*Original Research Article*

# Growth and Yield Responses of NERICA Rice Varieties to Different Sources of Organic Fertilizer in Transitory Rainforest Zone of Nigeria

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**ABSTRACT**

Two field studies were conducted to investigate growth and yield responses of NERICA rice cultivars to organic fertiliser sources, at the Teaching and Research Farm of Federal University of Agriculture, Abeokuta (FUNAAB) between May 31 and September 30 of 2009 and OgbeEruku Village (OEV), Owode - Egba, Ogun State, Nigeria between July 7 and November 30 also in 2009. FUNAAB is a transition between rainforest and a derived savanna whereas OEV is in a rainforest zone. The experiment was a 10 × 3 × 2 factorial in a Randomized Complete Block Design (RCBD) replicated three times. The treatments were three rice varieties (NERICA 1, NERICA 2, and Ofada) and three application rates of different manure types (poultry manure at 0 t/ha$^{-1}$, 10 t/ha$^{-1}$ and 20 t/ha$^{-1}$; cow dung at 0 t/ha$^{-1}$, 7 t/ha$^{-1}$ and 14 t/ha$^{-1}$; swine manure at 0 t/ha$^{-1}$, 3.5 t/ha$^{-1}$ and 7 t/ha$^{-1}$). These levels are equivalent to 0 kg N/ha$^{-1}$, 45 kg N/ha$^{-1}$, and 90 kg N/ha$^{-1}$. The results indicated significant ($P < 0.05$) varietal variability on dry matter accumulation at maturity in the order NERICA 1 > Ofada > NERICA 3. Inorganic fertiliser source at recommended rate recorded significantly ($P < 0.05$) higher effect on all growth parameters compared to organic sources. Growth characters were significantly higher at FUNAAB than OEV, conversely grain yield was significantly higher at OEV, where NERICA 1 at higher application rates of poultry and swine manure recorded grain yield comparative to inorganic fertiliser at recommended rate.

**Keywords:** NERICA, Ofada, growth, leaf area index (LAI), yield, cow dung, poultry manure.

## INTRODUCTION

Rice (*Oryza sativa*), is one of the most consumed staple food for most people in the developing countries (Dowling et al., 1998), especially in Asia and West African Sub-region. Its production is constrained by biotic, abiotic stresses (Herdt, 1991; Chen and Murata, 2002) and socio-economic factors. Among the abiotic factors, nutrient deficiency and drought are among the limiting factors in this tropical region, owing to high level of precipitation, low soil organic matter and high soil acidity (Agboola and Corey, 1973). Farming activities are predominantly practised by peasant farmers with low incomes. Various strategies could be adopted to increase the performance of rice under such farming systems by using organic matter (Takahashi et al., 2004) and introducing high performing, stress-tolerant rice cultivars. Organic sources from livestock, poultry and crop residues are readily available in most farms in West Africa. The adoption of organic matter has been hampered by the volume and availability of manure materials. But its advantages could be premised on the low cost of procurement and its long term effect on environmental sustainability. Farmers could leverage on sustained- the slow releasing properties and environmental sustainability of organic fertiliser sources.

Introduction of interspecific rice cultivar NERICA, a cross between *Oryza sativa* and *Oryza glaberrima* by African Rice could go a long way, with other low input technology in alleviating production constraints and improving productivity of rice in the tropical region. NERICA rice was reported to be resistant to drought and diseases, with high water use efficiency in water-limited environment (Fujii et al., 2006; Onyango et al., 2007). It is comparatively high yielding relative to the existing local cultivars, with short phenological phase, thus suitable for double cropping, and is rich in protein (Matsunami et al., 2009).

Little had been documented about the growth response of NERICA in the rainforest transitory zone of Nigeria and its eventual agronomic performance. Investigating its crop physiology and development can elucidate the ambiguity behind NERICA's crop performance. Plant growth characters apart from genotypic and environmental factors play a significant role in crop performance. These include formation of the necessary organs for the interception of light, water and nutrients, in this case leaf and root system and at the same time optimal coordination of processes such as carbon and nitrogen economy in plant, biomass allocation to various organs and the chemical composition of various organs (Lambers and Poorter, 1992).

The objective of the present study is to explicate if different sources of manure at different rates of application could lead to different growth responses in NERICAs and its implication on their agronomic performances in the rainforest transitory zone of Nigeria.

## MATERIALS AND METHODS

### Characterisation of location and site

Two field trials were conducted at the Teaching and Research farm of Federal University of Agriculture Abeokuta (FUNAAB) between May 31 and September 30 in 2009 and Ogbe Eruku Village (OEV), Owode - Egba, Ogun State, Nigeria between July 7 and November 30 also in 2009. The agro-ecology of FUNAAB ($7^0$9' 38.9'' N lat., and $3^0$21' 53.9''E long.; 140 m asl) is a transition between rainforest and derived savanna while OEV ($6^0$57'N lat., and $3^0$31'E long., 107 m asl) is in rainforest zone. The total rainfall during the period of experimentation in FUNAAB and OEV was 737.7 mm and 439.2 mm, respectively. The average temperature and relative humidity during the period were 26.8 **°C** and 75.7% in FUNAAB and 28.3 °C and 85.2% in OEV (Table 1). Soil samples were collected for nutrient analyses according to Van Averbeke et al., 2007. Soil pH was determined in 1:2.5 (soil: water) and KCl solution (1:1) using glass electrode pH meter. Available phosphorus was extracted using Olsen's extract while the P in the extract was determined by the use of spectrophotometer; total nitrogen in the soil was digested and analyzed using the Kjeldahl method. Exchange cations (Na, K) were extracted with 1 N ammonium acetate, Na and K in the extract were determined by flame photometry. Hydrometer method was utilized in the determination of particular size distribution of the soil. The soil at FUNAAB experimental field was loamy sand with 0.05% total nitrogen while the soil at OEV was sandy clay loam with 0.09% total nitrogen (Table 2).

### Design and Treatments

The experiment was a 10 × 3 × 2 factorial in a Randomized Complete Block Design (RCBD) replicated three times. The treatments were three rice varieties (NERICA 1, NERICA 2, and Ofada) and three levels of each manure types (poultry manure at 0 t/ha, 10 t/ha and 20 t/ha; cow-dung at 0 t/ha, 7 t/ha and 14 t/ha; swine manure at 0 t/ha, 3.5 t/ha and 7 t/ha). These levels are equivalent to 0 kg N/ha$^{-1}$, 45 kg N/ha$^{-1}$ and 90 kg N/ha$^{-1}$. Inorganic fertiliser at recommended rate (45 kg N/ha$^{-1}$) was used as control (N P K 20: 10: 10 and Urea). The land was prepared manually at both locations and the fields were marked out into 3 m by 4 m plots. The total experimental field area at each location was 1 414.5 m$^2$. Rice was seeded directly, at four per hole by dibbling at a depth of 4-5 cm with a spacing of 25 cm × 25 cm. The experiment was rainfed. Each plot consisted of 16 rows and each row consisted of 12 hills to obtain

**Table 1**. Summary of weather data during the cropping season at Federal University of Agriculture, Abeokuta and Ogbe Eruku, Obafemi/ Owode Local Government Area, Ogun State (2009)

| Month | FUNAAB | | | | Ogbe | | | |
|---|---|---|---|---|---|---|---|---|
| | Total rainfall (mm) | Average Temperature (°C) Max. | Min | Relative Humidity % | Total rainfall (mm) | Average Temperature (°C) Max. | Min. | Relative Humidity % |
| January | - | 26.4 | 26.2 | 59.9 | 0.0 | 34.9 | 23.5 | 71 |
| February | - | 26.0 | 26.5 | 67.1 | 26.5 | 36.1 | 25.5 | 78 |
| March | 96.0 | 26.9 | 26.4 | 64.0 | 34.2 | 35.4 | 25.3 | 79 |
| April | 101.0 | 26.4 | 26.2 | 53.0 | 238.2 | 33.7 | 24.6 | 83 |
| May | 124.0 | 26.0 | 26.1 | 73.0 | 269.8 | 32.9 | 24.1 | 82 |
| June | 140.0 | 26.5 | 26.0 | 72.0 | 213.7 | 31.6 | 23.7 | 83 |
| July | 160.0 | 27.0 | 26.4 | 77.2 | 152.9 | 30.8 | 22.9 | 87 |
| August | 162.1 | 26.7 | 26.2 | 80.7 | 56.8 | 39.4 | 22.5 | 87 |
| September | 151.6 | 35.0 | 24.0 | - | - | - | - | - |
| October | 180.1 | 26.9 | 26.4 | 74.7 | 141.4 | 31.3 | 23.1 | 86 |
| November | 64.6 | 26.0 | 26.1 | 68.0 | 88.0 | 33.6 | 22.7 | 81 |
| December | 10.4 | 26.2 | 26.1 | 63.7 | 0.0 | 35.7 | 24.4 | 78 |

Sourced from

1. Department of Agrometrological Station, Ogun Oshun River Basin Development Authority
2. Nigeria Metrological Agency, Abeokuta synoptic

**Table 2**. Physico-chemical properties of the soils of the experimental locations before the commencement of the experiment at Federal University of Agriculture, Abeokuta and Ogbe Eruku (OEV), Obafemi Owode Local Government Area, Ogun State in 2009 at soil depth of 0-20 cm.

| Soil properties | FUNAAB | Ogbe Eruku Village |
|---|---|---|
| PH | 5.9 | 6.1 |
| Organic carbon(%) | 0.45 | 1.82 |
| Organic matter(%) | 0.77 | 2.56 |
| Total Nitrogen (%) | 0.05 | 0.09 |
| Available P (mg/kg) | 2.28 | 2.60 |
| **Exchangeable Cations** | | |
| $K^{+}$cmo/kg | 0.18 | 0.09 |
| $Na^{+1}$ cmol/kg | 0.12 | 0.17 |
| $Zn^{2+}$ mg/kg | 2.29 | 2.13 |
| $Fe^{2+}$ mg/kg | 0.32 | 0.44 |
| **Particle Size Distribution** | | |
| **Soil Texture** | | |
| Sand (%) | 74.40 | 48.40 |
| Silt% | 12.8 | 20.30 |
| Clay% | 12.8 | 18.29 |

192 hills per plot. The manure was thoroughly cured, air dried before incorporation. The manure was subjected to analysis to determine its nutrient composition (macro and micronutrients) by standard procedure (Maynard and Kalra, 1991; Cater, 1993). The organic manure types were applied by incorporation 14 days before planting to ensure decomposition and thorough mix with the soil. Weed control was conducted three times manually.

**Table 3**. Chemical properties of the manure used for the experiment

| | Cow dung | Poultry manure | Swine manure |
|---|---|---|---|
| Nitrogen (%) | 0.63 | 0.47 | 1.23 |
| Phosphorus (mg/kg) | 8855 | 14760 | 3690 |
| Ca (Mg/kg) | 12025 | 144375 | 9725 |
| Mg (mg/kg) | 5225 | 7063 | 3338 |
| Zn mg/kg | 96.60 | 254.20 | 46.70 |
| Cu mg/kg | 37.60 | 37.85 | 4.95 |
| Mn mg/kg | 243.60 | 320.20 | 283.00 |
| Fe mg/kg | 0.18 | 0.21 | 0.15 |
| C (%) | 17.78 | 18.25 | 33.14 |
| Pb mg/kg | 13.85 | 44.30 | 17.60 |
| CO mg/kg | Nd | 18.50 | Nd |

**Nd:** No data

**Sampling and data collection**

A composite sample of manure from FUNAAB was taken for each manure source and mixed thoroughly to obtain samples for nutrient analysis. The macro minerals in animal manure on air dry basis are cow dung (0.63% N, 0.48% P, and 1.69% K), poultry droppings (0.47% N, 1.71% P, and 2.15% K) and swine faeces (1.23% N, 3.15% P, and 1.13% K) (Table 3).

**Data analysis**

Data were collected on vegetative growth characters

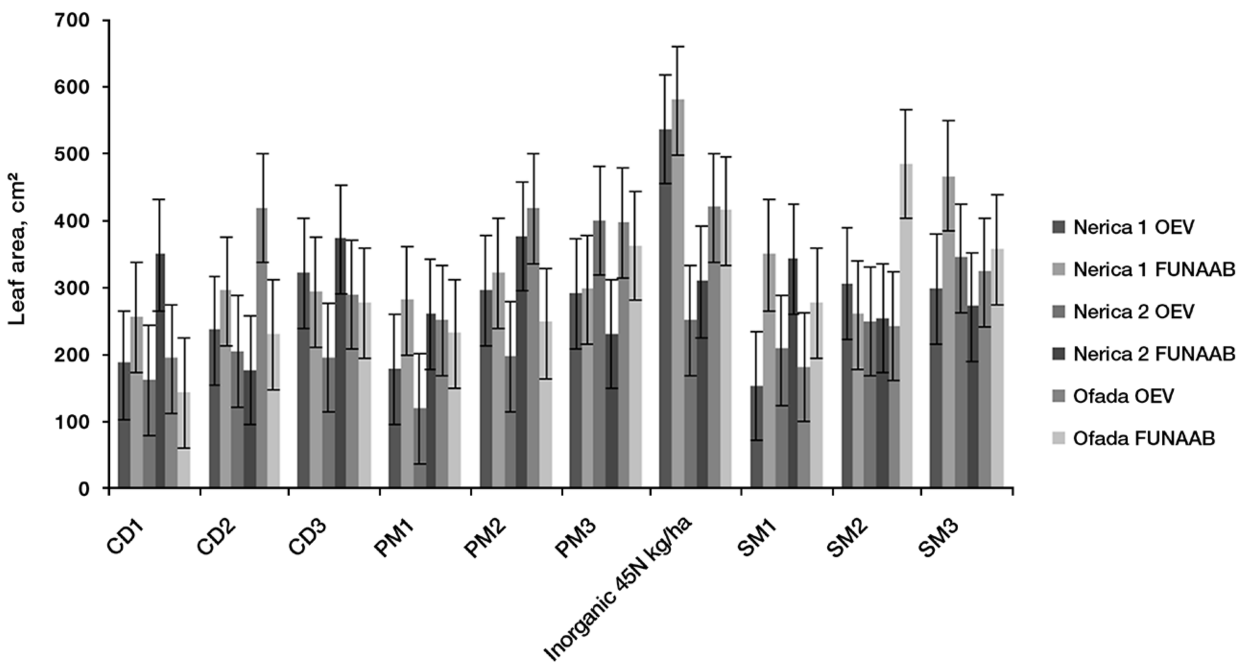


**Fig. 1.** Interaction of fertilizer sources × variety × location on leaf area at mid tillering at OEV and FUNAAB

and yield. Combined Analysis of Variance (ANOVA), fixed model at the two experimental sites with the aid of Genstat12th Edition was conducted and significant treatment means were separated using Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) at 5% probability level. All graphical illustrations were conducted using Genstat 12th Edition.

## RESULTS

Significant interaction of ($P < 0.05$) varieties × organic fertiliser sources × location was observed (Fig. 1). In NERICA 1, there were no significant differences in leaf area at mid tillering when organic fertiliser sources at different rates were applied at OEV and FUNAAB, with leaf area ranging between (152.5 $cm^2$ – 466.9 $cm^2$). Inorganic fertiliser source at recommended rate (N 45 kg/$ha^{-1}$) displayed similar trend as observed in organic fertiliser sources with no significant differences in leaf area at OEV (536.0 $cm^2$) and FUNAAB (579.4 $cm^2$), respectively. NERICA 2 recorded similar trend as observed in NERICA 1. Ofada displayed similar trend as observed in either varieties, but swine manure 3.5 $tha^1$ recorded a higher leaf area (485.2 $cm^2$) at mid tillering in FUNAAB compared to OEV (243.3 $cm^2$), indicating a 50% increase. A significant location × organic fertiliser sources ($P < 0.05$) was recorded for leaf area at 50% (Fig. 2). FUNAAB (414.1$cm^2$) recorded significantly higher leaf area at 50% flowering compared to OEV (281.7$cm^2$), a 32% increase in leaf area. Cow dung at 7 t/$ha^{-1}$ and cow dung at 14t/$ha^{-1}$ yielded no significant differences in the leaf area in both locations. FUNAAB had a significantly higher leaf area (418.5 $cm^2$) compared to (264.0 $cm^2$) at OEV when poultry manure 0 t/$ha^{-1}$ was applied. However, at higher application rates of poultry manure, there were no significant differences in leaf area in both locations. Swine manure equally displayed similar trend in leaf area when the lowest rate of swine manure 0 $tha^{-1}$was applied with FUNAAB (458.9 $cm^2$) recording higher value than OEV (279.1 $cm^2$), a 39% increase in leaf area. At other rates of swine manure application there were no significant differences in leaf area in both locations. Inorganic fertiliser source at recommended application rate (N 45 kg/$ha^{-1}$) did not lead to any significant differences in leaf area at 50% tillering in both locations. At maturity, there was no significant difference ($P > 0.05$) in leaf area among the varieties. However, fertiliser sources had a significant effect ($P < 0.05$) on leaf area, with inorganic N 45 kg/$ha^{-1}$recording the highest leaf area (754.0 $cm^2$), while there was no significant difference in leaf area when other organic fertiliser sources were applied. At maturity, leaf area (606.0 $cm^2$) at FUNAAB was significantly higher than (552.0 $cm^2$) at OEV.

Significant effect of varieties, fertiliser sources and location ($P < 0.05$) was recorded on leaf area index (LAI) at mid tillering (see Table 1). NERICA 1 and Ofada recorded the highest LAI at mid tillering, (0.49), with no significant differences between them. However, NERICA 2 had the least LAI at mid tillering (0.416). The highest LAI at mid tillering was observed when inorganic N at 45 kg/$ha^{-1}$(0.652) and swine manure (0.473) was applied at

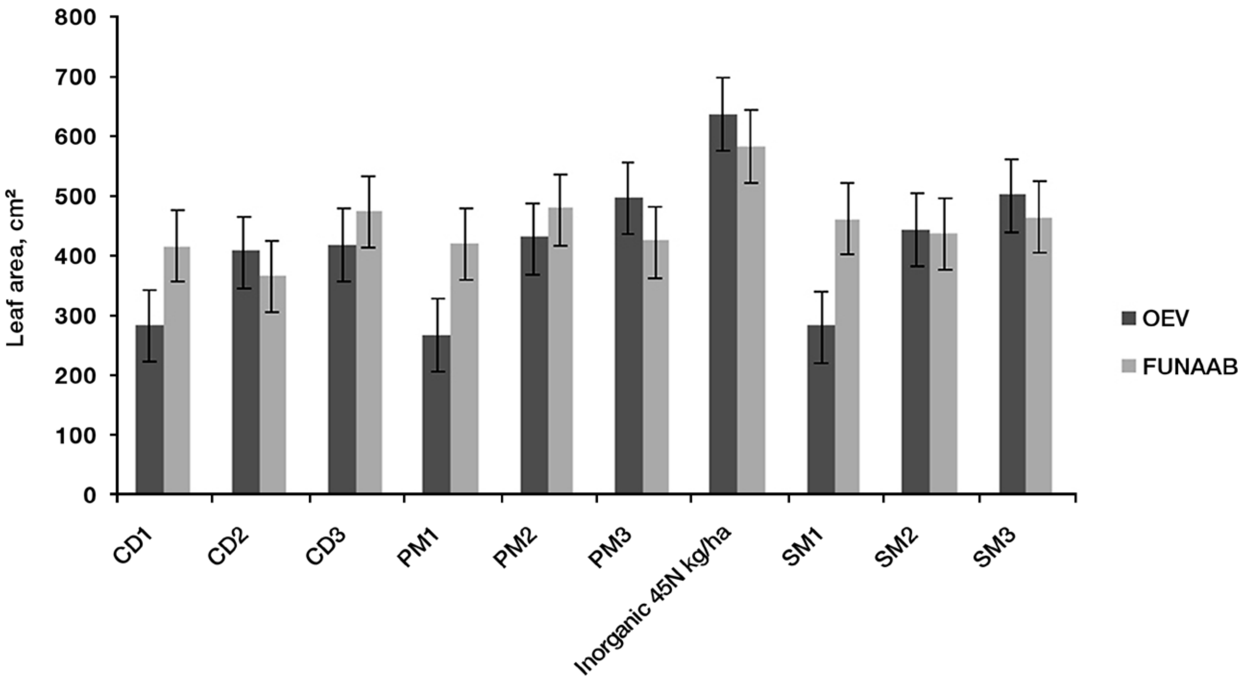


**Fig. 2.** Interaction of fertilizer sources × location on leaf area at 50% flowering

7 t/ha$^{-1}$ with no significant differences between them. The least LAI of (0.344) was observed with cow dung 0 t/ha$^{1}$. FUNAAB recorded higher LAI (0.495) at mid tillering than OEV (0.439). Variety and location had no significant effect ($P$ > 0.05) on LAI at 50% flowering, however, fertiliser sources had significant effect ($P$ < 0.05) on LAI at 50% flowering, with inorganic N 45kg/ha$^{-1}$ (0.973), swine manure 7 t/ha$^{-1}$ (0.970), poultry manure at 10 (0.723) and 20 t/ha$^{-1}$ (0.723) recording the highest LAI at 50% flowering. However, there was no significant difference between them. At maturity, LAI recorded no significant differences among the treatments at all levels.

There was a significant effect ($P$ < 0.05) of variety, fertiliser sources and location on number of tillers at vegetative stage of growth (Table 1). NERICA 1 and Ofada recorded the highest number of tillers (11.95 and 12.08), with no significant differences between them. However, the least number of tillers was observed in NERICA 2 (9.95). Inorganic fertiliser (13.39), swine manure at 7 t/ha (12.61) and poultry manure at 20 t/ha (12.44) recorded the highest number of tillers with no significant differences between them. Cow dung at zero (9.44) and 7 t/ha (10.56) was not significantly different from poultry manure at zero rate (9.78), recorded the least number of tillers. FUNAAB (11.97) recorded a higher number of tillers than OEV (10.69).

There was a significant effect ($P$ < 0.05) of variety, sources of fertiliser and location on plant height at vegetative stage (see Table 1). NERICA 1 (56.97 cm) and Ofada (60.04 cm) recorded the highest plant height at vegetative stage, with no significant differences between them. NERICA 1 and NERICA 2 recorded no significant differences in plant height at vegetative stage. Inorganic fertiliser (64.41 cm), swine manure at 7 and 3.5 t/ha$^{-1}$ (62.17 cm and 59.12 cm, respectively), poultry manure at 10 and 20 t/ha$^{-1}$ (59.13 cm and 59.47 cm, respectively) recorded the highest plant height at vegetative stage with no significant differences between them. The least plant height at vegetative stage was observed when poultry manure at zero rate was applied (52.20 cm), which was not significantly different from the plant height when cow dung was applied at all rates. FUNAAB (59.36 cm) recorded a higher plant height at vegetative stage compared to OEV (55.71 cm). At maturity, plant height was significantly affected ($P$ < 0.05) by variety and fertiliser sources, while location had no significant effect ($P$ > 0.05) on it (see Table 1). Ofada (87.85 cm) and NERICA 2 (84.90 cm) recorded the highest significant plant height with no significant difference between them. The least was observed in NERICA 1 (82.10 cm). There were no significant differences in plant height when all fertiliser sources at different application rates were applied, except swine manure 3.5 t/ha$^{-1}$ (85.39 cm), which was not significantly different from inorganic fertiliser source (93.11 cm) at recommended rate of application.

**Table 4**. Effect of variety, organic fertilizer sources and location on growth characters of NERICA

| Treatments<br>Varieties | Leaf area @ maturity, cm$^2$ | LAI @ mid tillering | LAI @ 50% flowering | LAI @ maturity | Number of tillers @ vegetative stage | Plant height @ vegetative stage, cm | Plant height @ maturity | Dry matter @ maturity |
|---|---|---|---|---|---|---|---|---|
| NERICA 1 | 580.0 | 0.494$^{a}$ | 0.763 | 0.944 | 11.95$^{a}$ | 56.97$^{ab}$ | 82.10$^{b}$ | 14.74$^{a}$ |
| NERICA 2 | 575.0 | 0.416$^{b}$ | 0.648 | 0.938 | 9.95$^{b}$ | 55.60$^{b}$ | 84.90$^{ab}$ | 9.40$^{c}$ |
| Ofada | 582.0 | 0.490$^{a}$ | 0.711 | 0.929 | 12.08$^{a}$ | 60.04$^{a}$ | 87.85$^{a}$ | 11.54$^{b}$ |
| SED± | 28.4 | 0.0300 | 0.0637 | 0.0450 | 0.380 | 1.643 | 1.552 | 0.915 |
| LSD | Ns | 0.0595 | Ns | Ns | 0.753 | 3.254 | 3.074 | 1.812 |
| **Rates of manure types** | | | | | | | | |
| Cow dung 0 tha$^{-1}$ | 525.0$^{b}$ | 0.344$^{d}$ | 0.513$^{c}$ | 0.867$^{b}$ | 9.44$^{d}$ | 53.38$^{cd}$ | 84.33$^{b}$ | 11.07$^{ab}$ |
| Cow dung 7 tha$^{-1}$ | 536.0$^{b}$ | 0.437$^{bcd}$ | 0.616$^{c}$ | 0.837b | 10.56cd | 53.54cd | 85.44b | 10.20$^{b}$ |
| Cow dung 14 tha$^{-1}$ | 611.0$^{b}$ | 0.452$^{bcd}$ | 0.682$^{c}$ | 0.979$^{b}$ | 11.61$^{bc}$ | 56.10$^{bcd}$ | 83.61$^{b}$ | 12.42$^{ab}$ |
| Poultry Manure 0 tha$^{-1}$ | 507.0$^{b}$ | 0.347$^{d}$ | 0.542$^{c}$ | 0.809$^{b}$ | 9.78$^{d}$ | 52.20$^{d}$ | 81.56$^{b}$ | 10.74$^{ab}$ |
| Poultry Manure 10 tha$^{-1}$ | 565.0$^{b}$ | 0.478$^{bc}$ | 0.723$^{ac}$ | 0.926$^{b}$ | 11.67$^{bc}$ | 59.13$^{abc}$ | 84.78$^{b}$ | 13.40$^{ab}$ |
| Poultry Manure 20 tha$^{-1}$ | 618.0$^{b}$ | 0.521$^{bc}$ | 0.723$^{ac}$ | 0.994$^{b}$ | 12.44$^{ab}$ | 59.47$^{abc}$ | 85.72$^{b}$ | 10.79$^{ab}$ |
| Swine manure 0 tha$^{-1}$ | 513.0$^{b}$ | 0.414$^{cd}$ | 0.623$^{c}$ | 0.852$^{b}$ | 10.50$^{cd}$ | 55.85$^{bcd}$ | 80.33$^{b}$ | 9.97$^{b}$ |
| Swine manure 3.5 tha$^{-1}$ | 567.0$^{b}$ | 0.473$^{bc}$ | 0.696$^{c}$ | 0.907$^{b}$ | 11.28$^{bc}$ | 59.12$^{abc}$ | 85.39$^{a}$ | 12.67$^{ab}$ |
| Swine manure 7 tons/ha | 594.0$^{b}$ | 0.473$^{ab}$ | 0.970$^{ab}$ | 0.957$^{b}$ | 12.61$^{ab}$ | 62.17$^{ab}$ | 82.22$^{b}$ | 13.57$^{ab}$ |
| Inorganic N 45kgha$^{-1}$ | 754.0$^{a}$ | 0.652$^{a}$ | 0.973$^{a}$ | 1.239$^{a}$ | 13.39$^{a}$ | 64.41$^{a}$ | 93.11$^{a}$ | 14.12$^{a}$ |
| SED ± | 51.8 | 0.0549 | 0.1164 | 0.0821 | 0.694 | 3.000 | 2.834 | 1.671 |
| **Location** | | | | | | | | |
| OEV | 552.0$^{b}$ | 0.439$^{b}$ | 0.711 | 0.901 | 10.69$^{b}$ | 55.71$^{b}$ | 85.07 | 10.01$^{b}$ |
| FUNAAB | 606.0$^{a}$ | 0.495$^{a}$ | 07704 | 0.973 | 11.97$^{a}$ | 59.36$^{a}$ | 84.83 | 13.78$^{a}$ |
| SED ± | 23.2 | 0.0245 | 0.0520 | 0.0367 | 0.311 | 1.342 | 1.267 | 0.747 |
| LSD | 45.9 | 0.0486 | Ns | Ns | 0.615 | 2.657 | Ns | 1.480 |

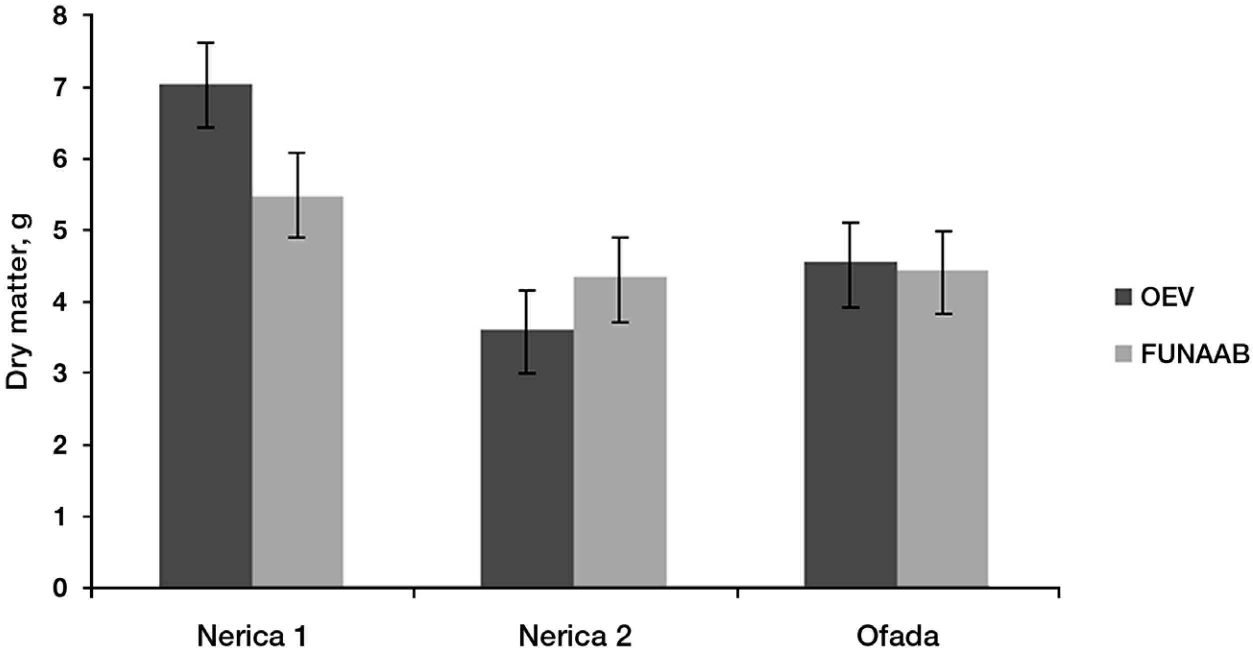


**Fig. 3.** Interaction of variety × location of dry matter at mid-tillering

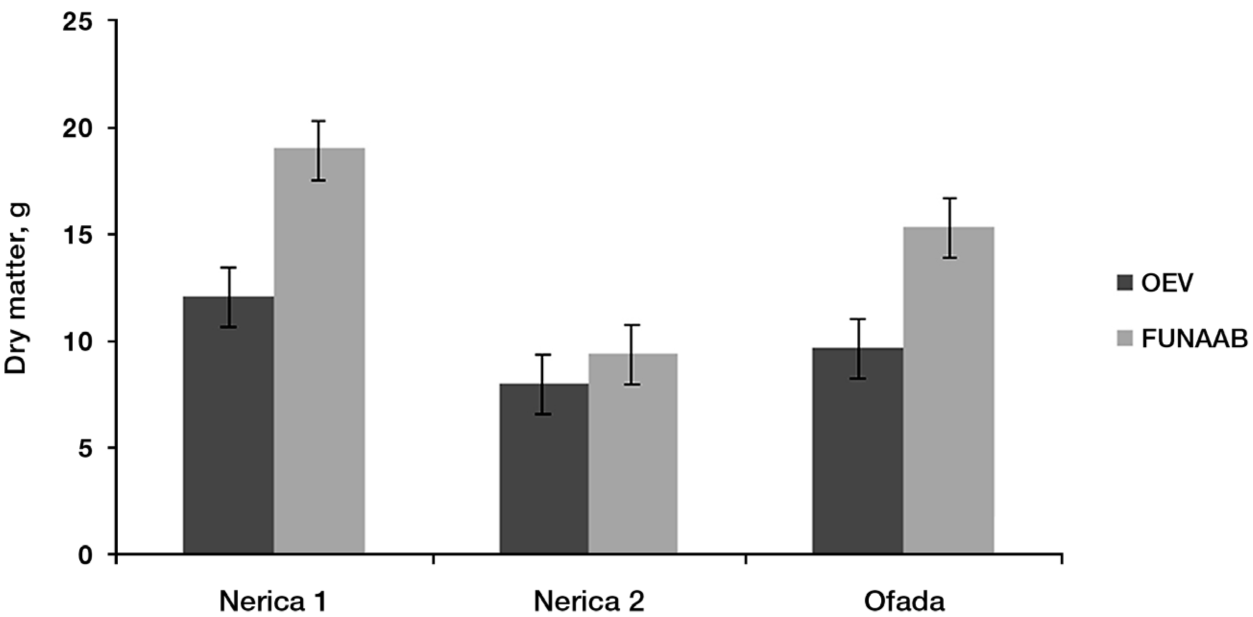


**Fig. 4.** Interaction of variety × location on dry matter at 50% flowering

A significant interaction ($P$ < 0.05) of location × variety on dry matter at mid tillering was observed (Fig. 3). NERICA 1 recorded a significantly higher dry matter at OEV (7.02 g) than FUNAAB (5.47 g), a 22% increase in weight. However, NERICA 2 recorded no significant differences in dry matter in both locations; similar trend was observed in Ofada.

A significant interaction of variety × location ($P$ < 0.05) was recorded on dry matter at 50% flowering (Fig. 4). NERICA 1 recorded a significantly higher dry matter (18.90 g) in FUNAAB, compared to OEV (12.02 g). However, there were no significant differences in the dry matter accumulation in both locations for NERICA 2. Ofada experienced a significantly higher dry matter at FUNAAB (15.29 g) than OEV (9.62 g). At maturity, significant effect ($P$ < 0.05) of variety, fertiliser sources and location was observed.NERICA 1 recorded the highest dry matter (14.74 g), while the least was observed in NERICA 2 (9.40 g). at

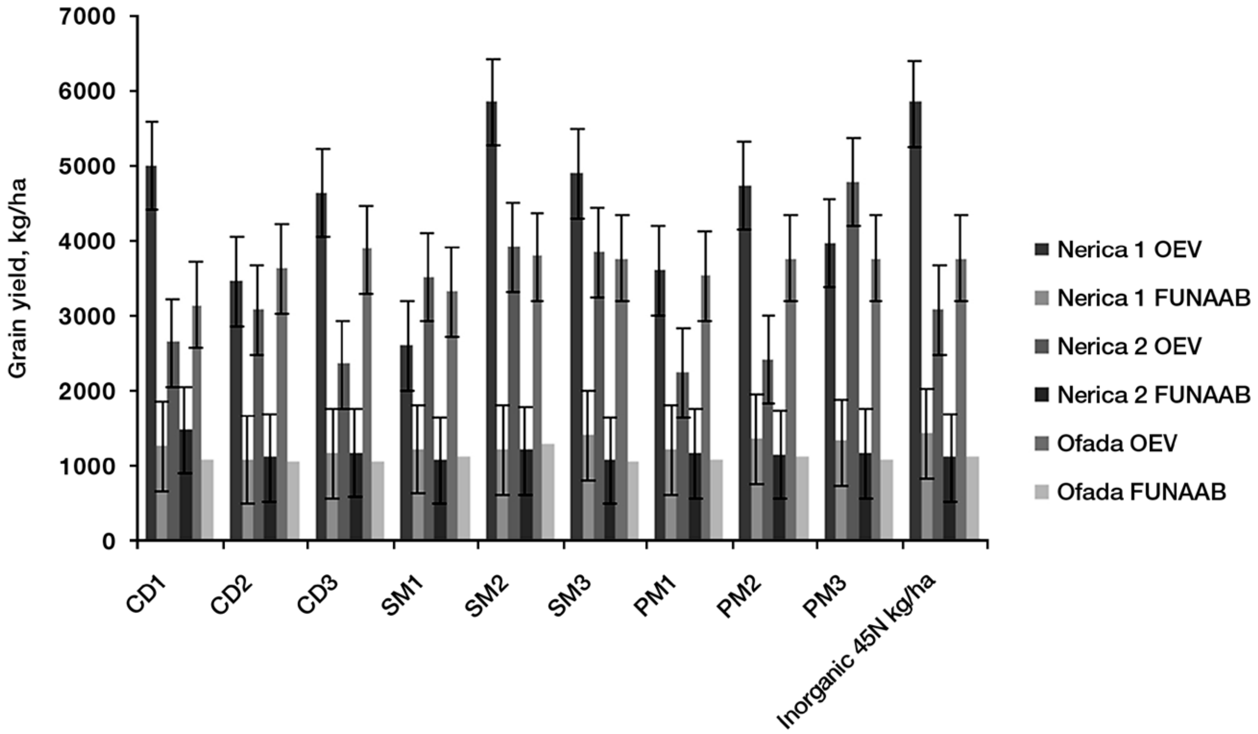


**Fig. 5.** Interaction of variety × fertilizer sources × location on grain yield at OEV and FUNAAB

different sources and varying rates of application it was observed that dry matter accumulated at same level, with inorganic fertiliser recording the highest accumulation of dry matter at maturity (14.12 g), which was not significantly different from others with the exception of cow dung at 7 t/ha$^{-1}$ (10.20 g) and swine manure at zero rate (9.97 g). FUNAAB (13.78 g) recorded significantly higher dry matter accumulation than OEV (10.01 g) (Table 4).

There was a significant interaction of variety × location × fertiliser sources ($P < 0.05$) on grain yield (Fig. 5). Inorganic fertiliser source at recommended application rate (N 45 kg ha$^{-1}$) recorded significantly highest grain yield for NERICA 1 at OEV (5 822 kg/ha$^{-1}$), however, it was not significantly different from swine manure (7 t/ha$^{-1}$), swine manure (10 t/ha), poultry manure (10 t/ha$^{-1}$), cow dung (14 t/ha$^{-1}$) and cow dung at zero rate of application. The highest grain yield was observed in NERICA 2 at OEV (4 778 kg/ha$^{-1}$) when poultry manure was applied (20 t/ha$^{-1}$). However, it was not significantly different from grain yield obtained when all rates of swine manures were applied. Highest grain yield in Ofada at OEV (3 778 kg/ha$^{-1}$) was observed when swine manure (3.5 t/ha$^{-1}$) was applied. However it was not significantly different from the yield of other fertiliser sources. The yield obtained at FUNAAB was significantly lower than those obtained at OEV for all the varieties investigated and there were no significant differences among them.

## DISCUSSION

The present study investigated growth and yield responses of NERICA in the rainforest transitory zone of Nigeria. At all phenological phases of investigation, varietal variability to leaf area was similar at all recommended rates of organic fertiliser, it was only when inorganic fertiliser was utilised that NERICA 1 recorded a higher leaf area value. This is consistent with the findings of Myint et al. (2010), who observed that plant growth characters were higher with inorganic fertiliser compared to the organic ones. However, this was not observed at maturity, where it was expected that growth of crops would have declined due to senescence or recycling of nutrients from other organs of the shoot components. The difference in leaf area when inorganic fertiliser was applied could be adduced to its inherent fast releasing property (Aung et al., 2010) and its absorption and uptake at the earlier phenological stage for rice to develop its vegetative structures for exploration of resources; nutrient and water, which are necessary in the later stage of rice development. Comparatively, at both locations, leaf area when examined at mid-tillering stage and maturity was higher at FUNAAB compared to OEV. Since the varieties displayed similar varietal responses with respect to leaf area, it possible to infer that other factors such as climatic and edaphic would have been responsible for that (Tables 1 and 2).

NERICA 1 still indicated its superior performance compared to others at early phenological phase when considering LAI. This could be attributed to its genotypic specificity under prevailing condition. Among the organic fertiliser sources, swine faeces at a higher rate produced a higher LAI at mid-tillering stage, which was comparable to value obtained when inorganic fertiliser was applied. As reported earlier FUNAAB still sustained a higher LAI compared to OEV. At the flowering stage, apart from swine faeces (7 tons/ha), poultry manure at a higher rates was able to elicit a higher LAI, unlike cow dung manure. Sims and Wolf (1994) and Serna and Pamares (1991) reported higher nutrient content and rate of mineralisation in poultry manure, which could have explained nutrient availability for growth characters at a later stage. Muhammed et al. (2003) also observed that application of higher rates of poultry manure resulted in higher LAI. At maturity, they all displayed similar LAI irrespective of the treatments, which was expected. When number of tillers was observed, similar trend as displayed in LAI was displayed. Guowei and Wilson (1998) reported that number of tillers has a relationship with dry matter production, yield components and the grain yield. Response to higher rates of organic fertiliser application would be explained by rate of nutrient mineralisation, which is favourable at a later stage in rice phenology and nutrient dynamics in the soil, a process mediated by enzymatic microbial action.

Plant height as one of the canopy architecture, was better expressed in NERICA 1 and Ofada at vegetative stage, while application of organic manures at a higher rate was able to elicit similar response as observed in inorganic fertiliser, this was better displayed in poultry manure and swine faeces, however, within organic manures they all had similar effect on plant height. However, at maturity, Ofada and NERICA 2 were taller than NERICA 1. The possibility of partitioning assimilates to other organs, especially reproductive organs could be expected in the absence of other growth limiting factor, which would confer on NERICA 1 a better performance, since there is always a compensatory relationship between vegetative and reproductive growth in plants. Dry matter of NERICA 1 was higher at OEV at the beginning of its growth, however, at a later stage, FUNAAB outperformed OEV. Yield of all varieties was higher at OEV, especially that of NERICA 1 at the highest rate of application of poultry manure and swine faeces which is comparable to that of inorganic sources. Compensatory effect could have explained superior performance of NERICA 1, since its dry matter was lower at a later stage of its development. Maybe assimilates were partitioned to yield bearing components, not precluding environmental effect, since other cultivars performed well at OEV. OEV is a rainforest zone, unlike FUNAAB, which is transitory rainforest. Even distribution of rainfall is more pronounced at OEV (Table 1), hence precluding water as a limiting factor in grain production. Other factors could be the level of soil degradation encountered at both locations.

This study was limited by the non-availability of canopy architecture characteristics, root parameters, yield components and the economic implication of the application of organic fertiliser, as a low resource input in the management of NERICA in the rain forest transitory zone of Nigeria. Canopy architecture parameters would have provided information on underlying genotypic specificity that resulted in significant varietal variability. Furthermore, physiological implication of increasing LAI with increasing application rates of poultry and swine manure on light interception through changes in leaf inclination and leaf carbon economy as reflected on changes in specific leaf weight was not included. Similar argument should have been considered with respect to yield components for clarity of mechanisms involved. For convenience, most root studies are better conducted in PVC pipes, which would have been cumbersome on the field. Economic benefits were beyond the scope of this study.

A further study on the dynamics of soil macronutrients, degree of decomposition and mineralisation should be encouraged to shed more light on rice performance variability with respect to location.

In conclusion, a significant ( $P < 0.05$) varietal variability on dry matter accumulation at maturity was in the order NERICA 1 > Ofada > NERICA 3, as reflected in its significantly higher growth characters examined. There was a significant ($P < 0.05$) increase in number of tillers and plant height at vegetative stage; LAI at mid tillering and 50% flowering with increasing application rates for poultry and swine manure, with the exception of cow dung. NERICA 1 at higher application rates of poultry and swine manure recorded grain yield comparative to inorganic fertiliser at recommended rate in OEV.

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