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THE EFFECT OF OGBONO WASTE (*Irvingia gabonensis*) ON THE AGRO AND PHYSIOLOGICAL PARAMETERS OF MAIZE (*Zea mays L.*)

Imhangbe Osayende[1*], Ebimieowei Etebu[2]
[1]*Department of Biological Sciences, Niger Delta University, Amassoma, Bayelsa State.*
[2]*Department of Microbiology, Niger Delta University, Amassoma, Bayelsa State.*

**Corresponding Author: Imhangbe Osayende*

ABSTRACT

The widespread disposal of Irvingia gabonensis (ogbono) fruit waste in the Niger Delta poses environmental challenges, yet its potential as an organic soil amendment for crop production remains underexplored. This study investigated the effects of ogbono waste on the agro-morphological, physiological, soil physicochemical, and proximate parameters of maize (Zea mays L.) in Amassoma, Bayelsa State, Nigeria. The aim was to evaluate its suitability as a sustainable alternative to conventional organic fertilizer. The experiment was conducted using a randomized complete block design with three treatments: control, organic fertilizer (4t/ha), and ogbono waste compost (4t/ha) replicated three times over a 12-week period. Growth parameters were measured at Weeks 4, 8, and 12, while soil and proximate analyses followed standard AOAC and APHA procedures. Results showed that ogbono waste significantly ($p < 0.05$) enhanced mid-growth performance of maize, particularly at Week 8, where plant height reached 101.89 ± 43.11 cm in Sammaz 51 compared to 47.00 ± 18.18 cm in the control. Leaf area (5.78 ± 0.93 cm²), stem girth (5.22 ± 0.64 cm), and node number (9.44 ± 2.64) were also higher under ogbono treatment. Soil pH increased from 5.10 (T0) to 6.15 (T3), while nitrate rose from 12.4 to 22.8 mg kg $^{-1}$, indicating improved soil fertility. Proximate analysis showed high carbohydrate content (74.83–76.98%) and enhanced mineral levels, particularly zinc (26.34 ± 1.78 mg/100 g). The study concludes that ogbono waste compost significantly improves maize growth and soil nutrient status and is recommended as an eco-friendly organic amendment for sustainable maize production in humid tropical environments.

KEYWORDS: *Irvingia gabonensis, Zea mays L., growth, nutrition, soil fertility.*

1.0 INTRODUCTION

Maize (*Zea mays* L.) is a member of the Poaceae family and is one of the most widely cultivated and economically significant cereal crops globally. It serves as a major source of calories for humans, a primary component of livestock feed and a critical raw material for diverse agro-industrial products, including starch, bioethanol, and processed foods [1]. Archaeological and molecular evidence indicates that maize was domesticated from its wild relatives (teosinte) in southern Mexico approximately 10,000 years ago, after which it spread rapidly across continents and became integral to global food systems [2]. In Nigeria, maize ranks among the leading staple crops in terms of cultivated area and production output, contributing substantially to national food security and rural livelihoods [3, 4]. Despite its agronomic importance, maize production is significantly constrained by a wide range of pathogenic organisms, including fungi, bacteria, and viruses. Major diseases such as northern corn leaf blight, rust, maize streak virus, and bacterial leaf streak can markedly reduce grain yield and quality, particularly under favorable environmental conditions. Warm temperatures, high relative humidity, and prolonged leaf wetness enhance pathogen infection, sporulation and dissemination, thereby increasing disease incidence and severity. In tropical and subtropical agro-ecologies, these conditions frequently coincide with periods of active crop growth, intensifying yield losses. Conventional disease management strategies primarily rely on the use of synthetic pesticides and the deployment of resistant cultivars. While these approaches can be effective, concerns regarding environmental contamination, pathogen resistance, and human health risks have stimulated interest in more sustainable and environmentally friendly alternatives. Consequently, the use of *Irvingia gabonensis* (ogbono) fruit waste in the Niger Delta presents a significant potential as an organic soil amendment for crop production although it still remains underexplored. This study therefore investigates the effects of ogbono on the agro-morphological, physiological, soil physicochemical and proximate parameters of maize (*Zea mays* L.) in Amassoma, Bayelsa State, Nigeria. The aim is to evaluate its suitability as a sustainable alternative to conventional organic fertilizer.

2.0 MATERIALS AND METHODS

2.1 Study Area

The specific study location was Amassoma in Southern Ijaw Local Government Area. Situated along the Nun River within the Niger Delta wetland system. Amassoma experiences a tropical rainforest climate with persistent moisture, swampy terrain, and seasonal flooding. These ecological conditions provide a suitable

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setting for evaluating maize performance under high rainfall and waterlogged environments.

2.2 Experimental Design

The experiment was arranged in a randomized complete block design (RCBD) to reduce the influence of field variability and improve the accuracy of treatment comparisons. Experimental units were grouped into relatively uniform blocks, and treatments were randomly assigned within each block. Four treatments were evaluated with three replicates each. Each plot measured 1.5 m and was separated by 0.9 m alleys to prevent runoff and cross-contamination. Treatments included a control (no amendment), organic fertilizer applied at 4t/ha, and *Irvingia gabonensis* fruit waste compost applied at 4t/ha. This design enabled effective assessment of soil amendments on maize growth under the prevailing field conditions.



Plate 1: Field View of Maize at the Vegetative Growth Stage under Experimental Conditions

2.3 Collection and Preparation of *I. gabonensis* Fruit Wastes

Fresh fruit wastes comprising peels and fibrous pulp of *Irvingia gabonensis* were obtained from local kernel-processing sites in Obunagha Community, Gbarian, Bayelsa State, Nigeria, where such residues are typically discarded. The materials were air-dried for two weeks to lower moisture content, then shredded to enhance decomposition. Composting was conducted using the windrow method by mixing shredded fruit waste with well-decomposed farmyard manure at a 1:1 ratio. The piles were turned weekly to maintain aeration and promote aerobic microbial activity. Compost maturity was reached after 8–10 weeks, indicated by temperature stabilization and a dark, friable texture, consistent with established compost maturity indicators [6].



Plate 2: Collected Maize Seed

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2.4 Soil Preparation and Maize Cultivation

The field experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Niger Delta University, Bayelsa State. The site was manually cleared, ploughed, and harrowed to obtain a suitable seedbed following standard maize production practices for humid tropical environments [7]. Certified improved maize seeds were procured from accredited agro-input dealers and handled under dry conditions before planting. Basal fertilizer (NPK 15:15:15) was applied at 60:60:40 kg ha^{-1} of N, P, and K in line with recommended guidelines [7, 8]. In designated plots, composted *Irvingia gabonensis* fruit waste was incorporated at 4 t ha^{-1} two weeks before planting to allow for nutrient release[6]. Seeds were sown at a spacing of 75 cm × 25 cm and at a depth of 3–5 cm, with thinning to one plant per stand after emergence to maintain optimal plant density [7, 9]. The trial lasted 12 weeks, during which routine agronomic practices were maintained and growth data were collected at two-week intervals following established field evaluation procedures[9].

2.5 Evaluation of physical performance of the maize

Maize growth was evaluated through periodic field measurements taken at four-week intervals. Representative plants were randomly selected from each plot to ensure unbiased assessment, following established field evaluation procedures [7, 9]. Plant height was measured from the soil surface to the tip of the uppermost leaf, while the number of fully expanded leaves was counted per plant. Leaf area was estimated using leaf length × maximum width × 0.75, a standard empirical correction factor for maize [10, 11]. Stem girth was measured approximately 5 cm above ground level, and the number of nodes and internodes was determined by direct counting along the main stem [12]. Soil samples were collected before planting and after harvest for laboratory analysis. Soil pH was measured using a 1:2.5 soil–water suspension, organic matter was determined by the Walkley–Black method, and essential nutrients were analyzed using standard soil analytical procedures [13]. Data obtained were subjected to appropriate statistical analysis to evaluate treatment effects.

2.6 Proximate Analysis Methodology

Proximate composition was determined using standard procedures of the Association of Official Analytical Chemists [14]. Parameters analyzed included moisture, ash, crude nitrogen (used to estimate crude protein), fat, and carbohydrate content. All determinations were performed in triplicate to ensure precision and reliability of results. Ash content was determined to estimate total mineral residue. A pre-weighed porcelain crucible was loaded with a known weight of sample and pre-heated to remove volatile components [15]. The sample was then incinerated in a muffle furnace at 775 ± 25°C until complete oxidation of organic matter produced a light-colored ash. After cooling in a desiccator, the crucible was reweighed, and ash percentage was calculated relative to the initial sample weight [14, 16]. Moisture content was determined using the oven-drying method. A known weight of sample was placed in a pre-weighed container and dried at 105°C for 24 hours until a constant weight was achieved. The dried sample was cooled in a desiccator and reweighed, and moisture content was calculated as the percentage weight loss relative to the original sample weight [14, 16]. Free nitrogen content was determined using the Kjeldahl method, involving digestion, distillation, and titration. A known weight of finely ground, dried sample was digested with concentrated sulfuric acid to convert organic nitrogen into ammonium sulfate. After alkalization with sodium hydroxide, ammonia was liberated, distilled into boric acid, and titrated with standard acid. Nitrogen content was calculated from the titration results, and crude protein was estimated by multiplying nitrogen by 6.25 [14, 17]. Fat and oil content was determined using the Soxhlet extraction method. Oven-dried, finely ground samples were placed in a thimble and extracted with petroleum ether under continuous reflux for 4–6 hours. The solvent was evaporated, and the remaining oil was dried, cooled, and weighed. Fat content was expressed as a percentage of the original dry sample weight [14, 18]. Carbohydrate content was determined by difference, subtracting the sum of moisture, ash, protein, and fat from 100%, providing an estimate of total carbohydrates, including sugars and starches [15, 18]. Where required, energy content was measured using a bomb calorimeter, with dried, ground samples combusted in oxygen and calorific value calculated from the temperature rise of surrounding water using benzoic acid for calibration.

3.7 Method of Soil Analysis

Soil samples were air-dried, crushed, homogenized, and passed through a 2 mm sieve to remove debris and stored in labeled containers prior to analysis [13, 20]. In-situ measurements of pH, temperature, electrical conductivity, salinity, and total dissolved solids were taken using a calibrated portable soil and water quality meter to provide reliable field estimates [19]. Soil pore water was extracted by mixing 1 part soil with 5 parts distilled water (w/v), shaking for 1 hour, centrifuging at 4,000 rpm for 20 minutes, and filtering the supernatant through Whatman No. 42 paper. The filtrate was used for subsequent nutrient analyses[21]. Ammonia was determined using the Nesslerization method at 425 nm, phosphate by the ascorbic acid method at 880 nm, sulphate turbidimetrically at 420 nm, and nitrate via the brucine–sulfanilic acid method at 410 nm. All analyses followed standard soil and water examination protocols [13, 19, 22]. Air-dried soil samples were digested with a 4:1 mixture of nitric and perchloric acids at 95°C until clear. The digest was filtered, diluted, and analyzed for manganese, copper, zinc, and iron using atomic absorption spectrophotometry with calibration from certified standards. This method ensures accurate and reliable determination of trace metals in soils [19, 23].

3.0 RESULT AND DISCUSSION

3.1 Results

3.1.1 The effect of *Irvingia gabonensis* on the growth performance of maize

Table 1 shows the influence of *Irvingia gabonensis* compost on maize growth. Growth and leaf parameters increased with plant age across all treatments, with minimal differences observed at

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Week 4. Application of *Irvingia gabonensis* waste significantly improved mid-growth performance (Week 8), resulting in greater plant height, leaf area, stem girth, nodes, and internodes compared to the control and organic fertilizer. By Week 12, differences among treatments were reduced, indicating that the amendments mainly affected early to mid-growth stages, while final growth stabilized across all plots.

Table 1: Treatments on Growth and Leaf Characteristics of Three Maize Varieties Across Different Growth Periods

Parameter	Species	Treatment	Week 4	Week 8	Week 12
Plant Height (cm)	Sammaz 51	Control	23.30 ± 4.40	47.00 ± 18.18	114.89 ± 22.55
		Organic Fertilizer	25.00 ± 4.20	44.89 ± 21.57	124.00 ± 26.88
		Ogbono Waste	25.00 ± 4.10	101.89 ± 43.11	142.28 ± 20.40
	Sammaz 52	Control	23.80 ± 4.10	43.33 ± 21.17	114.17 ± 25.32
		Organic Fertilizer	25.00 ± 4.00	35.67 ± 15.27	105.06 ± 27.71
		Ogbono Waste	23.80 ± 4.30	54.28 ± 27.95	134.83 ± 16.70
	Oba Super 6	Control	24.00 ± 4.20	57.72 ± 38.98	106.33 ± 18.38
		Organic Fertilizer	24.00 ± 4.30	57.39 ± 26.13	112.50 ± 16.23
		Ogbono Waste	23.50 ± 4.20	69.72 ± 27.52	127.17 ± 12.81
Number of Leaves	Sammaz 51	Control	6.22 ± 1.41	9.04 ± 1.37	8.11 ± 1.21
		Organic Fertilizer	6.33 ± 1.14	9.06 ± 1.27	8.29 ± 1.05
		Ogbono Waste	6.44 ± 1.11	11.83 ± 1.41	8.06 ± 1.41
Leaf Area (cm^2)	Sammaz 51	Control	3.63 ± 0.43	4.89 ± 0.97	4.42 ± 0.89
		Organic Fertilizer	3.67 ± 0.39	4.33 ± 0.68	4.76 ± 1.01
		Ogbono Waste	3.74 ± 0.42	5.78 ± 0.93	5.53 ± 0.92
Stem Girth (cm)	Sammaz 51	Control	3.57 ± 0.36	4.33 ± 0.61	4.00 ± 0.74
		Organic Fertilizer	3.63 ± 0.39	4.38 ± 0.46	4.00 ± 0.95
		Ogbono Waste	3.70 ± 0.41	5.22 ± 0.64	4.73 ± 0.93
Number of Nodes	Sammaz 51	Control	4.11 ± 0.74	7.00 ± 2.06	7.53 ± 1.36
		Organic Fertilizer	4.06 ± 0.87	6.67 ± 2.41	7.67 ± 1.21
		Ogbono Waste	3.94 ± 0.81	9.44 ± 2.64	7.87 ± 1.66
Number of Internodes	Sammaz 51	Control	2.78 ± 0.71	5.72 ± 2.41	6.74 ± 1.24
		Organic Fertilizer	2.78 ± 0.73	5.50 ± 2.40	6.83 ± 1.29
		Ogbono Waste	2.83 ± 0.78	7.33 ± 2.86	6.87 ± 1.48
Yellow–Green (Y/G)	Sammaz 51	Control	1.61 ± 0.75	3.52 ± 2.27	3.11 ± 1.84
		Organic Fertilizer	1.50 ± 0.73	3.17 ± 2.01	3.76 ± 2.05
		Ogbono Waste	1.61 ± 0.79	2.67 ± 1.77	3.46 ± 2.11
Green–Yellow (G/Y)	Sammaz 51	Control	1.56 ± 0.72	1.33 ± 1.01	1.00 ± 0.73
		Organic Fertilizer	1.55 ± 0.74	1.94 ± 1.55	1.21 ± 0.79
		Ogbono Waste	1.56 ± 0.75	0.89 ± 1.27	1.10 ± 0.86

Values are presented as mean ± standard deviation (SD). Measurements were taken at Weeks 4, 8, and 12 after planting for three maize varieties (Sammaz 51, Sammaz 52, and Oba Super 6) under Control, Organic Fertilizer, and Ogbono Waste treatments. Parameters assessed include plant height, number of leaves, leaf area, stem girth, number of nodes, number of internodes, and leaf colour indices (Yellow-to-Green and Green-to-Yellow ratios).

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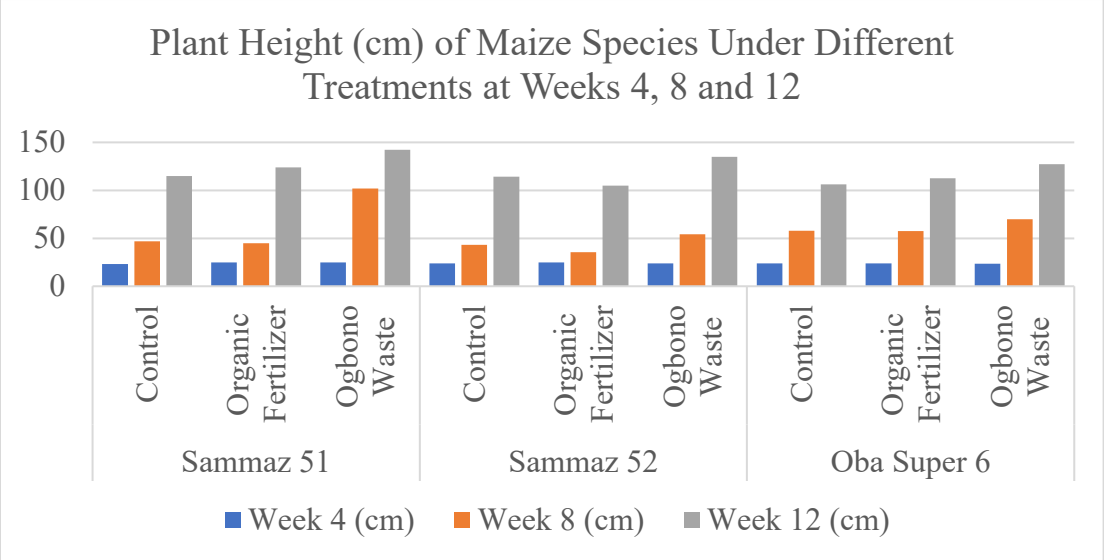


Figure 1: Plant height of maize species under different treatment of 4, 8 and 12 weeks

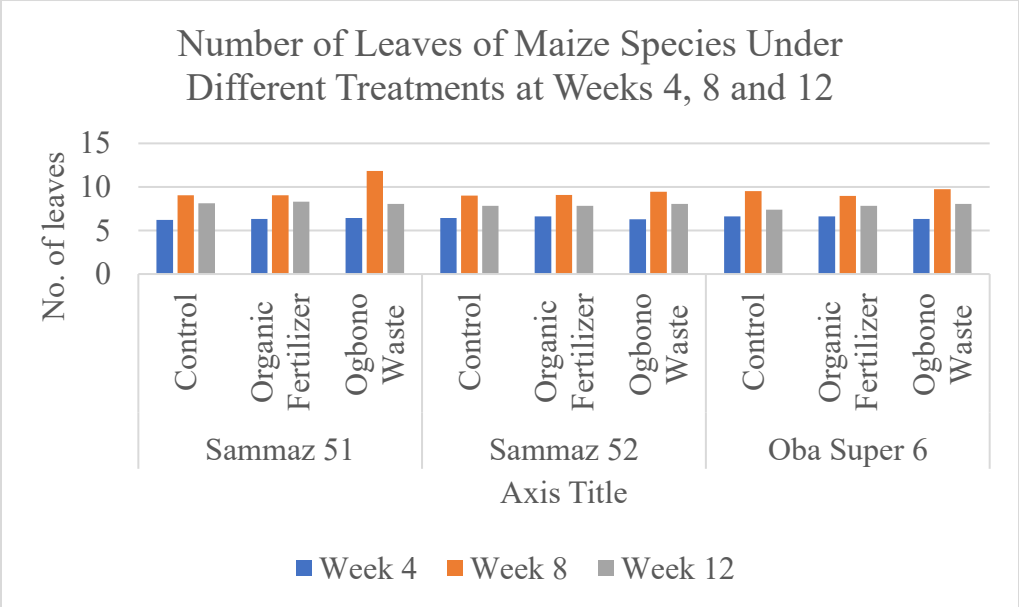


Figure 2: Number of leaves of maize species under treatments at 4, 8 and 12 weeks

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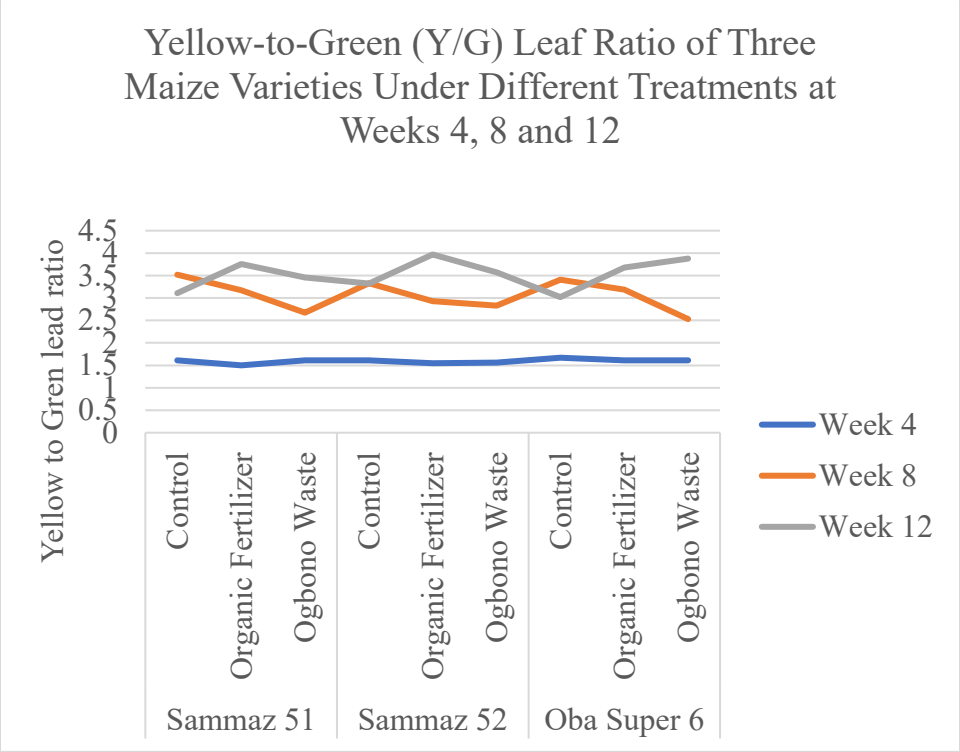


Figure 3: Yellow to Green leaf ratio of maize species varieties under different treatment of 4, 8 and 12 weeks.

3.1.2 Proximate Analysis

Table 2 shows the proximate and mineral composition of three maize cultivars treated with *Irvingia gabonensis* waste (T0–T3) and organic fertilizer (F0–F3). Parameters measured included protein, moisture, ash, fat, carbohydrate, free nitrogen, dry matter, organic matter, energy, calcium, copper, manganese, and zinc. Both treatments influenced maize composition, with protein, fat, and mineral levels varying according to treatment, while carbohydrate content remained consistently high, reflecting differences in nutrient availability across amendments.

Table 2 Proximate and Mineral Contents of Maize Cultivars under Ogbono Waste and Organic Fertilizer Treatments

Parameter	T0 / Ogbono 0	T1 / Ogbono 1	T2 / Ogbono 2	T3 / Ogbono 3	F0	F1	F2	F3
Protein (%)	4.10 ± 0.08	3.00 ± 1.72	2.50 ± 0.32	2.94 ± 0.38	2.17 ± 1.06	2.61 ± 0.70	3.17 ± 1.35	1.38 ± 1.19
Moisture (%)	12.20 ± 1.44	13.68 ± 0.21	12.59 ± 0.21	12.82 ± 0.94	12.00 ± 1.73	12.80 ± 1.71	11.90 ± 1.35	12.97 ± 0.91
Ash (%)	1.34 ± 0.00	1.32 ± 0.03	1.34 ± 0.67	1.34 ± 0.00	1.34 ± 0.00	1.12 ± 0.39	1.34 ± 0.00	1.56 ± 0.38
Fat (%)	5.17 ± 0.40	4.47 ± 1.60	4.47 ± 0.70	5.17 ± 0.66	2.63 ± 1.40	3.59 ± 1.06	4.03 ± 2.30	2.36 ± 0.95
Carbohydrate (%)	74.83 ± 1.35	75.33 ± 3.54	76.98 ± 1.75	75.69 ± 1.53	79.51 ± 1.91	78.11 ± 1.96	77.41 ± 2.45	79.54 ± 0.60
Free Nitrogen	0.66 ± 0.01	0.48 ± 0.27	0.40 ± 0.05	0.47 ± 0.06	0.35 ± 0.17	0.42 ± 0.11	0.51 ± 0.22	0.22 ± 0.19
Dry Matter (%)	87.80 ± 1.44	86.32 ± 0.21	87.41 ± 0.21	87.18 ± 0.94	88.00 ± 1.73	87.20 ± 1.71	88.10 ± 1.35	87.03 ± 0.91
Organic Matter (%)	98.75 ± 0.50	98.33 ± 0.87	99.05 ± 0.14	98.67 ± 0.56	98.59 ± 0.15	98.30 ± 0.33	98.60 ± 0.20	99.01 ± 0.08
Energy (kcal/100g)	362.53 ± 3.23	344.59 ± 6.20	351.68 ± 11.67	357.51 ± 5.31	348.39 ± 10.37	346.67 ± 8.14	354.41 ± 14.49	345.10 ± 7.49
Calcium	22.93 ± 5.07	15.67 ± 4.45	23.71 ± 5.88	20.75 ± 5.56	28.80 ± 3.50	30.85 ± 3.09	32.08 ± 3.61	28.37 ± 1.79
Copper	1.98 ± 0.12	2.30 ± 0.17	2.33 ± 0.22	2.44 ± 0.23	1.82 ± 0.07	2.22 ± 0.12	2.44 ± 0.13	2.33 ± 0.22
Manganese	2.72 ± 0.15	2.92 ± 0.18	3.12 ± 0.23	3.12 ± 0.12	2.43 ± 0.11	2.96 ± 0.15	3.07 ± 0.17	2.95 ± 0.07
Zinc	20.38 ± 1.96	20.34 ± 1.90	24.01 ± 4.92	26.34 ± 1.78	16.81 ± 1.30	20.93 ± 2.86	26.33 ± 3.89	23.70 ± 2.28

Table 2 Proximate and mineral composition of three maize cultivars (Oba Super 6, Sammaz 51, and Sammaz 52) under different levels of Ogbono Waste (T0–T3) and Organic Fertilizer (F0–F3). Values represent the mean ± standard deviation (SD) of three replicates. Parameters measured include protein (%), moisture (%), ash (%), fat (%), carbohydrate (%), free nitrogen, dry matter (%), organic matter (%), energy (kcal/100 g), calcium (mg/100 g), copper (mg/100 g), manganese (mg/100 g), and zinc (mg/100 g). Horizontal entries indicate treatment levels, while vertical entries indicate the measured proximate and mineral contents. The table allows for comparison of the effects of organic amendments on the nutritional quality and mineral enrichment of the maize cultivars.

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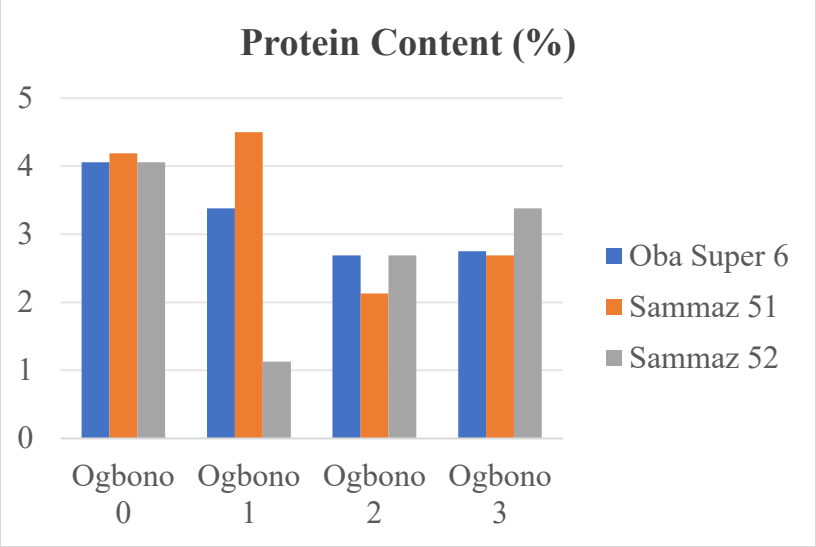


Figure 4: The protein content of three maize cultivars, Oba Super 6, Sammaz 51, and Sammaz 52, subjected to four levels of Ogbono waste amendment.

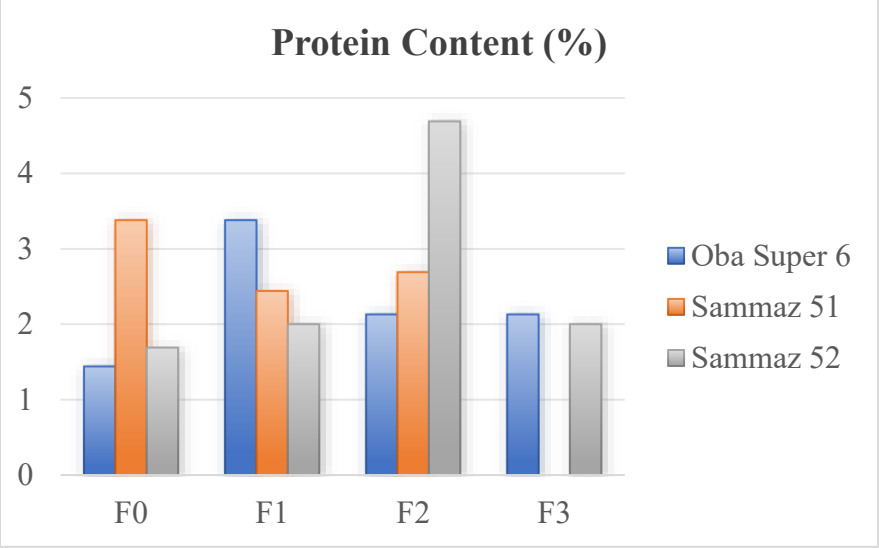


Figure 5: The protein content of three maize cultivars, Oba Super 6, Sammaz 51, and Sammaz 52, subjected to four levels of Organic amendment

3.1.3 Physicochemical parameters of soil samples

Table 3 shows the physicochemical properties of soil under varying levels of *Irvingia gabonensis* waste (T0–T3) and organic fertilizer (F0–F3). Soil pH, electrical conductivity, total dissolved solids, and concentrations of nitrate, sulphate, and phosphate increased with higher amendment levels, indicating improved nutrient availability and soil fertility. Organic fertilizer generally produced slightly higher values than *Irvingia gabonensis* waste, suggesting a stronger effect on nutrient enrichment.

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Table 3: Physicochemical Properties of Soil: Levels of Ogbono Waste and Organic Fertilizer Amendments

Treatment Category	Level	pH	Conductivity (µS/cm)	TDS (mg/L)	Nitrate (mg/kg)	Sulphate (mg/kg)	Phosphate (mg/kg)
A: Ogbono Waste	**T0**	5.10	145	92	12.4	18.5	16.2
	T1	5.45	188	120	15.6	22.1	18.8
	T2	5.82	215	138	19.2	26.4	22.5
	T3	6.15	240	155	22.8	30.2	25.4
B: Organic Fertilizer	**F0**	5.10	145	92	12.4	18.5	16.2
	F1	5.30	210	134	18.5	24.5	21.0
	F2	5.55	285	182	24.2	32.8	28.6
	F3	5.70	320	205	28.4	38.6	32.4

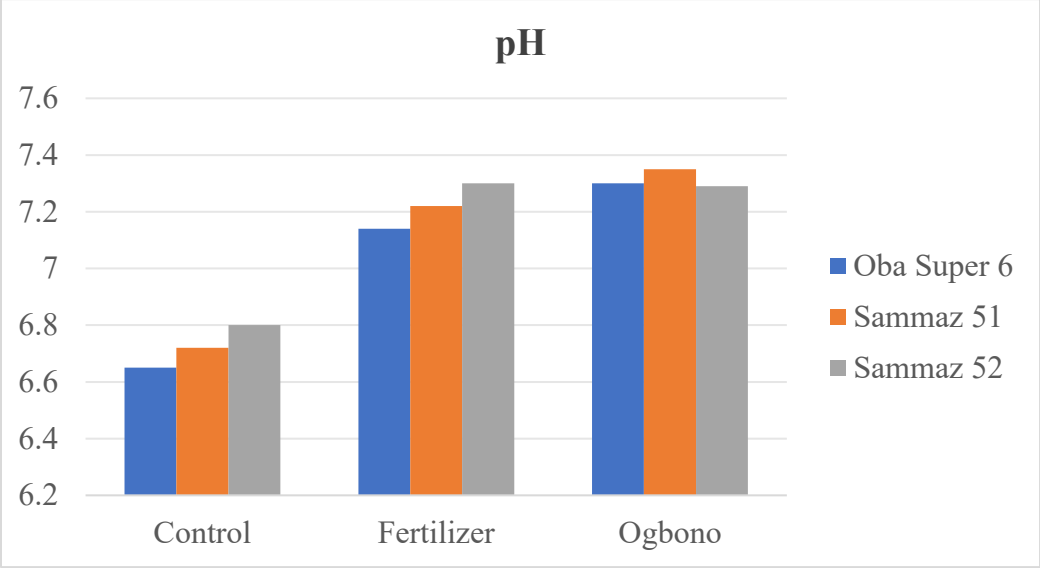


Figure 6: pH Contents of Different Soil Samples

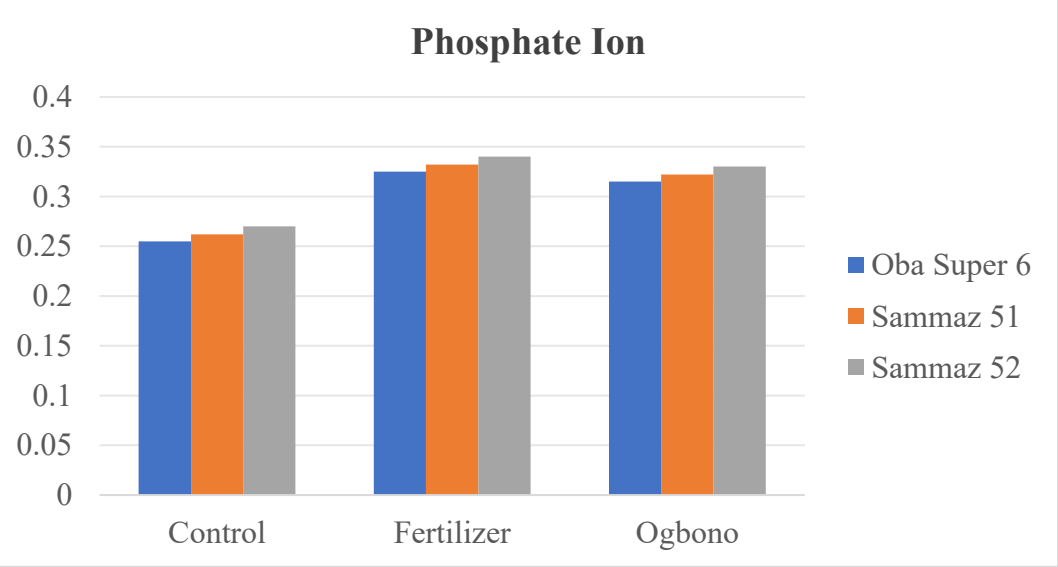


Figure 7: Phosphate Ion Contents of Different Soil Samples

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3.2 DISCUSSION

3.2.1 Growth Performance of Maize

The study showed that *Irvingia gabonensis* (Ogbono) waste significantly enhanced maize vegetative growth, particularly during mid-growth (Week 8). Treated plants exhibited greater height, leaf area, stem girth, nodes, and internodes compared to control and organic fertilizer, while differences stabilized by Week 12 [6, 24, 25]. This improvement is attributed to better soil nutrient availability, slow-release nitrogen, and enhanced soil structure, consistent with previous findings on organic amendments improving vegetative traits in maize and other cereals [6, 24, 25]. Leaf area increases under Ogbono waste indicate improved photosynthetic capacity and biomass accumulation, while higher stem girth suggests stronger structural support and potential yield advantage. Color ratio variations (Y/G and G/Y) further reflect positive effects on chlorophyll dynamics and nutrient assimilation. Overall, Ogbono waste outperformed organic fertilizer during key vegetative stages due to its nutrient composition and gradual nutrient release pattern.

3.2.2 Proximate Contents of Maize

Proximate and mineral analysis revealed that carbohydrate content remained high across all treatments, while protein and fat levels varied, with Ogbono waste generally improving protein, fat, and certain mineral concentrations [6, 24, 26]. Minerals such as calcium, manganese, and zinc increased with Ogbono waste, enhancing enzymatic activity and plant development. Energy values were highest in carbohydrate-dense treatments, and free nitrogen levels were slightly higher under Ogbono waste, indicating improved nitrogen bioavailability. Moisture and dry matter remained stable across treatments. These results demonstrate that Ogbono waste enhances both vegetative growth and grain nutritional quality, supporting its role as a biofortifying organic amendment [6, 24, 26].

3.2.3 Physicochemical Parameters of Soil

Soil analysis indicated that both Ogbono waste and organic fertilizer improved fertility, increasing pH, electrical conductivity (EC), total dissolved solids (TDS), and concentrations of nitrate, sulphate, and phosphate [6, 27, 28]. Organic fertilizer showed slightly higher immediate nutrient enrichment, whereas Ogbono waste promoted gradual nutrient release, improving long-term soil health and buffering capacity [6, 27, 28]. Enhanced pH improved nutrient solubility and microbial activity, while higher EC and TDS indicated increased cation availability. Macronutrients such as nitrate, sulphate, and phosphate rose with amendment intensity, supporting better plant nutrition. Overall, Ogbono waste contributes to sustainable soil fertility, potentially reducing disease incidence by promoting soil microbial health, while organic fertilizer provides more immediate nutrient availability [6, 27, 28].

3.3 Conclusion

The study demonstrates that *Irvingia gabonensis* (Ogbono) waste is an effective organic amendment for maize cultivation. Its application significantly enhanced vegetative growth, particularly during early and mid-growth stages, improved grain nutritional quality by increasing protein, fat, and mineral contents, and positively influenced soil physicochemical properties, including pH, nutrient availability, and organic matter. Compared with conventional organic fertilizer, Ogbono waste provided a gradual nutrient release, promoting sustainable soil health and potentially reducing crop susceptibility to stress. Overall, Ogbono waste presents a viable, eco-friendly, and locally available strategy to improve maize productivity, grain quality, and soil fertility in humid tropical environments.

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