



Fertility Status of Some Selected Floodplain Soils and the Management Recommendations on the Maximun Yield of Tomato (*Lycopersicum Esculentum*) in Kebbi State, 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

The study was under taken to assess the fertility status of the flood plain soils of some selected local government areas of Kebbi State and recommend management practices to be provided for the maximum yield of tomatoes in Kebbi State. Soil samples were analyzed for the various physical and chemical properties following the standard procedures. The study revealed that the soils were predominantly sandy loam in texture with the mean particles composition of 715.71 gkg⁻¹, 87.42 kg⁻¹ and 196.87 kg⁻¹ for sand, silt and clay, respectively. The soils contained low organic carbon of 6.0 gkg⁻¹ and high concentration of nitrogen (0.8 gkg⁻¹) which might be due to frequent addition of nitrogenous fertilizers on the soil. The low available phosphorus of 0.64 mgkg⁻¹ was observed which might be due to acidity level of the soils (pH 5.6). On the basis of exchangeable bases, the soils were discovered to be low in Ca (1.51cmolkg⁻¹), but high in Mg content (1.78 cmolkg⁻¹). The soils contained high Na value of 0.59cmolkg⁻¹ an indication ofsodicity hazard. The K content of 0.64 cmolkg⁻¹ was also high in the soils of the study area. Based on the obtained values of the above parameters, the soils could be considered as medium in fertility. Based on the concentration of EC (0.55 dsm⁻¹) ESP (6.04%) and pH 5.6, the soils could be considered to be free from salinity and sodicity at least for now, but has

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1. INTRODUCTION

In the semi-arid and arid savannah agro-ecological zones, where precipitation (rainfall) is limited for agricultural productivity, flood plain soils provide the backbone of arable crop production. Northern Nigeria's flood plains, also known as "fadamas," have gained prominence as a result of their usage for intensive agricultural cultivation [1]. Fadama soils have a low gradient and are susceptible to seasonal floods during the rainy season [2]. Fadama is a Hausa term that refers to a low-lying swampy location with fluvial deposits and large exploitable aquifers [3]. Because of variances in morphogenesis, location, hydrological regimes, lithologic sources, and climatic conditions, fadama soils have a broad range of morphological and chemical features both within and across valleys. Flood plain soils constitute the back bone of arable crop production in the semi-arid and arid savannah agro-ecological zones where precipitation (rainfall) is limited for agricultural productivity. The flood plains also known as "fadamas" in northern Nigeria have become very prominent because of their use for intensive agricultural production [1]. Fadama soils usually have low gradient and are liable to seasonal flooding at the peak of rainy season [2]. Fadama is a Hausa word meaning low-lying swamp area consisting of fluvial deposits and extensive exploitable aquifers [3]. The fadama soils vary widely in their morphological and chemical characteristics both within and between valleys owing to differences in morphogenesis, location, hydrological regimes, lithologic origins and climatic condition [4]. Fadama is considered as a land of great agricultural potential. Ojanuga [5]. stated that fadamas in Nigeria are extensive, fairly unexploited parcel of land resources that have great potential for all-year-round agricultural production. He further stated that when fadama soils are used properly, they have the capacity to contribute to sustainable food security in the country. Singh [6]. opined that if exploited fully, fadama can prove an assured "mini food basket" for Nigerian teeming population especially during the dry season. Idoga [7]. considered fadama as unique agricultural land which allows hydrophyte plants such as swamp rice to grow in the rainy season while vegetables are grown in the dry season.

In the presence of efficient irrigation facilities such as tube wells and water pumps, the fadama

lands are sites for most agricultural activities during the dry season. They can produce 2-3 short duration crops during a year. Fruits from trees such as mango, guava, banana and papaya can be produced all year round. The common crops grown on the fadama land are rice, onion, garlic, sugarcane, carrot, tomatoes, pepper, egg-plant, okro, sweet potatoes, tobacco and a number of leafy vegetables [8]. As a result of high demand of tomatoes in Kebbi State, most local government areas in the state especially those along riverine areas and those blessed with stream plain fadamas, grow tomatoes in large scale almost all year round.

Tomato is the delicious, often red fruit/berry of the nightshade *Solanum lycopersicum*, also known as the tomato plant (Chen, et al., 2003). Tomatoes are eaten in a variety of ways, including raw, as a component in a variety of cuisines, sauces, salads, and beverages. The fruit is high in lycopene, which may offer health benefits (Chen, et al., 2003). Tomatoes thrive in warm climates with temperatures ranging from 21 to 24°C (69.8–75.2°F). They need a deep, loamy, well-drained soil with a pH of 5.5 to 6.8. Tomatoes may be grown on raised beds if soil drainage is an issue. Tomatoes, like other fruiting plants, need full light for the most of the day (Kopsell, 2000). Nutritional content per 100 g (3.5 oz) Carbohydrates (3.9 g); Sugars (2.6 g); Dietary fibre (1.2 g); Fat (0.2 g); Protein (0.9 g); Energy 74 kJ (18 kcal); Vitamins, Vitamin A equivalent beta-carotene (123 g); lutein 42 g (4%), zeaxanthin (5%), 449 g, Thiamine (B1) (3 percent) Niacin (B3) 0.037 mg (4 percent) Vitamin B6; 0.594 mg (6 percent) Vitamin C, 0.08 mg (17 percent) Vitamin E 14 mg (4 percent) 0.54 mg; Vitamin K (8%) 7.9 g; Magnesium (3%) 11 mg; Manganese (5%) 0.114 mg; Phosphorus (3%) 24 mg; Potassium (5%) 237 mg; Water 94.5 g; Lycopene 2573 g (Rickman, et al., 2007).

In view of the above, it becomes necessary to ascertain the current fertility status of the soils of the state, particularly those irrigated with tube well water.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Kebbi State which is situated in the extreme north-west of Nigeria

between latitudes $10^{\circ}06^1$ - $13^{\circ}10^1$ North and longitudes $3^{\circ}0^1$ - $6^{\circ}03^1$ East (KARDA, 1998). It shares boarder with both Niger and Benin Republics in the west. On the East, it is bordered by Sokoto State and in the South by Niger State.

The State enjoys a semi-arid climate where precipitation is usually less than the normal requirement of most agricultural crops. The rainy season consists of a short (May – October) period with rainfall poorly distributed throughout the growing period. Frequent and heaviest precipitation is experienced between August and September. The annual rainfall ranges from 400 to 850mm increasing both in quantity and intensity within the state from north to south [9]. The continental air mass from Sahara usually brings a season of very cold weather (the harmattan) with very low temperatures in the night during the months of November to early February. The harmattan winds during this period are very descating and blow a lot of sand.

During the month of March-June, the weather is predominantly hot. Arnborg (1988) stated that areas situated within the semi-arid sub-Saharan

region, Kebbi State inclusive, enjoy the mean maximum and minimum temperatures of 40°C and 15°C respectively. KARDA (1998) gave the mean temperatures for Kebbi state as 23°C with slight variations in different locations of the State.

The natural vegetation in Kebbi State follows the rainfall pattern and other climatic elements. KARDA (1998) reported that the vegetation of the State is broadly classified as Savanna and can be divided into three categories: Northern Guinea which occupies south- eastern parts of the state, Sudan Savanna which is found in the middle of the state and the Sahel which is found in the extreme northern part of the State where sparse trees and shrubs of different kinds are dominated. According to KICL [9] the state has the following soils types: Sandy soils found in the upland locations of the North, North West and Central parts of the State; Ferruginous tropical soils found in the Souuth – Eastern parts of the state; Lateric soils found all over the state; Black Cotton soil found in the South-Eastern and Southern parts of the State and Hydromorphic soils found in the floodplains of the major rivers and enclosed depressions (Fadama areas).

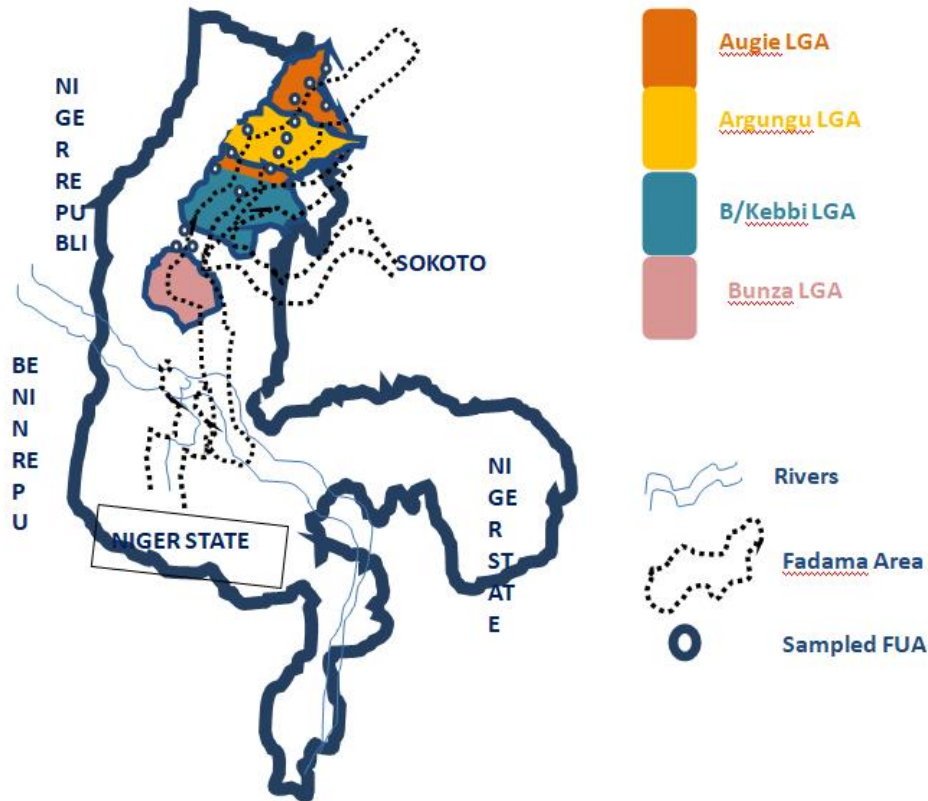


Fig. 1. Map of Kebbi State Showing the Sampling Areas

2.2 Sampling Techniques

Three farms were randomly selected in a community from each of the selected local government areas of Augie, Argungu, Birnin Kebbi and Bunza. Three composite soil samples of 0 – 15cm depth were randomly collected in each of the field where crops were grown. A control sample was collected away from the farm plots. Making a total of ten (10) composite samples per community/local government area. The samples were collected using soil auger. They were air dried, gently crushed and sieved through a 2mm sieve before the analysis.

2.3 Soil Sample Analysis

The methods described by Page et al. were used to analyse each soil sample [10]. The particle-size analysis was performed using the bouyoucous hydrometer method described by Bouyoucous [11] and the texture was determined using the USDA textural triangle. Total nitrogen was determined using the macro-kjeldahl digestion and distillation method described by Black [12]. The organic carbon was determined using the Walkely-Black wet-combustion method (CF 1.33), as described by Walkely et al. [13]. The Bray-1 method, as described by Bray and Kurtz, was used to calculate available phosphorus [14]. Chapman's ammonium saturation method was used to calculate cations exchange capacity (CEC). Ca and Mg levels were measured using an atomic absorption spectrophotometer. K and Na were determined using flame photometry. The pH of the soil-water mixture was determined using pH meter at a 1:2.5 soil-water ratio. A conductivity metre was used to measure electrical conductivity (EC) in a 1:2 soil-water ratio at 25°C. The result was multiplied by 6.4, as suggested by Landon [15] to obtain the EC of saturated extract. The exchangeable sodium percentage (ESP) was calculated as follows:

$$ESP = \frac{\text{Exchangeable Na}^+}{CEC} \times 100\%$$

Where Na and CEC are in $\text{Cmol}(+)\text{kg}^{-1}$ of soil.

2.4 Statistical Analysis

The data obtained was subjected to analysis of variance (ANOVA) using SPSS 2000. Means obtained were separated using DMRT test.

3. RESULTS AND DISCUSSION

This study assessed the inherent fertility and salinity status of the floodplain soils of Kebbi

State, Nigeria. The results obtained gave a guide on the quantities and types of fertilizers to be supplemented for the attainment of the maximum yield of tomatoes in the study.

3.1 Soil Texture

The texture of a soil determines many of its physical, physico-chemical and chemical properties. The content of iron, calcium, magnesium, potassium and many other nutrients that are present in the inorganic portion of the soil, as well as phosphorus present in both organic and inorganic portions is determined mainly by soil texture.

The data on the particle size distribution of the floodplain soils of some selected Local Government areas of Kebbi State were presented in Table 1. The results revealed that there was a significant ($P>0.05$) difference in the particle size distribution of the floodplain soils of the various local government areas of Kebbi State except in the silt component of the soils where the result showed there was no significant ($P>0.05$) difference among the Local Government areas studied.

The results revealed that Augie local government area has mean values of 689.33 g/kg sand, 73.50 g/kg silt and 237.17 g/kg clay. This indicated that the soils were sandy clay loam in texture. Argungu floodplain soils have mean values of 711.09 g/kg, 83.33 g/kg, 205.58 g/kg and Birnin Kebbi local government area have 631.42 g/kg, 117.69 g/kg and 251.33 g/kg of sand, silt and clay respectively, indicating that both Argungu and Birnin Kebbi floodplain soils were sandy loam in texture, while Bunza local government area floodplain soils have mean values of 831.42 g/kg, 75.17 g/kg and 93.41 g/kg of sand, silt and clay indicating that the soils were sandy in texture. The overall mean values of the textural classes of the study area were 715.71, 87.42 and 196.42 g/kg, for sand, silt and clay, respectively. This indicated that the soils were sandy loam in texture and good for the production of many agricultural crops including tomatoes.

3.2 Chemical properties of the Floodplain Soils of Some Selected Local Government Areas of Kebbi State

3.2.1 Organic carbon

Organic carbon is a measure of organic matter status in a soil. The organic matter serves as a

store house for many plant nutrients such as nitrogen, sizeable portion of phosphorus and sulphur and small amounts of potassium, calcium, magnesium and other nutrients [16].

The data on organic carbon (OC) of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was no significant ($P > 0.05$) difference in soils organic carbon between the selected local government areas. However, when comparing the three selected local government areas, Birnin Kebbi local government area recorded higher value of soil organic carbon with mean value of 7.30gkg^{-1} . It was then followed by Augie local government area with mean value of 6.45gkg^{-1} . While Argungu and Bunza recorded soil organic carbon mean values of 5.10 and 5.15gkg^{-1} , respectively. The overall mean value was 6.0g/kg . Based on the ratings by Esu [3] the soils were rated low in organic carbon content. This result was similar to the findings of Singh [17] who also reported low soils organic carbon content of 7gkg^{-1} for Zamfara state fadama soils. Similarly Sharu *et al.* [18] reported low organic carbon content value of 1.38gkg^{-1} for soils in Dingyadi district. Augie also reported a low organic carbon content range of $0.2-0.63$ (mean 0.20) gkg^{-1} for fadama soils of Sokoto State. Low organic carbon content in the area might be attributed to frequent bush burning in the area and excessive grazing after harvest.

3.2.2 Total Nitrogen (TN)

Nitrogen is an essential component of many compounds, including chlorophyll and enzymes which are essential for plant growth processes. It is an essential component of amino acids and protein which are important in the building of plant tissue.

The data on total nitrogen (TN) of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was no significant ($P > 0.05$) difference in soil total nitrogen within the selected local government areas. However, the result indicated that Bunza local government area recorded higher value of soil total nitrogen with mean value of 0.85gkg^{-1} . It was then followed by Augie local government and Birnin Kebbi local government areas with mean values of 0.68 and 0.61gkg^{-1} , respectively. A lowest soil total nitrogen content of 0.57gkg^{-1} was observed in Argungu local government area. Based on the ratings by Esu [3] all the local government areas were rated high in soils total nitrogen content.

Singh reported low total nitrogen range of $0.001-0.650\text{gkg}^{-1}$ for fadama soils of Kebbi state. Similarly Augie [19] reported low total nitrogen range of $0.002-0.060$ (mean 0.017) for sokoto state fadama soils. The obtained high nitrogen content of 0.68g/kg could be due to addition of excess nitrogenous fertilizers during the period of plant growth.

3.2.3 Available Phosphorus (AP)

The data on available phosphorus (AP) of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was a significant ($P > 0.05$) difference in soils available phosphorus within the selected local government areas. The result showed that Augie local government area was significantly ($P > 0.05$) higher in soils available phosphorus when compared with the other local government areas with mean value of 0.67mgkg^{-1} . It was followed by Birnin Kebbi local government area with mean value of 0.65mgkg^{-1} . The phosphorous value for Bunza local government area was 0.63mgkg^{-1} while a lower mean value of available phosphorus of 0.62 was observed in Argungu local government area. The soils contained low overall mean value of AP was 0.64mgkg^{-1} . This was lower than the findings of Singh and Tsoho who reported available P values of $3-6$ and $1-7\text{mgkg}^{-1}$ for soils around Rima River and Rima Sokoto. Respectively. Based on the ratings by Esu [3] all the local government areas were rated low in soils available phosphorus. The lower level of available phosphorus, particularly in fadama soils could be due to phosphorus fixation into unavailable forms such as calcium phosphate, which could be attributed to large quantities of calcium deposited in the farm through irrigation and flooding water. Low available phosphorous might also be attributed to low organic carbon (organic matter) content in the study area. The low phosphorous content of the soil might be attributed to acidity (5.9) pH level of the soils. According to Isrim *et al* (2010), availability of phosphorous to plants tend to decrease because as soils become acidic proportion of Al and Fe to phosphorous increases.

3.2.4 Exchangeable Cations (Ca^{2+} , mg^{2+} , K^{\vee} and ak^+)

3.2.4.1 Exchangeable Calcium

Calcium is among the macronutrients that are essential for plant growth. Most economic crops yield better in soils where Ca dominate the exchange complex.

Table 1. Soil Textural Class Distribution of some selected Local Government area Areas of Kebbi State

LGA	Sand g/kg	Silt g/kg	Clay g/kg	Textural class
Augie	689.33b	73.5	237.17a	Sandy Clay Loam
Argungu	711.09b	83.33	205.58a	Sandy Loam
B/ Kebbi	631b	117.67	251.33a	Sandy Loam
Bunza	831.42a	75.17	93.41b	Sand
Overall Mean	715.71	87.42	196.17	Sandy Loam
LSD.	*	NS	*	
SE±	23.335	7.814	16.482	

Means bearing different letter(s) along the same column differed significantly ($p < 0.05$)

Table 2. Chemical properties of Soils of some selected Local Government area Areas of Kebbi State

LGA	pH	EC dsm ⁻¹	Org.C gkg ⁻¹	Org.M gkg ⁻¹	Total N gkg ⁻¹	Avail.P mgkg ⁻¹	Ca Cmol(+)/kg ⁻¹	Mg	K	Na	CEC	BS	PBS (%)	ESP (%)
Augie	5.6 ^b	0.25 ^a	6.45	11.14	0.68	0.67 ^a	1.57 ^a	1.45 ^b	0.53 ^b	0.50	8.80 ^b	4.15 ^b	46 ^{bc}	5.65 ^b
Argungu	6.0 ^a	0.54 ^b	5.10	8.81	0.57	0.62 ^b	1.04 ^b	2.49 ^a	1.03 ^a	0.74	10.43 ^a	5.29 ^a	50 ^{ab}	6.82 ^a
B/Kebbi	5.4 ^b	0.42 ^b	7.30	12.59	0.61	0.65 ^{ab}	1.51 ^{ab}	1.17 ^b	0.58 ^b	0.42	8.67 ^b	3.69 ^b	41 ^c	4.96 ^c
Bunza	5.5 ^b	0.99 ^a	5.15	8.87	0.85	0.63 ^{ab}	1.95 ^a	2.00 ^a	0.42 ^b	0.70	9.93 ^a	5.25 ^a	52 ^a	6.72 ^a
Overall mean	5.6	0.55	6.0	10.36	0.68	0.64	1.51	1.78	0.64	0.59	9.46	4.60	47.25	6.04
Sig.	*	*	NS	NS	NS	*	*	*	*	NS	*	*	*	*
SE±	0.072	0.087	0.579	1.000	0.054	0.082	0.070	0.113	0.067	0.053	0.181	0.158	1.100	0.413

Means bearing different letter(s) along the same column differed significantly ($p < 0.05$)

The data on exchangeable calcium (Ca) of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was a significant ($P > 0.05$) difference in soils exchangeable calcium within the selected local government areas. The result indicated that Bunza local government area was significantly ($P > 0.05$) higher in soils exchangeable calcium when compared with the other local government areas with mean value of 1.95Cmolkg^{-1} . It was followed by Augie local government area with mean value of 1.57Cmolkg^{-1} then Birnin Kebbi local government area with mean value of 1.57Cmolkg^{-1} and a low mean value of exchangeable calcium of 1.04Cmolkg^{-1} was observed in Argungu local government area. Based on the ratings by Esu (1991) all the local government areas were rated low in soil exchangeable calcium. The overall mean value of Ca was 1.51cmolkg^{-1} . This value fell within the range of $0.07\text{-}2.20 \text{Cmolkg}^{-1}$ for sokoto state fadama soils as given by Augie [20] Similarly Singh reported Ca value of $0.9\text{-}56 \text{Cmolkg}^{-1}$ for fadama soils of Kebbi state which was also with the obtained Ca value of 1.51cmolkg^{-1} for the selected local government areas.

3.2.4.2 Exchangeable Magnesium

Magnesium like calcium is one of the dominant cations in the soils of West African savanna. The data on exchangeable magnesium of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was a significant ($P > 0.05$) difference in soils exchangeable magnesium within the selected local government areas under studies. The result indicated that Argungu local government area was significantly ($P > 0.05$) higher in soil exchangeable magnesium with mean value of 2.49Cmolkg^{-1} . It was followed by Bunza local government area with mean value of 2.00Cmolkg^{-1} and Augie local government area had soil exchangeable magnesium mean value of 1.45Cmolkg^{-1} while a lower mean value of 1.17Cmolkg^{-1} for Mg was observed in Birnin Kebbi local government area when compared with other selected local government areas of the state. Based on the ratings by Esu [3] all the studied areas were rated high in soil exchangeable magnesium. The overall mg value of 1.78Cmolkg^{-1} agreed with the findings of Mustspha and Nnalee who reported high exchangeable magnesium range of $1.05\text{-}2.05 \text{Cmolkg}^{-1}$ for fadama soils in Jos north. Similarly Singh and Tsoho [21] reported soils

exchangeable magnesium range of $1.2\text{-}2.5$ and $1.0\text{-}2.9$ for fadama soils along Sokoto River and Streams respectively. However, Singh reported an overall mean value of exchangeable magnesium of 6.6Cmolkg^{-1} for fadama soils of Kebbi state. High appreciable concentration of Mg in the soils would create fear of soil salinization in the near future.

3.2.4.3 Exchangeable Potassium

The data on exchangeable potassium (k) of the floodplain soils of some selected local government areas of Kebbi state was presented in Table 2. The result revealed that there was a significant ($P > 0.05$) difference in soils exchangeable potassium within the selected local government areas. The result indicated that Argungu local government area was significantly ($P > 0.05$) higher in soil exchangeable potassium when compared with the selected local government areas. It was then followed by Birnin Kebbi and Augie local government areas with mean values of 0.58Cmolkg^{-1} and 0.53Cmolkg^{-1} , respectively. Lower soils exchangeable potassium mean value of 0.42Cmolkg^{-1} was observed in Bunza local government area. Based on the ratings by Esu (1991) all the selected local government areas were rated high in soil exchangeable potassium content. The overall mean value of k was 0.64cmolkg^{-1} . These result fell within the range of $0.1\text{-}2.5$ (mean 0.3) Cmolkg^{-1} for Kebbi state fadama soils. High concentration of exchangeable K indicated possibility of soil salinization in the near future [22].

3.2.4.4 Exchangeable Sodium (Na)

The obtained value of exchangeable sodium (Na) of the floodplain soils of some selected local government areas of Kebbi state were 0.50 , 0.74 , 0.42 and 0.70cmolkg^{-1} for Augie, Atungu, Birnin Kebbi, Bunza local government areas, respectively, and the mean value was 0.59cmolkg^{-1} . Table 2. The result revealed that there was no significant ($P > 0.05$) difference in soils exchangeable sodium within the selected local government areas. However, the result showed that Argungu local government area has a high exchangeable sodium content with mean value of 0.74Cmolkg^{-1} . It is then followed by Bunza local government area with mean value of 0.70Cmolkg^{-1} and Augie local government area recorded exchangeable sodium mean value of 0.50Cmolkg^{-1} while a low soil exchangeable sodium mean value of 0.42Cmolkg^{-1} was observed in Birnin Kebbi local government area.

The overall mean value of 0.59cmolkg^{-1} agreed with the findings of Singh and Tsoho who reported soil exchangeable sodium ranges of 0.4-0.8, 0.3-0.9 and 0.8-1.4 Cmolkg^{-1} for soils around rivers, streams and Goronyo dam, respectively. Based on the ratings by Esu [3] all the soils of the selected local government areas were rated high in soil exchangeable Na. Such high Na indicated that the soils have potential threat to sodicity problem.

3.3 Cations Exchange Capacity (CEC)

Cations held at the edges and on the surfaces of the soil particles have ready access to the outer solution and are described as exchangeable cations. The capacity of the soil to hold these cations is known as cation exchange capacity (CEC) and is an indication of the nutrient holding capacity of the soil.

The data on cations exchange capacity (CEC) of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was a significant ($P > 0.05$) difference in soils cation exchange capacity within the selected local government areas. The result showed that Argungu local government area was significantly ($P > 0.05$) higher in soils cation exchange capacity when compared with other selected local government areas with mean value of 10.43Cmolkg^{-1} . It was then followed by Bunza local government area with mean value of 9.93Cmolkg^{-1} and Augie local government area recorded mean value of 8.80Cmolkg^{-1} while the least soils cations exchange capacity with value of 8.67Cmolkg^{-1} was observed in Birnin Kebbi local government area. Based on the ratings by Esu [3] all the selected local government area were rated medium in soils cations exchange capacity. The overall mean value of 9.46cmolkg^{-1} was in line with the findings of Singh who reported that the overall CEC range of 10-80.4 (mean 9.4) Cmolkg^{-1} . However, Sharu *et al.* reported a soils CEC value of 4.43Cmolkg^{-1} in Dingyadi District of sokoto state. Similarly, Kefas *et al.* [23] observe a CEC range of 0.1-2.9 (mean 1.5) Cmolkg^{-1} in some selected floodplain soils in Nigeria.

3.4 Percentage Base Saturation (PBS)

The percentage base saturation refers to the percentage of the exchangeable complex saturated with basic cations searches Ca^{2+} , mg^{2+} , k^{+} and Na^{+} . It is a very good measure to use in describing soil fertility status because a high

percentage base saturation indicates desirable nutrients levels and low percentage base saturation indicates low fertility status. The data on percentage base saturation (PBS) of the floodplain soils of some selected local government areas of Kebbi state were presented in Table 2. The result revealed that there was a significant ($P > 0.05$) difference in the soil percentage base saturation between the selected local government areas. The result showed that Bunza local government area was significantly ($P > 0.05$) higher in the soils percentage base saturation with mean value of 52%, it was followed by Argungu and Augie local government areas with PBS mean values of 50 and 46% respectively while a significantly ($P > 0.05$) lower PBS mean value of 41% was recorded in Birnin Kebbi local government area. Based on the rating by Esu (1991) all the local government area were rated medium in soils PBS. This result was similar to the finding of Singh and Tsoho (2001) who reported PBS of 30%, 56%, 43% and 50% for soils around Rima River, Kandoli Shela Stream, Tureta Lakes and Goronyo Dam, respectively.

3.5 pH of Soils of the Study Area

The overall mean pH value of the soils of the selected local government areas was 5.6 Table 2. The result also revealed that there was a significant ($P > 0.05$) difference in soils pH within the various local government areas. The result indicated that Argungu local government area tested significantly ($P > 0.05$) higher in soil pH when compared with other local government areas with mean value of 6.0. It was followed by Augie local government area with pH mean value of 5.6. Bunza local government area recorded pH mean value of 5.5 and the lowest soil pH mean value of 5.4 was observed in Birnin Kebbi local government area. These values fall within the range of 4.0-8.9 (mean 5.6) as reported by Singh for Kebbi state fadama soils. It also agreed with the report of Idoga and Ogbu, who reported that fadama soils are slight to moderately acidic in reaction with a general trend of decreasing pH value with depth.

3.6 Exchangeable Sodium Percentage (ESP)

The data on exchangeable sodium percentage (ESP) of the floodplain soils of some selected local government area area of Kebbi state were presented in Table 2. The overall mean value of ESP was 6.04% and also the result indicated that there was a significant ($P > 0.05$) difference in the

soil exchangeable sodium percentage between the selected local government areas. The result indicate that Argungu local government area has a higher ESP mean value of 6.82%. It was then followed by Bunza local government area with mean value 6.72%. Augie local government area recorded mean value of 5.65% while a lower mean ESP value of 4.96% was observed in Birnin Kebbi local government area. The ESP values obtained from all the selected local government areas were higher than 1.30% as reported by Singh *et al.*, and also higher than 2.30% reported by Augie for floodplain soils of Kebbi State but low than 15% the critical limit for classifying salt affected soils. According To Landon ESP value of 15 is a critical limit for classifying the salt affected soils. According to him, saline soils have ESP of <15 while saline Sodic and Sodic soils both have ESP of >15. Based on these criteria, all the soils of the study area were free from sodicity hazard at least for now.

3.7 Salinity/ Sodicity Status of Soils of the Study Areas

The data on salinity and sodicity status of the floodplain soils of some selected local government area area of Kebbi state were presented in Table 2. According to the criteria mentioned by Landon (1984) that soils with $EC > 4 dSm^{-1}$, $ESP < 15$ and $pH < 8.5$ are saline, those with $EC > 4 dSm^{-1}$, $ESP > 15$ and $pH < 8.5$ are saline –sodic while those with $EC < 4 dSm^{-1}$, $ESP > 15$ and $pH > 8.5$ are Sodic. The result showed that Augie local government area has EC of $0.25 dSm^{-1}$, ESP 5.65% and pH 5.6. Argungu local government area has EC $0.54 dSm^{-1}$, ESP 6.82% and pH 6.0 and Birnin Kebbi local government area has EC $0.42 dSm^{-1}$, ESP 4.96% and pH 5.4 while Bunza has EC $0.99 dSm^{-1}$, ESP 6.72 % and pH 5.5 respectively. As per these criteria, the floodplain soils of all the selected local government areas could be said to be free from salinity and sodicity hazard at least for now. However, due to high concentration of Na^+ there is potential threat to sodicity problem in the near future.

4. CONCLUSION

Although the chemical characteristics of the floodplain soils differed amongst the local government area regions studied, all of the soils were devoid of salinity/sodicity hazards. The soils contain low organic carbon (OC) and Ca contents, but high total nitrogen (TN), Mg, K, Na,

and medium CEC concentrations, suggesting poor soil fertility. They were somewhat acidic but not too so (pH 6.0)

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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