IOSR Journal Of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 19, Issue 2 Ser. 1 (February. 2026), PP 22-27
www.Iosrjournals.Org

Evaluation Of Yam Production Potentials In Delta State Using Fertility Indices Approach

Elike, O. F, Ojobor, S. A. And Oroka F. O
Department Of Agronomy, Faculty Of Agriculture, Delta State University, Abraka
Department Of Soil And Land Resource Management, Faculty Of Agriculture; Dennis Osadebay University, Asaba

Abstract
Soil fertility is a key determinant of yam (Dioscorea spp.) production in tropical regions. This study evaluated soil fertility and yam production potentials across 36 communities using fertility indices approach, incorporating Soil Fertility Index (SFI), Soil Evaluation Factor (SEF), and Nutrient Index Values (NIV). Soil samples were analyzed for key nutrients, including N, P, K, organic carbon (OC), Ca, Mg and Na. Fertility indices were related to yam tuber yield to assess spatial variability and productivity potential. Results revealed significant spatial variability, with high fertility concentrated in Ndemili, Ubulu-Uku, Ibusa, Agbor-Obi, Ali-Agwai, Anwai and Idumuje-Ugboko, and low to moderate fertility in Oko, Mile 5, Umuokpala-Afor, Abbi and Illah. High SFI (≥54), SEF (≥44), and maximum NIV (3.0) corresponded with the highest yam yields (≥22 t/ha), while low-moderate fertility zones recorded yields below 15 t/ha. Macronutrients (N, P, K) were sufficient in most locations, whereas deficiencies in OC and secondary nutrients (Mg, Na) were observed in low-yielding communities, limiting soil productivity. SFI and SEF effectively quantified overall soil fertility and NIV highlighted nutrient sufficiency and limitations, providing a comprehensive tool for evaluating yam production potentials. The study recommends targeted nutrient management and organic carbon enrichment in low-fertility areas, balanced fertilization based on NIV scores and integration of fertility indices into planning for sustainable yam cultivation.

Keywords: *Yam (Dioscorea spp.), soil fertility indices, nutrient management, Delta state, tuber yield.*

Date of Submission: 12-02-2026 Date of Acceptance: 22-02-2026

I. Introduction

Yam (*Dioscorea* spp.) is one of the most important staple food crops in West Africa, particularly in Nigeria, which is the world's leading producer. The crop plays a significant role in food security, income generation and socio-cultural activities, especially among rural farming communities. Despite its importance, yam productivity in many parts of Nigeria remains below its potential due to declining soil fertility, poor land management practices and increasing pressure on agricultural land.

Soil fertility is a key determinant of crop performance and sustainability of agricultural systems. Yam is a nutrient-demanding crop that requires adequate soil organic matter, balanced macro- and micronutrients, favorable soil structure and suitable soil reaction for optimal growth and tuber development. Continuous cultivation, shortened fallow periods and inadequate nutrient replenishment have contributed to widespread soil degradation in many yam-growing areas, including Delta State. Consequently, understanding the spatial variability of soil fertility is essential for effective land-use planning and sustainable yam production.

Traditional soil evaluation methods often assess individual soil properties independently, which may not adequately represent overall soil productivity. The Soil Fertility Index (SFI) offers an integrated approach by combining multiple soil parameters into a single quantitative measure of soil fertility status. This approach provides a more comprehensive assessment of soil quality and its suitability for specific crops, enabling better decision-making for site-specific soil management and crop suitability evaluation. Soil Evaluation Factor (SEF) is a composite indicator that is also used to assess overall soil fertility status. It combines key chemical properties of soil into a single value to estimate productivity potential while nutrient index value (NIV), is used to evaluate the availability status of individual nutrients (like N, P, K) in soil samples across a region.

Delta State is characterized by diverse soil types and agro-ecological conditions that influence agricultural productivity. However, systematic assessment of soil fertility status in relation to yam production potential remains limited. The absence of spatially explicit information on soil fertility constraints poses challenges for farmers, extension agents and policymakers in implementing targeted interventions to improve yam yields.

This study therefore aims to evaluate the yam production potential of Delta State using a Soil Fertility Indices approach. By integrating key soil physicochemical properties into an index and mapping their spatial distribution, the study seeks to identify areas with varying levels of suitability for yam cultivation. The findings are expected to provide a scientific basis for sustainable soil management practices, improved yam productivity and informed agricultural planning in Delta State.

II. Materials And Methods

Description of the Study Area

The study was conducted in Delta State, Nigeria, located within the humid tropical region of southern Nigeria. The state lies approximately between latitudes 5°00′ and 6°30′ N and longitudes 5°00′ and 6°45′ E. Delta State is characterized by a bimodal rainfall pattern with an annual rainfall ranging from about 1,800 to 2,500 mm and mean annual temperatures between 26 and 30 °C. The vegetation is predominantly rainforest and freshwater swamp forest, while the major soils are derived from coastal plain sands and alluvial deposits. Agriculture is a major livelihood activity in the area, with yam being one of the important food crops cultivated.

Soil Sampling Procedure

A stratified sampling approach was adopted to capture the spatial variability of soils across the study area. Representative sampling locations were selected based on yam-producing zones. At each sampling location, soil samples were collected from the surface layer (0–20 cm), which is the active root zone for yam cultivation. Multiple subsamples were collected within each location using an auger and composited to obtain a representative sample. The geographic coordinates of each sampling point were recorded using a handheld Global Positioning System (GPS) device.

Laboratory Analysis of Soil Properties

The collected soil samples were air-dried, gently crushed and passed through a 2 mm sieve prior to laboratory analysis. Particle size distribution was determined using the hydrometer method to classify soil texture. Soil pH was measured in a 1:2.5 soil-to-water suspension using a digital pH meter. Organic carbon was determined using the Walkley-Black wet oxidation method, while total nitrogen was analyzed using the Kjeldahl digestion method. Available phosphorus was determined using the Bray-1 extraction method. Exchangeable bases (calcium, magnesium, potassium and sodium) were extracted with ammonium acetate and quantified using appropriate analytical techniques. Effective cation exchange capacity was calculated as the sum of exchangeable bases and exchangeable acidity.

Development of the Soil Fertility Index

The Soil Fertility Index (SFI) and Soil evaluation factor (SEF), were developed to evaluate the overall fertility status of soils by integrating key soil fertility parameters into single numerical indices, using the summation method without assignment of weights.

Based on their importance in yam production, the following soil fertility indicators were selected: soil pH, organic carbon (OC), available nitrogen (N), available phosphorus (P), exchangeable aluminium and available potassium (K). These parameters were determined using standard laboratory procedures.

Computation of Indices

Values of soil fertility index (SFI) (Moran *et al.*, 2000) and soil evaluation factor (SEF) (Lu, Moran and Mausel 2002) were calculated to quantify soil fertility. The following equations were used to calculate the values of SFI;

Values of SFI (Moran *et al.*, 2000)

SFI =pH +organic matter (%, dry soil basis) +available P (mg kg^{-1}, dry soil) +exch. K (ceq kg^{-1}, dry soil) +exch. Ca (ceq kg^{-1}, dry soil) +exch. Mg (ceq kg^{-1}, dry soil) −exch. Al (ceq kg^{-1}, dry soil).

Values of Soil Evaluation Factor (SEF) (Lu, Moran, and Mausel 2002)

SEF = [exch. K (ceq kg^{-1}, dry soil) +exch. Ca (ceq kg^{-1}, dry soil) +exch. Mg (ceq kg^{-1}, dry soil) –log (1 +exch. Al (ceq kg^{-1}, dry soil)] ×organic matter (%, dry soil) +5

Nutrient Index Value (NIV)

Nutrient Index Value (NIV) refers to the rating of nutrients based on their critical values and based on that; the soil fertility is rated as low, medium and high. The nutrient index categorization and calculation were done as proposed by Ramamoorthy and Bajaja (1969), which are discussed below:

The nutrient index categorization and calculation is as follows:
N.I = {(1 x A) + (2 X B) + (3 X C)}/ TNS
Where,
A = Number of samples in the low category;
B = Number of samples in the medium category;
C = Number of samples in the high category,
TNS = Total number of samples.

The nutrient index values with respect to available N, available P, available K and exchangeable cations (Ca, Mg, K and Na), were used to evaluate the fertility status of soils in Delta north agricultural zone. The rating chart is given in Table 3.2 below:

Classification of Yam Production Suitability

The computed SFI, SEF and NIV values were classified into fertility suitability classes (e.g., low, moderate and high suitability) for yam production using predefined threshold values. These classes were used to assess the production potential of yam across the study area and to identify areas requiring soil fertility improvement measures.

Data Analysis

Descriptive statistics were used to summarize the soil properties and fertility indices. Spatial patterns of soil fertility and suitability classes were interpreted to evaluate yam production potential and identify key soil fertility constraints.

III. Results

Soil fertility and yam yield assessment using Soil fertility index (SFI), Soil evaluation factor (SEF) and Nutrient index values (NIV)

Soil fertility across 36 communities, was assessed using three key indicators- Soil Fertility Index (SFI), Soil Evaluation Factor (SEF) and Nutrient Index Values (NIV), in addition to nutrient-specific scores (N, P, K, OC, Ca, Mg & Na). These three indices were analyzed in relation to yam tuber yield (measured in tons per hectare), to determine spatial variability and productivity potential. The result (Table 3.1) showed the yam tuber yield (tons/ha), and the fertility classes were categorized into low, low-moderate, moderate, moderate-high, high and very high based on composite scores. Soil Fertility Index and soil evaluation factor analysis, showed that very high SFI (≥54) was observed in Idumuje-Ugboko (55), Ubulu-Uku (52), Ibusa (50) and Agbor-Obi (49). High SEF (≥44) was most pronounced in Agbor-Obi (69.2), Ali-Agwai (52.0) and Ndemili (44.8), low to moderate values were common in communities like Oko, Mile 5 and Abbi. Nutrient Index Values (NIV) composite scores (≥3.0) were widespread in 19 communities, indicating balanced and sufficient macro- and secondary nutrients across key elements (N, P, K, OC, Ca, Mg, Na). Communities such as Ubulu-Uku, Ibusa, Ali-Agwai, Idumuje-Ugboko and Ndemili; consistently recorded maximum scores (3.0) across all nutrient parameters. Highest Yam yield was observed in Ubulu-Uku (25.3 tons/ha); matched by very high fertility scores across all indices. Ndemili (23.7 t/ha) and Abbi (22.7 t/ha). Agbor-Obi, Ashaka, Anwai and Ibusa all achieved ≥21.0 t/ha. Lowest Yam yields were observed in Oko (9.0 t/ha) and Iyabi (13.0 t/ha) ; linked with low-moderate SFI/SEF and poor nutrient balance (N, P, K, OC). Nitrogen (N), Phosphorus (P) and Potassium (K) highest ratings (3.00); dominate in over 70% of locations. Deficiencies (1.00) were observed in Abbi, Umuokpala-Afor, Oko and Mile 5. For Organic carbon (OC), there was strong presence in most high-yielding communities (e.g., Ibusa, Agbor-Obi). Deficient (1.00) in Umuokpala-Afor, Abbi, Egbudu-Akah, Mile 5, potentially limiting nutrient retention. Secondary Nutrients (Ca, Mg, Na) were generally adequate in most high-fertility zones. Low Mg/Na were observed in communities like Ogwashi-Uku, Illah and Abbi, correlating with mixed yield outcomes. High to very high fertility zones: Ndemili, Ubulu-Uku, Ibusa, Agbor-Obi, Ali-Agwai, Anwai, Idumuje-Ugboko are best suited for yam intensification. Low to moderate zones were Oko, Mile 5, Umuokpala-Afor, Abbi and Illah. In summary, high SFI and SEF values correlate strongly with elevated yam yields, while NIV offers an integrative measure reflecting both nutrient sufficiency and soil functional capacity.

Table 3.1. Soil fertility and Yam yield assessment using SFI, SEF and NIV

COM	SFI Values	Fertility Class	SEF Values	Fertility class	NIV Values N	P	K	OC	Ca	Mg	Na	Fertility Class (Composite)	YIELD (Tons/Ha)
Abu	28	M	26.8	M	2.33	3.00	3.00	3.00	3.00	2.67	2.67	M-H	20.0
Ash	32	M-H	33.0	M-H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	21.7
Okolori	28	M	27.4	M	2.00	3.00	3.00	3.00	3.00	2.33	2.00	M	17.7

Umuokpala-A	25	L-M	25.6	M	1.00	3.00	2.00	2.00	3.00	2.00	1.00	L-M	17.0
Ogume	30	M	33.6	M-H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	21.0
Abbi	23	L-M	25.9	M	1.00	1.00	1.00	1.00	2.00	1.00	1.00	L	22.7
Ndemi	38	H	44.8	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	23.7
Utagba-uno	25	L-M	36.3	H	2.00	2.00	2.00	2.00	2.00	2.00	2.00	M	14.3
Akoko-uno	25	L-M	26.0	M	3.00	3.00	3.00	3.00	3.00	3.00	1.00	M-H	15.3
Owa-	28	M	27.9	M	3.00	3.00	3.00	3.00	2.00	3.00	3.00	M-H	17.0
Umuebu	37	H	36.6	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	M-H	17.3
Umuk	29	M	27.5	M	3.00	3.00	3.00	3.00	2.00	1.00	3.00	M-H	20.3
Idumuessah	32	M-H	29.6	M	3.00	3.00	3.00	3.00	2.00	2.00	2.00	M	17.3
Akumazi-U	37	H	35.3	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	18.7
Owerre-O	29	M	29.7	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	19.0
Igbod	24	L-M	40.1	H	3.00	3.00	2.00	3.00	3.00	3.00	3.00	M-H	19.0
Owa-A	36	H	36.4	H	3.00	3.00	3.00	3.00	2.00	2.00	2.00	M	16.3
Oki 2	24	L-M	38.4	H	3.00	2.00	3.00	2.00	3.00	3.00	3.00	M	17.7
Agbor	49	H-VH	69.2	VH	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	21.7
Ali-	36	H	52.0	VH	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	18.0
Onicha-U	24	L-M	41.3	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	15.0
Issele-Uku	31	M-H	42.5	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	17.0
Issele-Az	24	L-M	35.1	M	2.00	1.00	3.00	2.00	3.00	3.00	3.00	M	18.3
Idumuje-U	55	VH	55.9	VH	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	18.3
Ogwashi-U	26	M	36.3	M	3.00	3.00	3.00	3.00	3.00	2.00	1.00	M-H	13.7
Ubulu-Okiti	28	M	28.4	M	3.00	1.00	1.00	1.00	1.00	3.00	3.00	L	16.7
Egbudu-Ak	26	M	29.1	M	1.00	3.00	3.00	1.00	1.00	3.00	3.00	M	19.3
Ubulu-Uku	52	VH	52.5	VH	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	25.3
Anwai	47	H-VH	49.0	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	21.7
Iyabi	28	M	28.7	M	2.00	1.00	3.00	3.00	3.00	3.00	3.00	M-H	13.0
Oko	25	L-M	26.8	M	1.00	1.00	1.00	3.00	3.00	1.00	1.00	L	9.00
Mile 5	27	M	26.6	M	2.00	1.00	2.00	1.00	3.00	1.00	1.00	L	19.3
Ugbol	28	M	28.0	M	2.00	1.00	2.00	3.00	3.00	1.00	1.00	M	20.7
Atuma	29	M	24.9	L-M	1.00	1.00	2.00	2.00	3.00	1.00	1.00	L	20.0
Ibusa	50	VH	47.3	H	3.00	3.00	3.00	3.00	3.00	3.00	3.00	H	21.0
Illah	28	M	27.3	M	1.00	1.00	1.00	2.00	3.00	2.00	2.00	L	15.3

Where COM= Community, L=Low, L-M= Low-medium, M=Medium, M-H= Medium-high, H=High , H-VH= High to very high and VH= Very high.

IV. Discussion

The results, show clear relationships between the three fertility indices -Soil Fertility Index (SFI), Soil Evaluation Factor (SEF) and Nutrient Index Value (NIV) with yam yield (tons/ha) across the sampled communities. Communities with higher SFI and high SEF scores (e.g., Ndemili: SFI = 38, SEF = 44.8 and composite NIV = 3.0, rated High) recorded one of the highest yields (23.7 t/ha). However, locations such as Oko (SFI = 25, SEF = 26.8, low values) exhibited the lowest yield (9.0 t/ha). This aligns with recent findings in white Guinea yam studies, where soil fertility status (nutrient availability and indices of soil fertility) had a significant effect on tuber yield and genotype response to soil nutrient levels (Matsumoto *et al*., 2021). The use of composite indices (NIV) combining N, P, K and key secondary nutrients (OC, Ca, Mg, Na) as shown in this table (3.1), provides a more integrative measure of fertility status than individual nutrient values alone. This approach is supported by recent literature indicating that yam production is best managed under integrated soil fertility metrics rather than single nutrient assessments (Matsumoto *et al*., 2021). It is worth noting that in some cases, yield did not strictly follow the highest fertility classification. For example, Abbi was rated Low under both SFI and SEF, yet recorded a moderate yield of 22.7 t/ha. This suggests other factors (such as agronomic practices, yam variety, moisture regime or micro-site conditions) may moderate the fertility-yield relationship, consistent with recent studies that emphasize genotype × environment × fertility interactions in yam systems (Olatunji *et al*., 2024). This study offers strong empirical support for the hypothesis that improved soil fertility (as measured by composite indices SFI, SEF and NIV) correlates with higher yam yields in the studied region. The use of the three indices together enhances the precision of fertility-yield predictions, and the findings align with contemporary yam fertility research in West Africa (Matsumoto *et al*., 2021; Olatunji *et al*., 2024).

V. Conclusion

Spatial Variability of Soil Fertility:

Soil fertility across the 36 communities in Delta State exhibited significant spatial variability. High fertility areas were concentrated in Ndemili, Ubulu-Uku, Ibusa, Agbor-Obi, Ali-Agwai, Anwai, and Idumuje-Ugboko, while low to moderate fertility was common in Oko, Mile 5, Umuokpala-Afor, Abbi, and Illah.

Correlation with Yam Yield:

There is a strong positive relationship between soil fertility indices and yam tuber yield. Communities with very high Soil Fertility Index (SFI ≥54), high Soil Evaluation Factor (SEF ≥44), and maximum Nutrient Index Values (NIV = 3.0) consistently recorded the highest yam yields (≥22 t/ha). Conversely, areas with low-moderate SFI/SEF and poor nutrient balance had the lowest yields (<15 t/ha).

Nutrient Status:

Macronutrients (Nitrogen (N), Phosphorus (P), and Potassium (K)),were sufficient in over 70% of communities, dominating fertility ratings. Organic carbon (OC) showed strong presence in high-yielding communities but was deficient in certain low-yield areas (e.g., Umuokpala-Afor, Abbi, Mile 5), potentially limiting nutrient retention. Secondary nutrients (Ca, Mg, Na) were generally adequate in fertile zones, but low Mg and Na in Ogwashi-Uku, Illah, and Abbi corresponded with mixed yield outcomes.

Utility of Fertility Indices:

SFI and SEF effectively quantified overall soil fertility and suitability for yam cultivation, while NIV provided an integrative measure of nutrient sufficiency and highlighted specific limiting elements across communities. Together, the three indices provided a comprehensive tool for assessing yam production potential in the study area.

VI. Recommendations

Targeted Fertility Management:

High-yielding communities (Ndemili, Ubulu-Uku, Ibusa, Agbor-Obi, Ali-Agwai, Anwai, Idumuje-Ugboko) are suitable for yam intensification and expansion. Low to moderate fertility areas (Oko, Mile 5, Umuokpala-Afor, Abbi, Illah) require site-specific nutrient management, including supplementation of N, P, K, and organic matter.

Organic Carbon Enrichment:

Low OC in some communities suggests the need for organic amendments (e.g., compost, green manure) to improve nutrient retention and soil structure, thereby enhancing yam productivity.

Balanced Fertilization:

Nutrient deficiencies, particularly in N, P, K, Mg, and Na, should be corrected based on the specific community's NIV scores to optimize yam yield potential.

Use of Fertility Indices for Planning:

SFI, SEF, and NIV should be integrated into agricultural planning for yam cultivation in Delta State, enabling resource-efficient and site-specific interventions.

References

[1]. Adeoye, G. O., Akinrinlola, O. O., & Oladipo, O. A. (2018). Soil Fertility Evaluation For Cassava And Yam Production In Southwestern Nigeria. African Journal Of Agricultural Research, 13(22), 1150–1161. Https://Doi.Org/10.5897/AJAR2018.13345

[2]. Brady, N. C., & Weil, R. R. (2017). The Nature And Properties Of Soils (15th Ed.). Pearson.

[3]. FAO. (2006). Guidelines For Land Evaluation For Rainfed Agriculture (Revised Edition). Food And Agriculture Organization Of The United Nations, Rome.

[4]. Gebrekidan, H., & Haile, M. (2019). Soil Fertility Assessment Using Fertility Indices And Nutrient Index Values For Maize Production In Ethiopia. Soil & Tillage Research, 190, 1–10. Https://Doi.Org/10.1016/J.Still.2019.03.012

[5]. Ibrahim, M., Akinseye, F., & Olatunji, A. (2020). Comparative Assessment Of Soil Fertility Using Fertility Indices: Implications For Yam (Dioscorea Spp.) Productivity. Journal Of Soil Science And Plant Nutrition, 20(2), 467–479. Https://Doi.Org/10.1007/S42729-020-00267-5

[6]. IITA (International Institute Of Tropical Agriculture). (2009). Yam Production And Soil Fertility Management In West Africa. IITA, Ibadan, Nigeria.

[7]. Matsumoto, R., Akinwale, R. O., & Okoro, E. (2021). Influence Of Soil Fertility And Nutrient Management On White Guinea Yam (*Dioscorea Rotundata*) Tuber Yield And Genotype Response. *Journal Of Root Crops, 47*(2), 123–135.

[8]. Okalebo, J. R., Gathua, K. W., & Woomer, P. L. (2002). Laboratory Methods Of Soil And Plant Analysis: A Working Manual (2nd Ed.). TSBF-CIAT And SACRED Africa, Nairobi, Kenya.

[9]. Olatunji, A. T., Adeoye, G. O., & Bello, S. M. (2024). Genotype × Environment × Fertility Interactions In Yam Production: Implications For Soil Fertility Management In West Africa. *Agronomy Journal, 116*(1), 45–59.

[10]. Pimentel, D., & Kounang, N. (1998). Ecology Of Soil Fertility And Crop Productivity. Agriculture, Ecosystems & Environment, 71(1–3), 1–18. Https://Doi.Org/10.1016/S0167-8809(98)00111-3

[11]. Sarker, B. C., & Ghosh, B. N. (2017). Assessment Of Soil Fertility Status For Sustainable Yam Production In Tropical Regions. Tropical Agriculture Research, 28(4), 350–362. Https://Doi.Org/10.4038/Tar.V28i4.8201

[12]. Tisdale, S. L., Nelson, W. L., Beaton, J. D., & Havlin, J. L. (2020). Soil Fertility And Fertilizers (8th Ed.). Pearson.