Status of pH, Available Sulphur, Organic Carbon and Total Nitrogen on Some Small Holders' Farms in the Sudan Savanna of Nigeria

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Abstract: **Surface samples were collected from 6 different local governments across Kano state: Ajingi, Gezawa, Gabassawa, Gwarzo, Kabo, Tofa local government areas. The collected soil samples (0-15cm depth) were analyzed using standard procedures to determine the levels of soil pH, Organic carbon, Total nitrogen and Available sulphur in sorghum and millet based cropping systems in the Sudan savanna of Nigeria. Results obtained shows that the soils were generally low in organic carbon (0.22 – 0.51%) while the total nitrogen fell within moderate range from (0.11 – 0.12%).The pH_{water} ranged between 6.02 – 6.46 and pH_{CaCl2} between 5.55 – 6.32. The available sulphur content of different cropping systems under the study were found to be within the moderate range from (8.3 to 21.9%) with the highest mean recorded from Cowpea, Soybean and Sorghum (COS) cropping system and the lowest mean was recorded in Cowpea, Groundnut and Millet (CGS) cropping system. Owing to the low total nitrogen and organic carbon content in the soil under the study area, it is therefore recommended that supplementary nitrogen application and improvement of the drainage conditions of all the soils should be employed to improve the nutrient status of the soils. Also, with the current intensive cropping pattern, sulphur contained fertilizer should be used frequently to prevent depleting the soils which are presently adequate in sulphur within few years.**

Keywords: **Sudan Savanna, pH, Organic Carbon, Sulphur, Total Nitrogen**

I. INTRODUCTION

With more than half of Nigeria's population currently employed in the agricultural sector (Manyong, Ikpi, Olayemi, Yusuf, Omonona, 2005), and with the vast majority of the individuals living in rural areas, the agricultural sector is key to Nigeria's economic development. Agriculture is a major source of raw materials as well as food and foreign exchange, employing over 70 percent of the Nigerian labor force, and serving as a potential vehicle for diversifying the Nigerian economy and enabling economic development (Lenis, Kuku, Ajibola, 2011).

However, the Population pressure on land resources is forcing farmers to use land more intensively and to cultivate less fertile soils on marginal land areas. In addition, agricultural production in Africa is hampered to a large extent by the predominance of fragile ecosystems, low natural soil fertility, and the low use of external inputs, pr incipally mineral fertilizers (Henao and Baanante 1999). Soil degradation due to nutrient mining, erosion and desertification is the major threat to food production in Northern Nigeria (Ba lasubramanian *et al*., 1984; Bationo *et al*., 1996; Chude, 2008).

In Northern Nigeria, agricultural intensification due to population and socio-economic pressures has led to land degradation and soil nutrient depletion, which have become a major constraint to agricultural productivity (Akinola, Alene, Adeyemo, 2011). Negative nutrient balances in soils of most semi-arid regions of west Africa not only mirror poor soil health, they also represent severe on-going depletion of the soil's nutrient capital, degradation of the environment, and vulnerability of the crop production system in terms of its ability to sustain high yields (Manyong *et al.*, 2001).

In general, nutrient mining and inadequate replenishment of removed nutrients, as well as continuous loss of organic matter from the soils are contributing to increasing erosion rates and the decline in the fertility of the soils. The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way. Information on the effects of various farming practices on soil fertility is required in order to understand some of the measures that could be taken to ensure sustainability of the systems. Therefore, this research is meant to provide additional information concerning short-term impact of various cropping system in the Sudan Savanna on soil pH, Organic Carbon, Total Nitrogen and Available Sulphur.

II. MATERIALS AND METHODS

2.1 Description of the Study Area.

The study was conducted in six local government areas of Kano State namely: Ajingi, Gwarzo, Gezawa, Gabasawa, Kabo and Tofa (Figure 1). The first three local governments (Gwarzo, Kabo, Tofa,) were located in the western part of Kano State and are referred to as sorghum zone. The three other local governments (Ajingi, Gezawa and Gabazawa local government area) were located at the Eastern part of the state and hereafter referred to as Millet Zone. The six local governments are almost experiencing the same climatic condition as with other local Governments of the state. Generally, Kano has mean annual rainfall that ranges from over 1000mm in the extreme South to a little less than 800mm in the extreme North. The rain usually last for three to five month with mean temperature ranges from 26^0C to 33^0C.

2.2 Sample Preparation

The fieldwork of this study started on

August 2013. A visit was made to the study area in order to select the farmer's field from which the soil samples would be collected for the study.

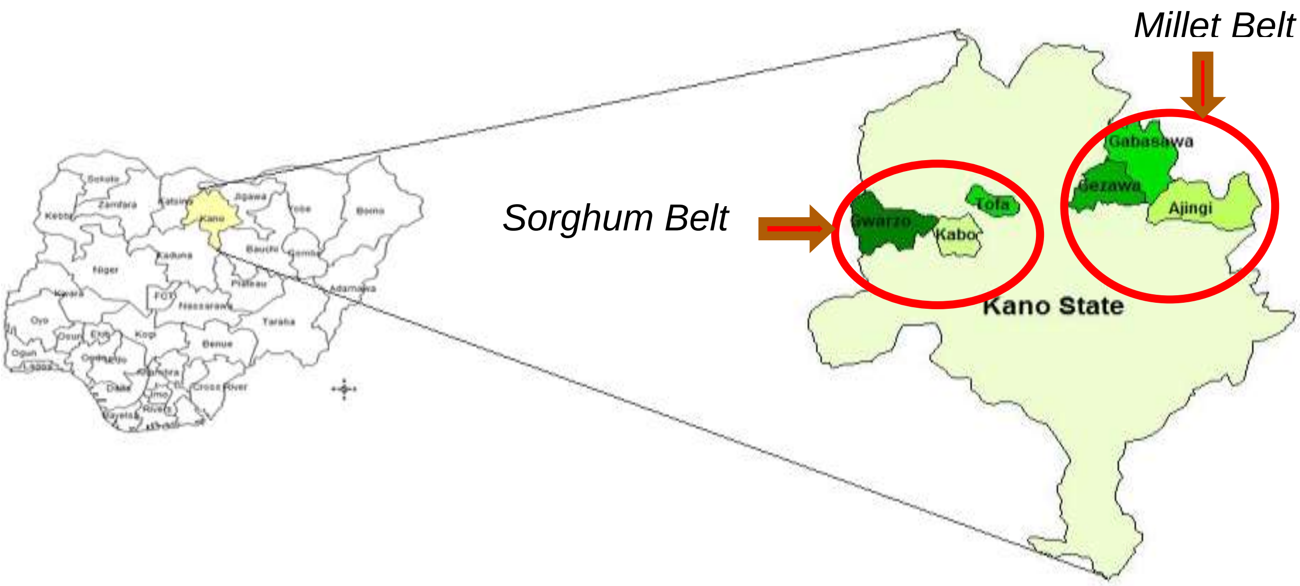

Figure 1: Map of Nigeria and Kano State showing study Locations

Soil samples were collected from five cropping systems; Cowpea, Soybean and Sorghum (COS), Groundnut, Soybean and Sorghum (GOS), Cowpea, Groundnut and Millet (CGM), Cowpea, Groundnut and Sorghum (CGS), Cowpea, Groundnut, Soybean and Sorghum (CGOS). Topsoil (0-15cm) samples were taken using soil auger at four different points in each management regime. The samples were then stored in a polyethene bag and taken to the laboratory for analysis. The soil samples were passed through 2mm sieve before the commencement of the laboratory analysis.

2.3 Soil Analysis

The Soil pH was determined by glass electrode method. 10g of each soil samples was weighed and place in a plastic container, 25ml of distilled water was added. Each sample was stirred for the first time and stirred again after 15 minutes. The samples were left for 30 minutes to settle down. The pH meter rod was inserted to each sample and the reading was taken. Also, the same procedure above was followed in taken reading for pH $CaCl_2$, where instead of distilled water, 25ml of $Cacl_2$ was added and the reading was taken.

The Organic Carbon content of the soil was determined by the dichromate acid oxidation method of Walkly and Black (1934). lg of soil sample was measured in to a 500m1 conical flask. The l0ml of 1N $K_2Cr_20_7$ solution was pipette in to the conical flask and swirled gently in order to disperse the soil. Then l0ml of concentrated H_2S0_4 from measuring cylinder was rapidly added and gently swirled until the soil and the reagent are properly mixed. Thereafter, the solution was vigorously swirled again for one minute with electric magnetic stirrer and allowed to stand for 30 minutes. Then, l00ml of distilled water was added and allowed to cool again. Then 5m1 of orthophosphoric acid was added in order to sharpen the colour change of the end point There after 3-4 drops of indicator was added and titrated with 0.5N ferrous sulphate solution, at the end point the solution change to light green. Blank determination was then carried out in the same way but, without soil sample to standardize the dichromate.

Total Nitrogen was determined by Kjeldahl method. 1g of soil samples were weighed into digestion tubes, concentrated sulfuric acid and a soil and plant catalyst (mixture of K_2SO_4 and H_gO) were also added. The mixture was heated continuously for about 2hours 30miutes. The tube was then allowed to cool and the content was transferred in to a wash bottle such that sand particle was retained in the original digestion tube because it will cause a severe bumping during distillation. The residue was wash with distilled water and each portion was transferred in to the same bottle. The bottle was made up to 100 level marks. 20ml of 2% H_3B0_3 solution was added in to a beaker which is then place under the condenser of the of the distillation apparatus. 10ml of 40% NaOH was added and l0ml of digest was added slowly in the distillation apparatus. Temperature was raised until it boils. The condensed was kept cool by allowing sufficient water to flow through mid-regulate heat to minimize frothing and prevent suck back. About 50m1 distillate was collected and distillation was stopped. Ammonia librated was titrated with standard 0.025N of HCl, 2 drops of indicator was added and the point was determined. Similarly a blank was run using all the procedures but without soil sample and also percent total nitrogen was calculated.

Available Sulphur content in the soil extracts was determined by Turbidimetric method. 5g of samples was weighed into wash bottles, 25ml of KH_2PO_4 was added, the samples were shaken for 30 minutes using mechanical shaker and the solution was then filtered using standard filter paper. 10 ml of the filtrate was measured into the round bottom flask of 20ml capacity. 10 ml of distilled water and 1ml of gelatin Barium chloride was added. The bottles were filled with distilled water to the marked level and then wait for 30 minutes. The reading was taken using Spectrophotometer.

III. RESULTS AND DISCUSSIONS

3.1 Summary Statistics of the Parameters among the Local Governments

The fertility ratings of Esu (1991), Landon (1991), and NSPFS (2005) were used in the discussion of the result of this study. The summary of chemical properties of the Millet belt is shown in (Table 1).

Ajingi Community was found to have pH_{water} ranged from (5.35 – 6.73) with a mean (6.15), while pH_{CaCl2} ranged from (4.68 – 6.49) with a mean value of (5.80). The soils were slightly acidic. The organic carbon (OC) contents which ranged from (0.06 – 0.18%) with the mean value of (0.10) fell within the low to medium fertility classes for Northern Nigerian savanna soils. The total Nitrogen (N) contents of the soils (0.07 – 0.18%) with the mean value of (0.12) which fell within the medium class. Available Sulphur (S) contents in the soils ranged from (6.76 – 21.5ppm) with mean value of (13.0) (Table 1) which fell within medium fertility class.

Gabasawa Community was found to have pH_{water} ranged from (5.62 – 6.79) with a mean value of (6.14), while pH_{CaCl2} ranged from (4.60 – 6.34) with a mean value of (5.55). The soils were slightly acidic (Table 1). The OC contents which ranged from (0.18 - 0.80%) with the mean value of (0.50) fell within the low to medium fertility classes for Northern Nigerian savanna soils (Table 1). The total N contents of the soils (0.07 - 0.14%) with mean value of (0.12). Available S contents in the soils ranged from (6.76 – 21.5ppm) with mean value of (13.0) (Table 1).

Gezawa Community was found to have pH_{water} ranged from (5.61 – 6.68) with a mean (6.18), while pH_{CaCl2} ranged from (4.44 – 6.41) with a mean value of (5.66). The soils were moderately acidic (Table 1). The organic carbon contents which ranged from (0.02 - 0.76%) with the mean value of (0.40) fell within the low to medium range (Table 1). The total N contents of the soils (0.07 - 0.14%) with mean value (0.11). Available S contents in the soils ranged from (2.61 – 32.8ppm) with mean value of (14.5) which fell within medium range (Table 1).

Gwarzo Community was found to have pH_{water} ranged from (5.32 – 6.71) with a mean (6.08), while pH_{CaCl2} ranged from (4.28 – 6.62) with a mean value of (5.47). The soils were strongly acidic (Table 2). The organic carbon contents which ranged from (0.02 – 0.94%) with the mean value of (0.49) (Table 2). The total N contents of the soils (0.07 - 0.14%) with mean value (0.11). Available S contents in the soils ranged from (5.00 – 8.91ppm) with mean value of (7.01), available S fell within medium range (Table 2).

Kabo Community was found to have pH_{water} ranged from (5.75 – 6.58) with a mean value of (6.26), while pH_{CaCl2} ranged from (4.42 – 6.50) with a mean value of (5.82). The soils were moderately acidic (Table 2). The organic carbon contents which ranged from (0.16 – 0.92%) with the mean value of (0.35) which is very low (Table 2). The total N contents of the soils (0.11 - 0.18%) with mean value (0.13) which is at moderate range. Available S contents in the soils ranged from (4.57 – 22.4ppm) with mean value of (12.4), available S fell within medium range (Table 2).

Tofa Community was found to have pH_{water} ranged from (5.87 – 6.81) with a mean (6.37), while pH_{CaCl2} ranged from (5.35 – 6.63) with a mean of (6.18). The soils were slightly acidic (Table 2). The organic carbon contents which ranged from (0.14 - 0.70%) with the mean value of (0.40) which fell within low range (Table 2). The total N contents of the soils (0.07 - 0.14%) with mean value (0.11). Available S contents in the soils ranged from (3.15 – 20.4ppm) with mean value of (10.9) (Table 2).

Table 1: Summary Statistics of the Parameters at Millet Belt

	pH water	pH $CaCl_2$	Organic Carbon %	Total Nitrogen %	Av. Sulphur (ppm)
AJINGI					
Mean	6.15	5.80	0.10	0.12	13.0
Maximum	6.73	6.49	0.18	0.18	21.5
Minimum	5.35	4.68	0.06	0.07	6.73
STD.	0.60	0.78	0.06	0.05	7.08
GABAZAWA					
Mean	6.14	5.55	0.50	0.12	6.88
Maximum	6.79	6.34	0.80	0.14	11.9
Minimum	5.62	4.60	0.18	0.07	1.67
STD.	0.39	0.66	0.24	0.03	3.41
GEZAWA					
Mean	6.18	5.66	0.40	0.11	14.5
Maximum	6.68	6.41	0.76	0.14	32.8
Minimum	5.61	4.44	0.02	0.07	2.61
STD.	0.34	0.69	0.28	0.02	10.4

Source: Laboratory Analysis

Table 2: Summary Statistics of the Parameters at Sorghum Belt

	pH water	pH $CaCl_2$	Organic Carbon %	Total Nitrogen %	Av. Sulphur (ppm)
GWARZO					
Mean	6.08	5.47	0.49	0.11	7.01
Maximum	6.71	6.62	0.94	0.14	8.91
Minimum	5.32	4.28	0.02	0.07	5.00
STD.	0.46	0.70	0.31	0.03	1.37
KABO					
Mean	6.26	5.82	0.35	0.13	12.4
Maximum	6.58	6.50	0.92	0.18	22.4
Minimum	5.75	4.42	0.16	0.11	4.57
STD.	0.25	0.78	0.24	0.03	6.45
TOFA					
Mean	6.37	6.18	0.40	0.11	10.9
Maximum	6.81	6.63	0.70	0.14	20.4
Minimum	5.87	5.35	0.14	0.07	3.15
STD.	0.34	0.40	0.20	0.03	4.99

Source: Laboratory Analysis

3.2 Comparison between Belts and Cropping Systems

Comparing the nutrient status of the soils under different cropping system (Sorghum Belt and Millet Belt)

Table 3: Chemical Properties of Soils in Millet and Sorghum Belt

Treatments (Belt)	pH-water	pH-$CaCl_2$	Organic Carbon %	Total Nitrogen%	Available Sulphur (ppm)
Sorghum belt	6.27	5.86	0.40	0.11	10.4
Millet Belt	6.19	5.77	0.36	0.11	10.6
SE ±	0.06	0.12	0.05	0.01	0.8
Significance	Ns	Ns	Ns	Ns	Ns

Source: Laboratory Analysis

3.2.1 pH-water and pH $CaCl_2$

pH_{water} was not significantly influenced by both belt and cropping systems. But, millet belt has the lowest pH (6.19) compare to Sorghum belt (6.27), thus, the results shows that soils of the study areas were found to be slightly acidic to moderately acidic in nature (Table 3). Similarly, COS cropping system has the highest pH (6.46) and the lowest being observed in CGOS (6.02) cropping system (Figure 2). However, the slightly acidic nature of the fields showed that the pH was at optimum level for the availability of most plant nutrients (Brady, 2002). For $pH_{CaCl2,}$ the millet belt has the lowest pH (5.77) and the sorghum belt has pH_{CaCl2} (5.86) (table 3). Furthermore, the pH_{CaCl2} was not influence by the various cropping systems, although COS cropping system has the highest pH_{CaCl2} (6.32) and the lowest at both GOS (5.55) and CGOS (5.55) cropping systems (Figure 2). Thus, the acidic conditions observed are still within tolerable limits for most arable crop production. This observation agrees with earlier report by Ekeleme, Jibrin, Kamara, Oluoch, Tofa (2013) for similar soils having similar pH range in Sudan Savanna of Nigeria.

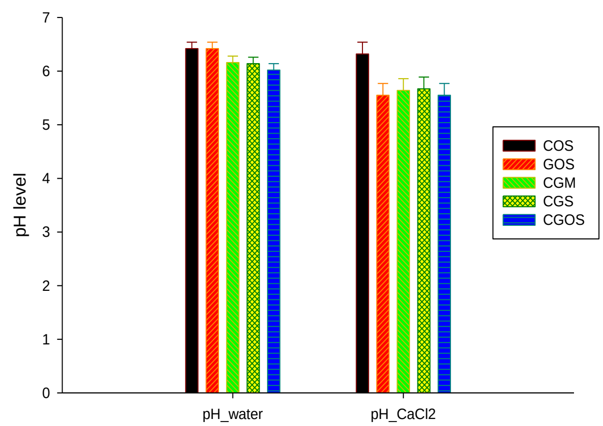

Figure 2: pH_{water} and pH_{CaCl2}

3.2.2 Organic Carbon

Most tropical soil has low organic carbon and nitrogen level. The level of these nutrient declines further with cultivation (Essiet, 2000). The scenario is the same for this study. The organic carbon content of the soil in the study areas which is an indicator of the organic matter content of the soil was found to be low at both the belts and the various cropping systems. The organic carbon content of the soil was seen not to be significantly affected by the various belts and the cropping systems, despite the higher mean of organic carbon content was observed at sorghum belt (0.40%) and lower means value of organic carbon content recorded at millet belt (0.36%) (Table 3). On the other hand, the organic carbon content of the soil was found not to be significantly influenced by the various cropping system with GOS having the higher mean value and CGOS having the lowest mean value of 0.51% and 0.22% respectively (Figure 3).

3.2.3 Total Nitrogen

The total nitrogen content of the soils shows no significant change between the two belts (Millet and Sorghum belt). However, both belts have an equal mean value of total nitrogen 0.11% (Table 3). The values were generally at moderate range based on soil fertility rating by (Esu, 1991). Figure 3 shows that the total nitrogen content ranged from (0.11% – 0.12%) a value within the range value reported by NSPFS (2005b) for cultivated Nigerian savanna soils. Even though there appeared to be a slight variability in total nitrogen content in the soils studied from the cropping systems, the differences were not statistically significant.

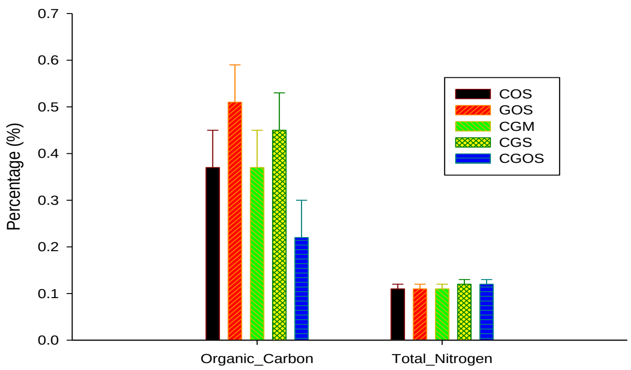

Figure 3: Organic Carbon and Total Nitrogen for the Cropping Systems

3.2.4 Available Sulphur

There was no significant different in available sulphur in the soil of millet and sorghum belt, in addition, the cropping systems do not influence the soil available S. The lowest mean value of available sulphur content in the surface of the soils was recorded in the soils from sorghum belt and CGS cropping system with the mean value of (10.4 ppm) and (8.33 ppm) respectively, likewise the highest mean was recorded in both millet belt and COS cropping system with the mean value (10.6 ppm) and (12.9 ppm) respectively (Table 3 and Figure 4). However, the available sulphur fell within medium range. As it was stated earlier, sulphur is one of the essential plant nutrients for plant growth with crop requirement similar to phosphorus (P); it has not received as much attention as P until recently. This lack of attention in the past may be attributed to subsistence farming, low crop yields, sulphur non-responsive varieties, incidental sulphur returns to soil through farmyard manure, and the use of conventional sulphur containing fertilizers, such as single superphosphate (SSP) and ammonium sulphate which contain 14 and 23 percent sulphur, respectively (FMANR,1990).

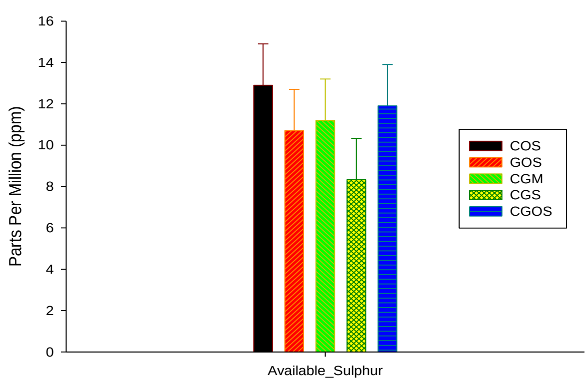

Figure 4: Available Sulphur

IV. CONCLUSION AND RECOMMENDATIONS

Cultivated soils in the study areas were found to be slightly acidic to moderately acidic in nature. The organic carbon of the study area was generally low and was seen not to be significantly affected by the various belts and the cropping systems. Also, total nitrogen fell within the moderate range and there was no significant variation in total N for these soil samples obtained from different sampling locations. The available S fell within medium range, this could be as a result of incidental sulphur returns to soil throug h farmyard manure, and the use of conventional Sulphur conta ining fertilizers, such as single super phosphate (SSP) and am monium sulphate which contain 14 and 23 percent sulphur res pectively. It is therefore recommended that supplementary nitrogen application and improvement of the drainage conditions of all the soils should be employed to improve the nutrient status of the soils. Also, with the current intensive cropping pattern, sulphur contained fertilizer should be used frequently to prevent depleting the soils which are presently adequate in sulphur within few years.

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