

THE USE OF CROP RESIDUES AND HIGH ACTIVITY CLAYS FOR THE MANAGEMENT OF SANDY SOILS FOR RICE PRODUCTION IN SOKOTO, NORTH-WESTERN NIGERIA

Abstract

A field experiment was carried out to assess the effects of various crop residues (rice husk, rice straw, groundnut husk, and millet husk as well as high activity clay (HAC) on some soil properties, growth and yield parameters of rice (*Oryza sativa* L). Sixteen treatment combinations, replicated thrice, were applied at the rates of 5tha⁻¹ and 10tha⁻¹ each for rice husk, rice straw, millet husk, groundnut husks and high activity clay. Results obtained from the field trial as presented in this paper, showed significant effect of some of the treatments on soil chemical parameters especially organic Carbon, available P and exchangeable K. Similarly, soil physical parameter such as texture was also significantly influenced by the treatments. The texture of the soil, which was initially loamy sandy before the incorporation of the amendments, was altered to new textural classes in all the treatments after the experiment. The treatments had significant effects on all the growth parameters except for plant height at four (4) weeks after transplanting. The treatments also had significant effects on all the yield parameters of the test crop (rice).

Key Words: Sandy soils, Crop Residues, High activity clay.

Introduction

Sandy soils are characterized by possession of less than 18% clay and more than 68% sand in the first 100 cm of the column (Brady, 2001). These soils are often considered as soils with physical properties that are easy to define such as weak structure or no structure, poor water retention properties, low nutrient retention highly sensitive to compaction with many adverse consequences (Bell *et al.*, 2004; Wada, 1996 and Ishida *et al.*, 1993).

Crop residues are plant materials remaining after harvest including leaves, stalks and roots. Their presence on the soil surface decrease erosion, increases organic matter, improve soil quality, increase water holding capacity and infiltration (Lal, 2014). High activity clays have a high cation exchange capacity (CEC) due to their large surface area. These soils have great capacity to retain and supply large quantities of nutrients such as calcium, magnesium and

potassium. They generate high CEC under all soil conditions regardless of soil pH (Masters, 2010).

Rice belongs to the tribe *Oryzae*, sub – family *poacoiddeae* 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 (RMRDC, 2005). Rice is the world's most important food crop, it feeds one third of the world's population to whom it supplies almost two third of the food requirement (Labrada, 1996). One third of the world's population depends on rice for 50% of their daily caloric intake. The world grows 153.8 million hectares of rice annually with average worldwide yield of 3.9 t/ha which gives a production of 598.8 million metric tons, which is greater than that of either corn or wheat (FAO,2008). Rice is an annual grass with round culms, bearing flat alternately arranged leaves that are clenched to the culms with the help of their sheaths. The growth habit is determinate with a terminal inflorescence. The floral organs are modified shoots consisting of spike on which a number of spikelets are arranged, which bears a floret that develops in to single grain (Caryopsis) when fertilized. A single seed is fused with the wall (*pericarp*) of the ripened ovary forming the grain. Rice production under current inputs and technologies will not meet projected population growth needs and meeting present and future demand will required increased use of inputs and technologies to improve yields (Rice Today, 2010). One of such inadequate technologies is the use of crop residues and high activity clay for sustainable rice production (RMRDC 2005).

MATERIALS AND METHODS

Experimental site and materials used

The experiment was carried out at the Fadama Teaching and Research Farm, Faculty of Agric.culture, Usmanu Danfodiyo University Sokoto. The soil of the study site belongs to the order Entisols in the United State Department of Agriculture (USDA) Soil Taxonomy system. The area is geographically located 34 kilometers south east of sokoto town in sokoto

state, Nigeria longitude 5° 25.58', latitude 12° 45.78' N and 256 mean sea level. the soils of the farm are mostly loamy sand in texture. The land was divided into 48 plots each measuring 3m X 3m. Three replicates were used with 1m as spacing between and within rows and laid out in a Randomized Complete Block Design (RCBD) with 16 treatment combinations. The gross plot was 9m²(3m x 3m) with a net plot area of 7.56m² (2.75 X 2.75) and total experimented area of 591.25m² (27.5 X 21.5).

The variety of rice used was Faro 44, which was obtained from National Cereal Research Institute(NCRI) out station, BirninKebbi. The high activity clay was obtained from the Inland Valley and flood plains along Illela Road, Sokoto State.

Experimental Layout

The total number of plots was 48 with each measuring 9m² in size and labeled for the various treatments combination i.e. mixture of crop residues and high activity clay at difference rates. The treatments consisted of a factorial combinations of two levels of high activity clay (HAC); 10tha⁻¹ and 15tha⁻¹ each of which was combined with two level each, 5 tha⁻¹ and 10 tha⁻¹, of groundnut shell, rice straw, rice husk and millet husk respectively giving a total of 16 treatment combinations laid out in a Randomized Complete Block Design (RCBD) replicated three times.

Soil analysis

The soil samples were analysed for physical and chemical properties before and after the experiment. Organic carbon was determined by Walkley and Black (1934) method. Total nitrogen was determined by the Micro kjeldal method. Available phosphorus extraction was done using Bray 1 solution (Bray and Kurtz, 1945). Textural triangle was used for soil texture determinations. The cation exchange analysis (CEC) of the soil was determined by using pH 7.0 buffer solution of calcium ammonium acetate while Ethylenediamine tetra acetic acid (ETDA) titration was used to measure the Ca²⁺, Mg²⁺ and K⁺. Soil pH was measured in both water (1:1) and 0.01m Cacl₂ (1:2.5). particle size distribution was carried out using the hydrometer method.

TREATMENT COMBINATIONS

ACRONYMS

Groundnut shell 5tha⁻¹ + HAC, 10tha⁻¹

G₁HAC₁

Groundnut shell 10 tha⁻¹ + HAC 15tha⁻¹

G₂HAC₂

Rice straw 5 tha ⁻¹ + HAC 10tha ⁻¹	RS ₁ HAC ₁
Rice straw 10tha ⁻¹ + HAC 15tha ⁻¹	RS ₂ HAC ₂
Rice husk 5tha ⁻¹ + HAC 10tha ⁻¹	RH ₁ HAC ₁
Rice husk 10tha ⁻¹ + HAC 15tha ⁻¹	RH ₂ HAC ₂
Millet husk 10tha ⁻¹ + HAC 10tha ⁻¹	MH ₁ HAC ₁
Millet husk 10tha ⁻¹ + HAC 15tha ⁻¹	MH ₂ HAC ₂
Groundnut shell 5tha ⁻¹ + HAC 15tha ⁻¹	G ₁ HAC ₂
Groundnut shell 10 tha ⁻¹ + HAC 10tha ⁻¹	G ₂ HAC ₁
Rice straw 5tha ⁻¹ HAC + 15tha ⁻¹	RS ₁ HAC ₂
Rice straw 10tha ⁻¹ + HAC 10tha ⁻¹	RS ₂ HAC ₁
Rice husk 5tha ⁻¹ + HAC 15tha ⁻¹	RH ₁ HAC ₂
Rice husk 10 tha ⁻¹ + HAC 10tha ⁻¹	RH ₂ HAC ₁
Millet husk 5tha ⁻¹ + HAC 15tha ⁻¹	MH ₁ HAC ₂
Millet husk 10tha ⁻¹ + HAC 10tha ⁻¹	MH ₂ HAC ₁

RESULTS AND DISCUSSION

The results of soil analysis before the experiment are presented in table 1. The particle size analysis revealed that the soil is loamy sand in texture, slightly acidic and low in organic matter, CEC and available phosphorus. The results indicate that; pH values based on the ratings by Chude *et al.* (2011), ranged from acidic with mean values of 5.2 (1:1 soil water ratio) and pH measured in CaCl₂ (1:1 soil solution ratio) was 4.5. Exchangeable cations (Ca, Mg, K, Na) were low.

The treatments had significant ($P < 0.05$) on soil pH both in water and CaCl₂. The initial pH recorded before the experiment were 5.3 and 4.5 for pH (H₂O) and pH (CaCl₂) respectively. (Table 2) This shows the pH was strongly acidic (Chude *et al.*, 2011). The pH value recorded

on MH_2HAC_2 (7.3) which is slightly alkaline for pH (H_2O) and 7.0 neutral for pH (CaCl_2). The significant increase in the soil pH on all treatments might be because of the release of basic cations by the crop residues (Vanlauwe *et al.*, 1994).

The result from table 2 shows that treatments significantly ($P < 0.05$) influenced soil organic matter. Treatment G_2HAC_2 recorded the highest value. Walkey and Black (1984) found out that the incorporation of groundnut residue will provide organic matter and other plant nutrients in the soil. Groundnut being a legume have the ability to fix atmospheric nitrogen which is directly related to increased organic matter in the soil.

Result in table 2 showed the treatments had significant effect on nitrogen. Treatment G_2HAC_1 recorded the highest total nitrogen. Anderson and Peterson (1983) found out that the groundnut residues can be incorporated to provide nitrogen for non leguminous crops such as rice. The water holding capacity of the clay might have aided the soil in conserving and releasing nutrients (Ashrif and Thornton, 1965).

The treatment (Table 2) had significant effect on CEC. Treatment RH_1HAC_2 had the highest CEC ($11.83 \text{ Cmolkg}^{-1}$) Singh *et al.*, (1980) reported that application of rice residues and manure resulted in increased CEC.

The treatments had significant effect on available phosphorus. The initial value of available P before the experiment (4.6 mgkg^{-1}) was low (Esu, 1991). Treatment RH_1HAC_2 recorded the highest value of Available Phosphorus. Brady and Weil (1999) reported that, clays that possess greater anion exchange capacity (due to positive surface charges) have a greater affinity for phosphorus ions.

The results in Table 2 indicated that all the treatments had significant effects on exchangeable calcium. Treatment RH_1HAC_2 gave the highest value (3.6 cmolkg^{-1}). There was an increase in exchangeable calcium in all treatments. This is supported by the findings of Ahmad (2015).

All the treatments had significant effects on exchangeable Magnesium.

Treatment (RH_2HAC_2) recorded the highest value. It was observed that exchangeable magnesium increase with increase in clay content (Schaetzi and Anderson, 2005).

The treatments had significant effect on exchangeable potassium. The highest value was recorded by treatment RH_2HAC_2 . Kaur and Benepal (2006) reported an increase in available K and water soluble K as a result of incorporation of rice residue and farm yard manure.

The exchangeable sodium was significantly ($P < 0.05$) affected by the treatments. Treatment RS_2HAC_1 recorded the highest value ($0.26 \text{ cmol kg}^{-1}$). This value is low according to the rating of Esu (1991).

Electrical conductivity (EC) was significantly affected by the treatments. The EC value of the soil before the experiment was 0.27 ds/m . Treatment RS_2HAC_1 recorded the highest value of EC (1.7 dS/m). The soils of the study area were generally non-saline, based on the rating of Landon (1991) who reported that soils of EC levels of $0\text{--}2 \text{ dS/m}$ are salt free soils.

The data on texture classes of the treatments is presented on table 3. The initial texture of the soil before the experiment (Table 1) was Loamy sand. As can be seen from Table 3, all the textural classes of the 16 treatments were altered. All treatments where 10 t ha^{-1} high activity clay was incorporated had their textural class altered to Loamy soil while all treatments where 15 t ha^{-1} high activity clay was incorporated changed to clay loam. This is irrespective of the type of crop residue that was combined with the high activity clay. This confirmed the assertion that soil texture is a fixed property that can only be changed by the addition of one Soil Separate or the other (Hall *et al.*, 2010).

The tiller count of rice in Table 4 was significantly affected by the treatments. Treatment RH_2HAC_2 recorded the highest tiller per stand. The result obtained may be attributed to an improved soil moisture retention condition as a result of higher rate of rice husk and clay. This assertion was earlier stated by Muktare *et al.* (2015). The treatments did not significantly ($P > 0.05$) affect plant height at 4 weeks after transplanting (WAT). However, plant height was significantly ($P < 0.05$) affected at 8 and 12 weeks after transplanting.

Treatment RH_1HAC_2 recorded the highest value both at 8 and 12 weeks after transplanting. This is in agreement with the work of Lal, (1997) who found that application of rice husk combined residues produced the highest plant height.

The effect of crop residue HAC on the number of spikes in rice is presented in Table 4. The treatments had significant ($P < 0.05$) effect on the number a number of spikelets per spike. Treatment RH_2HAC_2 recorded the highest value with a mean of 15.00. This was attested by Ogboghodo *et al.* (2008), whose results showed that nutrient uptake increased as the rate of application of rice husk and clay increased. The number of grains per spike (Table 4) was significantly ($P < 0.05$) influenced by the treatments. Treatment RH_2HAC_2 recorded the highest number of grains per spike. This was earlier confirmed by Hall *et al.*, (2010) who

found that the addition of 15 t/ha clay to sandy top soil increased number of grains per spike in rice. The Grain yield had significant effect on the treatments. RH₁HAC₂ recorded the highest grain yield. This may be attributed to the high quality of N, K Mg and Ca as attested by Muktare *et al.* 2015).

Roychand and Marschner(2013) also found that the amendment of sandy soil with rice husk and clay rich sub soil could increase grain yield in wheat. The treatments had of significant (P<0.05) effect on straw yield of rice. Gupta (2002) reported high straw yield in rice where rice husk amended was combined with 8 t/ha clay. The treatments had significant (P<0.05) effect on one thousand (1000) grain weight. Treatment RH₂HAC₂ recorded the highest value of one thousand (1,000) grain weight. This was supported by findings of Samonite (2008) who recorded a similar result. They reported that the high magnesium (0.36cmolkg⁻¹) and Calcium (0.61cmolkg⁻¹) as being responsible for high yield in one thousand (1000) grain weight. Schweizer *et al.* (1999) reported increased soil organic carbon retention and a high one thousand grain weight where rice residues amendments were used in rice cultivation. This finding is in conformity with Oghoghodo *et al.* (1995) who found out that the incorporation of rice crop residues as being superior over removal or burning of crop residue practices possibly due to improved physical, chemical and biological properties of soils due to increase organic carbon content in the soil.

CONCLUSION

The result of study results showed that all the treatment had a significant effect on chemical and physical parameters of the soil.. Also most of the chemical and physical parameters such as organic carbon, phosphorus, potassium EC, CEC, pH increased at the end of the experiment. However sodium level in the soil decreased. Also, all the textures of the soils before the experiment (Loamy sand) was completely altered in the 16 treatments. This was a result of addition of various rates of clay to the soil. This was irrespective of the quantity of

crop residue applied. The treatments had significant effects on the plant height (8 and 12 weeks after transplanting), number of tillers, number of spikelets per spike, number of grains per spikelet, straw yield grain yield and one thousand 1000 grain. Treatment RH₂HAC₂ proved to be the best among the 16 treatments. Crop residues and high activity clay may be effective in improving the physical, chemical and biological properties of the soil. The need to assess and screen such materials to determine their suitability for soil amendment and amelioration is becoming increasingly important. Their use or re- investment and /or subsequent pollution site if left to accumulate unused.

Table 1: Physical and chemical properties of the soil before the experiment

Soil Property	
Sand (%)	70
Silt (%)	22
Clay (%)	8
Textural class	Loamy sand
pH (H ₂ O) 1:1	5.3
pH (CaCl ₂) 1:1	4.5
EC(dS/m)	0.27
Org.matter (g kg ⁻¹)	12.7
Total N (g kg ⁻¹)	0.95
Org.C (g kg ⁻¹)	5.02
Av. P (mg kg ⁻¹)	4.6
CEC (Cmol kg ⁻¹)	9.2
ExchCa (Cmol kg ⁻¹)	1.55
Exch Mg (Cmol kg ⁻¹)	1.36
Exch K (Cmol kg ⁻¹)	0.80
Exch Na (Cmol kg ⁻¹)	1.6

Table 2: Effect of crop residues and high activity clay on soil physical and chemical properties of the soil

TRT	pH (H ₂ O 1:1)	pH (CaCl ₂ 1:1)	CEC (Cmol kg ⁻¹)	EC (dS/m)	Ca (cmol kg ⁻¹)	Mg (cmol kg ⁻¹)	O.C (g kg ⁻¹)	O.M (g kg ⁻¹)	K (cmol kg ⁻¹)	N (g kg ⁻¹)	Avail P (mg/kg ⁻¹)	Exh Na (cmol kg ⁻¹)
RH ₂ HC ₂	6.93 ^{hi}	6.86 ^{ab}	11.8 ^a	0.57 ^h	2.13 ^c	12.20 ^a	24.0 ^h	68.70 ^h	0.97 ^c	0.66 ^d	7.63 ^a	0.11 ^e
RH ₁ HC ₂	6.83	5.70 ^f	11.0 ^a	1.18 ^{bc}	3.63 ^a	4.56 ^b	40.3 ^a	41.3 ⁿ	0.55 ^g	0.63 ^{de}	8.00 ^a	0.17 ^e
RS ₂ HC ₂	6.93 ^{hi}	6.86 ^{ab}	11.7 ^b	0.57 ^h	2.13 ^c	2.33 ^j	26.6 ^g	46.13 ^l	0.56 ^g	0.66 ^d	5.56 ^{cde}	0.21 ^b
RH ₂ HC ₁	6.96 ^h	6.86 ^{ab}	10.7 ^c	0.93 ^e	2.20 ^c	3.67 ⁱ	33.3 ^e	47.37 ^k	0.81 ^{de}	0.60 ^e	6.66 ^b	0.17 ^c
G ₂ HC ₂	7.26 ^a	6.96 ^a	10.7 ^d	0.83 ^f	2.40 ^{bc}	3.77 ^{ef}	39.0 ^b	69.20 ^a	0.75 ^e	0.73 ^c	4.80 ^{ef}	0.13 ^d
G ₂ HC ₁	7.15 ^{bcd}	6.83 ^{ab}	10.2 ^d	1.02 ^d	2.33 ^c	4.23 ^c	36.3 ^d	62.77 ^e	0.83 ^d	0.96 ^a	51.13 ^{def}	0.13 ^d
RS ₂ HC ₁	7.16 ^{abcd}	6.86 ^{ab}	10.1 ^d	0.57 ^h	2.17 ^c	2.80 ^h	27.7 ^g	47.37 ^k	0.81 ^{de}	0.76 ^c	5.43 ^{ef}	0.26 ^a
G ₁ HC ₂	7.13 ^{cd}	6.43 ^{cde}	9.97 ^e	0.93 ^e	2.67 ^b	3.70 ⁱ	38.7 ^{bc}	67.37 ^c	1.10 ^b	0.84 ^c	47.33 ^{ef}	0.17 ^c
RH ₁ HC ₁	6.86 ^j	6.06 ^{ef}	9.83 ^f	0.73 ^g	2.27 ^c	3.83 ^{de}	30.0 ^f	52.23 ^h	0.50 ^g	0.67 ^d	6.66 ^b	0.17 ^c
G ₁ HC ₁	7.06 ^{def}	6.53 ^{bcd}	9.77 ^f	1.13 ^c	2.13 ^c	3.50 ^g	35.8 ^d	63.63 ^d	0.60 ^f	0.84 ^c	4.86 ^{ef}	0.08 ^f
RS ₁ HC ₁	7.00 ^{efgh}	6.86 ^{ab}	9.71 ^f	1.60 ^a	3.47 ^a	3.70 ^{def}	27.7 ^g	48.13 ^j	0.55 ^g	0.76 ^c	5.26 ^{def}	1737 ^c
RS ₁ HC ₂	7.06 ^{defg}	6.80 ^{abc}	9.71 ^f	0.30 ⁱ	3.63 ^a	2.60 ⁱ	24.0 ^h	41.93 ⁿ	0.65 ^f	0.73 ^c	5.13 ^{def}	0.26 ^a
MH ₂ HC ₂	7.23 ^{abc}	7.00 ^a	9.57 ^g	0.56 ^h	2.27 ^c	3.83 ^d	26.0 ^g	43.13 ^m	0.54 ^g	0.60 ^{de}	5.73 ^{cd}	0.17 ^c
MH ₁ HC ₁	7.06 ^{def}	6.90 ^{ab}	9.24 ^h	1.13 ^c	2.13 ^c	2.67 ⁱ	37.6 ^c	68.50 ^b	0.51 ^g	0.73 ^c	6.23 ^{bc}	0.17 ^c
MH ₂ HC ₁	7.25 ^{ab}	7.03 ^a	9.17 ^h	0.60 ^g	2.24 ^c	3.63 ⁱ	29.0 ^f	51.53 ⁱ	0.56 ^g	0.67 ^d	5.70 ^{cd}	0.17 ^c
MH ₁ HC ₂	7.07 ^{de}	6.33 ^{de}	8.21 ⁱ	1.43 ^b	2.23 ^c	2.53 ⁱ	34.7 ^e	59.83 ^f	0.64 ^f	0.64 ^{de}	6.20 ^{bc}	0.17 ^c
P	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.01	<0.001	<0.001	0.001
S. E	0.03240	0.0324>	0.0458	0.03073	0.1083	0.03985	0.45	0.001	0.023	0.01555	0.2165	0.001113

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 3: Particle Size Distribution at the end of the Experiment

Treatment	% Sand	% Silt	% Clay	% Textural Class
G ₁ HAC ₁	50	30	20	Loam
G ₁ HAC ₂	36.4	33.4	30.2	Clay Loam
G ₂ HAC ₁	49	31	20	Loam
G ₂ HAC ₂	40.4	24.4	35.3	Clay Loam
MH ₁ HAC ₁	49.4	31.1	20.2	Loam
MH ₁ HAC ₂	42.4	22.4	35.2	Clay Loam
MH ₂ HAC ₁	44.3	35.3	20.4	Loam
MH ₂ HAC ₂	36.4	33.3	30.3	Clay Loam
RH ₁ HAC ₁	50	29	21	Loam
RH ₁ HAC ₂	30.2	39.4	30.4	Clay Loam
RH ₂ HAC ₁	49.4	31.1	20.2	Loam
RH ₂ HAC ₂	39	31	30	Clay Loam
RS ₁ HAC ₁	51	29	20	Loam
RS ₁ HAC ₂	24	40	36	Clay Loam
RS ₂ HAC ₁	50	30	20	Loam
RS ₂ HAC ₁	32.4	25.3	33.3	Clay Loam

Table 4: Effect of crop residues and high activity clay on growth parameters of rice in Sokoto (field experiment)

Treatment	Tiller (M²)	Plant height (cm) 4WATP	Plant height (cm) 8WATP	Plant height (cm) 12WATP
G ₁ HAC ₁	39.67 ^{bcd}	31.00 ^a	58.67 ^{cd}	70.33 ^{gh}
G ₂ HAC ₁	39.33 ^{bcd}	32.33 ^a	62.33 ^{bcd}	70.67 ^g
RS ₁ HAC ₁	38.33 ^{bcd}	34.00 ^a	64.67 ^{abcd}	82.33 ^{ef}
RS ₂ HAC ₁	37.00 ^{cde}	33.67 ^a	67.33 ^{abc}	87.00 ^{de}
RH ₁ HAC ₁	31.33 ^e	31.67 ^a	70.33 ^{ab}	94.00 ^{bcd}
RH ₂ HAC ₁	41.00 ^{abcde}	32.33 ^a	71.00 ^{ab}	98 ^{abc}
MH ₁ HAC ₁	35.67 ^{cde}	33.33 ^a	55.67 ^d	68.67 ^{gh}
MH ₂ HAC ₁	40.00 ^{bcd}	31.67 ^a	59.00 ^{cd}	71.33 ^{gh}
G ₁ HAC ₂	40.67 ^{abcde}	32.33 ^a	56.33 ^{cd}	69.67 ^{gh}
G ₂ HAC ₂	39.67 ^{bcd}	38.67 ^a	56.33 ^{cd}	73.00 ^{gh}
RS ₁ HAC ₂	32.67 ^{de}	32.67 ^a	56.33 ^{cd}	89.00 ^{de}
RS ₂ HAC ₂	34.67 ^{cde}	34.33 ^a	62.33 ^{bcd}	91.00 ^{cd}
RH ₁ HAC ₂	48.33 ^{ab}	33.67 ^a	73.67 ^a	99.00 ^{ab}
RH ₂ HAC ₂	50.67 ^a	33.67 ^a	71.00 ^{ab}	102.67 ^a
MH ₁ HAC ₂	42.33 ^{abcd}	32.33 ^a	56.00 ^{cd}	66.33 ^h
MH ₂ HAC ₂	43.33 ^{abc}	32.00 ^a	58.67 ^{cd}	75.67 ^{fg}
Significance	*	NS	*	*
SE	3.101	2.231	3.351	2.46
P – Value	0.010	0.832	0.002	0.001

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

* = Significant at 5% level of probability

NS = Not significant at 5% level probability

Table 5: Effect of crop residues and high activity clay on yield parameters of rice in Sokoto

Treatment	Number of Spikes	Number of grains perspike	Grain yield Kg^{ha}⁻¹	Straw yield Kg^{ha}⁻¹	One thousand grain weight (g)
G₁ HAC₁	7.66 ^{def}	9.00 ^{de}	3.88 ^{cd}	8.62 ^{cd}	23.07 ^{efg}
G₂ HAC₁	6.33 ^f	11.00 ^{bcde}	3.30 ^{cd}	11.33 ^{bc}	23.73 ^{ef}
RS₁ HAC₁	6.66 ^{ef}	9.33 ^{cde}	4.00 ^{cd}	8.40 ^{cd}	22.80 ^{efg}
RS₂ HAC₁	9.00 ^{bcde}	8.33 ^e	4.62 ^{cd}	8.29 ^{ed}	27.33 ^{cd}
RH₁ HAC₁	8.66 ^{bcd}	8.67 ^e	8.14 ^b	10.23 ^{bc}	30.50 ^{bc}
RH₂ HAC₁	9.66 ^{bcd}	12.33 ^{abcd}	8.47 ^b	13.67 ^b	32.50 ^b
MH₁ HAC₁	6.66 ^f	9.33 ^{cde}	2.63 ^{cd}	7.97 ^{cd}	19.87 ^g
MH₂ HAC₁	8.33 ^{cdef}	11.00 ^{bcde}	2.00 ^d	7.03 ^d	20.83 ^{fg}
G₁ HAC₂	9.33 ^{bcd}	10.00 ^{cde}	4.17 ^{de}	6.92 ^d	23.30 ^{efg}
G₂ HAC₂	9.33 ^{bcd}	12.00 ^{abcd}	4.18 ^{cd}	6.47 ^d	25.43 ^{de}
RS₁ HAC₂	10.33 ^{bc}	8.33 ^e	3.80 ^{cd}	8.58 ^{cd}	27.43 ^{cd}
RS₂ HAC₂	11.00 ^b	10.33 ^{bcde}	4.93 ^c	8.10 ^{cd}	28.53 ^{cd}
RH₁ HAC₂	13.67 ^a	13.33 ^{ab}	9.57 ^{ab}	13.53 ^b	30.67 ^{bc}
RH₂ HAC₂	15.00 ^a	15.00 ^a	11.68 ^a	17.77 ^a	38.17 ^a
MH₁ HAC₂	9.67 ^{bcd}	11.00 ^{bcde}	3.29 ^{cd}	8.067 ^{cd}	21.40 ^{fg}
MH₂ HAC₂	10.00 ^{bcd}	11.00 ^{bcde}	2.82 ^{cd}	7.140 ^d	21.72 ^{fg}
Significance	*	*	*	*	*
SE	0.726	0.982	0.798	1.057	1.130
P – Value	0.001	0.001	0.001	0.001	0.001

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

* = Significant at 5% level of probability

NS = Not significant at 5% level probability

Acknowledgement

We wish to acknowledge TFTFund for providing the funds for this research through the Institutional Based Research (IBR) fund accessed through the Usmanu Danfodiyo University, Sokoto-Nigeria

REFERENCES

- Ahmad, N. (2015). *Fertilizer use efficiency in Rice*. paper presented on rice research and production, 29th – 31 March, 1988 Islamabad, Pakistan.
- Anderson, F.N. and Peterson, G.A. (1973). Effect of continuous corn (*Zeamays L.*) manuring and N fertilization on yield and protein content. *Agronomy Journal* 65:697-700
- Ashrif, M.I., and Thornton, I. (1965). Effect on grass mulch on groundnut in Gambia, *Journal of Agriculture* 1:145-152.
- Bell, R.W., Dell, B. and Huang, L. (2004). Importance of micro nutrients in crop production. In: International Fertilizer Association symposium on Micro-nutrients Delhi, 23-25 Feb, 2004. Published at <http://www.fertilizer>.
- Brady, N and Weil, R.R. (1999). *The nature and properties of soil*, 12th Edition. Prentice Hall Incorporation, London, 881 pp.
- Chude, V.O., Jayeoba, O.J. and Berdin, F. (2011). A soil fertility map of Nigeria showing different P,N,Zn, B and K classes of the top soil. National Programme for Food Security, Adekunle Ademola Crescent, Wuse, Abuja, Nigeria. 8pp.
- Esu, I.E. (1991). Detailed soil survey of NIHORT Farm at Bunkure, Kano State, Nigeria. Institute for Agricultural Research, Ahmad Bello University, Zaria, Nigeria. 72 pp.
- Gupta, R. (2002). Study on agroclimatic condition and productivity pattern of sugarcane in India. *Sugar Technology*, 6 (3): 142-149.
- Hall, D.J.M., Jones, H.R.H., Crabtree, W.L., and Daniels, T.L. (2010). Claying and dip ripping can increase crop yields and profits on water repellent sands with marginal fertility in Southern Western Australia. *Australian Journal of Soil Research* 48:178-187.
- Ishida, H., Chairaj, P., Morakul, P, and Wongwiwachai, C. (1993). Techniques to improve productivity of sandy upland soil in Northeast Thailand. ADRC technical paper No. 10. (Agricultural Development Research Centre) 45p.
- Kaur, N. and Benipal, D.S. (2006). Effect of crop residue and farmyard manure on K forms in soils of long-term fertility experiment. *Indian Journal of crop science*, 1(2): 161-164.

- Lal, R. (1997). Residue Management, conservation tillage and soil restoration for mitigating greenhouse effect by CO₂ – enrichment. *Soil and Tillage Research* 43: 81-107.
- Lal, R. (2014). Farm Management: encyclopedia of Agriculture and Food systems, ACADEMIC Press, 100-112.
- Landon, J.R. (1991). Booker Tropical Soil Manual. A hand-book for soil survey and agricultural land evaluation in the tropics and subtropics. John Wiley and sons Publishers, New York. 841pp.
- Mckissock, I., Gilkes, R.J., and Walker, E.L. (2002). The reduction of water repellency by added clay as influenced by clay and soil properties. *Applied Clay Science* 20:225-25
- Masters, B. (2010). “Best Practice Clay Spreading and delving- a summary of responses to a survey of clay spreading and delving contractions”. Final report. Rural solutions SA. *Agronomy* 6:86-92.
- Muktar, S., Rahman, M.M. and Morrtoza, M.G (2005). Yield and nutrient content of tomato as influenced by the application of vermicompost and chemical fertilizers. *Journal of Environmental Sciences and Natural Resources*, 8 (2): 115-122.
- Oghoghodo, I.A. and Hegar, P.I. (1995). The use of cassava Peels and Rice Husk as Soil Ammendments. *Nigerian Agriculture Journal* 28:96-100.
- Oghoghodo, I.A., Akpowhere, M.S. and Chokor, J.U. (2008). The effects of rice husk and abbatoir effluent on soil properties, nutrient uptake, microbial species and some maize (*Zea mays* l.) growth parameters II: field experience. *Nigerian Journal of Soil Science*. 18:39-47.
- Roychand, P. and Marschner, P. (2013). Respiration in a sand amended with clay Effect of residue type and rate. *European Journal of Soil Biology*, 58:19-23.
- RMRDC (2005). *Rice: A survey report of ten selected agro raw material in Nigeria*. Maiden edition. Raw materials research and development council, 17 Aguiyi Ironsi Street, Maitama Garki Abuja, Nigeria.
- Samomite, S.O. (2008). Nitrogen and rice and its research at texas Agrilife. *Texas Rice* 8(2) 1-9

- Schweizer, M., Fear, J. and Cadisch, G. (1999). Isotopic (^{13}C) fractionation during plant residue decomposition and its implications for soil organic matter studies. *Rapid Communications in Mass Spectrometry* 13:1284-1290.
- Singh, L., Verma, R.N.S. and Lohia, S.S. (1980). Effect of continuous application of FYM and chemical fertilizer on some soil properties. *Journal of the Indian Society of soil science*, 28:170-172.
- Vanlauwe, B., Dendoven, L., Merckx, R. (1994). Residue fractionation and decomposition: the significance of the active fraction. *Plant and soil* 158:263-274.
- Wada, H. (1996). Dissimilarities between Japanese and Thai paddy soils. In: Attanadana, T. (ed). proceedings of international symposium on maximizing sustainable rice yield through improved Soil and Environmental Management. Nov. 11-17, 1996, Khonkae Thailand. 743-758.
- Walkey, A. and Black, C.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposal modification or chronic acid titration method. *Soil Sci.* 37: 29-38.

APPEND IX I

Critical Limit for Interpreting Levels of Analytical Soil Parameter

Parameter	Rating			Units
	Low	Medium	High	
Ca ⁺⁺	< 2	2-5	> 5	cmol (+) kg ⁻¹
Mg ⁺⁺	< 0.3	0.3 – 10	> 1.0	cmol (+) kg ⁻¹
K ⁺	< 0.15	0.15-0.30	> 0.30	cmol (+) kg ⁻¹
Na ⁺	< 0.1	0.1-0.3	> 0.30	cmol (+) kg ⁻¹
CEC	< 6	6-2	> 12	cmol (+) kg ₁
Organic C	< 10	10-15	> 15	gkg ₁
Total N	< 0.1	0.1-0.2	> 0.2	Percent
Available P	< 10	10-20	> 20	mg kg ⁻¹
Base Saturation	< 50	50-80	> 80	percent

Source: Esu(1991)

FIELD LAYOUT OF THE EXPERIMENTAL AREA

