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Effects of NPK and Cow Dung on the Performance of Rice (*Oryza sativa*) in the Sudan Savanna Agro-ecological Zone of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SAL and MA designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors AUD and HGA reviewed the experimental design and all drafts of the manuscript. Authors MMS, MH and SSN managed the analyses of the study. Author SAY performed the laboratory analysis. Authors AS and NGH performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

This study evaluated the effect of Nitrogen, Phosphorus and Potassium (NPK 20-10-10) and cow dung on the performance of rice at two locations (Sokoto and Talata Mafara) in the Sudan savanna zone of Nigeria, during the 2012/2013 dry season. The treatments consisted of nine different combinations of cow dung and NPK fertilizer with an absolute control, using rice (FARO 44) as a test crop. The treatments were laid out in a Randomize Complete Block Design (RCBD) and replicated three times. The combined application of cow dung and NPK fertilizer significantly ($p <$ 0.05) increased most of the results obtained with regards to locations compared to the control plots. The growth and yield parameters of rice considered were significantly ($p <0.05$) affected by the

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treatments except one thousand grain weight. Application of 8 t ha^{-1} of cow dung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto, while application of 12 t ha^{-1} of cow dung in combination with 300 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (6.50 t ha^{-1}) at Talata Mafara. In conclusion, it is recommended that application of 12 t ha^{-1} of cow dung in combination with 300 kg ha^{-1} NPK 20:10:10 resulted in the best soil nutrient enrichment and yield of rice in Sokoto and Talata Mafara. The result showed that judicious application of cow dung with NPK fertilizers could be a useful practice for better performance of Rice in the study areas compared to the control plots which significantly recorded the least.

Keywords: NPK; cow dung; rice performance; Sudan savanna.

1. INTRODUCTION

Rice belongs to the tribe *Oryzeae*, sub-family *Poacoideae* in the grass family *Poaceae* (syn. *Gramineae*). The genus *Oryza* is said to contain six species of which *Oryza sativa* L. is commercially, the most important in world rice cultivation [1]. Rice is one of the most important cereal crops in the world followed by wheat and maize. It is indispensable in terms of importance as food crop because it provides more calories per hectare than any other crop. It is also use in the manufacture of wines and spirits, cosmetics and textile. The bran is a valuable poultry feed, and the oil extracted from it, is used as cooking oil, for soap manufacture, as carrier for insecticides and as anti-corrosive and rust-resistant oil [2]. In West Africa, Nigeria is the largest producer of rice, accounting for 45% of all rice produced in the region and 40% of total rice cropping area and is also a major consumer with an annual consumption estimated at 5 million tons in 2006, of which 1.6 million tons was produced domestically and the remaining 3.4 million was imported [3]. Nigeria has a potential area for rice production of between 4.6 to 4.9 million hectares, however only 1.7 million hectares, representing 35% of total land mass is cropped to rice [4]. However, crop production in the tropical soils such as Nigeria and many African countries are constrained by the nutrients deficiency problems as a result of soil erosion, crop harvesting and prevailing environmental conditions [5]. The application of mineral fertilizer (Nitrogen, Phosphorus and Potassium inorganic fertilizers) as a sole soil fertility management method under intensive continuous cropping is also no longer feasible due to scarcity and high cost of the fertilizers [6]. The need for renewable forms of energy and reduced cost of fertilizing crops, have revived the use of organic manures worldwide [7]. However, sole use of organic manures as sources of soil improvement is hindered by its bulkiness, low nutrients quality and mineralization, cost of transportation and handling which constitute a constraint to its use by peasant farmers [8] and [9]. Several researches have shown that proper use of NPK fertilizers increased the yield and improved the quality of rice significantly [10,11] and [12]. Use of organic manure especially cow dung and poultry droppings helps in improving physical condition of soil and serves as major contributor of plant nutrients [13]. Many researchers have found the integrated soil nutrient management of combining organic wastes and mineral fertilizers, to be more feasible in maintaining soil nutrients status as well as crop production than single application of mineral or organic fertilizers. Hence the objective of this study was to investigate the effect of NPK and Cow dung on growth and yield of rice in Sudan savanna agro-ecological zone of Nigeria.

2. MATERIALS AND METHODS

2.1 The Study Areas

Two-location field experiments were conducted during the 2012/2013 dry season at the Usmanu Danfodiyo University Teaching and Research Fadama farm, Kwalkwalawa, about 5 km from Sokoto (L1), located at Latitude 13° 01^{1} N and longitude 5° 15^{1} E at an altitude of 300 meters above sea level and Irrigation Research farm of the Institute for Agricultural Research, Talata Mafara (L2) located at Latitude 12° 33^{1} N and longitude 6° 04^{1} E at an altitude of 309 meters above sea level. Minimum and maximum temperatures ranges between 15 and 40℃. The average annual rainfall is 629 mm for Sokoto [14], while at Talata Mafara, minimum and maximum temperatures are 18 and 40℃, while the average annual rainfall is 650 mm [15].

2.2 Sample Collection and Preparation

A composite soil sample of one auger borings (0 – 30 cm depth) per plot was collected at each location. At the end of the study, a composite soil sample from each of the experimental plots was also collected to the same depth. The samples were air-dried, ground and passed through 2mm-mesh sieve and used for laboratory analysis. Cow dung obtained from Sidi Mamman Cattle Farm Sokoto, was air dried, weighed and appropriate quantities applied on plot by broadcasting and worked into the soil with hand hoe. The composition of the cow dung used is shown in Table 3. The sub-samples were used for physical and chemical analysis using standard procedures as described by [16]. Particle size distribution was determined by standard hydrometer method [17] using sodium hexametaphosphate as dispersant, soil pH was determined in water and 0.01 M $CaCl_2$ with a pH meter at 1:1 soil to liquid ratio [18]. Organic carbon by wet oxidation method of [19] while organic matter was determined by multiplying percentage organic carbon by 1.724. Exchangeable bases were determined by extraction with neutral 1*N* NH_4OAC saturation method; calcium and magnesium were read using atomic absorption spectrophotometry, potassium and sodium by using flame photometer [20]. Available phosphorus was extracted by Bray No 1 method, and determined by the molybdenum blue method [21]. Total N was determined by Kjeldahl digestion distillation method [22] while exchangeable acidity was determined by 1.0*M* KCl extract method of [23]. Samples of growth and yield parameters considered were collected from five randomly tagged plants from each experimental unit.

2.3 Treatments and Experimental Design

The treatments were consisted of three levels of cow dung (4, 8 and 12 t ha^{-1} represented as $Cd_{1,}$ Cd_2 and Cd_3) and three levels of NPK (200, 300 and 400 kg ha^{-1} represented as $M_{1,}$ M_2 and M_3) to give nine treatment combinations with an absolute control (without fertilizer) using the rice variety, FARO 44, as a test crop. The treatment combinations and code are shown in Table 1. The treatments were laid out in a Randomized Complete Block Design (RCBD) replicated three times. The gross plots measuring 2.5 m x 1.5 m (3.75 m^2) were pegged and separated from each other by 0.5 m between plots and 1 m between blocks, with a net plot area of 2 m x 1 m (2.0 m^2) and a total experimental area of 235.75 m^2.

2.4 Cultural Practices

The seedbeds (nursery plots) measuring 2 x 4 meters were carefully prepared before sowing at both locations. The nursery plots were hand ploughed using traditional hoe and then manually harrowed to a fine tilth and leveled. The seedbeds were kept moist for two days. The seeds were then soaked overnight and sown in the nursery. The beds were kept moist until full germination then regularly irrigated as needed without flooding. Three weeks old seedlings were transplanted at a spacing of 25 $_X$ 25 cm. Pre-emergence herbicide (Butachlor 50% EC of Chloroacetanilide family) was applied before transplanting at the rate of 1.5 kg a.i ha^{-1} and thereafter, manual weeding was carried out as at when due using hoe. Mineral fertilizer (NPK 20:10:10) was applied in split doses of two halves. First dose was applied two weeks after transplanting, and the second dose was applied at panicle initiation. Cow dung was incorporated two weeks before transplanting in plots requiring it, to allow the residues to further decompose adequately at the rate of 4, 8 and 12 t ha^{-1} respectively. The experimental plots were irrigated as and when due. Birds were controlled by scaring while rodents were controlled by using baits and traps. No disease outbreak was recorded. The crop was manually harvested on 24th July, 2013 from the net plots at physiological maturity using sickles. The crop data regarding plant height (cm), number of leaves, number of tillers per plant, number of panicle per plant, thousand grains weight (g) and grain yield in (kg ha^{-1}) were recorded.

2.5 Data Analysis

The data collected were subjected to analysis of variance (ANOVA) computation was done using SAS General linear Model Procedure of SAS [24] and treatment means where significant, were separated using the Duncan's New Multiple Range Test (DNMRT) at 5% level of probability, unless otherwise stated.

3. RESULTS AND DISCUSSION

3.1 Initial Physical and Chemical Properties of the Soils

Soils of the experimental fields are sandy loam (Sokoto) and loam (Talata Mafara) in texture, low in organic carbon, total nitrogen, exchangeable sodium (Na) and cation exchange capacity (CEC), while available phosphorus is moderate (Table 2).

Table 1. Treatment combinations and designation

Treatment combinations	Designation
Cow dung at 4 tonnes ha^{-1} + 200 kg ha^{-1} NPK	Cd_1M_1
Cow dung at 4 tonnes ha^{-1} + 300 kg ha^{-1} NPK	Cd_1M_2
Cow dung at 4 tonnes ha^{-1} + 400 kg ha^{-1} NPK	Cd_1M_3
Cow dung at 8 tonnes ha^{-1} + 200 kg ha^{-1} NPK	Cd_2M_1
Cow dung at 8 tonnes ha^{-1} + 300 kg ha^{-1} NPK	Cd_2M_2
Cow dung at 8 tonnes ha^{-1} + 400 kg ha^{-1} NPK	Cd_2M_3
Cow dung at 12 tonnes ha^{-1} + 200 kg ha^{-1} NPK	Cd_3M_1
Cow dung at 12 tonnes ha^{-1} + 300 kg ha^{-1} NPK	Cd_3M_2
Cow dung at 12 tonnes ha^{-1} + 400 kg ha^{-1} NPK	Cd_3M_3
Control	Cd_0M_0

Table 2. Chemical and physical properties of the soils before the experiment

Soil property	Sokoto (L1)	Talata Mafara (L2)
pH (H_2O) 1:1	5.53	6.13
pH ($CaCl_2$) 1:1	4.83	5.33
Org. Matter (g/kg)	12.9	12.6
Total N (g/kg)	0.90	1.00
Available P (mg/kg)	7.20	8.03
CEC (Cmol/kg)	2.92	3.06
Exch. Ca (Cmol/kg)	1.83	1.97
Exch.Mg (Cmol/kg)	0.40	0.44
Exch. K (Cmol/kg)	0.15	0.16
Exch. Na (Cmol/kg)	0.10	0.08
Exch. Acidity (Cmol/kg)	0.44	0.39
Sand (g/kg)	716.00	416.00
Silt (g/kg)	188.00	418.00
Clay (g/kg)	96.00	166.00
Textural class	Sandy loam	Loam

3.2 Chemical Composition of the Cow Dung Used for the Experiment

The results of some selected chemical properties of the cow dung used in the experiment are shown in Table 3. The results indicated that, the cow dung used was slightly alkaline in pH, high in organic carbon and total nitrogen, low in available phosphorus and moderate in cation exchange capacity (CEC) and exchangeable bases (Ca^{2+}, Mg^{2+}, Na^+ and K^+).

3.3 Effects of Combined NPK and Cow Dung on Growth Parameters of Rice

Effects of combined NPK and cow dung on growth parameters of rice are presented in Table 4. The results indicated that, treatments had significant ($p < 0.05$) effect on plant height at both locations, and the treatments differed significantly from one another as shown in Table 4. At Sokoto, the tallest plants (81.7 cm) were recorded from the application of Cd_3M_2 and the shortest plants (66.8 cm) were recorded from the control plot. While at Talata Mafara, Cd_3M_3 recorded the tallest plant (74.83 cm) and the shortest plants (64.6 cm) were recorded from the control plots. Generally, there was increase in plant height with increasing rate of fertilization. This trend is in consonance with the findings of [2] who worked on influence of varied NPK (15:15:15) fertilizer on growth and yield performances of some upland rice (*Oryza sativa* L.) cultivars in Uyo, Akwa-Ibom state, Nigeria. The number of leaves was significantly ($p <0.05$) varied among the treatments at both locations as shown in Table 4. The highest number of leaves at Sokoto were recorded with the application of Cd_2M_2 (117) followed by Cd_2M_3 (109) and Cd_3M_3 (109) whereas, the least number of leaves were recorded from the control plot (80). At Mafara, Cd_2M_3 recorded the highest number of leaves per plant (112) followed by Cd_2M_2 (101) which was statistically ($p <0.05$) the same with Cd_3M_3 and Cd_3M_2 also the result obtained for Cd_1M_1 was statistically the same with the control value

(Table 4). Increase in the number of leaves in rice as fertilizer rate increases had earlier been reported by [2].

Table 3. Chemical composition of cow dung used for the experiment

Chemical property	Value
pH (H_2O) 1:1	7.70
Org. Carbon (g kg^{-1})	36.27
Total Nitrogen (g kg^{-1})	7.1
Available P. (mg kg^{-1})	3.43
CEC (cmol kg^{-1})	6.84
Extractable Ca (cmol kg^{-1})	2.67
Extractable Mg (cmol kg^{-1})	2.23
Extractable K (cmol kg^{-1})	0.23
Extractable Na (cmol kg^{-1})	1.33

Values are mean of triplicate samples

Effects of NPK and cow dung on number of tillers are presented in Table 4. Results showed that, treatments had significant ($p < 0.05$) effect on number of tillers at both locations. At Sokoto, Cd_3M_2 recorded the highest number of tillers (578) which were statistically the same with Cd_2M_2 (573) while the remaining treatments gave a lower value of tiller number and the least number was observed in the control plot. While at Mafara, Cd_3M_3 recorded the highest number of tillers per square meter (418) which was statistically the same with Cd_2M_2 (412). [25] attributed higher tiller numbers to greater space available for individual plant to put forth more tillers. When soil fertility is high, larger row spacing will promote production of healthier and more panicle bearing tillers.

3.4 Effects of NPK and Cow Dung on Yield and Yield Components of Rice

Effects of NPK and cow dung on yield and yield components of rice are presented in Table 5. The results showed that, there was significant ($p < 0.05$) effect of the treatments on the number of panicle at both locations. Application of Cd_2M_3 recorded the highest number of panicles (276) at Sokoto followed by Cd_1M_2 (245) and Cd_3M_2 which were statistically at par, the remaining treatments differed significantly and the least number of panicle was recorded in the control plot (171). At Talata Mafara, Cd_2M_2 significantly recorded the highest (344) number of panicle, which was followed by Cd_2M_3 (326), the remaining treatments differed significantly except Cd_1M_2 (299) and Cd_3M_2 (298) which were statistically similar, the least number of panicle (168) was recorded in the control plot. Generally, the number of panicles increased with the increase in fertilizer level (Fig. 1). This is in agreement with the findings of [26,27] and [2]. Studies have shown that panicle number is the most important factor in increasing grain yield of rice and 89 % of yield changes is due to the effect of this factor [28] and [29].

Table 4. Effects of NPK and cow dung on growth parameters of rice at 8 weeks after transplanting

Treatment	L1 (Sokoto)			L2 (Talata Mafara)		
	Plant height (cm)	No. of leaves/plant	No. of tillers/m^2	Plant height (cm)	No. of leaves/plant	No. of tillers/m^2
Cd_1M_1	69.50^{de}	88.00^{de}	379.70^{de}	63.93^{d}	78.33^{d}	308.27^{bc}
Cd_1M_2	75.30^{abcd}	91.70^{cde}	450.10^{c}	68.50^{bcd}	84.47^{cd}	329.60^{bc}
Cd_1M_3	78.10^{abc}	98.70^{bcd}	530.10^{ab}	72.13^{abc}	90.60^{bc}	347.73^{abc}
Cd_2M_1	72.20^{cde}	104.40^{abc}	422.40^{cde}	68.13^{cd}	83.30^{cd}	331.73^{bc}
Cd_2M_2	80.40^{ab}	117.40^{a}	572.80^{a}	74.07^{abc}	101.00^{b}	412.80^{a}
Cd_2M_3	79.40^{abc}	109.30^{ab}	531.20^{ab}	74.53^{ab}	112.33^{a}	370.13^{ab}
Cd_3M_1	74.30^{bcd}	100.50^{bcd}	429.90^{cd}	71.93^{abc}	84.40^{cd}	323.20^{bc}
Cd_3M_2	81.70^{a}	109.10^{ab}	578.10^{a}	73.87^{abc}	97.13^{b}	379.73^{ab}
Cd_3M_3	77.40^{abc}	103.30^{abc}	485.30^{bc}	74.83^{a}	98.20^{b}	418.13^{a}
Control	66.80^{e}	80.70^{e}	363.70^{e}	64.63^{d}	74.80^{d}	279.47^{c}
Significance	*	*	*	*	*	*
SE$\pm$	2.17	4.35	19.86	2.26	1.78	15.16

*Means followed by the same letter(s) within the same column are statistically the same at 5% level of probability using Duncan's New Multiple Range Test (DNMRT). * = Significant at 5% level of probability*

Table 5. Effects of NPK and cow dung on yield parameters of rice at Sokoto and Talata Mafara

Treatment	L1 (Sokoto)			L2 (Talata Mafara)		
	No. of panicle m^{-2}	Grain yield (kg ha^{-1})	One thousand grain weight(g)	No. of panicle m^{-2}	Grain yield (kg ha^{-1})	One thousand grain weight(g)
Cd_1M_1	207^{d}	3900^{c}	21.60	255^{de}	3900^{f}	21.87
Cd_1M_2	245^{bc}	4833^{abc}	21.70	299^{bc}	5450^{d}	21.73
Cd_1M_3	229^{bcd}	4800^{abc}	21.60	309^{b}	5850^{cd}	20.80
Cd_2M_1	203^{d}	4550^{bc}	21.60	234^{e}	4000^{f}	20.93
Cd_2M_2	258^{ab}	4967^{abc}	22.00	344^{a}	5700^{cd}	22.40
Cd_2M_3	276^{a}	5767^{a}	21.60	326^{ab}	6000^{bc}	21.47
Cd_3M_1	221^{cd}	4833^{abc}	21.30	270^{cb}	4950^{e}	21.60
Cd_3M_2	252^{ab}	5000^{abc}	21.90	298^{bc}	6500^{a}	20.27
Cd_3M_3	240^{cd}	5650^{ab}	21.20	267^{cd}	6400^{ab}	21.60
Control	171^{e}	2733^{d}	21.50	168^{f}	2883^{g}	20.53.
Level of significance	*	*	NS	*	*	NS
SE$\pm$	9.12	328.19	0.46	10.49	159.48	0.74

*Means followed by the same letter(s) within the same column are statistically the same at 5% level of probability using Duncan's New Multiple Range Test (DNMRT). * = Significant at 5% level of probability. NS = not significant at 5% level of probability*

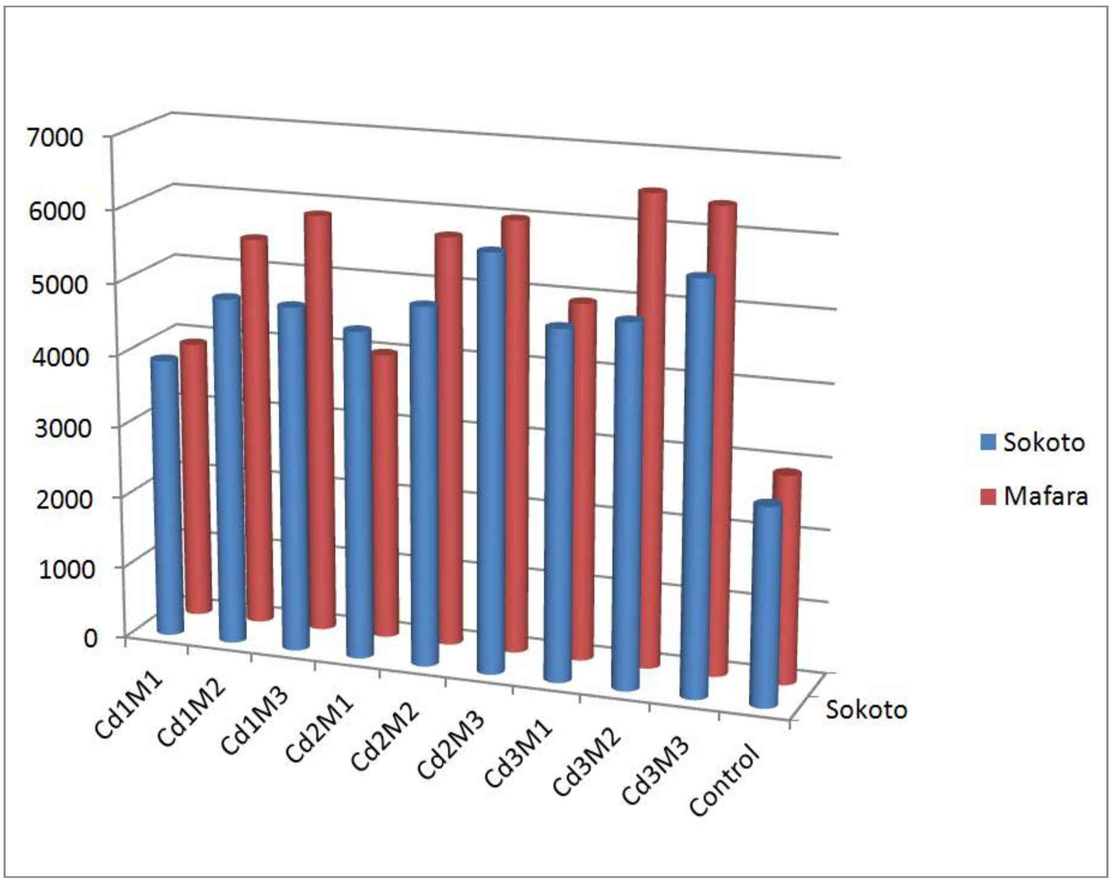

Fig. 1. Effect of NPK and cow dung on grain yield (kg/ha) of rice in Sokoto and Talata Mafara

Results of the effect of NPK and cow dung on grain yield of rice are presented in Table 5. The treatments had significant ($p < 0.05$) effect on grain yield of rice at both locations. At Sokoto Cd_2M_3 significantly recorded the highest grain yield of 5.77 t ha^{-1} followed by Cd_3M_2, Cd_2M_2 Cd_1M_3 Cd_1M_2 while the control plots recorded the lowest yield of 2.73 t ha^{-1}. Similarly, at Talata Mafara, Cd_3M_2 statistically recorded the highest yield (6.50 t ha^{-1}) which is statistically the same with Cd_3M_3 (6.40 t ha^{-1}), the remaining treatments differed significantly. The least grain yield was recorded from the control plots. [30] have reported a higher yield of maize from a combined use of NPK fertilizer and poultry manure than from sole applications. [31] have observed that the nutrient use efficiency of a crop increased through a combined application of organic manure and mineral fertilizer. Generally, the trend of results obtained at both locations showed an increase in yield with increase in the rate of fertilizer application (Fig. 1). This is in agreement with the findings of [32,27,13] and [12] who reported similar trend.

The effects of NPK and cow dung on one thousand grain weight are presented in Table 3. The treatments had no significant ($p > 0.05$) effect on one thousand grain weight at both locations. This corroborate with the findings of [33] who reported that, weight of one thousand grain of rice is one of the major yield components and stable property that have higher genetic stability than other yield components.

4. CONCLUSION

The results of the study conducted have shown that, complementary application of cow dung and NPK fertilizers significantly ($p < 0.05$) affected the yield and performance of rice in the Sudan savanna agro-ecological zone of Nigeria compared to the control plots were no fertilizer was applied. Furthermore, complementary application of cow dung and NPK fertilizer increased most of the important growth and yield parameters (plant height, number of leaves per plant, number of tillers per squared meter, grain yield and number of panicles per plant) considered except thousand grain weight.

5. RECOMMENDATIONS

Application of 8 t ha^{-1} of cow dung in combination with 400 kg ha^{-1} NPK 20:10:10 is recommended for better rice production in Sokoto, while application of 12 t ha^{-1} cow dung in combination with 300 kg ha^{-1} NPK 20:10:10 is recommended for better rice (FARO 44) production in Talata Mafara and for enrichment of soil fertility.

DISCLAIMER

This manuscript was not presented in the conference. It was only the abstract (e-copy) of this manuscript that was sent to the "40th Annual Conference of the soil science society of Nigeria 2016" but I was not able to attend the conference and present the paper. Finally it was not published in the proceedings.
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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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