Journal of Agroforestry and Environment

Volume 18, Issue 1, 2025

Journal DOI: https://doi.org/10.55706/jae
Journal homepage: www.jagroforenviron.com

Direct Sowing and Transplant Influenced Performance of Tiger Nut (*Cyperus esculentus L.*) Fertilized with NPK and Poultry Manure in Southern Nigeria

Ehizogie Joyce FALODUN[1*] and Boris Osarobo OKONOKHUA[2]

[1]Department of Crop Science, Faculty of Agriculture, University of Benin, Nigeria
[2]Department of Agronomy and Environmental Management, Faculty of Agriculture and Agricultural Technology, Benson Idahosa University, Benin City, Nigeria.

[*]Correspondence: ehizogie.falodun@uniben.edu; Phone:+2348080641084

Received: 11/05/2025
Accepted: 27/06/2025
Available online: 05/07/2025

Abstract: Tiger nut (*Cyperus esculentus* L.) cultivation is a possible and effective way to increase food production in the humid rainforest of Nigeria. However, the response of tiger nuts to sowing methods and fertilizer application are yet to be fully explored. The aim of this experiment is to determine the impact of direct sowing, transplant and fertilizer application on the vegetative and yield characters of tiger nut. The treatments had a combination of two sowing methods D (direct sowing) and T (transplant) and four fertilizer rates F1 (control), F2 (400 kg ha^{-1} NPK 15:15:15), F3 (poultry droppings 20 t ha $^{-1}$), F4 (poultry manure 10 t ha $^{-1}$ + 200 kg ha $^{-1}$ NPK 15:15:15). The results showed that some of the agronomic traits of tiger nut in the direct sowing method were superior to the transplant. Plant height (98.35 cm), leaf area (67.95 cm ^{2}), number of tubers plant $^{-1}$ (27.12) and fresh tuber yield (4.29 t ha $^{-1}$) increased significantly above the values obtained for the transplants. Additionally, plants that received fertilizer application demonstrated distinct advantages compared with the control. Therefore, for higher tuber yield sowing tiger nut (*Cyperus esculentus* L.) directly with any of the fertilizer rates used for this experiment can be recommended for tiger nut farmers in this locality.

Keywords: Direct sowing; Fertilizer; Tiger nut; Transplant; Yield.

INTRODUCTION

Tiger nut (*Cyperus esculentus L.*) is a tuber crop belonging to the family *Cyperaceae*. The crop is commonly known as earth almond, Chufa nut grass and Zulu nut. According to Adejuyitan, (2011), in Nigeria, the crop is locally called "Ayaya" in Hausa, "Ofio" or "Imumu" in Yoruba and "Aki-hausa" in Igbo where it is cultivated. The plant requires a well-drained sandy or loamy soils for its production which increases as the ambient temperature increases (Bamishaiye & Bamishaiye, 2011). Adejuyitan, (2011) reported that tiger nuts produce edible tubers that are between 0.3 cm - 1.9 cm in diameter which are usually eaten uncooked and rich in dietary fiber, carbohydrate, protein, vitamins, and minerals, making them a valuable addition to any diet. The dried nuts can be ground into powder and incorporated into various foods and the oil extracted from tiger nut also known as chufa oil is used in cooking and manufacturing of body and hair creams. Zang & Sun, (2023); Liu, *et al*., (2020) stated that tiger nut oil is a naturally high oleic edible oil, which can reduce the levels of total and saturated fats while increasing unsaturated fatty acids and these attributes made it widely acceptable for consumption.

The crop has been described by Chukwuma, *et al*., (2010) as an important food of high nutritional and economic values and a good source of starch for human consumption and industrial use. Despite its high application and utilization value, its production in southern Nigeria is at an abysmal level the total area under its cultivation and tonnage produced in Nigeria is not known due to paucity of information about the crop but it is believed to be very low due to unimproved methods of cultivation on a small scale in nutrient deficient soils which usually leads to very low crop yields on farmers' fields. A concerted effort is required to encourage farmers to grow tiger nut to meet both local and export demands. Fertilizer application and planting methods such as direct sowing and transplanting are cultural practices that greatly influence the shoot growth and tuber yield of tiger nut because it gives better field stand, survival and ultimately high and quality yield. Direct sowing has been considered a cost-effective method of stand establishment since transplanting would require the additional costs for raising the transplants in nurseries and high labor costs of transplanting (Ketema, *et al.,*(2013); Palma & Laurance, (2015). Kiziloglu *et al.,* (2015) found that direct sowing often results in slower initial growth compared to transplanting but can catch up in later stage. Seeds sown directly in the ground may also be vulnerable to pest damage, and the timing of sowing is critical to align with the local climate and growing season. Transplanting can enhance crop uniformity and early growth stages by allowing for precise spacing between plants (Durojaiye *et al.,* 2015). Leskovar & Othman, (2021) stated that transplants consistently exhibited increased vegetative growth and yield attributes of artichoke cultivars over direct seeded cultivars. The choice between transplanting and direct sowing depends on various factors, and both methods have their place in horticulture and agriculture. Additionally, inorganic fertilizers can help maintain consistent quality in tiger nut crops by ensuring a steady supply of nutrients required for the development of desirable tuber characteristic (Ojeniyi *et al.,* 2012). Combined application of poultry manure and NPK fertilizer may result in synergistic effects, as organic matter from poultry manure can improve the soil's ability to retain and release nutrients from the NPK fertilizer (Ojeniyi *et al.,* 2017). Information documented especially in the southern rain forest on the sowing methods and fertilizer application and other agronomic practices on tiger nut is scanty. It is therefore important to carry out relevant research on tiger nuts and find a suitable sowing method and nutrient requirements for this crop. The objective of this study was to determine the best sowing method and fertilizer rates for tiger nut growth and tuber yield in Edo, rain forest agro ecological zone of Nigeria.

MATERIALS AND METHODS

Experimental site description

A two-year field study was conducted at the Department of Crop Science Research Farm, Faculty of Agriculture, University of Benin, Benin City, Nigeria during the cropping seasons of 2023 and 2024. The experimental site lies between (latitude 06º 20 'N and longitude, 5º 36 'E) at an altitude of 162 m above sea level and located in the rain forest agro ecological zone of Nigeria. The rainfall pattern is bimodal with peaks in July and September. The total annual rainfall in the area is about 2300 mm with a dry spell in August while the mean annual temperature is 28 °C. The soil at the site of the experiment is an Ultisol characterized by sandy loam with low nutrient content.

Determination of soil properties

Prior to planting, soil samples from the top soil were randomly collected from a depth of 0 – 15 cm using a metal soil auger and bulked together to form a composite soil sample. Composite soil samples and poultry manure were air-dried and sieved using a 2-mm sieve and analyzed for pH, organic carbon and total nitrogen. Soil pH was determined using a soil–water medium at a ratio of 1:2 with a digital electronic pH meter. Soil organic carbon (OC) was determined by the procedure of Walkley & Black, (1962) using the dichromate wet oxidation method. Organic matter was then estimated by multiplying the organic carbon with a value of 1.724 (Van Bemmmelen factor). Total N was determined by the micro-Kjeldahl digestion method. The Available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry. Exchangeable K, Ca, and Mg were extracted using 1 M ammonium acetate (Hendershot, *et al*., 2007). K and Na in the extract were read on a flame photometer while Ca and Mg were read on Atomic Absorption Spectrophotometer (AAS). The textural class of the soil was determined by the method of Gee & Or, (2002). The result of the physical and chemical properties of the soil of the experimental field and chemical analysis of the poultry is shown in (Table 1).

Source of planting materials

The tiger nuts tubers used for the experiments were purchased from a reliable seed store in Benin City while the inorganic fertilizer (NPK 15:15:15) was obtained from Agricultural Development Program (ADP), Edo and the poultry manure was obtained from the animal section of University of Benin, Farm Project.

Experimental design

The experiment was laid in a randomized complete block design (RCBD) in three replications consisting of two sowing methods D (direct sowing) and T (transplant) and four fertilizer treatments F1 (control), F2 (400 kg ha^{-1} NPK 15:15:15), F3 (poultry droppings 20 t ha $^{-1}$), F4 (poultry manure 10 t ha $^{-1}$ and 200 kg ha $^{-1}$ NPK 15:15:15).

Tiger nut cultivation

The land was prepared by clearing and tilling the soil manually, the site was marked out and beds of 1 m x 1 m spaced at 0.5 m apart were raised. Each replicate had 8 plots for a total of 24 plots.

The cured poultry manure was applied immediately into the experimental plots while the inorganic NPK 15:15:15 fertilizer was applied using band placement, 4 weeks after planting (WAP) according to the treatments. A hand-held hoe was used to work the manure into the soil to a depth of approximately 10 cm and left for two weeks before planting of tiger nuts to allow for decomposition and mineralization of the poultry manure. The tiger nut seeds to be planted were selected of uniform sizes and tested for viability using floatation method for 24 hours, the floating tubers were discarded and the viable tubers which sank to the bottom of the beaker planted. Direct seeding and transplanting were performed simultaneously, two seeds were sown directly into prepared soil beds to a depth of about 5cm, at an inter-row spacing of 25 cm and intra-row spacing of 25 cm and later thinned to one plant per stand on sprouting to give a plant population of 16 plants per plot and 160,000 plants per ha. For the transplant treatment, tiger nut seeds were sown 8 cm apart in the nursery bed and germination was monitored for 7 days after sowing and seedlings were transplanted from the nursery to the field 6 weeks after sowing (WAS) at a spacing of 25 cm x 25 cm. The beds were mulched with dry leaf litter to conserve soil moisture and suppress weeds,

DOI: https://doi.org/10.55706/jae1810

insects were controlled when necessary and the plots were weeded manually at 2, 4 and 6 weeks after transplanting (WAT).

Data collection

Four plants were randomly selected from each plot and tagged for the purpose of data collection. Vegetative characters measured were plant height (cm), stem diameter(cm), no of leaves and leaf area (cm^2). At harvesting, when the tubers were matured, parameters were measured on number of tubers per plant, fresh tuber weight (g), tuber diameter (cm) fresh herbage weight (g), tuber yield (t ha^{-1}), herbage yield (t ha^{-1}), total yield (t ha^{-1}) and harvest index (%).

Statistical analysis

The data collected were subjected to analysis of variance using SAS statistical package and the significant difference between the treatment means were separated using least significant difference (LSD) at 5% level of probability.

RESULTS

Soil and poultry manure properties

The results of the soil of the site prior to the experiment and the chemical analysis of poultry manure is shown in Table1. The soils of the site was sandy loam in texture, strongly acidic pH (5.06), moderately high in soil organic matter (6.45 %) low in N (0.06 g kg^{-1}), K (0.18 cmol kg^{-1}) and Ca (0.75 cmol kg^{-1}) but high in Mg (0.80 cmol kg^{-1}) and in P (21.40 mg kg^{-1}). The Ca: Mg value for this experimental soil is approximately (1:1) less than 3:1.

Table 1. Physical and chemical properties of the soil and poultry manure used for the experiment

Parameters	Soil	poultry manure
pH	5.06	6.21
Total Nitrogen (g kg^{-1})	0.06	2.26
Available Phosphorus (mg kg^{-1})	21.40	1.34
Potassium (cmol kg^{-1})	0.18	1.25
Calcium (cmol kg^{-1})	0.75	0.72
Magnesium (cmol kg^{-1})	0.80	0.13
Sodium (cmol kg^{-1})	0.23	0.35
Hydrogen (cmol kg^{-1})	0.35	-
Aluminium (cmol kg^{-1})	0.06	-
Organic carbon (%)	3.74	18.89
Organic matter (%)	6.45	32.58
Sulphur (mg kg^{-1})	8.44	-
Sand (%)	88.20	-
Silt (%)	4.62	-
Clay (%)	7.18	-
ECEC	2.69	-
Textural class	Sandy loam	-

The result of the poultry manure (Table 1), shows that it contains adequate nutrients, rich in organic matter content and its Ca : Mg value is approximately (6:1).

Vegetative growth

The effect of sowing methods was not significant on number of leaves and stem diameter of tiger nut but it was significant on plant height and leaf area. In both years, direct sowing increased plant height (98.35 cm; 87.45 cm) and leaf area (67.95 cm^2; 65.50 cm^2) compared with transplants, (68.81 cm; 62.43 cm) and (40.67 cm^2; 60.44 cm^2) respectively Table 2. Similarly, fertilizer application significantly enhanced some of the vegetative characters measured. Plants that received fertilizer were statistically similar and superior in growth compared with the control which received no fertilizer treatment. In 2022, cropping season, application rate of F2 (20 t ha^{-1} poultry manure) significantly produced highest value for leaf area (62.85 cm^2) which was at par with (56.71 cm^2) when a combination of F3 (200kg ha^{-1} NPK 15:15:15 + 10 t ha^{-1} Poultry manure) was applied. In 2023, all the plants that received fertilizer were statistically similar and plant height increased in this order, F1(76.86 cm) < F2 (78.80 cm) < F3 (79.12 cm) while the number of leaves, stem diameter and leaf area followed the same trend and increased in this order (F1 < F3 < F2). Application rate of 20 t ha^{-1} poultry manure notably increased plant height (78.80 cm), number of leaves (12.36), stem diameter (0.43 cm) and leaf area (78.32 cm^2) compared with the control (70.12 cm, 9.24, 0.25 cm and 66.39 cm^2) which significantly produced lower values for plant height, number of leaves, stem diameter and leaf area respectively (Table 2).

Table 2. Effect of sowing methods and fertilizer application on some vegetative characters of Tiger nut (*Cyperus esculentus*)

	2022 Cropping season				2023 Cropping season			
Treatments	**Plant height (cm)**	**Number of leaves**	**Stem diameter (cm)**	**Leaf area (cm^2)**	**Plant height (cm)**	**Number of leaves**	**Stem diameter (cm)**	**Leaf area (cm^2)**
Sowing Methods								
Direct sowing	98.35^a	13.80^a	0.32^a	67.95^a	87.45^a	10.93^a	0.29^a	65.50^a

DOI: https://doi.org/10.55706/jae1810

Transplant	68.81^{b}	13.73^{a}	0.24^{a}	40.67^{b}	62.43^{b}	10.26^{a}	0.26^{a}	60.44^{b}
Significance	*	NS	NS	*	*	NS	NS	*
LSD	5.87	3.54	1.91	6.04	4.81	2.73	0.05	5.01
Fertilizer Application								
F0 (control)	76.54^{b}	9.43^{a}	0.64^{a}	47.92^{c}	70.12^{b}	9.24^{b}	0.25^{b}	66.39^{b}
F1 (400 kg ha^{-1} NPK 15:15:15)	84.33^{ab}	9.49^{a}	0.72^{a}	49.74^{bc}	76.86^{a}	11.42^{a}	0.39^{a}	74.22^{a}
F2 (20t ha^{-1} Poultry manure)	89.76^{a}	13.00^{a}	4.71^{a}	62.85^{a}	78.80^{a}	12.36^{a}	0.43^{a}	78.32^{a}
F3 (200kg ha^{-1} NPK 15:15:15 + 10t/ha Poultry manure)	83.53^{ab}	10.30^{a}	0.75^{a}	56.71^{ab}	79.12^{a}	11.23^{a}	0.40^{ab}	75.69^{a}
LSD (0.05)	*	NS	NS	*	*	*	*	*
Significance	8.30	5.01	5.53	8.34	3.28	0.60	0.07	6.32

Means with the same letters along the same column are not significantly different at 5% level of probability.
Ns = Not significant, (*) = significant at 0.05 probability

Yield and yield components

In Table 3, the number of tubers per plant (27.13 and 24.21) and fresh tuber weight per plant (18.21 g and 15.60 g) were higher with direct sowing compared with the transplant (23.52 and 20.18) and (16.22 g and 13.16 g) respectively.

Table 3. Effect of sowing methods and fertilizer application on some yield components of Tiger nut (*Cyperus esculentus*)

	2022 Cropping season				**2023 Cropping season**			
Treatments	**Number of tubers plant^{-1}**	**Tuber diameter (cm)**	**Fresh tuber wt. plant^{-1} (g)**	**Herbage fresh wt. plant^{-1} (g)**	**Number of tuber plant^{-1}**	**Tuber diameter (cm)**	**Fresh tuber wt. plant^{-1} (g)**	**Herbage fresh wt. plant^{-1} (g)**
Methods of sowing:								
D	27.13^{a}	0.95^{a}	18.21^{a}	9.32^{a}	24.21^{a}	0.92^{a}	15.60^{a}	9.45^{a}
T	23.52^{b}	0.94^{a}	16.22^{b}	8.41^{a}	20.18^{b}	0.92^{a}	13.16^{b}	8.74^{a}
Significance	*	Ns	*	Ns	*	Ns	*	Ns
LSD	3.02	0.08	2.01	2.26	3.13	0.05	2.23	3.15
Fertilizer Application								
F0 (control)	15.78^{b}	0.95^{a}	12.12^{b}	7.63^{b}	15.44^{b}	0.78^{a}	10.17^{b}	5.29^{b}
F1 (400 kg ha^{-1} NPK 15:15:15)	25.56^{a}	0.94^{a}	18.15^{a}	10.19^{a}	23.21^{a}	0.80^{a}	12.92^{ab}	8. 22^{a}
F2 (20 t ha^{-1} Poultry Manure)	29.65^{a}	0.95^{a}	20.85^{a}	10.15^{a}	27.39^{a}	0.85^{a}	12.08^{a}	8.02^{a}
F3 (200 kg ha^{-1} NPK 15:15:15 + 10t ha^{-1} Poultry manure)	27.34^{a}	0.94^{a}	20.56^{a}	10.17^{a}	26.74^{a}	0.82^{a}	12.39^{ab}	8.25^{a}
LSD (0.05)	7.44	0.04	4.22	4.07	7.94	0.07	4.05	3.12
Significance	*	Ns	*	Ns	*	Ns	*	*

Means with the same letters along the same column are not significantly different at 5% level of probability.

DOI: https://doi.org/10.55706/jae1810

Additionally, fertilizer application significantly p ≤ 0.05 influenced all the yield components except the tuber diameter which was not significantly different. Number of tubers per plant, fresh tuber weight per plant and herbage fresh weight per plant were statistically at par and increased with fertilizer application above the control. Herbage fresh weights increased in this order F2 (10.15 g) < F3 (10.17 g) < F1(10.19 g) while the control F0, significantly produced lowest herbage fresh weight (7.63 g and 5.29 g) in both years (Table 3).

Table 4. Effect of sowing methods and fertilizer application on yield and yield components of Tiger nut (*Cyperus esculentus*)

	2022 Cropping season				2023 Cropping season			
Treatments	**Fresh tuber yield (t ha $^{-1}$)**	**Fresh herbage yield (t ha $^{-1}$)**	**Total fresh yield (t ha $^{-1}$)**	**Harvest index (%)**	**Fresh tuber yield (t ha $^{-1}$)**	**Fresh herbage yield (t ha $^{-1}$)**	**Total fresh yield (t ha $^{-1}$)**	**Harvest index (%)**
Sowing methods:								
Direct planting	4.29^{a}	3.54^{a}	7.83^{a}	62.33^{a}	4.72^{a}	2.66^{a}	7.38^{a}	52.52^{a}
Transplant	3.36^{b}	3.10^{b}	6.46^{b}	62.00^{a}	4.58^{a}	2.41^{a}	6.99^{a}	50.43^{a}
LSD (0.05)	0.45	0.04	1.20	9.31	0.45	0.34	1.27	8.29
Significance	*	*	*	Ns	Ns	Ns	Ns	Ns
Fertilizer Application								
F0 (control)	3.26^{b}	1.52^{a}	4.78^{b}	62.12^{a}	3.02^{b}	1.32^{a}	4.34^{b}	60.26^{a}
F1 (400 kg ha^{-1} NPK 15:15:15)	4.20^{a}	2.86^{a}	7.06^{a}	63.26^{a}	4.08^{a}	2.28^{a}	6.36^{a}	60.74^{a}
F2 (20 t ha^{-1} Poultry Manure)	4.29^{a}	2.80^{a}	7.09^{a}	63.37^{a}	4.10^{a}	2.14^{a}	6.24^{a}	60.85^{a}
F3 (200 kg ha^{-1} NPK 15:15:15 + 10t/ha Poultry manure)	4.47^{a}	2 81^{a}	7.28^{a}	63.04^{a}	4.14^{a}	2.12^{a}	6.26^{a}	60.82^{a}
LSD (0.05)	1.87	1.41	2.22	9.36	1.08	1.22	1.56	9.18
Significance	*	Ns	*	Ns	*	Ns	*	Ns

Means with the same letters along the same column are not significantly different at 5% level of probability.
N.S= Not significant, (*) = significant at 0.05 probability

In Table 4, although, the yield parameters in 2023, cropping season were not significantly affected by sowing methods however, direct sowing in 2022 cropping season increased the fresh tuber yield (4.29 t ha^{-1}), fresh herbage yield (3.54 t ha^{-1}) and total fresh yield (7.83 t ha^{-1}) above the transplants (3.36 t ha^{-1}), (3.10 t ha^{-1}) and (6.46 t ha^{-1}) respectively, (Table 4). Comparing both planting methods across the study period, data from all the Tables showed that direct seeded crops had higher mean values in most of the growth and yield parameters as compared with transplants. Furthermore, fertilizer application was only significant for fresh tuber yield and total fresh yield. Fresh tuber yield increased from (3.36 t ha $^{-1}$ to 4.47 t ha $^{-1}$) and (3.02 t ha $^{-1}$ to 4.14 t ha $^{-1}$) in both years and in this order F0 < F1 < F2 < F3 and all the plants that received fertilizer were statistically similar and were increased above the control plants. The control plots significantly produced the lowest fresh tuber yield (3.26 t ha^{-1}and 3.26 t ha^{-1}) and lowest total fresh yield (4.78 t ha^{-1} and 4.34 t ha^{-1}) in both years. (Table 4).

DISCUSSION

Critical values of soil nutrients have also been reported by Adeoye & Agboola (1985) and according to Akinrinde & Obigbesan, (2000), the critical level of 3.0% OM, 0.20% N, 0.20 cmol kg^{-1} K, 2.00 cmol kg^{-1} Ca, 0.40 cmol kg^{-1} Mg and available P, 0.16–0.20 cmol kg-^{1} has been recommended for crop production in most agro ecological zones of Nigeria. However, the result of the soil analysis used for this experiment shows that some of the essential nutrients needed for optimum crop production were below the critical nutrient concentration levels hence the need for soil amendments. Nkwopara *et al.*, (2019) reported similar results for some soils of southern Nigeria and this is due to the high amount of rainfall in the area and the coarse texture of the soils leading to leaching of some basic cations and dominance of acidic cations on the exchange complex of the soil. In addition, Johnstone, (2011) reported that fertile soils usually have Ca : Mg ratio range of 3:1 – 7:1. The Ca: Mg value for this experimental soil is approximately (1:1) less than 3:1 which is typical of low fertility status soils (Landon, 1991). Furthermore, Udo *et al.*, (2009) stated that Ca: Mg ratio of less than 3:1 in the soil is an indication of possible Ca deficiency and P inhibition. The result of the poultry manure and the Ca : Mg value shows that it contained adequate nutrients which is typical of high nutrient status that can support crop production. The significant increase in plant height and leaf area with the direct sowing could be as a

DOI: https://doi.org/10.55706/jae1810

result of better cell division, stem elongation and diverse root growth compared with the transplant. The newly transplanted seedlings could not have developed enough root systems to adequately supply enough water and nutrient to the shoot at the early stage of growth leading to transplant shock which slowed down the initial growth process. (Leskovar & Othman, 2016). Grossnickle, (2005) reported that the ability of seedlings to overcome post planting stress is affected by several factors such as root architecture root–soil interaction, and root hydraulic conductivity. Additionally, the enhanced leaf area as a result of direct sowing will enable the plants to trap more light for photosynthesis which might later translate to higher dry matter yield (Zang, *et al*., 2009). The enhanced vegetative growth demonstrated by the direct sowing method when compared with the transplant supports the work of Leskovar *et al*., (2001) on muskmelon but contrast with those found in other crops, such as tomato, watermelons, artichoke, rice (Hall, 1989) and bell peppers (Leskovar and Cantliffe, 1994). The contrast might probably be due to the ease of transplanting these crops which are known to have a high rate of root regeneration after transplanting (Aguyoh, *et al*., 1999). Early research in some crops have demonstrated that root architecture in direct seeded and transplants are quite different. While direct seeded plants develop a vertical strong taproot in non-compacted soils, transplanted seedlings develop a distinctive root system with typically more basal roots. Furthermore, the lower yield and yield components observed in the transplant may be due to restricted taproot usually associated with transplanted vegetables. Conversely, direct-seeded plants have an unrestricted taproot development, which position them for a greater potential for root proliferation and exploration at greater soil depths for moisture and nutrient uptake. The positive growth response demonstrated by plants applied with sole NPK, Poultry manure and a combination of NPK + Poultry manure on tiger nut might be as a result of an increase in the nutrients in the soil due to applications of these treatments which consequently led to increased absorption of nutrients by the plants (Shokalu *et al*., 2010). The increase in the growth parameters with respect to poultry manure application supports the work of Adediran *et al.,* (2015) and Akanbi *et al*., (2005) who reported that organic fertilizer improved cell division and elongation in *Corchorus olitorius* and *Telfairia occidentalis* respectively. This result also corroborates the work of Aruna *et al*., (2020) who worked mainly on organic soil amendments for tiger nut yield and revealed that the fertilizer and manure used for the experiment mineralized and nutrients in them were released to the soil thereby enhancing greater efficiency of nutrient uptake and increase in plant growth. Furthermore, the observed significant higher leaf area recorded in sole application of poultry manure against that recorded for NPK and the non-significant difference between the values of plant height, number of leaves and stem diameter recorded in poultry manure treated plants and NPK treated plants in 2022 cropping season, suggests that poultry manure is a better alternative to NPK fertilizer for the cultivation of *C. esculentus* and where poultry manure is available can conveniently replace NPK fertilizer in order to ameliorate the adverse effect of the use of chemical fertilizers for a better environmental protection (Adediran, *et al*., 2015). Poultry manure has been reported to be one of the most valuable of all manures because it contains higher essential nutrients needed for plant growth than most animal manure. According to Micheal and George (1998) poultry manure is known to improve biological activities, soil tilth and soil chemical properties while Arisha *et al.,* (2003) stated that poultry manure is capable of activating many species of microorganisms which release phytohormones that stimulate nutrient absorption and plant growth. Furthermore, this superiority observed in poultry manure application could be due to its slow and consistent release of nutrients to meet the nutrient demands of plants throughout their growth stages unlike inorganic fertilizer that is easily lost soon after application. The lower values recorded for the control plots could be due to the fact that the plants under the control plots had to depend solely on the low inherent soil nutrients which reduced their growth and subsequently yield. Although, the harvest index was not significantly influenced by sowing methods and fertilizer application in both years, the increase in the tuber fresh yield and total fresh yield suggests that soil nutrient amendment is inevitable for a successful crop production.

CONCLUSION

The two-year field assessment revealed that direct sowing, transplant and fertilizer application significantly influenced most of the vegetative characters which were translated into tuber yield of tiger nut (*Cyperus esculentus*). Direct sowing and either sole or combined application of fertilizer consistently exhibited increased in almost all the parameters measured across the study period against transplants and zero fertilizer application. Since higher tuber yield is the main concern for tiger nut growers, this study supports that farmers in this locality should cultivate tiger nut with direct sowing method using either sole application of F2 (400 kg ha^{-1} NPK 15:15:15), F3 (poultry droppings 20 t ha^{-1}) or combined application of F4 (poultry manure 10 t ha^{-1} and 200 kg ha^{-1} NPK 15:15:15) for good soil fertility, ease of cultivation and higher tuber yield of tiger nut (*cyperus esculentus*).

Author's contributions

Authors contributed to the conception and design of the study. The first draft of the manuscript was written by EJF and BOO proof read the manuscript. All authors commented on previous versions of the manuscript. Authors read and approved the final manuscript.

Conflict of Interest

There is no conflict of interest to declare.

Acknowledgement

The authors are grateful to University of Benin for enabling environment to carry out the research and to Messrs Ediale Anthony and Otubeje Victory for data collection.

REFERENCES

Adediran, O.A., Ibrahim, H., Tolorunse, K.D., & Gana, U.I. (2015). Growth, Yield and Quality of Jute Mallow (*Corchorus olitorius* L.) as Affected by Different Nutrient Sources. *International Journal of Agriculture Innovations and Research,* 3 (5): 1443 - 1446

Adejunitan, J. A. (2011). Tiger nut processing: Its food, uses and health benefits. *American Journal Food Technolnolgy.* 6 (3): 197 - 201.

Adeoye, G.O., & Agboola, A.A. (1985). Critical levels for soil pH, available P, K, Zn and Mn and maize ear leaf content of P, Cu and Mn in sedimentary soils of south-western Nigeria. *Fertilizer Research* 6 (1): 65-75.

Aguyoh, J., Taber, H.G., & Lawson, V. (1999). Maturity of fresh market sweet corn with direct- seeded plants, transplants, clear plastic mulch, and row cover combinations. *HortTechnology*, 9 : 420 - 425.

Akanbi , W.B., Akande,M.O., & Adediran, J.A. (2005). Suitability of composted maize straw and mineral nitrogen fertilizer for tomato production. *Journal of vegetable Science*, 11(1), Pp. 57-65.

Akinrinde, E.A. & Obigbesan, G.O. (2000). Evaluation of the fertility status of selected soils for crop production in five ecological zones of Nigeria. In: *Proceedings of the 26th Annual Conference of Soil Science Society of Nigeria*, pp. 279–288.

Arisha, H.M.E., Gad, A.A., & Younes, S.E.(2003). Responses of some pepper cultivars to organic and mineral nitrogen fertilizer under sandy soil conditions. *Zagazig Journal Research*, *30,* Pp. 1875-1899.

Aruna, O.A., Abiola, F.O., Titilayo, T.A., Charity, A., Wutem S.E., Yetunde M.I., Abiodun G., & Adeniyi O. (2020). Effects of cow dung and wood biochars and green manure on soil fertility and tiger nut (*Cyperus esculentus* L.) performance on a savanna Alfisol. *Scientific Reports* 10: 21021

Bamishaiye, E. I. & Bamishaiye, O. M. (2011). Tigernut: As a plant, its derivatives and benefits AJFAND scholarly, Peer reviewed online 11 (5) September 2011. ISSN16845374.

Chukwuma, E.R., Obioma, N., & Christophe, I.O., (2010). The phytochemical composition and some biochemical effects of Nigerian tiger nut (*Cyperus esculentus* L.) tuber, *Pakistan Journal of Nutrition*, (9), 7 : 709 - 715.

Food and Agricultural Organization (FAO) (2004). A provisional methodology for land degradation Assessment. Food and Agricultural Organization, Rome.

Gee, G. W. & Or, D. Particle-size analysis. (2002). In: Dane, J H. & Topp, G. C. (Eds.), *Methods of Soil Analysis. Part 4. Physical Methods*. Soil Science Society of America Book Series No. 5, Madison, WI, USA, pp. 255–293.

Grossnickle, C. (2005). Importance of root growth in overcoming planting stress. *New Fortier* (30): 273–294.

Hall, M.R. (1989). Cell size of seedling containers influences early vine growth and yield of transplanted watermelons. *Hort Science* 24:771–773.

Hendershot, W. H., Lalande, H. & Duquette, M. (2007). Ion exchange and exchangeable cations. In: Carter, M. R. & Gregorich, E. G. (Eds.), *Soil sampling and methods of analysis*. Canadian Society of Soil Science, 2nd ed. CRC Press, Boca Raton (Florida), pp. 197– 206.

Johnstone, J. (2011). Assessing soil fertility: the importance of soil analysis and its interpretation. Potash development association, P. 19

Ketema, S., Dessalegn, L., & Tesfaye, B. (2013). Effect of planting methods on maturity and yield of onion (*Allium cepa* var. cepa) in the central rift valley of Ethiopia. *Ethiopia. Journal of Agric. Science.* 24, 45–55.

Kiziloglu, F. M. & Turan, M. A. (2015). Growth, Water Use, and Nutrient Efficiency of Maize and Tomato Plants in Sandy Soil Amended with two types of Sewage Sludge under Greenhouse Conditions. Archives of Agronomy and Soil Science, 61(10):1439-1453.

Landon, J.R. (1991). Booker tropical soil manual: A handbook for soil survey and Agricultural land evaluation in the tropics and subtropics. Longman Scientific and technical Essex, New York 474 p.

Leskovar, D., & Cantliffe, D. (1994). Transplant production systems influence growth and yield of fresh-market tomatoes. *Journal American Society Horticultural Science*. 119, 662– 668.

Leskovar, D.; Clark, J.; Sprague, R. (2001). Yield, quality, and water use efficiency of muskmelon are affected by irrigation and transplanting versus direct seeding. *Hort Science*, 36, 286-291.

Leskovar, D.& Othman, Y. (2016). Low nitrogen and fertigation practices can improve artichoke transplant quality and yield. *HortScience* , 51, 567–572.

Leskovar, D.& Othman, Y. (2016). Pre-transplant conditioning to mitigate heat, drought and biotic stresses in artichoke. Acta Horticulturae, 1147, 145–154.

DOI: https://doi.org/10.55706/jae1810

Leskovar, D.I. & Othman, Y.A. (2021). Direct seeding and transplanting influence root dynamics, morpho-physiology, yield, and head quality of globe artichoke. *Plants* 10, 899. https://doi.org/10.3390/10050899

Liu, D.; Ji, H.; Yang, Z. (2020). Functional characterization of three novel genes encoding diacylglycerol acyltransferase (DGAT) from oil-rich tubers of *Cyperus esculentus*. *Plant Cell Physiolology*, 61, 118–129.

Michael, S. & George, R. (1998). Fertilizing crop land with poultry manure. University of Minnesota Extension Service. *Minnesota Agricultural Service news bulletin.*

Nkwopara, U.N., Okoli, N.H., Nnadozie, J., Onwudike, S.U., Ihem, E.E. (2019). Evaluation of fertility status of selected eroded and non-eroded soils in an ultisol in a humid tropical environment using elemental ratio. *International Journal of Agriculture and Rural Development* 22(2): 4474 - 4484.

Ojeniyi, S. O. and Ayodele, O. J. (2012). Influence of Inorganic Fertilizer on the Quality of Tiger Nut (*Cyperus esculentus* L.). *African Journal of Agricultural Research*, 7(15):2386-2391.

Ojeniyi, S. O., Adebiyi, F. M., Olubode, O. S. and Adebayo, G. S. (2017). Soil Fertility Improvement and Yield Response of Maize (*Zea mays* L.) to Organic and Inorganic Fertilizers in a Tropical Rainforest Ultisol. *International Journal of Agronomy*, pp. 1-9.

Palma, A., & Laurance, S. (2015). A review of the use of direct seeding and seedling plantings in restoration: What do we know and where should we go? *Applied Vegetable Science*, 18, 561–568.

Shokalu, A. O., Ojo, A. O., Ezekiel-Adewoyin, D. T., Akintoye, H. A. & Azeez, J. O. (2010). Evaluation of *Tithonia diversifolia* for soil improvement in Celosia (*Celosia argentea*) production. *Electron. J. Environ. Agric. Food Chem.* 9(5), 951-957 .

Udo, E.J., Ibia, T.O., Ogunwale, I.A., Ano, A.O., Esu, I.E. (2009). Manual of soil plant and water analysis. *Sibon Book limited*. Festac Lagos, pp 183.

Walkley, J & Black, J.P. (1962). A critical examination of a rapid method for determining organic carbon in soils. Effects of variation in digestion conditions and of organic carbon constituents. *Soil Science*. 63:251 – 263.

Zhang, H., Xue, Y., Wang, Z., Yang, J.& Zhang, J. (2009). Morphological and physiological traits of roots and their relationships with shoot growth in "super" rice. *Field Crop. Res*ources 113, 31–40.

Zhang, Y. & Sun, S. Tiger nut (*Cyperus esculentus* L.) oil (2023) : A review of bioactive compounds, extraction technologies, potential hazards and applications, *Food Chemistry*.

DOI: https://doi.org/10.55706/jae1810