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Different Levels of Sodium Fertilizer Application to Pasture 1: Effects of Soil Types on the Acclimation and Productivity of Rain-Fed *Brachiaria Decumbens* in Semi-Arid Sokoto State, Nigeria

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Abstract: *An on farm study was conducted at the college farm, Umaru Ali Shinkafi Polytechnic Sokoto in late rainy season (April 202l-March 2022), to examine the effects of different levels of Sodium (Na+) fertilizer application on the acclimation and productivity of Brachiaria decumbens on different soils. The research consisted of 2x1m factorial combination of two soil types and four treatments (High, Medium, Low and Nil Na+/300kg NPK/ha/y^{-1}) in three replicates at each location. Laid out in a Completely Randomized Block Design (CRBD) with herbage cover and growth rates (leaf number/stand; leaf length/stand; stem height/stand; number of tillers/stand; and leaf width) as variables. The results indicated significant differences (P<0.05) of soils particle sizes between soil depths and locations. The values for particle sizes obtained indicated sandy and loamy sand soil types respectively of upland and lowland areas. There were significant differences (P<0.001) of chemical content of soils between depths and locations. The range of soil pH (5.4 – 6.2) recorded in all depths were within the range considered adequate for most crops. The range of soil EC (24.7-37.0 meg/100l) obtained indicated non to very low salinity. The range of CEC values (5.03-6.80 meg/100l) were lower than <6 in upland soil, and 6-12 in lowland soil indicating very low and low nutrients holding capacities respectively. The generally low nutrients recorded indicated low organic matter content in the soils. The results for leaf number differed significantly (P<0.05) in low and 0Na+ levels in upland soil however, did not differ significantly (P>0.05) in high and medium Na+ levels between locations, the values for means stem height obtained in upland soil did not differ significantly (P>0.05) within treatments, however, differed significantly (P<0.05) between locations. The generally higher means stem heights obtained in lowland soil were due to higher soil-moisture retaining capacity of the soil. The results for the number of tillers, leaf length and width indicated no statistical differences (P>0.05) between treatments and locations. The values for leaf length (11.7–13cm) recorded at one month fall within the range of 10-20cm density pubescent leaf length considered important component for adaptation to drought-prone environments. The foliage covers in 0Na+ in both locations differed significantly (P<0.05) with Na+ added to fertilizer. The values in both locations tended to increase linearly with decreasing levels of sodium indicating sensitivity of Brachiaria decumbens to Na+ without exhibiting toxicity symptoms. It was concluded from this study that the levels of Na+ added to fertilizer did not affect the productivity of rain-fed Brachiaria decumbens. Thus, the plant shows promising to shorten the hardships of feed's scarcity and quality for livestock in dry semi-arid Sokoto State. Soil salinity tests, mild irrigation between rainy days at high ambient temperature, and moderate nitrogenous fertilization in both locations are recommended in late rainy season*

***Keywords**: Brachiaria decumbens, Semi-Arid, Soil salinity, Acclimation, Productivty*

INTRODUCTION

Ruminant's livestock in Nigeria are mostly produced on rangelands (Kallah, 1992), which is the worldwide cheapest source of feeds for herbivores (Akinola, 2019). The productivity of rangelands however is low with declining soil fertility and erratic precipitation (Bello, 2011). The quantity and quality of herbage decline linearly with physiological maturity and seasons of the year (Malami, 2005), affecting livestock productivity (Bello *et al.,* 2014). This phenomenon is more pronounced in the extreme Northern Nigeria, in these areas rainy season is characterized by 3-4 months, and 8-9 months of dry seasons (SABAS, 1996). The herbage are dominated by annual species, mostly unpalatable thus avoided by grazing animals in rainy seasons (Shaefer *et al.,* 1998). However, these plants species are cherished in dry seasons (Malami, 2005), in the absence of any other feed (Michael *et al.,* 1990; Bello, 2011).

Tropical soils vary in their physical and chemical composition (Kyiogwom *et al.*, 1998). The ability of the soils to retain water and supply it to plants is the major limiting factor affecting tropical agriculture. Seasonal forage productivity is related to plant species, soil fertility and precipitation (Ribeizo *et al.,* 2009). In the savannah areas, soils were reported to be predominantly sandy, at least in surface horizon (Kowal and Kassan, 1978), as well as in different profiles (Lokotoro and Singh, 2000). However, loamy sand soils, as well as silt loamy and clay soils were reported in fadama areas of Sokoto State (Sharu and Yahaya, 2020). The soils are usually acidic with pH values 5 – 6.5 occupying large proportion of the upland areas (Yakubu and Ojanuga, 2013). In their salinity study of the soils in fadama areas of Sokoto State Obinna and Mohammed (2021) reported saline-sodic soil, with Magnesium bicarbonate and calcium chloride identified as the major contributors to absolute salt concentration. Spatial and seasonal variations in soil nutrients were also reported in tropics (Sunday *et al.*, 2020). Most authors agreed that the acid reaction of soil indicates its poor nutrients status (Bello, 2011). However, flood-plain soils are fairly rich in the three primary nutrients (SADP, 2016).

The abundance of palatable perennial herbage species on the range is one of the indicators of a very good range condition (Nbaya *et al.,* 2014). Most perennial herbage species worldwide used for pasture establishment are not recommended in Sudano-Sahelian ecological zones due to rainfall pattern (Onifade and Agishi, 1990). Most authors concluded that efforts need to be intensified to find appropriate perennial herbage cultivars, and other means to reduce the long hardship of herbage quantity and quality in dry semi-arid areas (Bello *et al.*, 2014).. *Brachiaria decumbens* (Signal grass) is one of the promising perennial herbage species. It is a medium lived (5 years), and reported to grow on a wide range of soils, including those with low fertility status (pH 3.5) (Deifel *et al.,* 2006). Its optimal growth occurs between temperatures 30 – 35^{0}C, and 1000-1500mm rainfall (FAO, 2016). However, it was reported to have a drought tolerance of up to 4-5 months in humid areas, and mild flood (FAO, 2016). Although Signal grass has low leafy stands on infertile soils, it response excellently and produce DM yield (10-30t/ha/yr^{-1}) with heavy fertilization and adequate moisture regime (Cook *et al.,* 2005).

Sodium (Na+) deficiency in pasture occurs in many parts of world especially in tropical Africa and Australia (McDonald, 1988). Although Na+ is not considered an essential element to plants due to its trace requirement (Broodwick *et al.,* 2021), Na+ can be beneficial in many conditions, particularly when soil is deficient in potassium, and in plants located in areas with high level of precipitation due to its mobile nature in soil (Frans *et al.,* 2014). However, a group of some C4 plants such as Atreplex spp, Millet, Corn, Sorghum and a number of C4 grasses Na+ at trace level can be classified an essential nutrient (Frans *et al.,* 2014). Apart from physiological function of Sodium in plants and animal's body, it play very important roles in ruminant digestion (Bello, 1990), increases rumen volume and outflow when given as NaCl2 (Weidmier *et al.,* 1987), increases rumen pH and proportion of cellulolytic microbes when fed as Sodium bicarbonate (Bello, 1990). Increased in herbage growth rate was also observed when Na+ fertilizer was applied as NaCl2 (Webb, 1988), however variability on plant's salt tolerance and stress were reported in different plants (Broodwck *et al.,* 2021). Researches on temperate soils indicated Na+ added to fertilizer on pastures increased herbage Na+ content (Chiy *et al.,* 2006), grazing time and drinking frequency increased linearly with increased Na+ fertilization (Phillips and Bello, 1991; Chiy *et al.,* 2006). The study aimed to examine the effects of soil types at different levels of Na+ added to fertilizer on the productivity of rain-fed *Brachiaria decumbens,* to shorten the inherent feed scarcity and quality for livestock in long dry season of Sokoto State.

MATERIAL AND METHODS

Study Area

The research was conducted at the college farm, Umaru Ali Shinkafi Polytechnic Sokoto, Nigeria. The study area is located between latitude 12^0 54' and13^0 02' North and Longitude 4^0 52 and 5^0 00 East/ The climate in the area consists of a short rainy season (April – September) and long dry season (October – March). The mean annual rainfall hardly exceed 731.2mm (SADP, 2016). The rainfall is frequently erratic and poorly distributed with wide gaps between rains are common (Adamu *et al.,* 1998). The temperature varies widely (15 - 40^0C). The soil is moderately deep and well drained (Bello *et al.,* 2014).

TREATMENTS AND EXPERIMENTAL DESIGN

The research consisted of a two streams 2x1m factorial combination of two soil types (Upland and Lowland) in four treatments sequences of High Sodium fertilizer (HSF) 64kg Na+/ 300kg NPK/ha/yr^{-1}; Medium Sodium fertilizer (MSF) 32kg Na+/ 300kg NPK/ha/yr^{-1}; Low Sodium fertilizer (LSF) 16kg Na+ /300kg NPK/ha/yr^{-1}and Nil Sodium fertilizer (0SF) Na+ /300kg NPK/ha/yr^{-1} as control in three replicates at each location. The research was laid out in a Completely Randomized Block Design (CRBD) with herbage cover and growth rate (leaf number/stand; leaf length/stand; stem height/stand; number of tillers/stand; and leaf width) as variables in late rainy season (July – September).

METHODOLOGY

Soil Sampling and Analysis

The study area was used as upland soil, while the Fadama soil was brought to the site to simulate lowland area. Soil samples from undisturbed fadama soil were collected before excavation at Kwalkwalawa area Sokoto. Five soil samples at each location were randomly collected for the depths of 0-20cm and 20-40cm respectively using graduated Soil Auger (0 – 20cm) (SADP, 2016). The samples from the two soils / depths were mixed separately and three composite samples from each depth per location were collected for laboratory analysis. Sample for texture analysis was analyzed in triplicate using Hydrometer method. The values for sand, silt and clay were compared to soil texture triangle and determined the soil types as described by Ritter (2006). The composite samples for the two soil depths at each location were also subjected to triplicate chemical analysis. Electrical conductivity (EC) of the soils was determined by conductivity meter (IITA, 1982); Hydrogen ion concentration (pH) of the soils was read using Gallenkamp pH meter (IITA, 1982). Nitrogen content of the soils were determined according to macro Kjeldah method (IITA, 1982); Calcium (Ca) and Magnesium (Mg) of soil samples were determined by Atomic Absorption Spectrophotometry method (IITA, 1982), while the Sodium and Potassium were determined by flame Photometry Method (IITA, 1982). Available phosphorus was determined by Bray 1 Method.

LAND PREPARATION AND TRANSPLANTING

Twelve 2x1m plots (beds) with irrigation channels at each location (upland and lowland) were prepared. For lowland soil, all the 12 plots were excavated to the depth of 0.5m and filled with fadama soil. Plots at each location were initially fertilized with equal quantity of cow dung manure to maintain pH levels and increased proportion of micronutrients in soils (Sharu and Yahaya, 2020). All plots were initially watered using irrigation. Young seedlings of *Brachiaria decumbens* sourced from National Animal Production Research Institute Shika (NAPRI) ABU Zaria were sorted and transplanted. One seedling / hole was transplanted at the distance of 0.3m between stands and rows in all treatments. The seedlings were trimmed to the height of 10cm from the soil surface (Naflalul, 2015) and watered daily until the stem of each seedling turned green. Dead seedlings were replaced before sodium fertilization commenced. Sodium Chloride (NaCl2) fertilizer was applied to each treatment two weeks later accordingly. All plots were subsequently irrigated if it did not rain within three days. First, second and third weeding were conducted at two weeks intervals. Data for herbage cover and growth rate were obtained at two weeks intervals monthly.

STATISTICAL ANALYSIS

Data collected was analyzed using ANOVA procedure using SPSS model software. Where means were found significant Duncan's Multiful Range Test was used to separate the means at 5% level.

RESULTS AND DICUSSION

Table 1: Physical properties of upland and lowland soils and soil types in the study areas

		Upland					**Lowland**		
Depths	Sand	Silt	Clay	Soil types	**Sand**	**Silt**	**Clay**	**Soil types**	**SEM**
0-20 cm	83.60	10.10	7.27	Sandy soil	**81.70**	**7.16**	**11.13**	**Loamy sand soil**	**1.08**
20-40 cm	81,96	10.47	8.57	Sandy soil	**84.53**	**5.90**	**9.57**	**Loamy sand soil**	**1.08**
Sig.	0.05	0.00	0.01		**0.05**	**0.00**	**0.01**		

Table 1 presents the means physical status of soils used for the study. The result shows significant difference (P<0.05) for sand, silt and clay content of soils between depths and locations (Upland and Lowland). The higher values of sand content of soils recorded in this study (Table 1) were in agreement with the findings of most authors (Bello *et al.,* 2014). The generally low values of silt and clay content of soils (Table 1) obtained agreed with the findings of Kowal and Kassan (1978) who reported silt and clay content of soils in semi-arid tropics were remarkably low. The values for soil particles size recorded in upland soil indicated sandy soil type (Table 1), probably due to sand deposited from dessert encroachment. Sokoto state was among the states in Nigeria that are prone to desertification (Ignatius and Adie, 2021). The values of sand obtained in lowland soil indicated loamy sand type (Table 1), probably due to sand deposited mainly from the flooding rivers. Similar findings were also reported by most authors (Lokotoro and Singh, 2000).

Table 2: Chemical content of soils from different depths and locations in the study area

Parameters	Upland soil		Lowland soil			
Depths	0-20 cm	20-40 cm	0-20 cm-	20-40 cm	SEM	Sig
pH	5.7	5.4	6.2	6.0	0.19	**
EC meg/100L	27.9	24.7	37.0	33.3		**
CECmeg/100L	5.36	5.03	6.80	6.30		***
N (mg/kg)	0.08	0.07	0.12	0,09		***
P (mg/kg)	0.78	0.62	0.83	0.81		NS
K (mg/L)	0.37	0.25	0.26	0.23		***
Mg (mg/L)	3.23	2.50	5.80	7.40		***
Ca (mg/L)	6.71	6.93	15.70	17.20		***
Na (mg/L)	0.21	0.21	0.53	0.33		***

** = Significant at (0.05) level; *** = Significant at (0.001), NS = Not significant

Table 2 presents the means chemical content of soils from different depths and locations. The results indicated significant differences (P<0.001) of chemicals content of soils between depths and locations. The range of soil electrical conductivity (EC) (24.7-37.0 meg/100l) obtained in all depths and locations (Table 2) indicated non to very low saline status of the soils (Sunday *et al.* 2020). The range of CEC values (5.03-6.80 meg/100l) in different depths and locations were lower than <6 in upland soil, and 6-12 in lowland soil reported as very low and low nutrients holding capacities respectively (Hazelton and Murphy, 2007). The chemical content of soils with exception of Mg+ and Ca+ in this study decreased with depths in all locations. Similar findings were also reported by most authors probably due to low organic matter content (Sharu *et al.,* 2020) The generally low values of soils nutrients recorded in this study indicated low organic matter content in the soils. Low organic matter of soils was reported to decrease soil pH and EC content (Sharu *et el.,* 2020) consequently affecting soil fertility. There were no apparent symptoms of salt toxicity observed in all treatments. The non-toxicity symptoms of Na+ exhibited by *Brachiaria decumbens* was probably due to low exchangeable ions recorded in the present study. Most authors agreed that the ions responsible for soils salinity are Na^+, Ca^+, K^+ Mg^+ and Cl^-2 (Webb, 1988).

Table 3: Means productivity of *Brachiaria decumbens* on different NaCl2 levels and soil types:

	Upland				Lowland			
Parameters	HSF	MSF	LSF	0SF	**HSF**	**MSF**	**LSF**	**0SF**
Leaf number	3.7[cd]	4.3[c]	5.7[a]	5.0[ab]	4,3[bc]	4.0[cd]	6.3[a]	4.7[bc]
Leaf length (cm)	13.0[a]	12.7[ab]	11.5[abc]	12.0[ab]	14.0[ab]	15.0[a]	14.0[ab]	14.9[a]
Stem height (cm)	11.3[abc]	10.0[bc]	10.0[bc]	12.0[ab]	10.7[c]	7.8[cd]	19.0[a]	14.7[b]
Number of tillers	0.3[d]	1.3[ab]	1.6[ab]	1.0[bc]	3.0[abc]	3.0[abc]	3.0[abc]	3.0[abc]
Leaf width (mm)	10.1[abc]	9.5[d]	10.3[ab]	10.5[ab]	10.3[ab]	10.2[abc]	10.3[ab]	10.4[a]
Foliage cover (%)	23.6[cd]	24.3[bc]	25.3[cd]	33.6[a]	25.2[c]	26.8[bc]	24.5[cd]	37.9[a]

Means within columns and rows with different superscripts differed significantly using Duncan's Multiple Range Test at 5% level

HSF = High Sodium fertilizer; MSF = Medium Sodium fertilizer; LSF = Low Sodium fertilizer; 0SF = Nil Sodium fertilizer

Table 3 presents the means productivity of *Brachiaria decumbens* on different NaCl2 levels and soil types: in dry semi-arid Sokoto State. The results of this study indicated the leaf number in high and medium Na+ levels did not differ significantly (P>0.05) within treatments and locations (upland and lowland soils) however, differed significantly (P<0.05) with low and zero Na+ fertilizer levels in upland soils (Table 3). The higher leaves number recorded in low and zero Na+ fertilization compared to high and medium Na+ fertilization (Table 3) was probably due to salt sensitivity of *Brachiaria decumbens* reported by most authors (Deife *et al.,* 2006). Data is not readily available for the range of leaf number recorded (3.7- 6.3) at one month in the present study for comparison. There were no statistical differences (P>0.05) for leaf length within treatments, and between locations (Table 3). The higher means of leaf length obtained in the lowland soil indicated high fertility status of the fadama soil compared to upland soil (Lokotoro and Sign, 2000. Bello *et al.,* 2014). The range of leaf length values obtained (11.7 – 13cm) in this study fall within the range of 10 – 20 cm reported as density pubescent leaf length considered important component for adaptation to drought-prone environment (Dus and Deyun, 2009). The values for means stem height obtained in upland soil did not differ significantly (P>0.05) with treatments, however, differed significantly (P<0.05) between locations (Table 3). The generally higher means stem heights obtained in lowland soil compared to the upland soil were probably due to soil-moisture retaining capacity of the lowland soil (Lokotoro and Singh, 2000). Data for the range of stem height (7.8-19cm) recorded at 1month in the present study is not readily available for comparison. The result of the present study shows no significant difference (P>0.05) between treatments and locations for leaf width (Table 3). The values (9.5-10.5mm) for leaf width obtained in this study fall within the range of 8-10 mm reported (Husson *et al.,* 2008). The foliage cover in zero Na+ fertilizer did not differ significantly (P>0.05) with corresponding zero Na+ fertilizer between locations, however differed significantly (P<0.05) with different Na+ levels in both locations (Table 3). The values for foliage cover in this study tended to increased linearly with decreasing Na+ fertilization in all locations. The generally higher foliage covers recorded in lowland soil compared to upland soil was probably due to higher soil moisture retaining ability of the fadama soil compared to upland soil. The moisture retaining capacity of the fadama soil was probably due to high clay content of the soil (SADP, 2016) as well as organic matter content of the soils (Sharu *et al.,* 2020).

CONCLUSION

It was concluded from this study that there was no sufficient rainfall for planting in early rainy season (April-June) in the study area. Sandy and loamy sand soils were the types of soils respectively of upland and lowland areas. The values for pH contents of soils fall within the range considered adequate for most crops. The values for soil conductivity indicated non to very low saline status. The generally low values of soils nutrients recorded in this study indicated low organic matter content in soils. The levels of Na+ added to fertilizer did not affect the productivity of rain-fed *Brachiaria decumbens* in all locations. Thus, the plant shows promise to shorten the hardships of feed scarcity and quality for livestock in dry semi-arid Sokoto State. Soil salinity tests, mild irrigation between rainy days at high ambient temperature, and moderate nitrogenous fertilization in both locations are recommended in the late rainy season

*****Malami Buwai (Late) Ph. D in Range Management (USA) was a former Chief Range Management officer Sokoto State and Minister, Federal Republic of Nigeria. He had gone through and made useful suggestions during the course of this research. May his soul rest in peace***

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