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SOIL FERTILITY STATUS OF MILLET AND SORGHUM FARMS IN WUDIL, KANO STATE NIGERIA AND THE AGRONOMIC IMPLICATIONS

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Abstract

The aim of the research was to evaluate soil fertility status of millet and sorghum farms in Wudil, Kano State Nigeria in order to advise the farmers for sustainable millet and sorghum productions. A total of 30 composite soil samples were collected at depth 0-15 cm (fifteen from each of millet and sorghum farms). Structured questionnaires were also administered to record the cultural and management practices of the farmers. The soil samples were analyzed for some chemical properties using standard laboratory procedures. Results of questionnaires indicated that majority of millet and sorghum farmers in the study area are individual own farms with sizes less than half a hectare and practices mixed cropping with a grossly low input system. The results of soil properties shows that the pH of the millet farms in Wudil ranged from 5.2-6.11 (mean 5.78) which is considered to be moderately to slightly acidic while that of the sorghum farms is slightly acidic with a pH range of 5.83- 6.68 (mean 6.186). It was also found that the exchangeable acidity values were low 0.25 and 0.21 for the millet and sorghum farms respectively, indicating a low buffering capacity. The organic carbon and organic matter for both the millet and sorghum farms were low (0.1-0.958 and 0.172-1.651; 0.18-0.858 and 0.31-1.479 with mean values of 0.543 and 0.936, and 0.532 and 0.917 respectively). The total N was low for both millet and sorghum farms which ranged between 0.03-0.14 and 0.035-0.14 with mean of 0.061% and 0.067% respectively. The results of available P in the study area indicate medium in both millet and sorghum farms ranges from 8.5-22.73 and 6.818-22.48 with a mean of 11.75 and 12.90 respectively. The results of exchangeable bases (Ca, Na, Mg and K) were low ranges from 0.99-1.89, 0.07-0.211, 0.38-1.45; and 0.255-0.96 with mean values of 1.259, 0.135, 0.865 and 0.449 respectively, thus recommends application of both organic and inorganic fertilizers.

Keywords: Soil fertility, cropping system, Sudan savannah

Introduction

The conservational cropping systems such as rotation and intercropping are known to improve soil structure and fertility. Cropping system has an immense effect on physical, biological and chemical soil properties and also on crop productivity (Alam et al., 2014). Soil and crop management decisions affect soil quality, soil nutrient dynamics and soil chemical properties (Tittonell et al., 2008). They further indicated that those management decisions include crop rotation, residue management and the intensity and frequency of tillage. Unsuitable management practices cause degradation in soil health as well as decline in crop productivity (Alam et al., 2014).

In a crop rotation, different crop species are planted in a particular order over sequential growing seasons; in contrast, a continuous monoculture consists of the same crop species being grown repeatedly over many years (Bullock, 1992). Mono-cropping carries many problems with it, such as deterioration of soil physicochemical properties and accumulation of toxic compounds. So mono-cropping system has negative impacts on the soil physical properties and structure, thus intercropping system is the better option to address these problems. Intercropping is the practice of growing two or more crops in close proximity in the same growing season. Intercropping is now becoming more important to improve soil quality and increase crop productivity. This cropping system is particularly significant in developing countries; where arable land was limited (Li et al., 1999).

Soil responds to improvement or deterioration in properties and fertility status due to farmers cropping and tillage practices (Olofin, 2000). Modification in soil properties within a region or agricultural zone due to farmers cropping practices had been noted. However little is known on the long-term impact of cropping systems on the chemical properties of soil in the study area. It is important to evaluate the effects caused by the activities of farmers on their fields in order to efficiently manage the soil resources.

The judicious management and conservation of the soil to guide against decreased crop yields under intensive cropping have become major areas of agronomic research. Soil productivity is of particular importance due to the doubling of global grain demand over the next several decades as the global population grows (Tilman et al., 2002). Therefore, any management practice that degrades the soil can reduce the productivity and reduce food production capacity (Cassman, 1999).

Due to the potential impact on global food security, it is vital to evaluate the long-term impact of farmers' management practices such as a short crop rotation or monoculture and more intensive cultivation on the soil productivity. The aim of this research was therefore to evaluate the soil physicochemical status of millet and sorghum farms in Wudil, Kano State Nigeria with the view of offering appropriate agronomic guide to the farmers for sustainable production of millet and sorghum.

Materials and Methods

Description of the Study Area

This study was conducted at Wudil local government area in Kano state Nigeria, its headquarters is in the town of Wudil local government area in Kano state Nigeria on the A237 highway, and it has an area of 362 km2. Wudil is located in the South-Eastern part of Kano state Nigeria. It lies between (Lat. 8.45oS and Long. 9oE). Wudil's climate is a local Steppe climate. There is little rainfall throughout the year. The climatic region of the area was characterized by tropical wet, dry climate and cold as (Aw) according to Koppen`s classification. Annual mean temperature and rainfall are between 28-320C and 400-950 ± mm respectively. The vegetation of Wudil is semi-arid Sudan savanna. The canopy of trees is very wide and most of them are less than 20 M tall (Olofin, 2002).

Soil Sampling Preparation

Thirty (30) composite soil samples were randomly collected from 30 farmers' field at depth of 0 - 15 cm using soil auger, the samples were air dried, grinded and passed through a 2 mm sieve and stored in polythene bags for analysis. The samples were analyzed in the laboratory for some physical and chemical properties using standard analytical procedures. Soil pH was measured with the glass-electrode pH meter on 1:1 soil – solution mixture. The organic carbon was determined by Walkey-Black method (Walkey – Black, 1934) and the total N was determined by the regular macro-Kjeldahl method (Bremner, 1996). Available P (mg kg-1) was determined by the Bray-1 method (Bray and Kurtz, 1945) while the exchangeable cations were extracted with 1NH4OAc solution (Thomas, 1982). Calcium, Na and K were measured with the flame photometer and Mg was determined with the atomic absorption spectro-photometer. Exchangeable acidity (H+) of the soil was determined by titration method. Effective cation exchange capacity (ECEC) was established as the sum of the exchangeable cations K, Na, Ca and Mg and H+ expressed in cmo1 kg-1 of soil (Brady and Weil, 1999).

In addition 30 farmers were interviewed using structured questionnaires to obtain information on their soil and agricultural production practices.

Statistical Analysis

The soil properties data obtained from the study area were subjected to descriptive statistics such as maximum, minimum, mean and coefficient of variability to estimate the variation between sampling locations using GENSTAT (version 15) at 5% level to test the significant.

Results and Discussion

The soil pH of the millet farms in Wudil ranged from 5.2-6.11 (mean 5.78) which was considered to be strongly to slightly acidic as presented in table 1. While that of the sorghum farms is slightly less acidic with a pH range of 5.83-6.68 (mean 6.186) this difference in pH can be attributed to the form of basic cations consumed by either crops and the application of more nitrogenous fertilizers (Table 1). This acidity problem might be due to the leaching of exchangeable cations because of the sandy nature of the soils to lower depths and probably the use of acid-forming fertilizers such as urea (Voncir et al., 2008; Mustapha et al., 2011). The low exchangeable acidity values 0.245 and 0.212 of the millet and sorghum farms indicating that the soils possess a low buffering capacity (Agboola et al., 1998). This also relates to the soils tenderness and fragility which means that the soil could be affected by any slight change in management (Mustapha et al., 2011).

The result showed that the values of organic carbon and organic matter for both the millet and sorghum farms (0.1-0.958 and 0.172-1.651; 0.18-0.858 and 0.31-1.479) were low as rated in accordance with Esu (1991). These very low values could be attributed to low application of organic manures, continuous cropping and bush burning. Lombin (1983) and Mustapha and Nnalee (2007) reported similar low values of organic C for soils in the guinea savanna zones of Nigeria. Otisi (1996) reported that soils with high accumulation of Ca, Mg and Na salts have low organic matter, and invariably organic carbon.

Table 1 and 2 present the values of percent total N in millet and sorghum farms respectively in Wudil LGA. The total N was low (range 0.03-0.14; mean 0.061%) for millet farms and (range 0.035-0.14; mean 0.067%) in sorghum farms. These low values might be attributed to the low nutrient inputs of the cropping systems adopted by the farmers (Table 1). These results are similar to earlier report by Mustapha et al., (2005) for soils in similar ecologies.

The low N can be attributed to impediments on N mineralization under anaerobic conditions which is subsequently loss as gas due to the failure to pass the ammonia stage (Brady and Weil, 1999).

Available P in the soils of the Millet farms ranged from 8.5-22.73 with a mean of 11.75 as shown in Table 1, was rated according to Esu (1991) to be from low to high values. Those obtained in the sorghum farms were similar with a range of 6.818-22.48 (Mean 12.90) as presented in Table 2. Low P values were expected as the farmers in the study area apply very little of NPK fertilizers compared to nitrogenous fertilizers. These findings corroborate with that of Mustapha et al. (2003) and indicate the need for P application especially in the farms rated low.

Data in Table 1 present the levels of exchangeable bases in millet farms in Wudil LGA. Ca levels with (range 0.99-1.89; mean 1.259) and Na with 0.07-0.211 (mean 0.135) were rated low; while Mg with values of (range 0.38-1.45; mean 0.865) and K with 0.255-0.96 (mean 0.449) were rated medium to high availability according to Esu (1991). Similar results were also obtained in the sorghum farms. A relatively medium to high contents of K and Mg was reported by Mustapha et al. (2011) in a similar study.

Table 1. Physicochemical properties of soils in Millet farms in Wudil, Kano

Farm ID	pH	Total Nitrogen %	P (mg/kg)	% Organic Carbon	% Organic Matter	Acidity	Ca cmol/kg	Mg cmol/kg	Na cmol/kg	K cmol/kg
M1	5.32	0.07	22.727	0.738	1.273	0.334	1.89	0.73	0.141	0.353
M2	5.2	0.14	9.848	0.958	1.651	0.501	1.01	0.84	0.127	0.392
M3	5.31	0.035	11.869	0.618	1.066	0.334	1.13	0.65	0.085	0.255
M4	5.49	0.07	8.586	0.658	1.135	0.167	0.99	1.28	0.099	0.372
M5	6.11	0.07	12.374	0.638	1.101	0.167	1.35	0.46	0.183	0.411
M6	5.5	0.035	9.343	0.559	0.963	0.334	1.25	0.62	0.211	0.45
M7	5.66	0.035	12.626	0.479	0.825	0.167	1.28	0.96	0.113	0.49
M8	5.92	0.07	9.091	0.459	0.791	0.167	1.08	0.5	0.197	0.431
M9	5.87	0.105	8.838	0.798	1.376	0.167	1.41	1.12	0.155	0.96
M10	5.89	0.07	10.606	0.579	0.997	0.167	1.3	1.13	0.169	0.372
M11	6.03	0.035	11.111	0.439	0.757	0.334	1.38	1.17	0.127	0.803
M12	6.01	0.035	17.172	0.279	0.482	0.167	1.51	0.38	0.099	0.333
M13	6.05	0.035	10.354	0.339	0.585	0.167	1.01	1.45	0.141	0.411
M14	5.92	0.035	10.101	0.1	0.172	0.167	1.21	1.29	0.113	0.313
M15	6.09	0.07	11.616	0.50	0.86	0.334	1.09	0.4	0.07	0.392
Minimum	5.2	0.035	8.586	0.10	0.172	0.167	0.99	0.38	0.07	0.255
Maximum	6.11	0.14	22.73	0.958	1.651	0.501	1.89	1.45	0.211	0.96
Mean	5.758	0.061	11.75	0.543	0.936	0.245	1.259	0.865	0.135	0.449
CV%	5.475	50.98	31.55	39.28	39.28	43.63	18.80	41.51	30.57	41.58

M = Millet Farm; CV = Coefficient of Variability

Conclusions

The chemical properties of the soils in the research area indicated low to medium in soil fertility probably as a result of continuous cropping, poor soil management and low fertilizer application. The pH of both millet and sorghum farms were moderately to slightly acidic, with a low buffering capacity. There was evidence of nutrient mining and excessive uptake of exchangeable cations due to continuous cropping and low organic matter input. Therefore, it was recommended that farmers that cultivate millet and sorghum in the research area should avoid the use of acid forming fertilizers and adopt a proper fertilizer application method to avoid low productivity of millet and sorghum with the corresponding waste of inputs. Specifically, the farmers should apply more of organic fertilizers and materials to improve the soil conditions of the area.

Table 2. Physicochemical properties of soils in sorghum farms in Wudil, Kano

Farm ID	pH	Total Nitrogen %	P (mg/kg)	% Organic Carbon	% Organic Matter	Acidity	Ca cmol/kg	Mg cmol/kg	Na cmol/kg	K cmol/kg
S1	5.93	0.035	8.838	0.479	0.825	0.334	1.27	2	0.169	0.568
S2	5.96	0.07	17.424	0.579	0.997	0.167	0.72	1.65	0.24	0.705
S3	6.22	0.035	14.141	0.439	0.757	0.167	1.91	1.04	0.183	0.431
S4	6.26	0.035	14.899	0.459	0.791	0.167	1.77	1	0.155	0.529
S5	6.31	0.105	18.434	0.519	0.894	0.167	1.57	1.26	0.225	0.411
S6	6.09	0.07	17.677	0.499	0.86	0.167	1.15	1.27	0.113	0.96
S7	6.05	0.035	9.091	0.359	0.619	0.167	1.89	1.42	0.254	0.45
S8	5.94	0.035	8.586	0.259	0.447	0.334	0.84	0.63	0.155	0.372
S9	5.83	0.105	7.323	0.698	1.204	0.167	1.39	0.76	0.099	0.999
S10	6.12	0.105	9.596	0.638	1.101	0.167	1.09	2.01	0.409	0.646
S11	5.9	0.035	9.343	0.459	0.791	0.334	1.05	0.96	0.211	0.49
S12	6.34	0.14	22.475	0.818	1.41	0.334	2	1.59	0.197	0.744
S13	6.68	0.07	6.818	0.738	1.273	0.167	1.99	1.35	0.127	0.999
S14	6.49	0.035	11.869	0.18	0.31	0.167	1.16	0.86	0.141	0.881
S15	6.35	0.105	16.919	0.858	1.479	0.167	1.22	1.67	0.24	0.529
Minimum	5.83	0.035	6.818	0.18	0.31	0.167	0.72	0.63	0.099	0.372
Maximum	6.68	0.14	22.48	0.858	1.479	0.334	2	2.01	0.409	1.00
Mean	6.16	0.067	12.90	0.532	0.917	0.212	1.401	1.298	0.195	0.648
CV%	3.92	53.42	37.63	36.33	36.35	36.14	30.38	32.97	39.34	34.25

S = Sorghum Farm; CV = Coefficient of Variability

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