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Growth, Yield and Storability Responses of Sweet Potato (*Ipomoea batatas* L.) to Nitrogen Source and Application Rate

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ABSTRACT

Field and storage experiments were conducted from July, 2022 to January, 2023 in Ibadan, Nigeria, using a split-plot randomized complete block design with three replications to evaluate the effects of different nitrogen rates from organic (poultry manure) and inorganic (NPK 15:15:15) sources on sweet potato growth, yield, and storability. Nitrogen was applied at four levels (0, 45, 90, and 135 kg ha^{-1} N). Growth parameters measured included vine length, number of leaves plant^{-1}, and number of vines plant^{-1}, while yield parameters included total tuber yield, marketable tuber yield, and non-marketable tuber yield. After harvest, tubers were stored for 10 weeks using two storage methods: elevated platform and bare floor storage systems. Results showed that nitrogen source did not significantly affect the number of leaves or vines, although poultry manure enhanced vegetative growth. Vine length increased significantly at 135 kg ha^{-1} N, and poultry manure produced the highest marketable yields. Total yield was highest at 90 kg ha^{-1} N. Weight loss during storage decreased with higher nitrogen rates, with the elevated platform method proving more effective in reducing losses than the bare floor. The study concluded that nitrogen application significantly influenced yield and storability, with poultry manure and 90 kg ha^{-1} N giving optimum yield. Storage on elevated platforms reduced physiological weight loss showing that improved nutrient management and storage practices enhance productivity and postharvest quality.

KEYWORDS: Fertilizer management, nitrogen rate, postharvest, poultry manure

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1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is extensively grown in the tropical and subtropical regions for its nutritious tuberous roots due to its high adaptability, productivity and nutritional value (Jung et al., 2011; Padmaja, 2009). The crop is an important source of carbohydrates, dietary fibre, vitamins, and antioxidants, particularly provitamin A carotenoids in orange-fleshed varieties. The economically valuable part of the plant is the starchy tuberous root, which serves as food, feed, and industrial raw material (Antia et al., 2006). Sweet potato is considered a major food security crop in developing countries and ranks the second most valuable root crop after cassava (Ray and Ravi, 2005) and the sixth most important food crop globally after cassava, rice, wheat, maize and potato (Dash et al., 2015). In sub-Saharan Africa, sweet potato plays a significant role food security, especially in regions affected by declining fertility and unstable climatic conditions such as Nigeria (Ikeokwu and Orji, 2022; Anonymous, 2004). Nigeria is one of the leading producers in Africa, with increasing cultivation driven by population growth and demand for affordable nutritious food (Mmeremikwu, 2023). However, the average productivity remains suboptimal due to challenges such as poor soil fertility and inefficient farming practices (Ezeano et al., 2009). These constraints have continued to limit both yield and postharvest quality of storage roots. Nitrogen is a key nutrient influencing vegetative growth, storage root formation, and yield in sweet potato (Ayyub et al., 2019; Deshpande et al., 2015; Ali et al., 2009). Proper nitrogen management can enhance yields by 32–84% depending on soil conditions (Adimula et al., 2022). Excessive nitrogen may reduce starch content, promote fibrous root growth, and decrease the marketable root yield (Antonious, 2024). Nutrient interactions particularly nitrogen with potassium and phosphorous have also been shown to significantly influence root development and quality. Fertilizer source have also been reported to influence postharvest performance of roots crops. Organic amendments have improved soil physical properties, microbial activity, and nutrient release patterns thereby improving root quality and storage stability inorganic (Akinrinola and Babajide, 2024; Willer et al., 2022). In contrast, excessive or imbalanced use of inorganic fertilizers may increase susceptibility to physiological deterioration, microbial spoilage, and storage losses (Ahiabor et al., 2021). Essilfie (2015) reported that organically fertilized sweet potato roots showed improved storage quality compared with roots produced under sole inorganic fertilization. Similarly, studies on root and tuber crops have shown that balanced nutrient management contributes to reduced weight loss and improved shelf life during storage (Mehedi et al., 2012; Edmunds et al., 2008). (Madakadze, 2004) Postharvest losses have remained a major constraint in sweet potato production, often ranging between 20–30% depending on storage conditions and cultivar (Parmar et al., 2017). These losses have mainly been attributed to moisture loss, sprouting, microbial decay and physiological deterioration during storage (Nabubuya et al., 2017). Storage environment and method have significantly influenced tuber longevity and quality retention.Optimizing both nitrogen management and storage methods is essential for improving productivity and reducing losses. This study examined (2022/2023 growing season) the effects of varying nitrogen rates from organic and inorganic sources on the growth, yield, and storability of sweet potato. This study further compared bare floor and elevated platform storage methods by assessing tuber weight loss over a 10-week storage period. These findings provide practical recommendations for improving sweet potato production efficiency and postharvest sustainability among smallholder farmers.

2. MATERIALS AND METHODS

2.1. *Study area and soil characteristics*

The field experiment was conducted between July and November 2022 at Ido, Ibadan, in the Ido Local Government Area of Oyo State, Nigeria (latitude 9°24'N, longitude 0°59'W; elevation 183 m). The site lies within the derived savannah agroecological zone, which was characterized by a bimodal rainfall pattern and sandy loam soils. The storage experiment was conducted from November, 2022-January, 2023 at the Crop Production Laboratory, Department of Crop and Horticultural Sciences, University of Ibadan. The soil was classified as sandy loam (77.4% sand, 16.0% silt, and 6.6% clay) with pre-planting properties as shown in Table 1.

2.2. *Experimental design*

A split-plot arrangement in a randomized complete block design (RCBD) was used. The main plot factor was the nitrogen source (poultry manure and NPK 15:15:15), while the subplot factor was the nitrogen application rate (45, 90, and 135 kg ha^{-1}), along with an unfertilized control. Each treatment was replicated thrice, resulting in 24 plots.

2.3. *Fertilizer application*

Well-decomposed poultry manure, collected from a local poultry farm, was air-dried for four weeks and analyzed for its nutrient content. It contained approximately 1.8% N, 1.2% P, and 1.3% K on a dry-weight basis. Poultry manure was incorporated into the soil two weeks before planting. NPK 15:15:15 granular fertilizer was applied at the designated nitrogen-equivalent rates two weeks after planting (Nyarko et al., 2022).

2.4. *Land preparation and crop establishment*

The land was cleared and sprayed with glyphosate at 4

Table 1: Particle size distribution and chemical properties of the experimental soil before cropping

Properties	Values	Critical range (Byju and George, 2005)
pH (1:1, H_2O)	6.5	6.6 – 7.2
Organic carbon (g kg^{-1})	10.2	10 – 14
Total nitrogen (g kg^{-1})	0.72	1.6 – 2.0
Available Phosphorus (mg kg^{-1})	8.1	7 –20
Exchangeable cations (cmol kg^{-1})		
Ca	4.79	
Mg	0.73	
K	0.39	0.3 – 0.6
Na	0.80	
Extractable acidity	0.40	
Extractable micronutrient (mg kg^{-1})		
Fe	81.00	30 – 35
Mn	27	
Cu	3	
Particle size distribution (g kg^{-1})		
Sand	774	
Silt	140	
Clay	86	
Textural class (USDA)	Sandy loam	

l ha^{-1}, followed by manual ridging. Each plot measured 5×3 m^2, with 1 m spacing between plots and 2 m between blocks. Healthy vine cuttings (30 cm) with leaves removed were planted at a 45° angle and spaced 40 cm apart along ridges. Weeding was performed manually at 3 and 9 weeks after planting.

2.5. *Data collection*

Growth data were collected from six non-border plants $plot^{-1}$ at 5 weeks after planting (WAP), and yield data were collected at harvest (16 WAP).

Growth parameters assessed included vine length (cm), number of leaves per plant, and number of vines per plant. Yield parameters measured comprised total tuber yield (t ha^{-1}), marketable tuber yield (t ha^{-1}), and non-marketable tuber yield (t ha^{-1}).

2.6. *Storage experiment*

Tubers from each treatment were carefully harvested, sorted to remove damaged ones, and stored under two different conditions: an open high platform and a bare floor. Storage lasted 10 weeks, with tubers weighed every two weeks to determine the % weight loss. Temperature and relative humidity were monitored using wet and dry bulb thermometers.

% weight loss=(Wp-Wc)/Wp)×100

Where Wp was the previous weight of the tuber and Wc was the current weight of the tuber.

2.7. *Statistical analysis*

All collected data were subjected to analysis of variance (ANOVA) using SAS 9.0 edition. Treatment means were separated using the Least Significant Difference (LSD) test at a 5% significance level $^*p<0.05$.

3. RESULTS AND DISCUSSION

3.1. *Growth parameters*

Five weeks after planting, the source of nitrogen (either poultry manure or NPK) had no significant influence ($^*p>0.05$) on the number of leaves (Table 2). However, the soils treated with poultry manure showed a higher number of leaves (42.54 leaves $plant^{-1}$) than those treated with NPK (41.29 leaves $plant^{-1}$). Although differences were not statistically significant ($^*p>0.05$), numerically higher values were observed at 135 kg ha^{-1} (43.50), while 90 kg ha N resulted in the lowest (42.49) (Table 2).

For the number of vines, poultry manure again showed higher values (2.87 vines $plant^{-1}$) than NPK (2.76 vines $plant^{-1}$), though not statistically significant. The 135 kg ha^{-1} N rate produced the most vines (3.03), while 45 kg ha^{-1} N yielded the fewest (2.50) (Table 2). The lack of significant differences suggested the adaptability of sweet potato to various nitrogen sources during the early growth stages (Lemma et al., 2023). The source of nitrogen did not significantly influence vine length, but the soil treated with NPK fertilizer had the longest vines. The application rates

Table 2: Growth parameters of sweet potato as influenced by source of nitrogen and application rate at 5 weeks after planting

Treatment	Number of leaves	No. of vines	Vine length (cm)
Poultry manure	42.54^a	2.87^a	61.71^a
N.P.K	41.29^a	2.76^a	69.71^a
Nitrogen rate			
0 kg ha^{-1}	40.39^a	2.97^a	66.06^a
45 kg ha^{-1}	41.30^a	2.50^a	67.36^a
90 kg ha^{-1}	42.49^a	2.78^a	59.67^a
135 kg ha^{-1}	43.50^a	3.03^a	69.76^a

Means with the same letters in a column were not significantly different ($^*p<0.05$)

also had a significant influence, with 135 kg ha^{-1} N resulting in the longest vines and 90 kg ha^{-1} N resulting in the shortest vines. A significant interaction between nitrogen source and rate was also observed for vine length, indicating improved vegetative growth when poultry manure was applied at higher rates (Table 3). This aligned with prior studies by Sowley et al. (2015) and Sidiky et al. (2019), who reported enhanced growth in sweet potato with organic nutrient amendments.

Table 3: Growth parameters of sweet potato as influenced by the interaction between source of nitrogen and application rate at 5 weeks after planting

Treatment	Number of leaves	Number of vines	Vine length (cm)
Control	44.56^{a}	2.75^{a}	48.89^{c}
PM×45 kg ha^{-1}	39.39^{a}	2.55^{a}	62.22^{abc}
PM×90 kg ha^{-1}	43.22^{a}	2.78^{a}	54.56^{bc}
PM×135 kg ha^{-1}	43.00^{a}	3.39^{a}	81.18^{ab}
NPK×45 kg ha^{-1}	45.67^{a}	2.22^{a}	72.5^{abc}
NPK×90 kg ha^{-1}	39.28^{a}	2.78^{a}	64.78^{abc}
NPK×135 kg ha^{-1}	37.83^{a}	3.50^{a}	83.22^{a}

Means with the same letters in a column were not significantly different ($^{*}p<0.05$); PM: Poultry manure

3.2. *Yield parameters*

For total root yield, poultry manure treatments showed higher values (8.72 t ha^{-1}) than NPK (8.00 t ha^{-1}), though the difference was not statistically significant (Table 4). The 90 kg ha^{-1} N rate produced significantly higher yields (10.74 t ha^{-1}) than 0 kg ha^{-1} N (5.14 t ha^{-1}), but was comparable to that of 135 kg ha^{-1} N (9.79 t ha^{-1}). This result suggested that poultry manure might be a suitable alternative to inorganic fertilizers, such as NPK, for promoting root yield in sweet potato. The application rate had a significant influence, with 90 kg ha^{-1} N resulting in the highest root yield and 0 kg ha^{-1} N resulting in the lowest yield. This result suggested that moderate rates of nitrogen application, specifically 90 kg ha^{-1} N, might be optimal for maximizing sweet potato tuber root yield.

Table 4: Yield parameters of sweet potato as influenced by source of nitrogen and application rate

Treatment	Total yield	Non marketable	Marketable
Poultry manure	8.72^{a}	23.42^{a}	6.62^{a}
N.P.K	8.00^{a}	26.53^{a}	5.67^{a}
Nitrogen rate			
0 kg ha^{-1}	5.14^{c}	14.35^{b}	4.39^{a}
45 kg ha^{-1}	7.77^{bc}	30.33^{a}	5.44^{bc}
90 kg ha^{-1}	10.74^{a}	25.92^{a}	25.92^{a}
135 kg ha^{-1}	9.79^{ab}	29.30^{a}	29.30^{ab}

Means with the same letters in a column were not significantly different ($^{*}p<0.05$)

For marketable yield, poultry manure showed higher values (6.62 t ha^{-1} vs. 5.67 t ha^{-1} for NPK). The 90 kg ha^{-1} N rate again performed best (7.94 t ha^{-1} with poultry manure), while the control plots had the lowest yield (4.39 t ha^{-1}) (Table 4). The significant performance of poultry manure might be attributed to improved soil structure and micronutrient availability (Dong et al., 2023; Zhong et al., 2010). The results of this study indicated that the source of nitrogen, whether from poultry manure or NPK fertilizer, did not significantly influence the marketable root yield of the crop. However, poultry manure resulted in a higher marketable sweet potato yield. This aligned with prior studies that indicated the beneficial effects of organic fertilizers, such as poultry manure, on crop yields due to nutrient-rich composition and ability to improve soil fertility (Agbede and Oyewumi, 2022; Cui et al., 2018).

Non-marketable yields were higher with NPK (26.53 t ha^{-1}) compared to poultry manure (23.42 t ha^{-1}). This difference was particularly noticeable at 45 kg ha^{-1} N, where NPK resulted in 28.93 t ha^{-1} and manure in 28.00 t ha^{-1} (Table 5). This finding might be attributed to NPK fertilizer being a concentrated source of essential nutrients, including nitrogen, phosphorus, and potassium. This concentration might have resulted in increased vegetative growth and biomass accumulation, including non-marketable roots, but did not necessarily translate into a higher marketable yield. This aligned with prior studies that indicated the importance of balanced nutrient management in crop production to optimize both marketable and non-marketable yield components (Ilozobhie et al., 2024; Manna et al., 2005).

Table 5: Yield parameters of sweet potato as influenced by the interaction between source of nitrogen and application rate

Treatment	Total root yield t ha^{-1}	Non marketable root weight	Marketable root weight
Control	6.31^{ba}	15.93^{bc}	5.34^{ab}
PM×45 kg ha^{-1}	7.81^{abc}	28.00^{ab}	5.75^{ab}
PM×90 kg ha^{-1}	10.41^{ab}	22.90^{abc}	7.94^{a}
PM×135 kg ha^{-1}	11.01^{a}	26.83^{ab}	7.47^{a}
NPK×45 kg ha^{-1}	7.72^{abc}	28.93^{a}	7.77^{a}
NPK×90 kg ha^{-1}	11.06^{a}	32.67^{a}	5.13^{ab}
NPK×135 kg ha^{-1}	9.25^{ab}	12.77^{c}	3.44^{b}

Means with the same letters in a column were not significantly different ($^{*}p<0.05$); PM: Poultry manure

3.3. Postharvest storability

While fertilizer source did not significantly affect storage weight loss, tubers from poultry manure plots exhibited slightly lower loss (average 14.5%) than those from NPK plots (17.2%). Weight loss decreased with increasing nitrogen application. The control treatment recorded the highest loss (21.8% at week 10), whereas 135 kg ha^{-1} resulted in the least loss (13.3%) (Figure 1–2). These results suggested that adequate preharvest fertilization enhanced postharvest.

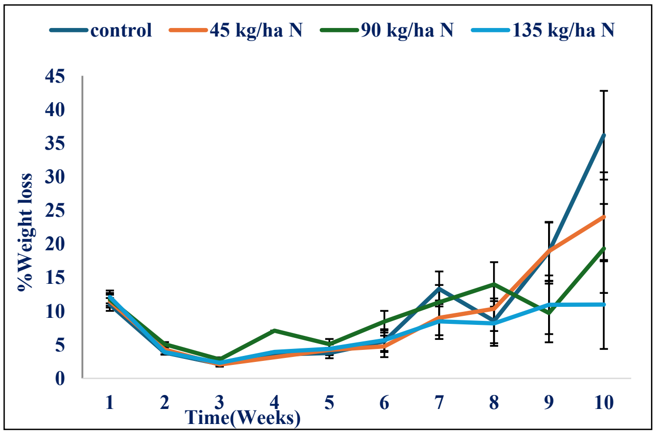

Figure 1: Weight loss of stored sweet potato as influenced by application rate of nitrogen fertilizer

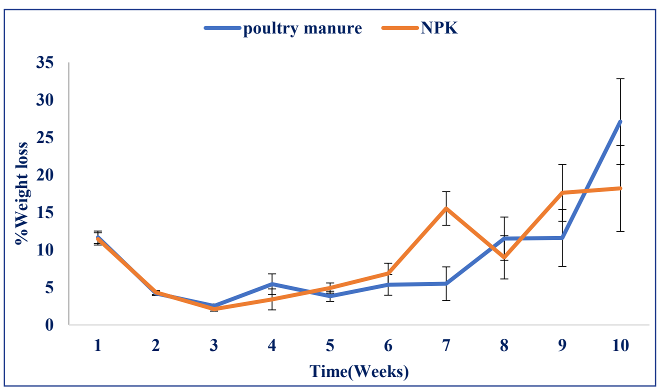

Figure 2: Weight loss of stored sweet potato as influenced by source of nitrogen fertilizer

This was consistent with previous studies by Naumann et al. (2019) who linked organic amendments and potassium nutrition to reduced storage losses in root crops.

3.4. Influence of storage method

Although not statistically significant across all time points, the storage method had a noticeable impact on weight loss trends. Tubers stored on elevated platforms consistently showed lower weight loss (13.7% at week 10) than those stored on bare floors (19.5%) (Figure 3). Improved ventilation and reduced microbial contact on the platforms likely contributed to this difference.

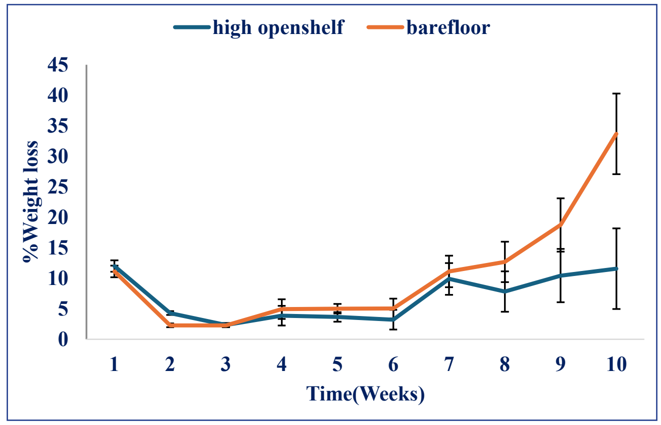

Figure 3: Weight loss of sweet potato as influenced by storage method

This observation was consistent with previous studies by John et al. (2023), who noted that elevated storage temperatures contributed to maintaining the postharvest quality of root crops. The present results also aligned with earlier research emphasizing the influence of storage methods on sweet potato storability. For instance, Dandango and Gungula (2011) and Duan et al. (2013) reported that nitrogen fertilization might affect the storage quality of sweet potato, though the outcome often depended on environmental conditions and the storage approach employed. Dandago and Gungula (2011) observed that storage techniques, including the use of sand and straw, impacted both weight loss and tuber quality of sweet potato. Similarly, Sugri et al. (2017) demonstrated that storage methods significantly influenced weight loss and sprouting in sweet potato. Edmunds et al. (2008) also demonstrated that proper postharvest handling, including the utilization of elevated platforms or controlled atmospheres, could reduce spoilage and maintain root crop quality throughout their storage. The combined effect of nitrogen management and proper storage illustrated the importance of integrated postharvest approaches. While higher nitrogen rates (90–135 kg ha^{-1}) improved yields, their benefits for storability were most evident when combined with proper storage infrastructure.

4. CONCLUSION

Nitrogen source and application rate influenced sweet potato yield and storability. Poultry manure produced higher marketable yields than NPK fertilizer. The application of 90 kg ha^{-1} nitrogen resulted in optimum yield, while 135 kg ha^{-1} reduced storage weight loss. Tubers stored on elevated platforms showed better storability than those on bare floors. Integrating organic fertilization with appropriate nitrogen rates and improved storage methods could enhance productivity and reduce postharvest losses

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