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Growth, Nutrient Uptake Efficiency and Yield of Upland Rice as Influenced by Two Compost Types in Tropical Rainforest-Derived Savannah Transition Zone

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Abstract

Cultivating traditional upland rice cultivars on nutrient depleted soil causes poor and low yield. Little attention is paid to performance of inter-specific NERICA cultivars grown on nutrient deficient soil augmented with different types of compost. Therefore, field trials were conducted during 2010 and 2011 planting seasons in Ibadan to evaluate growth, dry matter, nutrient uptake efficiency and grain yield of upland rice grown on nutrient deficient soil augmented with different types of compost. There were nine treatments comprising of three upland rice cultivars: NERICA I, NERICA II and Ofada, two compost types applied at the rate of 8 t·ha^{-1}: poultry dropping + maize stover (PDMC) and cattle dung + maize stover (CDMC) and control. The treatments were laid out in randomized complete block design and replicated three times. CDMC enhanced growth, nutrient use efficiency, dry matter and grain yield of upland rice cultivars. Performance of Ofada was better than NERICA cultivars. N (24.55 g), P (12.45 g) and K (35.41 g) uptake concentration and grain yield (5.45 t/ha) were highest in Ofada plots augmented with CDMC. Residual effect of compost on growth, yield and nutrient uptake efficiency of upland rice on nutrient deficient soil was marginal.

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Keywords

NERICA, Compost, Poor Soil, Dry Matter, Nutrient Uptake Efficiency

1. Introduction

Consistent utilization of inorganic fertilizer with dearth of technical application expertise among rice farmers in developing countries including Nigeria constitutes soil nutrient imbalance and environmental pollution. Studies have focused on evolving organic fertilizer as an alternative source of external soil fertility input to boost arable crop production. Utilization of plant and animal residues in form of compost as plant nutrients and nutrient cycling is an age long agronomic practices. These activities enhance sustainable soil fertility management for the teeming populace as well as minimizing environmental pollution. Diverse studies across different agro-ecosystems have shown importance of organic nutrient sources in improving crop yield and improving soil quality [1]-[3]. In Nigeria, livestock industry is booming where it discharges huge amount of farm yard manure such as poultry manure—cattle dung, poultry manure etc., into the environment indiscriminately [4]. Also, an estimated half a million tons of plant residue especially from rice and maize stover are generated daily [5] [6]. These animal and plant remains constitute environment hazards. However, their utilization to improve nutrient deficient soil in the form of compost is yet to be explored maximally.

Reference [7] reported that response of rice to nutrient supply by organic and inorganic fertilizer is universal but may vary with locations, soil and fertilizer types. Similarly, crops have been reported to respond differently to different composts under similar soil fertility condition. Reference [8] has reported that maize yield was better on cucumber canopy compost than rice straw compost or maize stalks composts. Also reference [9] reported that pea-rice hull compost and cattle dung-tea compost differed in their nitrogen composition, as well as in their effect on plant height, number of tillers, dry matter yield and nutrient uptake N, P, and K of rice plants.

It is however not clear if mineralization and nutrient uptake efficiency equally varies with different types of composts derived from livestock and plant origin. The response of high yielding interspecific upland NERICA and low yielding traditional cultivar to different composts in rainforest agro-ecosystem have not been studied in details. In this regard, an attempt has been made to study the growth, nutrient uptake efficiency and grain yield of these upland rice cultivars as influenced by cattle dung + maize stover compost (CDMC) and poultry droppings + maize stover compost (PDMC).

2. Materials and Methods

2.1. Study Site

The study was carried out at the upland rice field of International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. The study site is located in the tropical rainforest-derived savannah transition zone on Latitude 7˚33'N and Longitude 3˚56'N with elevation of 213 m above sea level. Temperatures were generally high and uniform throughout the period of study. The site received bimodal rainfall of 704.39 mm and 220.22 mm in year 2010 and 2011 respectively. Mean monthly temperature range from 25˚C - 27˚C, relative humidity was generally high with a range of 73% - 80%. The soil is Alfisol [10] with pH (H_2O) 6.5, N (1.1 $g\cdot kg^{-1}$), P (9.7 $g\cdot kg^{-1}$), K (0.5 $cmol\cdot kg^{-1}$), organic matter (1.9 $g\cdot kg^{-1}$), Ca (1.4 $g\cdot kg^{-1}$) and Na (0.8 $g\cdot kg^{-1}$). The sandy loam soil contains sand (670 $g\cdot kg^{-1}$), silt (166 $g\cdot kg^{-1}$) and clay (164 $g\cdot kg^{-1}$). The first field trial was carried out between June and November 2010 while the second trial which tested the residual effect of the applied compost was carried out between May and October 2011.

2.2. Preparation of Compost

Composts were prepared from combination of cattle dung + maize stover (CDMC) and poultry droppings + maize stover (PDMC). The proportion of the maize stover to livestock remains was 3:1 on dry weight basis. Each of the organic material was laid out in layers, a layer made up of 30 kg maize stover and 10kg of cattle dung/poultry droppings. Ten (10) of such layers made up a heap of about 3.1 × 1.0 × 1.0 m^3 compost. Each compost type was prepared separately. These were prepared using concrete surface heap method described by [11] [12]. Each heap was watered every other week to facilitate speedy decomposition by decomposing organisms such as bacteria, protozoa, actinomycetes etc. The heap was covered with black polyethene to generate and conserve heat. Temperature of the heap was monitored on weekly basis until a constant temperature was attained. The heap was properly turned and stirred every fortnight till maturity at 75 days after proper decomposition.

2.3. Analysis of Soil and Compost Nutrient Composition

Samples of the matured compost were taken for physical and chemical analysis in the laboratory using standard methods [13]. Soil samples were taken randomly from each of the plot within the depth of 0 - 15 cm and 15 cm to 30 cm (*i.e*. from surface and sub surface soil respectively). The composite soil sample was air dried and crushed to pass through a 2 mm and 0.5 mm sieve to remove plant root and other debris. 2 kg of the sample was weighed and was taken to the laboratory for routine analysis to determine their nutrient level prior to application of compost. Representative samples was analyzed for pH, particle size [14], total nitrogen using the micro-kjeldahl method and exchangeable cations (K, Ca, Mg and Na) after extraction with 1N NH4OAC (pH 7). K in the filtered extract was determined with a flame photometer, whereas Ca, Na, and Mg were determined with an atomic absorption spectrophotometer (AAS model, Buck 200). Available phosphorus (Bray -1-P) was determined by colorimeter using the method of [15], organic carbon by [16].

2.4. Experimental Design and Treatments

The experimental design was a randomized complete block design with three replicates. The study was a 3 × 3 factorial combination of two compost types, a control and three rice cultivars respectively and the three rice cultivars were NERICA 1, NERICA 2 (Improved varieties) and Ofada (Traditional variety). CDMC or PDMC were applied at the rate of 8 t/ha while no compost or conventional fertilizer was supplied to the control plots.

2.5. Land Preparation and Crop Management

Three rice cultivars: NERICA 1(WAB 450-1-B-38-HB) (FARO 55), NERICA 2 (WAB 450-1-P-28-HB) (FARO 56), and Ofada (Traditional upland variety) cultivated were obtained from Africa Rice Centre (AfricaRice) at International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State. The field used was formerly grown to upland rice cultivars and left to fallow for four months. The land was prepared mechanically. Ploughing was done followed by harrowing after two weeks. The net dimension of the study area was 17.5 m × 17 m. The dimension of each plot was 5 m × 2 m, with 1m walk way in-between the plots. The treatments were replicated thrice. Seeds of rice were planted directly on the field using drilling method with 2 - 4 seeds per hole at the depth of 3 - 4 cm. It was later thinned to two plants per stand. Seeds were planted at a spacing of 25 cm by 20 cm to give a population of 550,000 plants per hectare. The plot was fenced round with wire mesh. Bird-scarer was employed at the heading stage till harvesting to scare the birds. The rice field was weeded regularly, especially during the early stage of growth. This was done manually using weeding hoe.

2.6. Plant Tissues Nutrient Contents

Plant samples were harvested at maturity (15 weeks after sowing). Fresh shoot and grain were dried in an oven at 70˚C till a constant weight was attained. Dried plant samples were milled and ground for tissue analysis. Total P were determined by the Vanadomolybdate method, K by flame photometry and total N was analyzed using micro-kjeldahl procedure according to methods of Association of Official Analytical Chemists [17]. Nutrient uptake was evaluated as described by [18] and used by [11] as:

Nutrient uptake concentration = % Nutrient content × sample dry weight (g)

Nutrient uptake efficiency (NUpE) was determined as

$$\text{NUp E}\ (\%) = \frac{\text{Nutrient taken up by the plant}}{\text{Nutrient applied}} \times 100$$

2.7. Data Collection

Data were collected on number of leaves, plant height (cm), number of tillers and leaf area index (LAI). Dried samples of shoots were analysed for tissue nutrient contents. At physiological maturity, the number of plants growing in the two middle rows in each plot were counted and harvested (excluding two plants at both end of each row). The following yield data were determined: number of panicles, weight of panicles, weight of 100 seeds (kg), grains per plant (g) and grain yield (t/ha). The weights were determined using a weighing balance.

2.8. Data Analysis

Data collected were analysed using ANOVA with Statistical Analysis System [19]. The differences in means were separated by Least Significant Difference (LSD) at $P \leq 0.05$.

3. Results and Discussion

Results of nutrient analysis of the compost showed that the two compost types are rich in organic matter and essential plant nutrients **Table 1**. These composts will be valuable in improving fertility of poor soil especially arable cropping system where continuous cultivation promotes decline in soil fertility.

Application of different compost types had no significant influence on growth of upland rice cultivars. However, growth response of rice was better on CDMC augmented plots (**Table 1**). The results suggest that either of compost could be used in augmenting fertility of poorly deficient soil. Nutrient supplied by the two compost types appeared adequate for optimal growth, development and grain yield of upland rice cultivars. Since the compost types used possess both macro and micro nutrients it is believed that these are made available for crop use. The observation in this study agrees with several studies on the importance of compost in improving soil fertility while supplying nutrient for plant use [11] [20] [21]. Nonetheless, cattle dung based compost (CDMC) significantly enhanced tiller formation. The better performance of CDMC compare to PDMC with regard to tiller formation suggests likelihood of minimal nutrient loss due volatilization, leaching, etc. in CDMC than PDMC. This is similar to the report of [3] on the effect of cattle manure compost on maize yield.

Growth responses of the three rice cultivars to different composts were not significantly different but growth response of Ofada cultivar was better than NERICA cultivars. Ofada was significantly better than NERICA I with regard to leaf area index. This observation disagrees with report of [2] on growth and yield of three maize hybrids under different compost types. Response of the three upland rice cultivars to two compost sources revealed that the genotypes are similar in their nutrient uptake and utilization pattern (**Table 1**). This observation contradicts report of [22] that different rice varieties responded differently to the application of mineral fertilizer. However, the observation in this study agrees with reference [23] report that four rice types responded similarly in terms of growth, dry matter and grain yield under similar nutrient conditions.

Effect of different compost types on growth attributes of three upland rice cultivars is shown in **Table 2**. The

Table 1. Nutrient analysis of compost types used for the study.

Nutrient	Compost type*	
	PDMC	CDMC
pH (H_2O)	3.0	1.8
Organic Carbon ($g \cdot kg^{-1}$)	34.6	20.0
Organic Matter ($g \cdot kg^{-1}$)	59.5	34.4
Total Nitrogen ($g \cdot kg^{-1}$)	34.6	20.0
P($mg \cdot kg^{-1}$)	45.0	85.0
K	18.3	10.0
Na	5.9	4.6
Ca	10.9	9.8
Mg	10.0	11.0
Cu	4.0	5.0
Mn	12	8
Fe	39	57
Zn	129	200

Dry weight basis; PDMC = Poultry dropping + Maize stover Compost, CDMC = Cattle dung + Maize stover Compost.

Table 2. Influence of two types of compost sources on growth of three upland rice cultivars grown on poor soil in tropical rainforest-derived savannah transition zone agro-ecology.

Compost types		2010 PLANTING SEASON				2011 PLANTING SEASON			
		Number of leaves	Plant height (cm)	Number of tillers	Leaf area index	Number of leaves	Plant height (cm)	Number of tillers	Leaf area index
Control		18.25	90.58	7.17	14.60	3.78	39.06	0.62	3.18
CDMC		22.83	93.48	9.23	38.32	4.61	45.83	1.23	6.67
PDMC		23.47	94.90	7.66	30.80	3.62	38.67	0.72	3.69
LSD (P ≤ 0.05)		**4.28**	**6.40**	**1.50**	**16.20**	**1.10**	**6.57**	**0.44**	**2.47**
Rice cultivars									
NERICA I		22.65	92.57	8.15	34.84	3.53	32.90	0.62	3.28
NERICA II		21.67	93.66	8.10	23.84	3.43	39.71	0.70	3.63
OFADA		26.63	96.35	9.08	45.00	5.38	55.66	1.62	8.63
LSD (P ≤ 0.05)		**5.25**	**7.84**	**1.83**	**19.84**	**1.34**	**8.04**	**0.54**	**3.03**
Interaction									
	NERICA 1	20.13	76.92	6.50	20.27	2.67	26.68	0.00	4.12
Control	**NERICA 11**	16.50	85.17	6.08	10.32	2.83	29.68	0.03	3.38
	OFADA	17.92	90.23	6.42	15.53	3.83	40.57	0.19	3.13
	NERICA 1	21.93	92.52	9.50	28.92	4.47	35.20	0.93	4.93
CDMC	**NERICA 11**	22.40	90.10	8.23	27.63	3.07	45.05	0.67	3.66
	OFADA	27.17	97.83	9.97	58.41	6.30	57.25	2.10	11.41
PDMC	**NERICA 1**	23.37	92.61	6.80	40.76	2.60	30.60	0.30	1.64
	NERICA 11	20.93	97.23	7.97	20.04	3.80	34.36	0.73	3.60
	OFADA	26.10	94.87	8.20	31.59	4.47	54.04	1.13	5.85
LSD (P ≤ 0.05)		**7.43**	**11.09**	**2.59**	**28.03b**	**1.90**	**11.38**	**0.76**	**4.28**

PDMC = Poultry droppings + Maize stover Compost, CDMC= Cattle dung + Maize stover Compost.

results revealed that Ofada cultivar performed better on plots augmented with CDMC than other cultivars on either of the compost types. Ofada cultivar had significantly number of tillers (9.97) and leaf area index (58.41) on plots augmented with CDMC. Better growth performance observed in Ofada grown on CDMC fertilized plots implies that this traditional cultivar adapt better than improved cultivars under optimum nutrient availability. This observation is in contradiction with that of [24] where they reported that improved upland rice cultivars performed better than traditional genotypes under low and high nutrient supply. Report of [25] that CG14 (traditional cultivar) showed much greater tillering ability and panicle number than NERICA cultivars confirms the observation in this study.

Dry matter accumulation and partitioning by three upland cultivars as influenced by different compost is presented in Table 3. There was no significant difference in the dry matter yield of upland rice cultivars grown on soil amended with either CDMC or PDMC. However dry matter production by upland rice cultivars was better on CDMC augmented plots. Biomass accumulation by the three upland rice cultivars was significantly influenced by types of compost applied. There was significant different in dry matter yield of the three rice cultivar

Table 3. Influence of two types of compost sources on dry matter of three upland rice cultivars grown on poor soil in tropical rainforest-derived savannah transition zone agro-ecology.

		Dry weight (g)/plant					
		2010 planting season			2011 planting season		
Compost types		**Shoot**	**Root**	**Total**	**Shoot**	**Root**	**Total**
Control		10.22	2.54	15.64	0.86	0.53	1.36
CDMC		25.06	7.83	32.89	1.35	1.04	2.42
PDMC		23.90	7.44	31.34	1.04	0.79	1.74
LSD ($P \leq 0.05$)		**6.00**	**2.20**	**7.40**	**0.36**	**0.41**	**0.71**
Rice cultivars							
NERICA I		24.41	7.37	31.77	1.28	1.02	2.22
NERICA II		19.16	6.47	25.63	1.12	0.88	2.02
OFADA		29.89	9.07	38.95	1.18	0.86	2.02
LSD ($P \leq 0.05$)		**7.35**	**2.69**	**9.07**	**0.44**	**0.50**	**0.11**
Interaction							
	NERICA 1	6.25	1.50	8.78	0.92	1.20	1.44
Control	NERICA 11	5.42	1.82	8.01	0.93	0.60	1.63
	OFADA	10.69	3.83	15.36	0.92	0.40	1.44
	NERICA 1	27.79	8.54	36.33	0.93	0.53	1.48
CDMC	NERICA 11	18.16	5.11	23.27	1.27	1.15	2.44
	OFADA	29.24	9.80	39.08	1.84	1.45	3.35
	NERICA 1	21.02	6.20	27.22	1.63	1.50	3.00
PDMC	NERICA 11	20.15	7.83	27.98	0.98	0.62	1.61
	OFADA	30.52	8.29	38.81	0.52	0.27	0.69
LSD ($P \leq 0.05$)		**10.40**	**3.01**	**12.82**	**0.63**	**0.71**	**0.79**

PDMC = Poultry droppings + Maize stover Compost, CDMC = Cattle dung + Maize stover Compost.

as influenced by compost application. Although, dry shoot (29.89 g) and total dry matter (38.95 g) was highest in Ofada cultivar but the biomass yield was not significantly different from NERICA I (24.41 g). The interaction between compost types and upland rice showed that augmentation of poor soil with CDMC significantly influenced dry matter accumulation and partitioning by Ofada cultivars (**Table 3**). However, performance of Ofada on CDMC plots was comparable to what was observed in PDMC augmented plots.

The better growth performance observed in Ofada with profuse tillers formation in plots fertilized with CDMC might have led to highest dry matter yield. Dry matter production had been linked to effective tiller formation [26] as well as better leaf area [21] which ultimately support efficient photosynthetic ability in vascular plants. The observation in this study is in consonance with that of [27].

Table 4 presents influence of types of compost on yield and yield attributes of upland rice. Yield and yield attributes of upland rice was not significantly affected by types of compost applied. Although, highest number of panicles (6.29) was produced on plots amended with PDMC but weight of panicles (3.93 g), grain weight (4.09 g), 100-seed weight (2.91 g) and grain yield (5.17 t/ha) were highest on field augmented with CDMC. Similarly, yield response of the rice cultivars as influenced by compost application revealed that grain yield (5.29 t/ha) of Ofada cultivar was higher but not significantly different from NERICA cultivars. Nonetheless, yield components were significantly influenced by interaction between different types of compost and the three upland rice cultivars

Table 4. Influence of two types of compost sources on yield and yield components of three upland rice cultivars grown on poor soil in tropical rainforest-derived savannah transition zone agro-ecology.

Compost types		2010 planting season						2011 planting season				
		Number of panicles	Weight of panicles (g)	Grain weight (g)	100-seed weight (g)	Grain yield (t/ha)	Harvest index	Number of panicles	Weight of panicles (g)	Grain weight (g)	Grain yield (t/ha)	Harvest index
Control		5.89	2.81	2.38	1.63	1.13	0.07	0.11	0.089	0.89	0.01	0.01
CDMC		6.19	3.93	4.09	2.91	5.17	0.15	0.15	0.100	1.37	0.02	0.04
PDMC		6.29	3.68	3.90	2.87	4.91	0.16	0.12	0.102	1.01	0.02	0.08
LSD (P ≤ 0.05)		**0.74**	**0.48**	**0.50**	**0.16**	**0.96**	**0.03**	**0.09**	**0.04**	**0.37**	**0.01**	**0.12**
NERICA I		6.25	3.98	3.98	2.89	4.98	0.12	0.37	0.03	0.98	0.01	0.05
NERICA II		5.75	4.08	4.08	2.82	4.86	0.16	0.15	0.11	1.03	0.02	0.01
OFADA		6.72	3.91	3.91	2.96	5.29	0.14	0.22	0.16	1.55	0.03	0.12
LSD (P ≤ 0.05)		**0.91**	**0.62**	**0.62**	**0.20**	**1.18**	**0.04**	**0.11**	**0.09**	**0.45**	**0.02**	**0.14**
Interaction												
	NERICA 1	4.75	3.33	1.80	2.67	3.50	0.04	0.02	0.02	0.03	0.001	0.01
Control	**NERICA 11**	5.10	2.42	1.42	2.62	2.84	0.03	0.13	0.05	0.83	0.001	0.01
	OFADA	5.21	3.54	2.62	2.90	2.92	0.01	0.18	0.07	1.05	0.002	0.02
	NERICA 1	6.13	4.35	4.36	2.96	5.42	0.16	0.01	0.01	1.07	0.002	0.09
CDMC	**NERICA 11**	5.33	3.83	4.06	2.86	4.65	0.16	0.24	0.16	1.13	0.030	0.21
	OFADA	7.10	3.60	3.84	2.91	5.45	0.14	0.20	0.13	1.90	0.025	0.01
	NERICA 1	6.37	3.50	3.61	2.83	4.54	0.17	0.06	0.05	0.90	0.003	0.02
PDMC	**NERICA 11**	6.17	3.73	4.10	2.79	5.08	0.16	0.06	0.05	0.93	0.010	0.01
	OFADA	6.33	3.80	3.99	3.01	5.12	0.14	0.25	0.20	1.20	0.040	0.24
LSD (P ≤ 0.05)		**1.28**	**0.83**	**0.87**	**0.28**	**1.66**	**0.05**	**1.99**	**0.13**	**0.64**	**0.03**	**0.20**

PDMC = Poultry droppings + Maize stover Compost, CDMC = Cattle dung + Maize stover Compost.

(**Table 4**). Whereas different compost had no significant influence on 100-seed weight, grain weight, grain yield (t/ha) of the three upland cultivars, Ofada rice performed better with respect to number of panicles (7.10) and grain yield (5.45 t/ha) than NERICA cultivars on plots fertilized with CDMC (**Table 3**).

The results imply that either of the compost type would improve yield factors of upland rice in nutrient depleted soils. Reference [28]-[30] have reported that organic fertilization is very important agronomic practice necessary for providing plant with nutritional requirements needed to enhance yield increase without any detrimental effect on the environment. The non significant responses of the three cultivars to compost application informs that under nutrient sufficiency condition, these varieties are likely to judiciously utilize the nutrients uptake for partitioning of photosynthate into sink. This is in agreement with [31].

The superior grain yield performance of Ofada over NERICA cultivars suggests that under better soil nutrient environment, the cultivar will out yield improved cultivars contrary to the report of [32]. The ability of Ofada to produced highest grain yield might be related to highest tiller formation and leaf area index which could aid in smothering weed interference thereby minimizing competition for space, nutrient and water which are essentials for growth and yield.

Table 5 presents effect of different types of compost on nutrient uptake concentration of the three upland rice genotypes. The results showed that application of different compost had no significant difference in nutrient uptake concentration by upland rice varieties. Our observation here disagrees with the report of [20] that different composts exhibit variations in terms of nutrient content and release for crop growth and development. Similarly,

Table 5. Influence of two types of compost sources on nutrient uptake by three upland rice cultivars grown on poor soil in tropical rainforest-derived savannah transition zone agro-ecology.

Compost type		Nutrient uptake concentration (g·plant^{-1})					
		N	P	K	Na	Ca	Mg
Control		11.24	5.58	18.56	9.07	18.45	15.24
CDMC		17.25	8.61	26.62	12.83	28.93	25.24
PDMC		15.31	7.92	25.58	13.54	28.25	27.47
LSD (P ≤ 0.05)		**4.95**	**2.60**	**7.46**	**3.71**	**7.93**	**7.61**
Rice cultivars							
NERICA I		15.22	7.43	24.77	11.97	27.06	24.29
NERICA II		17.82	9.54	26.89	14.14	29.02	27.15
Ofada		15.80	7.81	26.63	13.441	29.54	27.63
LSD (P ≤ 0.05)		**6.06**	**3.18**	**9.14**	**4.54**	**9.71**	**9.32**
Interaction							
	NERICA1	8.25	7.14	18.10	9.32	15.57	14.33
Control	**NERICA II**	7.85	6.98	12.47	7.11	12.27	14.24
	OFADA	9.10	5.32	16.46	8.35	18.13	20.13
	NERICA1	12.65	5.83	18.50	8.94	21.03	16.34
CDMC	**NERICA II**	24.55	12.45	35.41	17.99	37.74	34.56
	OFADA	14.56	7.56	25.96	11.54	28.03	24.81
	NERICA1	17.80	9.04	31.44	15.00	33.09	32.23
PDMC	**NERICA II**	11.00	6.65	18.38	10.28	20.30	19.74
	OFADA	17.04	8.06	27.31	15.33	31.06	30.45
LSD (P ≤ 0.05)		**8.57**	**4.51**	**12..93**	**6.42**	**13.73**	**13.19**

Poultry droppings + Maize stover Compost, CDMC = Cattle dung + Maize stover Compost.

response of the three upland rice varieties to nutrient uptake on field amended with different compost was not significantly different. This observation contradicts separate reports of [22] [24] that improved rice cultivars responded better to N application than traditional variety. However, N (17.82 g), P (9.54 g), K (26.89 g) and Na (14.14 g) uptake concentration per plant were highest in NERICA II cultivar whereas, Ca (29.54 g) and Mg (27.63) uptake concentration were highest in Ofada. Interaction between different compost types and upland rice genotypes significantly influenced nutrient uptake concentrations. Highest nutrient uptake was observed in NERICA II cultivar plots augmented with CDMC. This observation agrees with that of [25].

Effect of different composts nutrient uptake efficiency by three upland rice cultivars is shown in **Table 6**. Nutrient uptake efficiency of upland rice was not significantly influenced by types of composts applied. However, N, Ca and Mg uptake efficiency were highest in CDMC augmented plots while uptake efficiency of P, K and Na were highest in PDMC. Also there was no significant difference in uptake efficiency of all the nutrients among the three rice varieties. Nonetheless, NERICA II had highest nutrient uptake efficiency than the other cultivars. It thus suggests that the nutrients in the composts were made available for crop use as needed unlike inorganic fertilizer which releases it constituents rapidly beyond the need of crop. It appears as if the improved NERICA II was more efficiency in nutrient uptake on CDMC augmented site than the traditional variety but with a comparable grain yield. This is likely to be linked to outcome of crosses to retrogress better yield traits of *O sativa* into *O. glaberimma* [25].

Table 6. Influence of two types of compost sources on nutrient uptake efficiency by three upland rice cultivars grown on poor soil in tropical rainforest-derived savannah transition zone agro-ecology.

Compost type		Nutrient uptake efficiency (%)					
		N	P	K	Na	Ca	Mg
Control		5.02	0.66	25.23	6.50	23.10	13.90
CDMC		10.78	1.27	33.29	14.58	36.90	32.68
PDMC		7.68	1.66	34.60	16.12	34.20	28.68
LSD (P ≤ 0.05)		**3.12**	**0.49**	**9.48**	**4.28**	**10.05**	**8.77**
Rice cultivars							
NERICA I		8.69	1.31	27.82	13.91	33.74	28.23
NERICA II		10.44	1.61	31.03	16.35	36.37	31.41
Ofada		8.58	1.47	27.82	15.79	36.54	32.40
LSD (P ≤ 0.05)		**3.82**	**0.60**	**11.61**	**5.24**	**12.30**	**10.74**
Interaction							
	NERICA1	7.50	0.74	26.00	6.66	19.46	15.92
Control	**NERICA II**	7.14	0.72	15.12	5.08	15.34	15.82
	OFADA	8.27	0.55	22.20	5.96	22.66	22.37
	NERICA1	7.90	0.86	23.13	10.16	26.82	18.57
CDMC	**NERICA II**	15.35	1.83	44.26	20.45	48.14	39.27
	OFADA	9.10	1.11	32.44	13.12	35.75	28.19
	NERICA1	9.47	1.76	32.52	17.67	40.66	37.90
PDMC	**NERICA II**	5.50	1.40	17.79	12.26	24.60	23.54
	OFADA	8.06	1.82	25.36	18.44	37.33	36.60
LSD (P ≤ 0.05)		**5.41**	**0.85**	**16.42**	**7.42**	**17.4**	**15.19**

Residual effect of different compost on growth of upland rice cultivar was not significant. Number of leaves, plant height, number of tillers and leaf area index were highest on plots previously fertilized with CDMC. The performance of Ofada with respect to growth parameters was better than NERICA cultivars. Ofada cultivar performed better than NERICA strains on plots previously augmented with CDMC. Dry matter accumulation by the three upland rice varieties was better on plots previously fertilized with CDMC. Residual effect of compost on dry matter yield by the three rice varieties was not significantly different. However, NERICA I had highest dry shoot (1.28 g), root (1.02 g) and shoot (2.22 g) on field previously augmented with compost. Interaction of the residual effect of different composts on three upland rice lines was significantly different. Growing Ofada on plots previously fertilized with CDMC significantly enhanced shoot and total dry matter yield.

Growth and yield responses of upland rice cultivars to residual effect of effect of compost derived from different sources were significantly different. The residual effect of the two compost sources was not significantly different with regard to number of leaves, and plant height but tiller formation and leaf area index were significantly influenced by residual compost. In the same vein, response of the three upland rice varieties on plots previously augmented with compost was significantly different with regard to growth parameters. Number of leaves (5.38), tallest plants (55.66 cm), tillers (1.62) and leaf area index (8.63) were significantly highest in Ofada cultivar (**Table 1**). Similarly, growth, dry matter and grain yield of Ofada rice was better on field previously amended with CDMC. Generally, performance of upland rice cultivars was poor during the second planting cycle. Application of different compost types had marginal residual effect on growth, dry matter and grain yield of upland rice cultivars in tropical rainforest agro-ecology.

This implies that one time application of compost to soil highly deficient in nutrients may not be beneficial to subsequent crops. This could be adduced to high degree of nutrient depletion whereby the residual effect of compost was infinitesimally negligible. This observation does not support report of previous study of [33] that residual effect of N- and P-based manure and compost application on corn yield and N uptake can last at least one growing season and [3] that residual effect of compost enhance grain yield in corn. This suggests that crop may benefit from previous compost application only when the native soil nutrients are mildly depleted.

4. Conclusion

Compost application enhanced fertility of nutrient depleted soil. Effect of CDMC on growth, nutrient use efficiency and grain yield was better than PDMC but comparable. Performance of upland rice to compost application depends on nutrient constituents of compost rather than types of compost. There was no negligible variation in the response of upland rice cultivars to different compost types. Response of upland rice cultivars to compost is dependent on nutrient availability. NERICA (Improved) cultivars compared favourably with (Ofada) traditional cultivar with respect to nutrient uptake efficiency and grain yield (t/ha). Onetime application of compost application will confer marginal benefits to upland rice on highly nutrient depleted soil. Annual application of CDMC is therefore recommended for upland rice field on Alfisol.

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