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EFFECT OF MILLET CHAFF AS ORGANIC AMENDMENT ON RICE YIELD IN SODIC SOIL - A CASE STUDY OF THOMAS IRRIGATION SCHEME IN KANO, NIGERIA

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ABSTRACT

Soil sodicity is one of the major threats affecting the quality of soil globally. Soil sodicity problems remain a critical issue of concern as it adversely affects the yield of crops. This study assessed the effect of millet chaff in ameliorating sodium-affected soils at Thomas Irrigation Scheme in Kano, Nigeria. The experiment consisted of three levels of millet chaff application plus a control labelled (M_1 = 1.44 kg/m^2, M_2 = 1.08 kg/m^2, M_3 = 0.68 kg/m^2 and C = Control). The treatments were replicated three times in a Randomized Complete Block Design and rice seedlings were transplanted in each plot. The results showed a significant difference of soil quality parameters in the treated plots. The pH of soil samples was found to be 5.93, 6.067 and 5.5 for M_1, M_2, and M_3 with percentage pH decrease from the control plot (C = 9.49) of 62, 64, and 58% respectively Similarly, the Sodium Adsorption Ratios were 5.723 for C, 0.188 for M_1, 0.133 for M_2 and 0.112 for M_3. Statistical analysis revealed that there was a significant difference in soil quality indicators from plots treated with millet chaff and that of control. However, the study showed no significant difference in the yield harvested between the treated plots and the control. This suggests that using millet chaff for a sodicity amendment has no significant effect on the yield of a rice crop in the study area because all the prevailing soil properties are within the FAO acceptable range for growing rice.

Keywords: Efficiency, Feeds, Firms, Ingredients and Poultry

INTRODUCTION

Soil is vital to the sustainability of life on earth because almost all the foods consumed by humans are grown on the earth's surface (Schoonover and Crim, 2015). Therefore, soils are of utmost importance as they play a significant role in attaining food security which is one of the major challenges now affecting the world. In many there are several problems that have been found to adversely affect the physical, chemical, biological and morphological properties of soil (Arsham et al., 1996; Kassu et al., 2017) and hence, fertility including erosion, salinity and sodicity. Soil salinity and sodicity are problems faced mainly in the arid and semi-arid regions. In humid regions, water leaches down the dissolved salt which makes salt problems rare (Bernstein, 1975). Soil salinity and sodicity reduce the quality of the soil and therefore decrease crop productivity. Accumulation of soluble salt in the soil solution poses a threat to agricultural production because it reduces yield and, in some cases, results in total failure of the crop. The accumulation of dispersive cat-ions such as potassium and sodium in the soil solution and the exchange phase affect the physical properties of the soil including hydraulic conductivity, structural stability and infiltration which will, in turn, affect crop production (Shainberg and Letey, 1984). Global salt-affected soils report revealed that, 340 million ha (23%) of cultivated lands are saline and 500 million ha (37%) are sodic (Szabolcs, 1980). In the arid and semi-arid regions, salinization and sodification of soils are gradually increasing and the world as a whole is estimated to lose at least 3 hectares of fertile soil every minute as a result of salinization/sodification (Aprol et al., 1988).

Sodic soil has a high concentration of sodium cations in the exchange complex or in the soil water, which affects the soil's physical and chemical properties. The breakdown of macronutrients (slaking), the release of individual clay platelets from aggregates (dispersion), and crusting are all examples of physical changes. These physical changes have a serious impact on the hydraulic conductivity, seedling emergence, and water retention capacity of the soil. Sodic soils have lower electrical conductivity (EC), but a high amount of sodium ion (Na^+) occupying exchange site. Often, this results in the soil having pH at or above 8.5; Abdullahi et al., 2021).

Preliminary surveys have revealed the existence of soil sodicity at Thomas Irrigation Scheme. Researchers have previously used several ways of soil supplements to lessen the effect of sodium on damaged soils and crops. However, Nasidi et al., (2018) discovered that applying millet chaff as an organic amendment to sodium-affected soils lowered the amount of sodicity in the soil. However, a field experiment has not been conducted using certain crop to evaluate the extent of soil reclamation and yield in the study area. On this background, this study aimed at evaluating the effect of millet chaff on sodic as soil amendment and its effect on rice yield.

MATERIALS AND METHODS

Study area

The study was carried out in cultivable lands located around Thomas Irrigation Scheme in Danbatta Local Government Area, Kano State, Nigeria. The Irrigation Scheme covers an area of 732 km^2. The experimental area has geographical coordinates 12° 25' 59" North and 8° 30' 55" East (Figure 1). The study area is being characterized by a mean temperature of 36°C and a yearly rainfall of about 780 mm. The crops grown in the irrigation project include rice, millet, maize, onions, tomatoes, cucumber among others (Adamu et al., 2022; Nasidi et al., 2018; Lawal et al., 2021).

Field survey

A survey of the study area was carried out in order to observe the nature of the soil, the response of crops to the affected area, size of the affected land, method of irrigation and the quality of the irrigation water to ascertain the claims of Nasidi et al., (2018). Plate one shows the soil condition in the experimental site and by the way of physical observations, some of the claims were obvious. To further confirm the claims, some chemical properties such as soil pH, EC, concentration of metallic ions, CEC etc. were then determined along with field experiments.

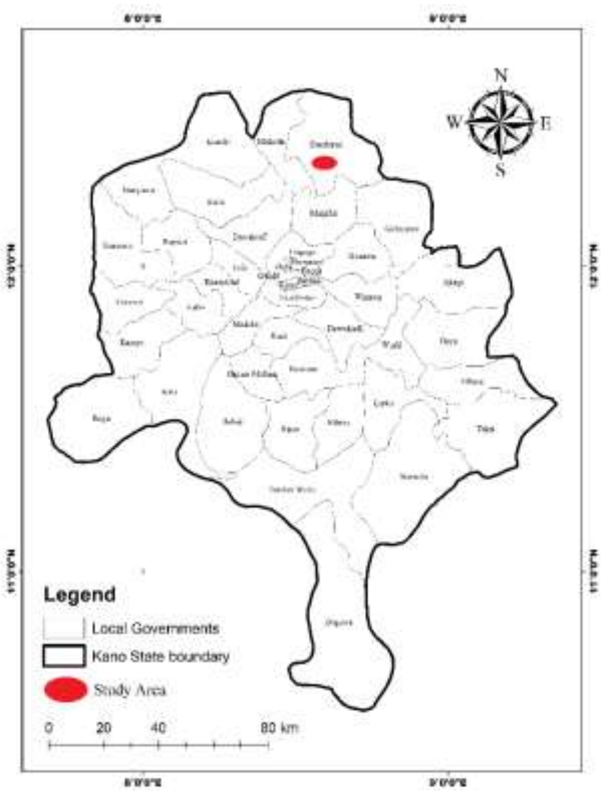

Figure 1 Study Area

Plate 1: Soil condition at the experimental field

Sample collection

The soil samples were collected according to Nasidi *et al*., (2015) to ensure good representative samples were collected. Within the experimental plot, samples were selected at random by dividing the area into three units and randomly selecting one from each unit. The samples were taken at 0-40 cm depth, the soil samples were taken before and after application of the amendment for laboratory analyses.

Laboratory Analysis

The soil sample were taken to the laboratory for analyses (Soil pH, electrical conductivity, concentration of Calcium, Magnesium, Sodium, Potassium, and Sodium Adsorption Ratio).

Determination of Soil pH and Electrical Conductivity (EC)

Soil pH was determined using pH meter in the laboratory and soil electrical conductivity was determine using saturation extraction method described in Udo *et al.,* (2009)

Determination of Calcium and Magnesium

The concentrations of Calcium and Magnesium in the experimental field soil were determined using the ElMahi et al., (1987) technique.

Determination of Sodium and Potassium

The available Potassium and Sodium in the soil were determined using the photometer flame technique.

Determination of Sodium Adsorption Ratio (SAR)

Sodium Adsorption Ratio was determined using Gapon equation as described in equation 1 (Quirk, 2001; Sumner, 1993).

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \quad (1)$$

Where:

SAR = Sodium adsorption ratio

Na, Ca and Mg = concentration of Sodium, Calcium and Magnesium in the soil solution (Cmol/kg)

Other chemical properties such as cation exchange capacity (CEC), carbonate concentration and bicarbonate concentration were also determined using standard laboratory procedure (Garuba et al., 2021).

Experimental Field Layout and Agronomic Operation

A land area of 8m × 6m was prepared into labelled basins of 2 m × 2 m as shown in plate 2. Four experimental plots were prepared and labelled as M_1, M_2, M_3, and C where C is control. Treatment was assigned randomly to each of the four experimental plots. The treatments consisted of application of various quantity of millet chaff which are (M_1 = 0.68 kg/m^2, M_2 = 1.08 kg/m^2, M_3 = 1.44 kg/m^2 and C = Control – No chaff was applied). Three times the four treatments were reproduced, for a total of twelve experimental treatments. The experimental design used the Randomized Complete Block Design (RCBD).

Nasidi et al., (2018) advocated applying millet chaff to the basins one month before planting (2018). To effectively eliminate all the weeds, the ground was sprayed with Glyphotex (Glyohosate IPA 41 percent SL) herbicide and left for two weeks as directed by the manufacturer.

The field was irrigated before transplanting. Rice seedlings (Jamila variety) were transplanted. Transplanting was done at plants spacing of 15 cm between plants and between rows (Plate 3). Manual weeding was carried out 15 days after transplanting and after another 15 days, Propashi (Propanil 360G/L + 2, 4-D Amine 200G/ L SL) herbicide was applied to the field. Plate 4 depicts paddy at fully maturity and ready for harvesting while Plate 5 and 6 shows how the harvesting of paddy was carried out.

Plate 2: Experimental plots

Plate 3: Transplanting of rice

Plate 4: Fully matured rice on days of harvesting

Plate 5: Paddy Rice at maturity ready for harvest

Plate 6: Harvested Paddy Rice

Computation of rice yield

As shown in plates 7 and 8, the rice yield was calculated for each of the experimental plots using equation 2 in accordance with (Igbadun et al., 2012).

$$Y = \frac{W}{A}\left(Kg / m^2\right) \qquad 2$$

Where Y is the rice yield (kg/m^2), W is the weight of harvested rice (kg) and A is the plot area of the harvested tomatoes (m^2).

Plate 7: Plots Harvested Paddies

Plate 8: Weighing of Harvested Paddies

Statistical analysis

The T-test was used to statistically analyse the influence of millet chaff on soil before and after application on sodic soil, as well as to compare the results with those obtained by Nasidi et al., (2018). The effect of millet chaff amendment on rice yield was also determined using analysis of variance (ANOVA).

RESULTS AND DISCUSSIONS

Soil analysis

Table 1 shows the average chemical characteristics of the soil before and after amendment treatment. The results of soil pH, EC, SAR and CEC were found to be 9.49, 1.11 ds/m, 5.72 and 10.43 cmol/kg in the control plot respectively. Other chemical properties of the soil were also presented in the same table.

Table 1: presents the mean values of chemical properties of the soil in the control plots and after application of millet chaff

Soil parameters	Control	M_1	M_2	M_3	Standard (FAO)
pH	9.49	5.93	6.07	5.50	6 – 8.5
EC(ds/m)	1.11	0.09	0.05	0.15	0 – 4
CO3 (mg/kg)	90.00	125.17	101.33	84.33	
HCO3 (mg/kg)	1142.33	252.50	222.71	170.35	
SAR	5.72	0.19	0.13	0.11	0 – 15
Ca (cmol/kg)	1.79	4.43	4.06	4.83	0 – 5
Mg (cmol/kg)	1.34	1.61	1.21	1.43	0 – 3
Na (cmol/kg)	7.04	0.32	0.18	0.20	
K (cmol/kg)	0.39	0.66	0.55	0.57	0 – 2
CEC (cmol/kg)	10.43	7.04	6.00	7.04	0 – 10

Table 2 shows the result of statistical analyses that compared the mean values of chemical properties of the experimental field soil before and after application of the amendments.

Table 2: Statistical analysis of the soil before and after the application of millet chaff

Soil Parameters	Mean		t-statistics	t-critical	Comment
	Before	After			
pH	9.49	6.74675	2.974168	2.353363	*
EC (dS/m)	1.107	0.3485	2.990966	2.353363	*
CO_3 (mg/Kg)	90	100.2075	-1.12914	2.353363	ns
HCO_3 (mg/Kg)	1142.33	446.9725	2.991984	2.353363	*
Ca (cmol/Kg)	1.785	3.7765	-2.91765	2.353363	*
Mg (cmol/Kg)	1.342	1.39975	-0.68222	2.353363	ns
Na (cmol/Kg)	7.044	1.938	2.999514	2.353363	*
K (cmol/Kg)	0.398	0.5455	-2.73051	2.353363	*
CEC (cmol/Kg)	10.43	7.628	2.902352	2.353363	*
SAR	5.723	1.539	2.999802	2.353363	*

*- Significant; ns – Not Significant at 5% LOS

Table 3: Statistical analysis of soil after application of millet chaff compared to that of (Nasidi et al., 2018)

Soil Parameters	Mean		t-statistics	t-critical	Comment
	Nasidi et al 2018	Zakari et al 2018			
pH	8.4825	6.74675	3.76055355	2.353363	*
EC (dS/m)	0.66175	0.3485	1.17295723	2.353363	ns
CO3 (mg/kg)	0	100.2075	-11.084814	2.353363	*
HCO3 (mg/kg)	5290	446.9725	2.25170699	2.353363	ns
Ca (cmol/kg)	2.21	3.7765	-1.9321625	2.353363	ns
Mg (cmol/kg)	0.405	1.39975	-14.276574	2.353363	*
Na (cmol/kg)	2.515	1.938	2.20202811	2.353363	ns
K (cmol/kg)	0.8975	0.5455	3.26142699	2.353363	*
CEC (cmol/kg)	5.3	7.628	-2.0982655	2.353363	ns
SAR	2.4925	1.539	1.97419448	2.353363	ns

*- Significant; ns – Not Significant at 5% LO

pH of soil

The result of the soil pH test is presented in Figure 2 and is compared with the result obtained by Nasidi et al., (2018). The average pH value of the control sample was found to be 9.49 and is out of the standard range (FAO, 2005). After treatment, the average values of pH for the soils treated with varying quantity of millet chaff reduced to 5.93, 6.07 and 5.50 for M_1, M_2, and M_3, respectively (Table 1) and are suitable for rice cultivation since rice grows optimally in acidic soils (Aondoakaa and Agbakwuru, 2012). Also, Table 3 shows that there is significant difference between the result of pH obtained and that of Nasidi et al., (2018) since t-statistics is greater than t-critical at 5% Level of Significance (LOS). This is due to the fact that there was a higher percentage reduction in pH after treatment (M_1=37.51%, M_2=36.07% and M_3=42.04%) than that reported by Nasidi et al., (2018) (M_1=19.33%, M_2=18.93% and M_3=18.32%). However, some of the values obtained are within the standard range and indicate safe for rice growth (FAO, 2005). Table 2 illustrates the mean variation in soil pH before and after millet chaff application as a statistical outcome. From the table 3, t-statistics is greater than t-critical meaning that the amendment is significant on soil pH at 5% level of significance (LOS).

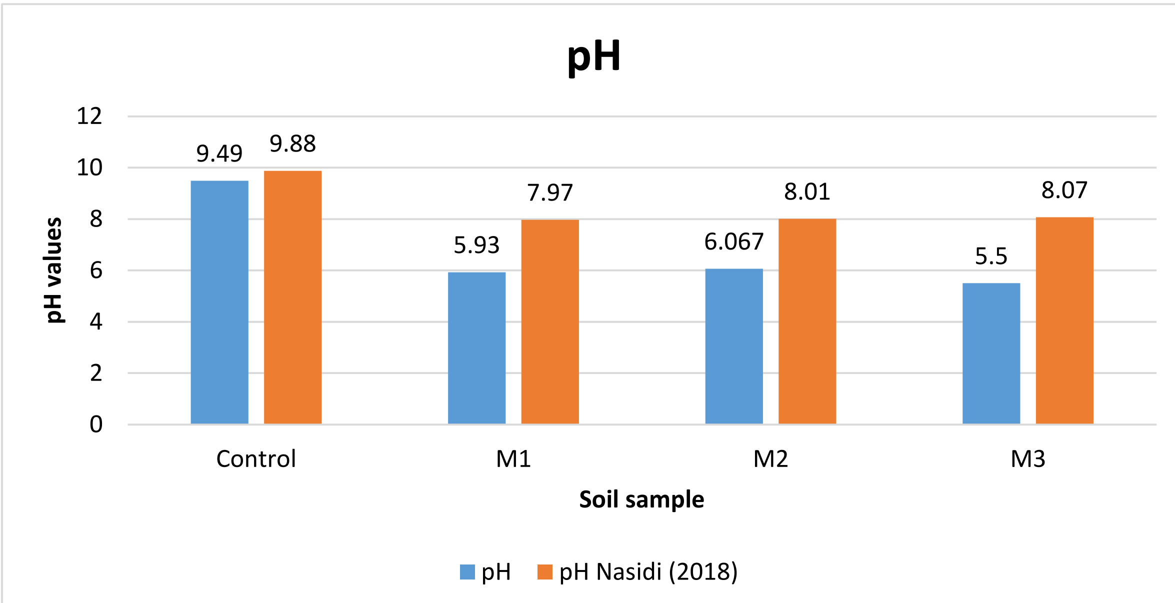

Figure 2: pH of soil sample

EC of soil sample

The results for soil electrical conductivity (EC) test is presented in Figure 3 and compared with the result obtained by Nasidi et al., (2018). The average E.C value for the control sample was found to be 1.107 dS/m and lies in the range of low salinity zone (FAO, 2005). There is a large difference between the EC obtained in the control plot and that of (Musa, 2017) which might be due to heterogeneity of soil. After application of millet chaff, the average values of E.C reduced to 0.091 (M_1), 0.05 (M_2) and 0.146dS/m (M_3) (Table 1). There was a 91.78%, 95.48% and 86.81% decreases in E.C for M_1, M_2 and M_3 respectively after the treatment. This demonstrates that there is a significant difference between the control and treatment plots, which is consistent with Nasidi et al., (2018) findings. These values of EC are within FAO standard and are safe to grow rice. Table 2 shows the variation of mean before and after the application of millet chaff and that the amendment is significant with t-statistics being greater than t-critical at 5% LOS. Table 3 further demonstrates that at 5% LOS, there is no significant difference between the EC results and those reported by Nasidi et al., (2018).

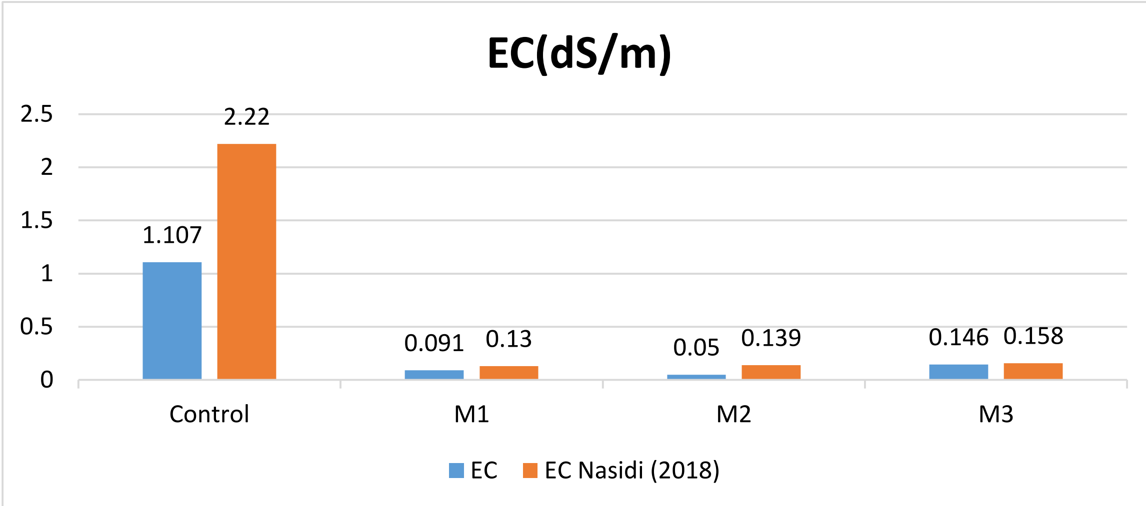

Figure 3: EC of soil sample

Carbonate concentration

Sodic soils are known to have a high concentration of soluble salts mostly carbonates and bicarbonates of sodium, capable of alkaline hydrolysis. High concentration of CO_3 can cause deficiency of available micronutrients (Zn, Fe, Mn) due to its low solubility as a result of high pH and immobilization (Chhabra, 2002). Figure 4 shows the carbonate concentration of the soil samples. Nasidi et al., (2018) reported that carbonate was found to be zero both in the control plot and treated plots but the result obtained in the study disagrees with that. The average value of carbonate concentration for the control sample was found to be 90 mg/kg. After treatment, the average values of carbonate of soil treated with varying quantities of millet chaff were 125.17mg/kg (M_1), 101.3 mg/kg (M_2) and 84.33 mg/kg (M_3) (Table 1). Hence there was a 39.07% and 12.55% increase in M_1 and M_2 respectively and a 6.3% decrease in M_3 after the treatment. These values are safe for rice growth (FAO, 2005). Table 2 shows the variation of means before and after millet chaff application. It also shows that t-statistics is less that t-critical which denotes that the treatment is not significant at 5% LOS. Table 3 further reveals that at 5% LOS, there is a considerable divergence between the carbonate results and those reported by Nasidi et al., (2018).

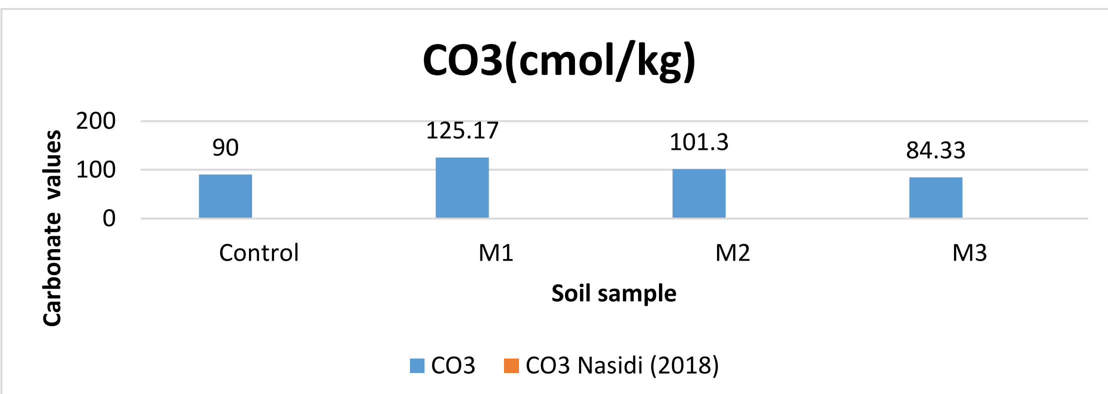

Figure 4: Carbonate concentration

Bi-carbonate Concentration

The result of bi-carbonate concentration of the soil samples is presented in Figure 5 and is compared with that of work done by Nasidi et al., (2018). The average bi-carbonate value of soil control sample was found to be 1142.33 mg/kg. After application of millet chaff, the average values of bi-carbonate were 252.5 (M_1), 222.71 (M_2) and 170.35 mg/kg (M_3) (Table 1). Thus, there was a 77.90%, 80.50% and 85.09% decrease in M_1, M_2 and M_3 respectively after the treatment. These values are safe for rice growth (FAO, 2005). The result is in accordance with Nasidi et al., (2018) who also reported that there was significant reduction of bi-carbonate values after the application of millet chaff. Bi-carbonates in the soil can tie up calcium, making it unavailable to the soil, which can increase sodium concentrations. The statistical analysis in Table 2 displays the means of soil bi-carbonate before and after the treatment. The table shows that t-statistics is greater than t-critical, and this signifies that the treatment is significant at 5% LOS. Also, At 5% LOS, there is no significant difference between the bi-carbonate results and those reported by Musa (2017), as shown in Table 3.

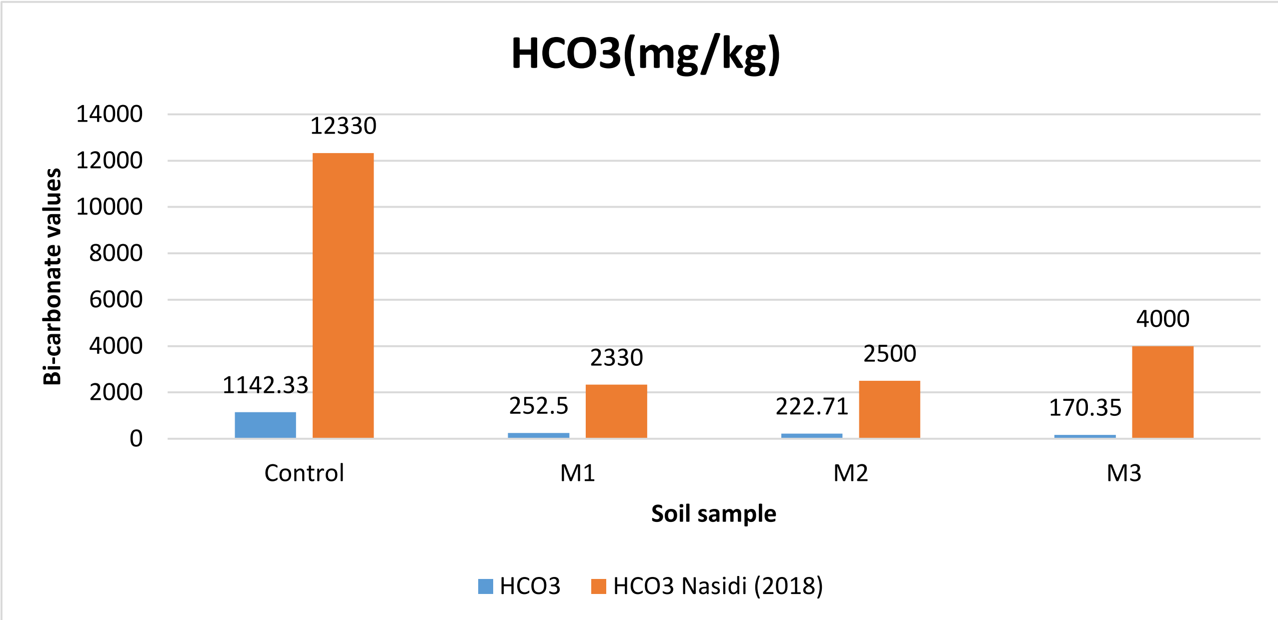

Figure 5: Bi-carbonate concentration

Calcium concentration

Figure 6 shows the result for soil calcium concentration compared with the result of work done by Nasidi et al., (2018). The average value of calcium in the control sample was found to be 1.785cmol/kg and after application of millet chaff, the values increased to 4.443 (M_1), 4.055 (M_2) and 4.83 cmol/kg (M_3) (Table 1). This means that there is a 148.91%, 127.17% and 170.59% increase in M_1, M_2 and M_3 respectively after the treatment. The result agrees with that of work done by Nasidi et al., (2018) who reported that there was increase in calcium in some of the plots treated with millet chaff. Lack of Ca results in disturbed Ca-Na-K ratio causing excess of Na and affecting yield (Chhabra, 2002). The values obtained are within FAO range (FAO, 2005). The statistical analysis from Table 2 presents the means of soil calcium before and after being treated with millet chaff. The table shows that t-statistics is greater than t-critical, hence the treatment is significant at 5% LOS. Furthermore, statistical analysis of Table 3 demonstrates that the calcium result obtained in this investigation and that obtained by Nasidi et al., (2018) at 5% LOS are not significantly different.

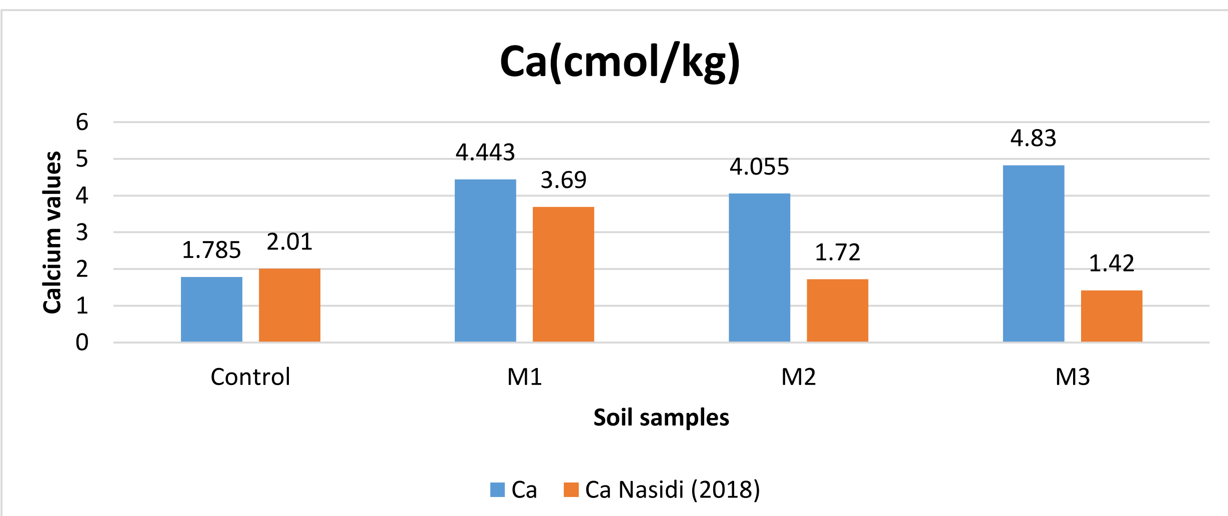

Figure 6: Calcium concentration

Magnesium concentration

For the structure and conformation of nucleic acids, magnesium is required as a cofactor for various enzymes, as a counteraction during separation of photosynthetic loads and as an element of chlorophyll. In plants growing on sodium or saline soils where Na^+ can inhibit Mg^{2+} uptake, magnesium deficiencies may occur (Gregory, 2013). Figure 7 shows the result for determination of magnesium compared with that obtained by Nasidi et al., (2018). The average value of the control sample was 1.342 cmol/kg. After the application of millet chaff, the average values of the treated plots were 1.613 (M_1), 1.21 (M_2) and 1.434cmol/kg (M_3) (Table 1). There was an increase of 20.19% and 6.86% in M_1 and M_3 respectively but M_2 reduced by 9.84%. As reported by Nasidi et al., (2018), the values obtained fluctuated across the treatment plots. These values are within the standard range and are suitable for rice growth (FAO, 2005). Table 2 shows the mean variation before and after millet chaff application. From the table, it can be seen that t-statistics is less than t-critical, this implies that the treatment is not significant at 5% LOS. Statistical analysis from Table 3 shows that the difference between the result of magnesium obtained in this study and that obtained by Nasidi et al., (2018) is significant at 5% LOS.

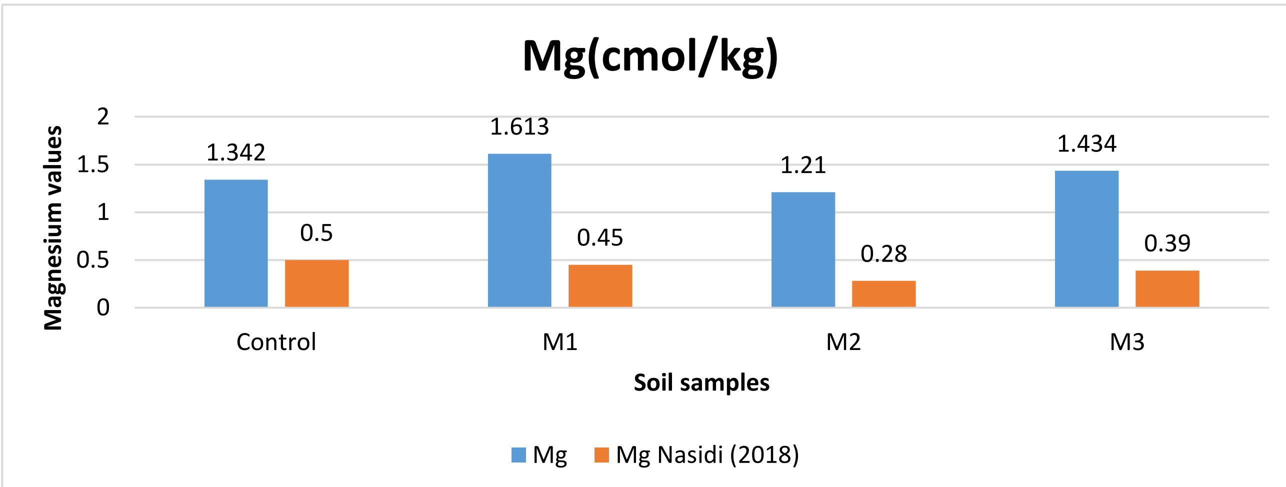

Figure 7: Magnesium concentration

Sodium concentration

Figure 8 displays the sodium level in the study area. Before the treatment, sodium was recorded to have considerably high values compared to the other metallic ions. Because sodium is not a plant nutrient, it is not required for plant growth (Roy et al., 2006). Soil structure, permeability, and plant growth are all harmed by high sodium levels (Horneck et al., 2011). The average sodium value for the control sample obtained was 7.044 cmol/kg and after treatment with millet chaff, the values of sodium reduced significantly to 0.322 (M_1), 0.184 (M_2) and 0.202 cmol/kg (M_3) (Table 1). There was a 95.43%, 97.39%, and 97.13% decrease in M_1, M_2 and M_3 respectively.

This result closely agrees with that of Nasidi et al., (2018) who also reported that there was noticeable difference in sodium values between the control plot and treated plots (Table 1). Also, Table 3 shows that the difference the results obtained and that obtained by Nasidi et al., (2018) is not significant at 5% LOS. Table 2 shows the statistical analysis of soil sodium content, it shows that the treatment is significant at 5% LOS since t-statistics is greater than t-critical.

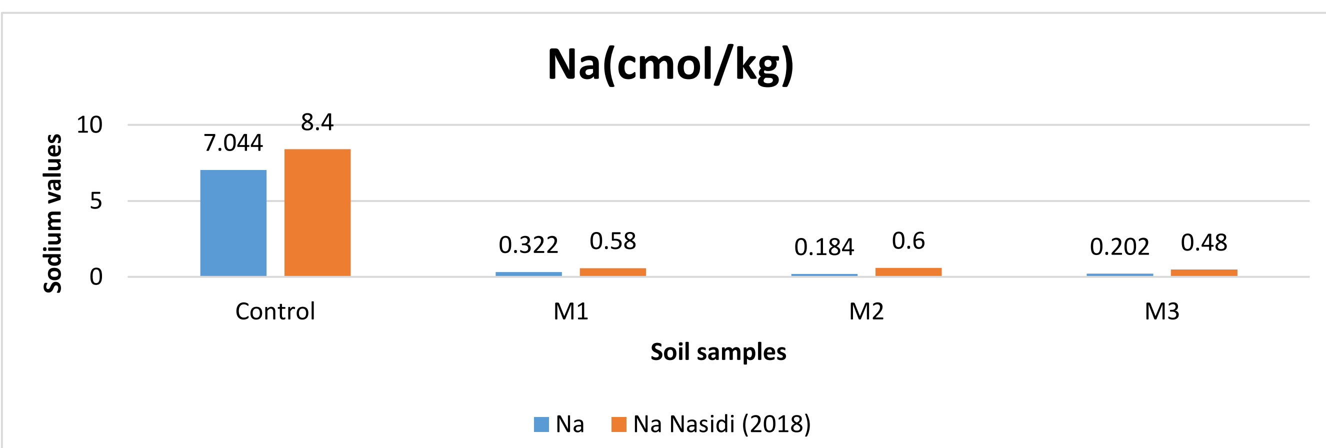

Figure 8: Sodium concentration

Potassium concentration

Figure 9 shows the result for determination of soil potassium. Excessive soil potassium levels can result in elevated potassium levels in grass forage crops, which may be detrimental to animal health. Conversely, very low soil test potassium levels can reduce plant growth (Horneck *et al*., 2011). The average potassium value for the control sample was obtained as 0.398cmol/kg. After the application of millet chaff, the average values increased to 0.657 (M_1), 0.554 (M_2) and 0.573 cmol/kg (M_3) (Table 1). The increase in potassium concentration may be due to the high potassium concentration in millet chaff (Nasidi et al., 2018) and is apparent that the plot having the highest quantity of millet chaff applied had the highest potassium concentration. This result is in accordance with that of work done by Nasidi et al., (2018). However, statistical analysis from Table 3 shows that there is significant difference between the result of potassium obtained in this study and that obtained by Nasidi et al., (2018) at 5% LOS. This is attributed to the fact that Nasidi et al., (2018) reported a higher percentage increase in potassium between the control and treated plots (M_1=152.94%, M_2=80.39% and M_3=70.59%) than that which was obtained (M_1=65.08%, M_2=39.20% and M_3=43.97%). The values obtained after millet chaff application are within the standard limit (FAO, 2005). Statistical analysis (Table 2) shows the means before and after the application of millet chaff. The table also shows that t-statistics is greater than t-critical, and this means that the treatment is significant at 5% LOS.

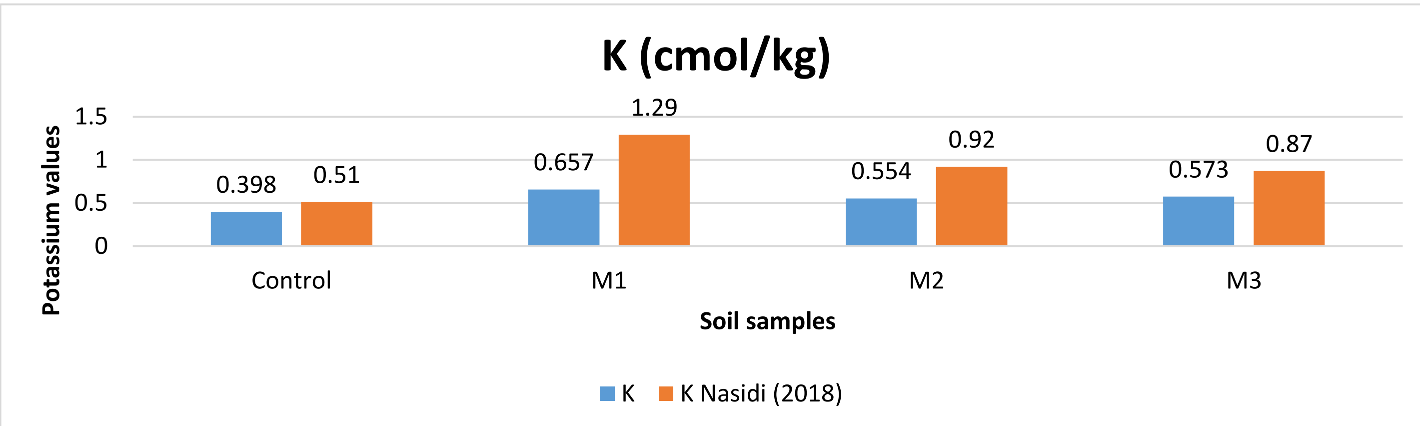

Figure 9: Potassium concentration

Cation-Exchange Capacity

The capacity of a soil to retain and release elements such as K, Ca, Mg, and Na is measured by its CEC. For this experiment, clay soil was employed. CEC is high in soils with a lot of clay and/or organic matter (Horneck et al., 2011). Although it is a single value and does not indicate which cat-ions are predominant, it may be important if there are concerns about Na and K building up in the soil (Oliver *et al*., 2013). The average CEC value for the control sample was found to be 10.43 cmol/kg which is above the standard range (FAO, 2005). After treatment of the soil with various quantities of millet chaff, the values reduced to 7.036 (M_1), 6.003 (M_2) and 7.043 cmol/kg (M_3) (Table 1). The CEC values decreased by 25.77%, 36.34% and 25.31% in M_1, M_2 and M_3 respectively. The findings are consistent with those of Nasidi et al., (2018), who similarly showed a drop in CEC following millet chaff treatment. Table 3 further reveals that there is no statistically significant difference between the results obtained in this investigation and those obtained by Nasidi et al., (2018) at 5% LOS. The CEC values of treated soil are within standard range and indicate that it is safe for crop growth (FAO, 2005) Figure 10. Table 2 shows the mean variation before and after treatment with millet chaff. The treatment is significant at 5% LOS since t-statistics is greater than t-critical.

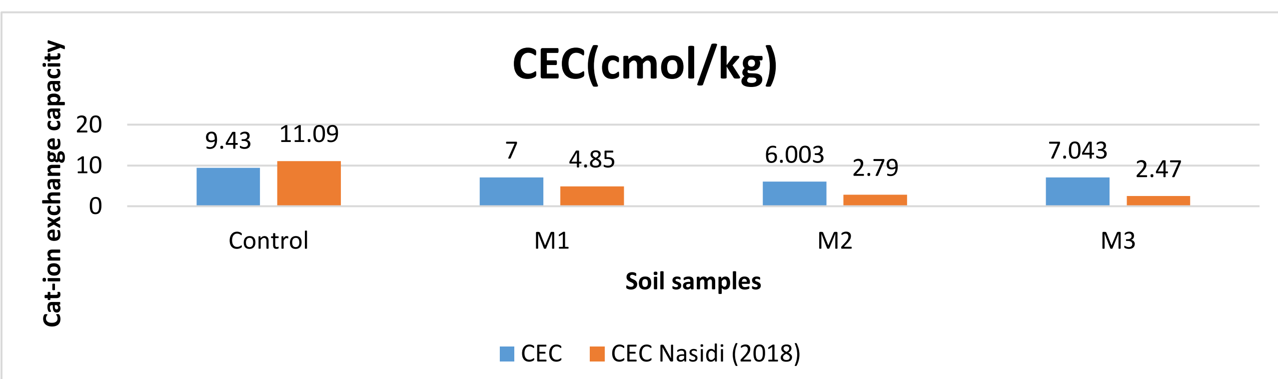

Figure 10: Cation-exchange capacity

Sodium absorption ratio

The SAR is used as an index to assess the possible sodium risk because the soil saturation extracts make it easy to calculate. Infiltration rate decreases as SAR increases, reflecting the effect of sodium on infiltration rate (Hanson and Grattan, 2006). Soil in the control plot SAR was found to be 5.723 which is within the acceptable range (FAO, 2005). After treatment of the soil with various quantity of millet chaff, the values reduced to 0.188 (M_1), 0.133 (M_2) and 0.112 (M_3) (Table 1). There was a drop in SAR by 96.55%, 97.68, and 98.04% in plots M_1, M_2 and M_3 respectively. Nasidi et al., (2018) also reported that there was a large difference in SAR between the control plot and the treated plots. It is graphically presented in Figure 11. Statistical analysis from Table 3 also reveals that there is no significant difference between the result obtained in this study and that of Nasidi et al., (2018) at 5% LOS. These SAR values of treated soil are within FAO standard are safe for rice growth (FAO, 2005). Table 2 shows the means before and after application of millet chaff and shows that t-statistics is greater than t-critical which denotes that the treatment is significant at 5% LOS.

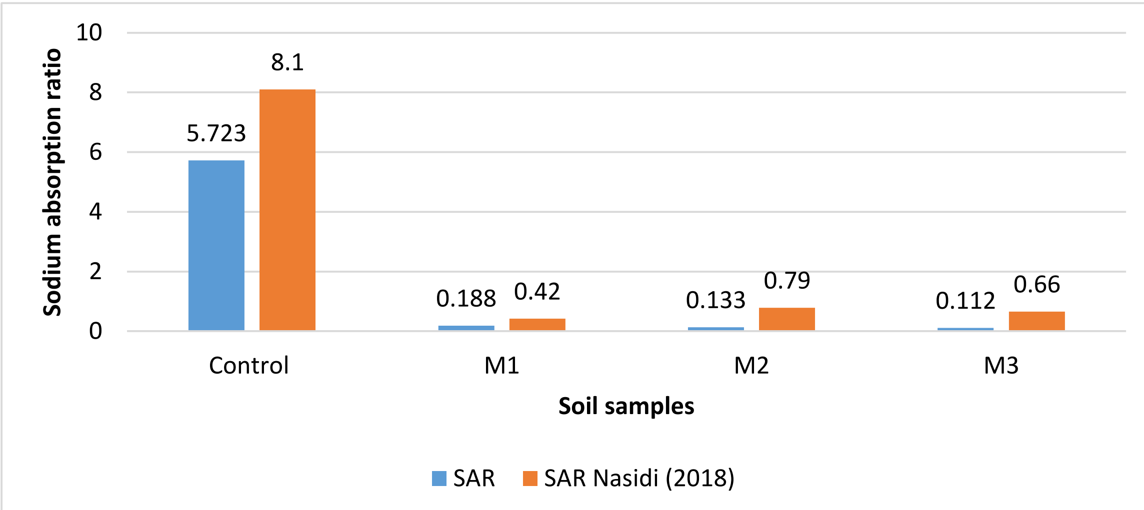

Figure 11: Sodium absorption ratio

Yield analysis

Table 4 shows the total and average yields of rice harvested in the experimental field. The yields ranged from 2.83 to 7.25 t/ha. The average yields were 5.47, 4.08, 4.77 and 4.45 t/ha with the highest yield from M_1 treatment and the lowest from M_2 treatment. It was expected that, the plot with the highest quantity of millet chaff (M_1) will produced the highest yield and that of control plot will produce the lowest yield since millet chaff is an organic material which believed that when applied to the soil it can add to the organic matter content of the soil but the result shows insignificance differences between the yields from the plots

Table 4: Yield of rice

Treatment	Rep 1 (kg/m^2)	Rep 2 (kg/m^2)	Rep 3 (kg/m^2)	Total	Average	Yield (t/ha)
M_1	0.478	0.438	0.725	1.641	0.547	5.47
M_2	0.378	0.458	0.388	1.224	0.408	4.08
M_3	0.417	0.519	0.496	1.432	0.477	4.77
C	0.593	0.283	0.459	1.335	0.445	4.45

Table 5: Analysis of Variance among the yields (ANOVA)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.03135	3	0.01045	0.7872335	0.5339919	4.0661806
Within Groups	0.106194667	8	0.0132743			
Total	0.137544667	11				

The null hypothesis cannot be rejected since F is smaller than F critical (0.7872335 < 4.0661806) and P value is more than the alpha level (0.5339919 > 0.05), as shown in Table 5. This suggests that, despite the variation in millet chaff applied, the yields' means are equal and there is no significant difference between them. This may be attributed to the fact that rice is classified as Moderately Tolerant and has a threshold salinity of 1.9 dS/m (Hanson and Grattan, 2006) hence, the salinity level in the control plot was not high enough to affect the yield (Table 1). It may also be due to the fact that some of the salt may have been leached out of the root zone owing to continuous irrigation of the rice hence reducing the salinity in the control plot.

CONCLUSION

The evaluation of millet chaff performance as an organic amendment of sodic soil and its effect on rice yield was conducted at Thomas Irrigation Scheme, Kano. The experiment showed that there was reasonable improvement in soil quality parameters after being treated with millet chaff and this was confirmed statistically. Hence, millet chaff proves to be a promising amendment for the reclamation of sodic soil. However, statistical analysis revealed that there was no significant difference between the mean yields of treatment plots. This suggests that, using millet chaff for a sodicity amendment has no significant effect on yield of a rice crop in the study area as all the prevailing soil quality conditions were within the FAO acceptable range for growing rice. It is therefore, recommended that, similar study should be conducted in areas with high level of sodicity problems.

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