the soil sample had a higher percentage of sand particles, followed by clay and then silt. The soil belongs to the textural class sandy clay loam. The pH of the soil ranged between 5.6 – 6.3, which is slightly acidic and suitable for tigernut cultivation. The poultry manure analysis showed that the poultry manure (PM) has 1.961 % N which implies that the PM has high nitrogen content. Analysis of variance (data not shown) revealed that the effect of the treatments applied were significant ($p < 0.05$) on the leaf length from the 6th to the 12th week after treatment application. Tigernuts grown with NPK 15:15:15 at 300 kg/ha produced the longest leaf length of 83.8cm while plants grown without fertilizer had the least with 71.8 cm at 12 weeks after transplanting (Table 2).

Number of leaves was not significantly ($p > 0.05$) influenced by the fertilizer combination (Table 3). However, NPK 15:15:15 had the highest number of leaves at all weeks except for the 2nd week after transplanting. Table 4 showed that the treatment application had no significant effect on the number of tillers at 5% probability level except at the 12th week. Application of poultry manure at 5 t/ha produced the highest number of tillers at the 12th week. On the yield parameters measured (Table 5), the seven-fertiliser combination significantly influenced below ground biomass, length of longest leaf, number of leaves, number of tubers, weight of tubers and whole plant biomass at 5% probability level. Fresh weight of leaves, length of longest leaf and weight of seed planted showed no significant difference ($p > 0.05$). NPK 15:15:15 (300 kg/ha) greatly influenced most of the yield parameters except length of longest root and weight of seed planted which was higher in seeds grown with NPK 20:10:10 (300 kg/ha). The biomass distribution shown on Table 6 was non significant at 5% probability level. Poultry manure at 5 t/ha gave the highest biomass followed by NPK 20:10:10 (150 kg/ha) + 3 t/ha poultry manure,

while the least were plants grown without fertilizer. The results of the correlation analysis among the yield and yield components of tigernut on Table 7, showed a highly significantly ($p < 0.01$) strong positive relationship between the fresh weight of leaves and below ground biomass, weight of tubers, whole plant biomass weight and a significantly ($p < 0.05$) strong positive relationship with length of longest leaf, number of leaves and tubers. However, the weight of seed planted had no relationship with any yield parameters measured.

Table 1: Physiochemical properties of the soil and poultry manure samples utilized

Properties	Soil	Poultry manure
Clay (%)	22	-
Silt (%)	11	-
Fine sand (%)	35	-
Coarse sand (%)	32	-
pH (H_2O)	6.3	7.8
pH (KCl)	5.6	7.1
Organic carbon (%)	1.733	41.105
Organic matter (%)	2.987	70.830
Total nitrogen (%)	0.154	1.961
Exchangeable Na (me/100g)	0.06	0.13
Exchangeable K (me/100g)	0.13	0.16
Exchangeable Ca (me/100g)	1.20	3.20
Exchangeable Mg (me/100g)	0.80	2.88
CEC (me/100g)	13.60	-
Base saturation (%)	16.10	-
Exchangeable acidity Al (me/100g)	0.20	-
Exchangeable acidity H (me/100g)	1.40	-
Available phosphorus (ppm)	8.46	0.346

Table 2: Response of leaf length to seven complementary fertilizer treatments

Treatment	Weeks after Transplanting					
	2	4	6	8	10	12
	Leaf length (cm)					
Control	52.0	67.6	73.4	74.3	73.9	71.8
NPK 15:15:15 (300kg/ha)	52.7	72.9	83.0	84.2	84.8	83.8
NPK 20:10:10 (300kg/ha)	52.3	70.2	76.9	77.5	77.7	78.2
Poultry manure (PM) 5t/ha	50.1	67.9	75.1	75.9	75.8	74.3
NPK 15:15:15 (150kg/ha) + 3t/ha PM	51.6	67.7	74.8	76.0	76.0	76.5
NPK 20:10:10 (150kg/ha) + 3t/ha PM.	53.8	72.4	79.4	79.5	80.4	78.8
$K(No_3)_2$ + $CaNo_3$(100kg/ha) + 2.5t/ha PM	54.4	72.2	79.7	82.2	82.1	81.4
LSD (0.05)	NS	NS	6.28	6.25	6.24	6.27

Table 3: Response of number of leaves to seven fertilizer treatments

Treatment	Number of Leaves					
Control	26.7	34.1	34.1	30.1	25.3	18.6
NPK 15:15:15 (300kg/ha)	25.4	39.0	41.6	38.5	33.2	28.2
NPK 20:10:10 (300kg/ha)	25.9	36.6	35.5	30.5	24.3	18.5
Poultry manure (PM) 5t/ha	28.2	35.7	34.1	29.7	23.1	19.2
NPK 15:15:15 (150kg/ha) + 3t/ha PM	24.4	31.5	34.0	30.2	24.2	20.0
NPK 20:10:10 (150kg/ha) + 3t/ha PM.	27.2	37.1	38.5	34.5	28.4	19.5
$K(No_3)_2$ + $CaNo_3$(100kg/ha) + 2.5t/ha PM	26.7	34.4	34.8	29.8	25.7	20.7
LSD (0.05)	NS	NS	NS	NS	NS	NS

Table 4: Effect of seven fertilizers treatment on the number of tillers

Treatment	Number of Tillers					
Control	3.2	3.2	3.2	3.2	3.1	3.1
NPK 15:15:15 (300kg/ha)	2.8	2.8	2.7	2.6	2.6	2.9
NPK 20:10:10 (300kg/ha)	2.7	2.7	2.8	2.8	2.8	2.6
Poultry manure (PM) 5t/ha	3.1	3.1	3.1	3.1	3.1	4.4
NPK 15:15:15 (150kg/ha) + 3t/ha PM	2.8	2.8	2.8	2.6	2.7	2.9
NPK 20:10:10 (150kg/ha) + 3t/ha PM.	2.8	2.8	2.8	2.8	2.8	3.2
$K(No_3)_2$ + $CaNo_3$(100kg/ha) + 2.5t/ha PM	2.3	2.3	2.3	2.0	2.3	2.6
LSD (0.05)	NS	NS	NS	NS	NS	0.94

Table 5: Effect of seven complementary fertilizer combinations on the yield of tigernut

Treatment	FWL	BGB	LLL	LLR	NOL
Control	8.9	11.4	76.3	11.7	17.3
NPK 15:15:15 (300kg/ha)	13.6	18.4	88.8	11.1	27.8
NPK 20:10:10 (300kg/ha)	10.4	13.6	84.9	14.4	16.4
Poultry manure (PM) 5t/ha	7.9	11.7	78.6	11.8	18.8
NPK 15:15:15 (150kg/ha) + 3t/ha PM	9.6	10.7	81.4	13.0	20.7
NPK 20:10:10 (150kg/ha) + 3t/ha PM.	9.8	14.4	84.2	12.7	18.3
$K(No_3)_2$ + $CaNo_3$(100kg/ha) + 2.5t/ha PM	8.8	12.2	83.6	11.2	19.2
LSD (0.05)	NS	3.73	7.5	NS	7.21

Treatment	NOT	WOT	WPBW	WSP
Control	14.3	7.6	20.1	2.7
NPK 15:15:15 (300kg/ha)	24.9	13.6	33.0	2.7
NPK 20:10:10 (300kg/ha)	17.9	9.4	23.5	3.0
Poultry manure (PM) 5t/ha	15.4	7.3	18.5	2.7
NPK 15:15:15 (150kg/ha) + 3t/ha PM	13.1	7.4	19.9	2.1
NPK 20:10:10 (150kg/ha) + 3t/ha PM.	20.3	10.7	23.8	2.8
$K(No_3)_2$ + $CaNo_3$(100kg/ha) + 2.5t/ha PM	17.4	9.1	20.8	2.7
LSD (0.05)	6.34	3.57	6.68	NS

FWL= Fresh weight of leaves; BGB= Below ground biomass; LLL= Length of longest leaf; LLR= Length of longest root; NOL= Number of leaves; NOT= Number of tubers; WOT= Weight of tubers; WPBW= Whole plant biomass weight; WSP= Weight of seed planted; LSD= Least significant difference; NS= non-significant.

DISCUSSION

The result of this study showed that tigernuts respond differently to varying levels of fertilizer application. On the leaf length, the effect of the fertiliser added became more evident from the 6^{th}week, which could be because the plants were yet to absorb and completely respond to treatment. NPK 15:15:15 had greater influence on the growth parameters, as the leaves were longer and had greater number of leaves. On yield parameters, NPK 15:15:15 at 300 kg/ha produced greater yield than other fertilizer applied. This may be due to the fact that NPK 15:15:15 is balanced and have more of potassium and phosphorus than NPK 20:10:10, where potassium and phosphorus contributes to the promotion of plant height, tillering, flowering and tuber formation whereas nitrogen stimulates vegetative growth. NPK 20:10:10 at 150 kg/ha plus 3 t/ha poultry manure had higher number of tubers after NPK 15:15:15 at 300 kg/ha. This might be due to the combined effect of poultry manure and NPK fertilizer. The nitrogen encouraged foliage development which enhanced photosynthetic capacity ultimately leading to increased crop yield. Greater number of tillers was recorded through poultry manure incorporation at 5 t/ha at the 12^{th} week after transplanting. The addition of poultry manure to the soil increased the soil organic matter content, leading to higher productivity, and facilitates plant root penetration by reducing compaction. Organic sources like poultry manure provide more balanced nutrition, especially micronutrients which have been observed to promote better tillering in plants (Miller, 2007). This conforms to the study conducted by Ebeniro *et al*., (2011) on effect of poultry manure and palm bunch ash on ginger. Abou-Elmagd *et al.,* (2006) reported that poultry manure, being rich in nitrogen and other plant nutrient and as a result, it favours the growth and development of root system, leading to improved growth, increased photosynthetic activity and greater accumulation of dry matter in plants.

Table 6: Effect of seven-fertilizer combination on the percent biomass partitioned to tigernut tubers

Treatment	Biomass partitioned (%)
Control	55.29
NPK 15:15:15 (300kg/ha)	56.68
NPK 20:10:10 (300kg/ha)	57.97
Poultry manure (PM) 5t/ha	67.49
NPK 15:15:15 (150kg/ha) + 3t/ha PM	54.68
NPK 20:10:10 (150kg/ha) + 3t/ha PM	62.77
$K(NO_3)_2$ +$CaNO_3$ at 100kg/ha + 2.5 t/ha PM	59.00
LSD (0.05)	NS

Table 7: Correlation coefficient of yield and yield component of tigernuts

** Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)

	Correlation								
	FWL	BGB	LLL	LLR	NOL	NOT	WOT	WPBW	WSP
FWL	1	.897**	.815*	-0.065	.788*	.818*	.891**	.971**	0.103
BGB		1	.828*	-0.202	0.716	.980**	.980**	.974**	0.401
LLL			1	0.063	0.605	.847*	.878**	.834*	0.226
LLR				1	-0.525	-0.243	-0.217	-0.186	0.126
NOL					1	0.655	0.708	.785*	-0.274
NOT						1	.983**	.926**	0.462
WOT							1	.965**	0.349
WPBW								1	0.254
WSP									1

Tigernuts grown with different fertilizer responded differently in total biomass accumulation due to the varying levels of nutrient applied. Highest biomass accumulation was observed in plants grown with poultry manure at 5 t/ha, followed by NPK 20:10:20 (150 kg/ha) + 3 t/ha PM and the least was found to be in plants grown without fertilizer. This could probably be as a result of the essential nutrients and micronutrients supplied by the poultry manure and NPK fertilizer. Similarly, study of Timon et al. (2019) in North Eastern Nigeria reported significant complimentary fertilizer effects on the growth and yield of tigernut. This also conforms to the study of Liang et al. (2012) who pointed out that continuous organic and inorganic fertilizer application under wheat and maize production system would significantly lead to increased yield when compared to unfertilized control plots.

It was evident from the study that NPK 15:15:15 at 300 kg/ha had a significant influence on growth and yield of tigernut, followed closely by NPK 20:10:10 at 150 kg/ha plus 3 t/ha poultry manure and were found most appropriate. A combination of organic and inorganic fertilizer will boost the yield and growth of tigernut. The results of Timon et al. (2019) and reports of the current study suggest high level of fertilizer responsiveness of tigernut. Meaning that the crop growth and yield can positively be manipulated via fertilizer management.

CONCLUSION

Empirical data derived from this study suggest that with appropriate fertilizer and other agronomic management strategies tigernut can be grown sustainably in southeastern Nigeria. Application of NPK 15:15:15 at 300 kg/ha was most appropriate but for sustainable land use management, application of NPK 20:10:10 at 150 kg/ha plus 3 t/ha poultry manure could be more preferable due to the role of poultry manure on soil health.

Further fertilizer management trials across spatial and temporal environments in southern Nigeria are advocated to enhance robust fertilizer recommendation for the region.

Conflict of interest

The authors have no conflict of interest to declare.

Author contribution

This research is the result of collaborative effort by all the authors. KPB developed the concept, designed and guided the conduct of the experiment and reviewed and corrected the manuscript. AJI, OO and EUI conducted the field trials, collected the data, carried out the analyses and developed the draft manuscript.

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