EFFECTS OF COMBINED USE OF ORGANIC AND INORGANIC FERTILIZERS ON THE PERFORMANCE OF UPLAND RICE (*Oryza sativa* L.) CULTIVARS

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ABSTRACT
Field experiments were conducted during the at the research field of the National Cereals Research Institute, Badeggi, Niger State, Nigeria (Lat. 9^o 45' N, Long.06^o 07' E) to evaluate the effects of combined use of organic manure and inorganic fertilizer on the growth and grain yield of upland rice The experiments were designed as 5 x 4 factorial in Randomized Complete Block and laid out in split-plot arrangement, replicated three times. The main plots consisted of five rice varieties (NERICA 1, FARO 48, FARO 49, FARO 55 and SOR- 2). The sub-plots were made up of four soil amendment combinations of organic manure (poultry manure (PM) and inorganic fertilizer (urea) (1.5 t/ha PM, 1 t/ha PM + 20 kg N/ha urea, 0.5 t/ha PM + 40 kg N/ha urea and 0 kg N/ha (control). Data were collected on plant height and tiller counts, both at 30, 60, and 90 days after sowing(DAS); length of central panicle and number of panicles at maximum booting, grain yield (kg/ha) 1000 grains weight. Data collected on various parameters were subjected to the statistical analysis of variance (ANOVA) using SAS (2002). Means were separated using the Least Significant Difference at 5% probability levels ($LSD_{0.05}$).

Results showed that the application of different combinations of organic manure and inorganic fertilizer resulted in significantly better growth and grain yield (2.51 t/ha for 1 t/ha + 20 kg N/ha urea and 2.26 t/ha for 0.5 t/ha + 40 kg N/ha urea), compared to the none application of any form of soil amendment (control) (1.38 t/ha), with the parameters also varying significantly ($p>0.05$) among the soil amendments. The application of 1 t/ha PM + 20 kg N/ha urea resulted in the best growth and grain yield of rice (2.51 t/ha), even though the values were sometimes not significantly better than with the application of 0.5 t/ha PM + 40 kg N/ha urea (2.26 t/ha). Value of grain yield obtained with the application of the sole organic manure (1.5 t/ha PM) (1.63 t/ha) was higher than with the non-application of any form of soil amendment (1.38 t/ha), although the difference was not significant ($P<0.05$). Rice varieties varied significantly($p>0.05$) in the measured parameters, with FARO 49 and FARO 55 showing the best growth parameters, while NERICA 1 was the best in grain yield (2.65 t/ha), possibly due to its large grain size as indicated by the larger 1000 grains weight (1.80 g). The results of the significant variety x soil amendment interactive effects revealed that the growth and grain yields of NERICA 1, FARO 48, FARO 49 and FARO 55 rice varieties were best with the application of 1 t/ha PM + 20 kg N/ha urea, while SOR-2 variety performed best with the application of 0.5 t/ha PM + 40 kg N/ha urea soil amendment. The use of combined organic manure and inorganic fertilizer (1 t/ha PM + 20 kg N/ha urea and 0.5 t/ha PM + 40 kg N/ha urea) produced significantly ($p>0.05$) better results than the use of the sole organic manure (1.5 t/ha PM). The use of combined organic manure and inorganic fertilizer, more importantly, 1 t/ha PM + 20 kg N/ha and the cultivation of the NERICA 1 rice variety, are hereby recommended for the farmers in Baddegi area of Nigeria.

Keywords: Poultry manure. Inorganic fertilizer (urea), grain yield, and 1000grain

INTRODUCTION

Cereal grains are unique among foods. Rice constitutes one of the most important staple foods of over half of the world's population (Normal and Otoo, 2006). On world basis, rice ranks third after wheat (*Triticum aestivum,* L) and maize (*Zea mays*, L) in terms of production. Rice is of significant importance to food security in many African countries and while the per capita rice consumption in some Asian nations is declining, it is growing rapidly in most countries in sub -Saharan African (Mohapatra, 2006). Annual demand for rice in sub-Saharan Africa is increasing by 6% per year, fueled by the rapid population growth and changes in consumption preferences (FAO, 2000).

In Nigeria, rice was ranked as the sixth major crop in cultivated area after sorghum *(Sorghum bicolor*, L), millet (*Haena sativa* L), cowpea (*Vigna unguiculata* (L) Walp), cassava (*Manihot esculentum*, L) and yam (*Dioscorea spp.*, L) (Olaleye *et al.,* 2004; Dauda and Dzivama, 2004). It is the only crop grown nationwide in all agro-ecological zones from Sahel to the coastal swamps. It remains an important diet in Nigeria and due to this, demand for rice rose far above its supply. Olaleye *et al.,* (2004) remarked that an estimated 2.1 million tons of rice are consumed annually. FAO (2006) reported that rice is the second highest worldwide produced crop after maize. During the past three decades demand for rice has been a steady increase and its growing importance is evident given its important place in the strategic food security planning.Nitrogen and phosphorus fertilizers are major essential plant nutrients and key input for increasing crop yield (Alam *et al.,* 2009; Alinajati and Mirshekari 2011; Dastan *et al.*, 2012). Nitrogen deficiency generally results in stunted growth and chlorotic leaves due to poor assimilate formation that leads to premature flowering and shortening of the growth cycle.

Application of organic materials as fertilizers provides growth regulating substances and improve the physical, chemical and microbial properties of the soil (Belay *et al.,* 2001). Several field research reports have indicated that high and sustainable crops yields are only possible with integrated use of mineral fertilizer with organic manure (Satyanarayana *et al.,* 2002). Complementary application of organic and inorganic fertilizers increase nutrient synchrony and reduces losses by converting inorganic nitrogen to organic forms (Kramer *et al.,* 2002). The use of organic and inorganic fertilizer has its advantages in the content of nutrient supply, crop growth and environmental quality.There are two broad categories of soil amendments: organic and inorganic. Organic amendments come from something that is or was alive. Inorganic amendments, on the other hand, are either mined or man-made (Davis and Wilson, 2008). Organic amendments include agricultural by-products, grass clippings, straws, wood ash, biosolids, sawdust, composts and manures. Unlike inorganic amendments, the organic amendments increase soil organic matter content and offer many benefits. Organic matter improves soil aeration and water infiltration, and it also improves both water and nutrient-holding capacity of soils. Organic matter serves as an important energy source for bacteria, fungi and earthworms that lives in the soil, some which are beneficial to the soil and plants. In addition, they serve as a slow- release for plant macro nutrients, and aid in plants micronutrients and facilitate water and air infiltration. They increase water retention by the soil and are important in maintaining soil tilth (Sarka and Siegh 2002). Ball *et al*., (2005) noted that organic fertilizers are also responsible for the formation of soil aggregates. Livestock manure supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (trace elements), hence it acts as a mix fertilizer (Tremblay *et al.,* 2011). Manure application in a given year will influence not only crops grown that year, but also crops in the succeeding years, because decomposition of the organic matter is not completed within one year (Bayu *et al.,* 2006).

This illustrates the fact that nutrients from poultry manure can be substituted for mineral fertilizers and is far better for the environment. Therefore, the main objectives of applying poultry manure to the soil are to supply balanced plant nutrition, increase soil fertility and build up soil organic matter that will later become a source of slowly released nutrients. These are influenced by the process of their decomposition in the soil. Synthesis of chemical fertilizers consumes a large amount of energy and money. However, an organic farming with or without chemical fertilizers seems to be possible solution for these situations (Prabu *et al.,* 2003). The integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards.

MATERIALS AND METHODS

Experiments were conducted at the National Cereals Research Institute (NCRI) upland rice field, Badeggi (Lat. 9^o 45' N, Long.06^o 07' E), 705 metres above sea level in the southern Guinea savanna ecological zone of Nigeria. The average annual rainfall of Bida is in the range of 1000 – 1500 mm.

The land was mechanically ploughed and harrowed using tractor-mounted disc plough and harrow. Thereafter, field layout was done to mark out the appropriate number of treatment plots, each measuring 4 m × 4 m prepared manually. Sowing of the rice seeds was done at a rate of four seeds per hill and spaced at 20 cm × 20 cm. The experiments were designed as 4 × 5 factorial in Randomized Complete Block and laid out in split-plots arrangement. The main plots consisted of five rice varieties (NERICA 1, FARO 48, FARO 49 FARO 55 and SOR–2) obtained from the seed unit of the NCRI, Badegi, while the sub plots were made up of four soil amendments (1.5 t/ha poultry manure (PM), 1 t/ha PM + 20 kg N/ha inorganic fertilizer, 0.5 t/ha PM + 40 kg N/ha inorganic fertilizer and 0 kg N/ha (control). All factorial combinations were replicated three times. The poultry manure at the appropriate rates mentioned above was incorporated into the soil prior to sowing of rice, while inorganic fertilizer in form of urea was split- applied at the rates mentioned above by broadcasting method on the plots that were to receive inorganic fertilizer urea, at 30 DAS and at booting stage. Weed control in each experimental plot was carried out by manual weeds removal using the traditional hoe, done twice at 3 and 6 weeks after sowing. One 1m × 1m quadrant was marked out from each of the plots and all the plants therein were used for data collection.

Data on plant growth parameters including plant height (cm), tiller counts, length of panicle (cm) and number of panicles per plant at maximum booting and grain yield (t/ha) at harvest, were collected from the designated 1 m^2 quadrant in each plot. The heights of rice plants from the 1m^2 quadrant in each plot were measured from the base of each plant to the tip of its newly emerged leaf. This was taken with the aid of a measuring tape and was done at 30, 60, and 90 days after sowing (DAS). The average values were taken to represent the height per rice plant at each assessment period. The number of tillers from the same1m^2 quadrant were counted at 30, 60, and 90 (DAS) in each plot. The average values were later taken to represent the number of rice tillers per plant. The length of panicle was measured from plants in the 1m^2 quadrant. This was measured with the use of a measuring tape. The average values of the measured panicles from each quadrant were recorded per plot. The number of rice panicles were counted from the 1m^{2}quadrant. This was carried by manual counting. The average values of the rice plants in each quadrant were determined and recorded per plot. The harvesting of the rice was done at maturity by cutting all plants from the 1 m^2 quadrant in each plot. The harvested rice plants were sun dried, threshed, winnowed to obtain the paddy rice which was thereafter weighed using a metric balance. Thereafter 1000 grain yield of rice was counted and weighed using an electronic weighing balance. The rice grain yield per hectare was finally estimated from the grain yield.

Data collected on various parameters were subjected to the statistical analysis of variance (ANOVA) using SAS (2002). Means were separated using the Least Significant Difference at 5% probability levels ($LSD_{0.05}$).

RESULTS

Results on Table 1 show that similar plant height values were obtained at the two years of assessment during the three periods of measurements. However, plant height values varied significantly (p>0.05) among the five rice varieties at both 30 and 60days after planting (DAP). At 30 DAP, plant height value was significantly (p>0.05) highest and lowest with FARO 49 and NERICA 1, respectively, while the values of the parameter were similar for the other varieties. At 60 DAP, NERICA 1 variety showed the least plant height value which was significantly lower than in all other varieties with similar plant height values, except SOR 2. However, at 90 DAP, even though the plant height value was highest with FARO 49 and lowest with NERICA 1, there were no significant differences in the plant height values of the evaluated varieties. The results of the main effects on Table 2 show that at 30 DAP, similar values of tiller counts were obtained between the two years assessment and among the varieties of rice evaluated. However, tiller count values varied significantly (p>0.05) among the evaluated types of soil amendment with the application of 1 t/ha PM + 20 kg N/ha in organic fertilizer resulting in the highest value and none application of any form of amendment showing the lowest value. At 60 DAP, tiller count values were also similar for the two years of assessment, while the parameter varied significantly (p>0.05) among the evaluated rice varieties and types of soil amendment. SOR -2 rice variety produced significantly (p>0.05)highest tiller count and NERICA 1 produced significantly lowest tiller count value, while all FARO rice varieties produced similar tiller count values which were significantly (p>0.05)better than that of NERICA 1 but inferior to that of SOR-2 variety. The application of 1 t/ha PM + 20 kg N/ha urea and 0.5 t/ha PM + 40 kg N/ha urea resulted in the same number of tillers which values were significantly (p>0.05) better than in the application of 1.5 t/ha PM, which nevertheless showed significantly better tiller count than in none application of any type of soil amendment. While 1000 grains weight and grain yield of rice were not significantly affected by the year of planting, both yield parameters were significantly affected by the rice variety and soil amendments, except 1000 grain weight which was not significantly (p<0.05) affected by variety. The interactive effects of variety and soil amendment were similarly significant (p>0.05) for the two yield parameters (Table 3).

Table 1. Main effects of year, variety and soil amendment on plant height of rice at 30, 60 and 90 DAP

	Plant Height (cm)		
Treatments	**30**	**60**	**90 DAP**
Year			
2011	33.23	57.89	67.93
2012	33.46	57.94	68.07
SED	0.120	0.148	0.052
$LSD_{0.05}$	NS	NS	NS
CV (%)	0.4	0.3	0.1
Variety			
NERICA 1	29.81d	48.40b	64.40
FARO 48	34.63b	60.96a	69.74
FARO 49	37.20a	64.61a	71.76
FARO 55	32.79bc	58.83a	68.67
SOR-2	32.30c	56.71ab	65.42
SED	1.019	4.184	3.827
$LSD_{0.05}$	2.160	8.871	NS
CV (%)	5.3	12.5	9.7
Soil Amendment			
0 kg N/ha	30.67b	53.46b	63.52b
1.5 t/ha PM	34.83a	52.21b	63.26b
1 t/ha PM+ 20 kg N/ha NPK	34.96a	62.74a	72.42a
0.5 t/ha PM + 40 kg N/ha NPK	32.93a	63.26a	72.79a
SED	1.027	2.628	2.493
$LSD_{0.05}$	2.054	5.257	4.987
CV (%)	11.9	17.6	14.2

Figures followed by the same letter(s) in each column are not significantly different by the least significant difference at 5% probability level
DAP = days after planting SED = standard error of difference CV= coefficient of variation
LSD = least significant difference NS = not significant

Table 2 Main effects of year, variety and soil amendment on tiller count of rice at 30, 60 and 90 DAP

	Tiller count (no.)		
Treatments	**30**	**60**	**90 DAP**
Year			
2011	21	25	28
2012	21	25	28
SED	0.23	0.13	0.23
$LSD_{0.05}$	NS	NS	N
CV (%)	1.4	0.6	1.0
Variety			
NERICA 1	19	22c	25c
FARO 48	20	25b	27bc
FARO 49	21	25b	28ab
FARO 55	21	26ab	29ab
SOR-2	23	27a	30a
SED	1.43	0.87	1.17
$LSD_{0.05}$	ns	1.83	2.47
CV (%)	11.9	6.0	7.2
Soil Amendment			
0 kg N/ha	19c	22c	25c
1.5 t/ha PM	20bc	24b	26c
1 t/ha PM+ 20 kg N/ha NPK	22a	27a	32a
0.5 t/ha PM + 40 kg N/ha NPK	21ab	27a	29b
SED	0.76	0.75	0.89
$LSD_{0.05}$	1.53	1.51	1.79
CV (%)	14.3	11.7	12.4

Figures followed by the same letter(s) in each column are not significantly different by the least significant difference at 5% probability level .
DAP = days after planting SED = standard error of difference CV=coefficient of variation
LSD = least significant difference NS=not significant

Table 3: Effects of year, variety and soil amendment on 1000 grain weight and grain yield

Source of variation	**df**	**Grain yield (t/ha)**	**1000 grains weight (g)**
Rep	2	0.175	0.28
Year (Yr)	1	0.003ns	0.007ns
Error (a)	2	0.003	0.00082
Variety (Var)	4	4.065***	0.14ns
Yr x Var	4	0.013ns	0.001ns
Error (b)	16	0.296	0.06
Soil Amendment	3	8.351***	1.19***
Yr x SA	3	0.003ns	0.0009ns
Var x SA	12	0.731**	0.22***
Yr x Var x SA	12	0.003ns	0.0001ns
Error (c)	60	0.255	0.032
Total	119		

*****, ****** and ******* denote effect significant at 5, 1 and 0.1 probability level, respectively
ns denotes effects not significant

DAP=days after planting SED= standard error of difference CV=coefficient of variation
LSD= least significant difference NS=not significant

DISCUSSION

The growth and yield parameters of rice were significantly influenced in response to the application of combined use organic (poultry manure) and inorganic fertilizers (urea). This may be due to beneficial effects of poultry manure on soil fertility (Satyanarayana *et al.,* 2002). Plant height, number of tillers, and yield of rice were significantly increased by the combined use of poultry manure and urea. This observation was in line with the report of Ainika (2010) who reported that poultry manure significantly increased growth characters such as plant height. The use of the combined organic materials with inorganic N fertilizer produced plants that were better than with the use of organic manure alone. This indicated that the high dose of organic manure can be reduced by half and mixed with nitrogen fertilizer as reported by Agbede *et al.* (2008). Nutrients seemed to be more available to rice plants with the mixture than the organic material alone. It has been observed that the application of a mixture of organic and inorganic fertilizers can be used to sustain rice production in the tropics (Satyanarayana *et al.,* 2002). A similar trend of response had earlier been reported for other crops such as maize (Makinde *et al.,*2001) and Sorghum (Bayu *et al.,* 2006).

Inorganic fertilizers are known to have the peculiarity of fast release of their nutrient contents. Nutrients supplied from the inorganic fertilizer seemed to be released fast enough at 30 DAS to give significantly taller plants in this study. Comparable rice yield from both the combined application of organic and inorganic fertilizers and those from the sole organic fertilizer is a further indication that the nutrients supplied from the combined application were more effective than those supplied with sole organic fertilizer. A similar result for maize has shown that grain yields from the combined application of organic and inorganic fertilizers to be higher than yield from sole organic manure application (Makinde *et al.,* 2001). It was also observed from the present study that the sole organic fertilizer (poultry manure) application did not benefit the yield of rice significantly better than the control (0 kg N/ha). The observed lower yield from sole organic fertilizer application from this study supported the earlier suggestion that organic fertilizers are better used for sustaining continuous cropping for 2-3 years than inorganic fertilizers (Agbim, 1985). Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantly available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil (Sarker *et al*., 2004). The increase in plant height, number of tillers per hill, 1000-grain weight and grain yield in response to the application of combined organic and chemical fertilizers is probably due to an enhanced availability of nutrients. The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients. Yadana *et al*. (2009) reported similar results with the application of organic manure and compost in rice production. The available nutrients might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilates and more dry matter accumulation. These results are supported by the earlier findings of Swarup and Yaduvanshi, (2000) and Yadana *et al*. (2009).

Tillering is an important trait for grain production and is thereby an important aspect in rice yield. Mirza *et al.* (2010) reported increase in the number of tillers in rice plants due to the influence of different fertilizer combinations. According to the authors, more number of tillers per square meter might be due to the more availability of nitrogen, which plays a vital role in cell division. Organic sources offer more balanced nutrition to the plants, especially micro nutrients which positively affect number of tillers in plants (Miller, 2007). The yield components of rice crop showed significant differences due to different soil amendments evaluated in the present study. Salem (2006) reported that the application of farm yard manure (FYM) in combination with nitrogen fertilizer significantly increased the number of panicles per square meter, panicle length, panicle weight, number of filled grains/panicle, 1000 -grain weight and grain yield in rice.

Increase in grain yield could be due to the increase in plant growth attributes (plant height, number of productive tillers/hill, panicle weight and 1000-grain weight). Significant differences in 1000-grain weight of rice as affected by variation in fertilizer packages were also reported by Mirza *et al*. (2010). These results were also supported by Channabasavanna and Biradar (2001). The increase in grain yield components can be due to the fact that the availability of more water enhanced nutrient availability which improved nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter content from source to sink (Akinrinde, 2006). Similar results were also reported by Awad (2001) and El-Refaee *et al*. (2006).

The variations in plant height of rice varieties may be attributable to the differences in the genetic makeup of the varieties and their differences in the utilization ability of the different rates of soil amendments applied. These observations were in consonance with that of Halder *et al.* (2000) and Hag *et al*. (2002) who reported that increased rate of the NPK fertilizer favoured the vegetative growth in rice plant. The significant differences observed in the number of tillers and panicles per plant can be ascribed to differences in the ability of the cultivars to utilize the fertilizer as well as partition their photosynthates and accumulation of dry matter. The differences in the ability of crop cultivars to utilize available nutrients and optimally partition its photosynthates had been recognized (Ndon and Ndaeyo, 2001). Halder *et al.* (2000) and Hag *et al.* (2002) reported that the number of panicles increased with increase in the nitrogen rates and that number of panicles per plant increased with increase in NPK rates. Rice panicle length and grain yield were also significantly different among the rice varieties. These observations are apparently due to the availability of more nutrients to the rice plant following the soil amendment application relative to the control treatment. The natural endowments of crop cultivars to optimally utilize available nutrients and subsequently partition its photosynthates for dry matter accumulation and conversion to economic yield vary (Ndon and Ndaeyo, 2001).

The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Miller (2007). Tillering is an important trait for grain production and is thereby an important aspect of rice growth improvement. Production of tillers in rice plant was also influenced by different fertilizer combination at all the growth stages.

The productivity of rice plant is greatly dependent on the number of productive tiller (tillers which bears panicle) rather than the total tiller numbers. From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective tillers if it can be can supplemented with organic manures. However, organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with poultry manure and vermicompost (Miller, 2007). This result was also supported by Belay *et al.,* (2001). Application of poultry manure combined with N enhances the nutrient availability and suitable soil condition for proper plant growth by reducing the losses of nutrient and hence produced the maximum dry weight. The production of maximum dry matter with proper manuring might be accounted for by the luxuriant growth of plant as well as higher number of tillers (Rahman *et al.,* 2007). The higher growth rate achieved by using poultry manure and urea fertilizer treated plants which would be associated with the positive effect of nitrogen, phosphorus and potassium. Singh *et al*. (2003) reported that crop growth rate, averaged across treatments, was highest at 45-60 days after transplanting of rice and significantly influenced by NPK fertilizers.

CONCLUSION

The results from this study show that growth and yield parameters of rice were significantly increased in response to the application of poultry manure combined with inorganic fertilizer. Plant height, number of tillers, and grain yield of rice were significantly increased by the combined use of poultry manure and urea fertilizer. Better rice grain yield from both the combined application of organic and inorganic fertilizer than those from the sole organic fertilizer is a further indication that the nutrients supplied from the combined application were more effective than those supplied with sole organic fertilizer. It was also observed from this study that the sole organic fertilizer (poultry manure) application did not benefit the grain yield of rice significantly better than the control (0 kg N/ha). In conclusion, the use of combined organic manure and inorganic fertilizer (1 t/ha PM + 20 kg N/ha urea and 0.5 t/ha PM + 40 kg N/ha urea) produced significantly better results than the use of the sole organic manure (1.5 t/ha PM), while NERICA 1 was the most outstanding rice variety.

From the foregoing results and discussion of the present study, the use of combined organic manure and inorganic fertilizer, particularly 1 t/ha PM + 20 kg N/ha urea and the cultivation of the NERICA 1 rice variety, are hereby recommended for the farmers in the experimental area.

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