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The Use of Crop Residues and High Activity Clays for the Management of Sandy Soils for Rice Production in Sokoto, North-Western Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 5 tha^{-1} and 10 tha^{-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 texturally was also significantly influenced by the treatments. The texture of the soil, which was initially loamy sand 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).

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1. 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 [1]. 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 [2,3,4].

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 [5]. 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 [6].

Rice belongs to the tribe *Oryzeae,*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 [7]. 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 [8] 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 [9]. 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 [10]. One of such inadequate technologies is the use of crop residues and high activity clay for sustainable rice production [7].

2. MATERIALS AND METHODS

2.1 Experimental Site and Materials Used

The experiment was carried out at the Fadama Teaching and Research Farm, Faculty of Agriculture, 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 4 kilometers North east of sokoto town in sokoto state, Nigeria latitude 12^o 45.78' N, longitude 5^o 25.58' and 256m mean sea level. The soils of the farm are mostly loamy sand in texture. The land was divided into 48 plots each measuring 3 X 3 m. Three replicates were used with 1 m and 25 cm as spacing between and within rows and laid out in a Randomized Complete Block Design (RCBD) with 16 treatment combinations. The gross plot was 9 m^2 (3 m x 3 m) with a net plot area of 7.56 m^2 (2.75 X 2.75) and total experimental area of 591.25 m^2 (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.

2.2 Experimental Layout

The total number of plots were 48 with each measuring 9 m^2 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.

2.3 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 [11] method. Total nitrogen was determined by the Micro khjeldal method. Available phosphorus extraction was done using Bray 1 solution [12] 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 Ca^{2+}, Mg^{2+} K^{+} and Na^{+}. Soil pH was measured in both water (1:1) and 0.01m $Cacl_2$ (1:2.5). Particle size distribution was carried out using the hydrometer method.

Treatment Combinations	**Acronyms**
Groundnut shell 5 tha^{-1} + HAC, 10 tha^{-1}	G_1HAC_1
Groundnut shell 10 tha^{-1} + HAC 15 tha^{-1}	G_2HAC_2
Rice straw 5 tha^{-1}+ HAC 10 tha^{-1}	RS_1HAC_1
Rice straw 10 tha^{-1} + HAC 15 tha^{-1}	RS_2HAC_2
Rice husk 5 tha^{-1} + HAC 10 tha^{-1}	RH_1HAC_1
Rice husk 10 tha^{-1} + HAC 15 tha^{-1}	RH_2HAC_2
Millet husk 10 tha^{-1} + HAC 10 tha^{-1}	MH_1HAC_1
Millet husk 10 tha^{-1}+ HAC 15 tha^{-1}	MH_2HAC_2
Groundnut shell 5 tha^{-1} + HAC 15 tha^{-1}	G_1HAC_2
Groundnut shell 10 tha^{-1} + HAC 10 tha^{-1}	G_2HAC_1
Rice straw 5 tha^{-1} HAC + 15 tha^{-1}	RS_1HAC_2
Rice straw 10 tha^{-1} + HAC 10 tha^{-1}	RS_2HAC_1
Rice husk 5 tha^{-1} + HAC 15 tha^{-1}	RH_1HAC_2
Rice husk 10 tha^{-1} + HAC 10 tha^{-1}	RH_2HAC_1
Millet husk 5 tha^{-1} + HAC 15 tha^{-1}	MH_1HAC_2
Millet husk 10 tha^{-1} + HAC 10 tha^{-1}	MH_2HAC_1

3. 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. [13], ranged from acidic with mean values of 5.2 (1:1 soil water ratio) and pH measured in $CaCl_2$ (1:1 soil solution ratio) was 4.5. Exchangeable cations (Ca, Mg, K, Na) were low.

The treatments had significant effect ($P< 0.05$) on soil pH both in water and $CaCl_2$. The initial pH recorded before the experiment were 5.3 and 4.5 for pH in (H_2O) and pH in ($CaCl_2$) respectively (Table 2). This shows that, the pH was strongly acidic [9]. The pH value recorded on MH_2HAC_2 (7.3) which is slightly alkaline for pH in (H_2O) and 7.0 neutral for pH in ($CaCl_2$). The significant increase in the soil pH on all treatments might be because of the release of basic cations by the crop residues [14].

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 [11] 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 [15] 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 [16].

The treatment (Table 2) had significant effect on CEC. Treatment RH_1HAC_2 had the highest CEC (11.83 $Cmolkg^{-1}$) Singh et al., [17] 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 [18]. Treatment RH_1HAC_2 recorded the highest value of Available Phosphorus. Brady and Weil [1] 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 [19].

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 [15].

The treatments had significant effect on exchangeable potassium. The highest value was recorded by treatment RH_2HAC_2. Kaur and Benepal [20] 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 cmolkg^{-1}). This value is low according to the rating of Esu [18].

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 [21] who reported that soils of EC levels of 0-2 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 10tha^{-1} high activity clay was incorporated had their textural class altered to Loamy soil while all treatments where 15tha^{-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 [22].

The tiller count of rice inTable 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 Muktar et al., [23]. 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, [24] who found that application of rice husk combined residues produced the highest plant height.

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_2O) 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
Avail. P (mg kg^{-1})	4.6
CEC (cmol kg^{-1})	9.2
Exch. Ca (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_2O 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})	Exch Na (cmol kg^{-1})
RH_2HAC_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_1HAC_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_2HAC_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_2HAC_1	6.96^{fh}	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_2HAC_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_2HAC_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_2HAC_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_1HAC_2	7.13^{cd}	6.43^{cde}	9.97^{e}	0.93^{e}	2.67^{b}	3.70^{f}	38.7^{bc}	67.37^{c}	1.10^{b}	0.84^{c}	47.33^{ef}	0.17^{c}
RH_1HAC_1	6.86^{ij}	6.06^{ef}	9.83^{f}	0.73^{g}	2.27c	3.83^{de}	30.0^{f}	52.23^{h}	0.50^{g}	0.67^{d}	6.66^{b}	0.17^{c}
G_1HAC_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}	0.08f
RS_1HAC_1	7.00^{efgh}	6.86^{ab}	9.71^{f}	$1.6\ 0^{a}$	3.47^{a}	3.70^{def}	27.7^{g}	48.13^{j}	0.55^{g}	0.76^{c}	5.26^{def}	1737^{c}
RS_1HAC_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_2HAC_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}	0.54g	0.60^{de}	5.73^{cd}	0.17^{c}
MH_1HAC_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_2HAC_1	7.25^{ab}	7.03^{a}	9.17^{h}	0.60^{g}	2.24^{c}	3.63^{f}	29.0^{f}	51.53^{i}	0.56^{g}	0.67^{d}	5.70^{cd}	0.17^{c}
MH_1HAC_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_1HAC_1	50	30	20	Loam
G_1HAC_2	36.4	33.4	30.2	Clay Loam
G_2HAC_1	49	31	20	Loam
G_2HAC_2	40.4	24.4	35.3	Clay Loam
MH_1HAC_1	49.4	31.1	20.2	Loam
MH_1HAC_2	42.4	22.4	35.2	Clay Loam
MH_2HAC_1	44.3	35.3	20.4	Loam
MH_2HAC_2	36.4	33.3	30.3	Clay Loam
RH_1HAC_1	50	29	21	Loam
RH_1HAC_2	30.2	39.4	30.4	Clay Loam
RH_2HAC_1	49.4	31.1	20.2	Loam
RH_2HAC_2	39	31	30	Clay Loam
RS_1HAC_1	51	29	20	Loam
RS_1HAC_2	24	40	36	Clay Loam
RS_2HAC_1	50	30	20	Loam
RS_2HAC_2	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 (m^2)	Plant height (cm) 4 WATP	Plant height (cm) 8 WATP	Plant height (cm) 12 WATP
G_1 HAC_1	39.67^{bcde}	31.00^{a}	58.67^{cd}	70.33^{gh}
G_2 HAC_1	39.33^{bcde}	32.33^{a}	62.33^{bcd}	70.67^{g}
RS_1 HAC_1	38.33^{bcde}	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^{bcde}	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^{bcde}	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 Duncan's New Multiple Range Test (DNMRT) * = Significant at 5% level of probability NS = Not significant at 5% level probability*

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 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. [25], 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., [22] who found that the addition of

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 $kgha^{-1}$	Straw yield $kgha^{-1}$	One thousand grain weight (g)
G_1 HAC_1	7.66^{def}	9.00^{de}	3.88^{cd}	8.62^{cd}	23.07^{efg}
G_2 HAC_1	6.33^{f}	11.00^{bcde}	3.30^{cd}	11.33^{bc}	23.73^{ef}
RS_1 HAC_1	6.66^{ef}	9.33^{cde}	4.00^{cd}	8.40^{cd}	22.80^{efg}
RS_2 HAC_1	9.00^{bcde}	8.33^{e}	4.62^{cd}	8.29^{ed}	27.33^{cd}
RH_1 HAC_1	8.66^{bcd}	8.67^{e}	8.14^{b}	10.23^{bc}	30.50^{bc}
RH_2 HAC_1	9.66^{bcd}	12.33^{abcd}	8.47^{b}	13.67^{b}	32.50^{b}
MH_1 HAC_1	6.66^{f}	9.33^{cde}	2.63^{cd}	7.97^{cd}	19.87^{g}
MH_2 HAC_1	8.33^{cdef}	11.00^{bcde}	2.00^{d}	7.03^{d}	20.83^{fg}
G_1 HAC_2	9.33^{bcd}	10.00^{cde}	4.17^{de}	6.92^{d}	23.30^{efg}
G_2 HAC_2	9.33^{bcd}	12.00^{abcd}	4.18^{cd}	6.47^{d}	25.43^{de}
RS_1 HAC_2	10.33^{bc}	8.33^{e}	3.80^{cd}	8.58^{cd}	27.43^{cd}
RS_2 HAC_2	11.00^{b}	10.33^{bcde}	4.93^{c}	8.10^{cd}	28.53^{cd}
RH_1 HAC_2	13.67^{a}	13.33^{ab}	9.57^{ab}	13.53^{b}	30.67^{bc}
RH_2 HAC_2	15.00^{a}	15.00^{a}	11.68^{a}	17.77^{a}	38.17^{a}
MH_1 HAC_2	9.67^{bcd}	11.00^{bcde}	3.29^{cd}	8.067^{cd}	21.40^{fg}
MH_2 HAC_2	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*

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. RH_1HAC_2 recorded the highest grain yield. This may be attributed to the high quality of N, K Mg and Ca as attested by Muktar et al. [23].

Roychand and Marschner [26] 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 significant ($P<0.05$) effect on straw yield of rice. Gupta [27] 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 RH_2HAC_2 recorded the highest value of one thousand (1,000) grain weight. This was supported by findings of Samonite [28] who recorded a similar result. They reported that the high magnesium (0.36 $cmolkg^{-1}$) and Calcium (0.61 $cmolkg^{-1}$) as being responsible for high yield in one thousand (1000) grain weight. Schweizer et al. [29] 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. [30] 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.

4. CONCLUSION

The result of the study 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 and pH increased at the end of the experiment. However sodium level in the soil decreased. Also, the textural classes of the soil were found to have changed as a result of the incorporation of high activity clay (HAC) in the treatments. 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 grain weight. Treatment RH_2HAC_2 proved to be the best among the 16 treatments. Crop residues and high activity clays are therefore promising in improving the physical and chemical properties of the soil judging by the findings of this study.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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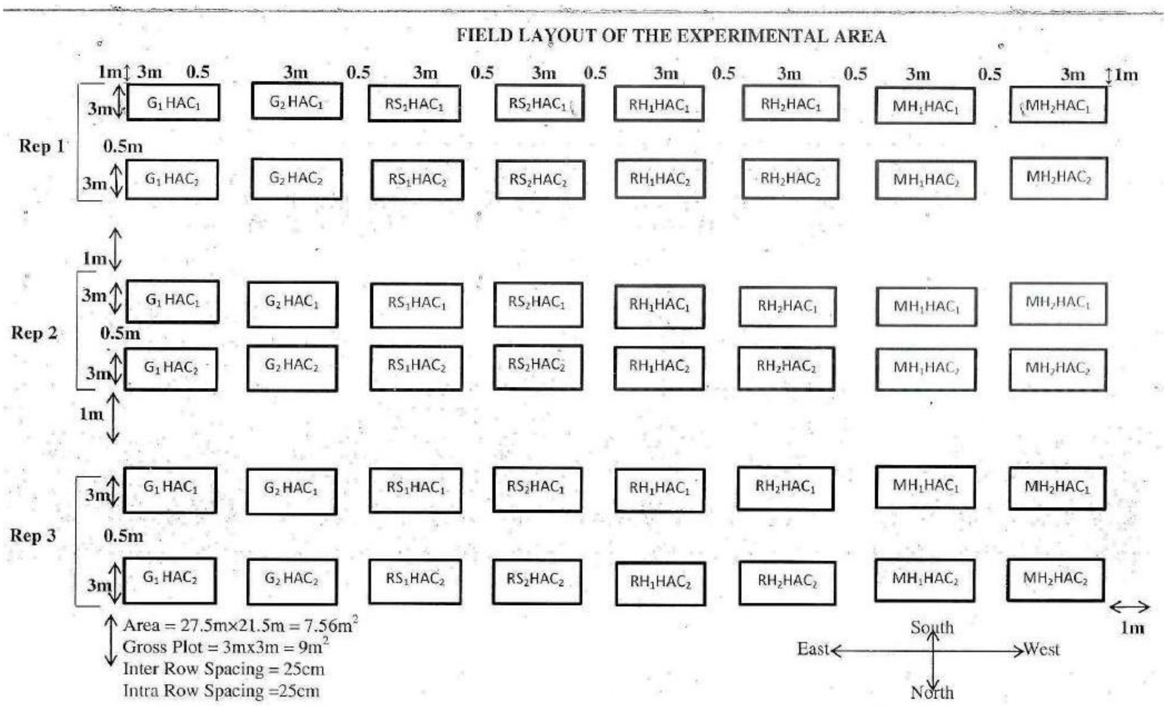
APPENDIX I

Critical Limit for Interpreting Levels of Analytical Soil Parameter

Parameter	Low	Medium	High
Org. C (g/kg)	<10	10-15	>15
TN(g/kg)	<0.1	0.1-0.2	>0.2
AP (mg/kg)	<10	10-20	>20
Ca^{2+} (cmol/kg)	<2	2-5	>5
Mg^{2+} (cmol/kg)	< 0.3	0.3-1	>1.0
K^{+} (cmol/kg)	<0.15	0.15-0.3	>0.3
Na^{+} (cmol/kg)	<0.1	0.1-0.3	>0.3
CEC (cmol/kg)	<6.0	6-12	>12
Base salt (%)	<30	30-80	>80

Source: Esu 1991

APENDIX II



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