

FERTILITY STATUS FOR SOILS OF TEACHING AND RESEARCH FARM, MODIBBO ADAMA UNIVERSITY, YOLA, SUDAN SAVANNA ZONE OF NIGERIA

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ABSTRACT

Experiment was conducted in 2019 to assess fertility status for soils of New Teaching and Research Farm, Modibbo Adama University, Yola. Twenty-three composite surface samples were collected using grid soil sampling technique. Collected samples were prepared in the laboratory by drying, crushing and sieving. Physical and chemical properties of the samples were analyzed using recommended procedures. The results show that top soil was predominantly sandy, with sand particles exceeding 80.00%, bulk density was within the normal range (60.0gcm^{-3}). Soil reaction (pH) was neutral (5.99), organic carbon was low (0.94gkg^{-1}), total nitrogen was very low (0.47gkg^{-1}), available phosphorus was also low (2.64mgkg^{-1}). Similarly, the exchangeable bases were all low, with calcium dominating the exchange complex of the soils. Total exchangeable bases, total exchangeable acidity and effective cation exchange capacity were also low. Fertility status for the soil of the new Teaching and Research Farm was rated as very low. For any meaningful research on the fields, application of the organic and inorganic amendments for the improvement of sandy texture, water-holding capacity and supply of soil essential nutrients could be recommended.

KeyWords: Fertility Status, Modibbo Adama University,

INTRODUCTION

Soil fertility status is the basis for understanding soil's capacity to sustain crop production and to some extent the type of crops to cultivate on a particular soil. It is therefore a fundamental aspect that supports land productivity and proper management for agricultural crop production. Agricultural sector plays a significant role in the Nigerian economy and remains a major economic activity after oil. Agribusiness is a critical component of agricultural sector in Nigeria with more than 80 percent of smallholder farmers contributing to this sector (FMARD, 2022). It is important as the oil sector, but is also critical to food security and enhances the contribution of small and medium enterprises in the national economy. According to Varela, (2021), agricultural sector contributed about 26. 21% of the national Gross Domestic Product (GDP) in the year 2020.

Nigerian Sudan Savanna Zone contributes major part of agricultural production

in the country which is a key factor to the sustenance of agribusiness in the country. The Zone is situated between latitudes $9^{\circ}3'$ and $12^{\circ}31'$ N and longitudes 4° and $14^{\circ}3'$ E and covers about 22.8 million hectares, representing about one quarter of Nigeria's geographical area (Shehu *et al.*, 2015). There is large expanse of arable land that exists in the Sudan Savanna Zone of Nigeria with potential for the production of grain crops like maize, sorghum, millet, rice and wheat (FFD., 2012). The major constrain preventing increase in agricultural production within the region is poor soil fertility (Amberger, 2006). Soil fertility depletion is one of the fundamental causes for declining food production in Sudan of Savanna of Nigeria (Sanchez, *et al.*, 1997).

Use of organic and inorganic fertilizer as means of soil fertility management for increased crop production in the zone have been recommended (Bapetel *et al.*, 2021). To adapt better fertility management practices for increased and sustainable production, periodic

and site specific evaluation of soil fertility status is critical. Soil testing assess the current fertility status and provides information regarding nutrient availability in soils prior to crop cultivation (FAO, 2020). Soil test results form the basis for fertilizer recommendations so as to maximize crop yields and to maintain the adequate fertility in soils for longer period (Dinesh *et al.*, 2016).

Teaching and Research Farms in the higher institutions and research centers form an integral part of field experimentation, particularly in agriculture. Soil fertility assessment in Teaching and Research Farms is therefore very important for the success of field experiments. The aim of this work is to assess the fertility status of the new Teaching and Research Farm Modibbo Adama University, Yola.

MATERIALS AND METHODS

Study Area

The study will be conducted in Modibbo Adama University, Yola (MAU), new Teaching and Research Farm located between latitude $12^{\circ}30'1.8''\text{E}$ and $12^{\circ}30'29.5''\text{E}$ longitude $9^{\circ}21'25.3''\text{N}$ and $9^{\circ}21'44.9''\text{N}$ of the equator. Adamawa state, which is in northeastern part of Nigeria and lies between Latitude 1° to 7°N and Longitude 11° to 14°E (Figure 1). The state shares boundary with Taraba state to the south, Gombe state to Northwest, Borno state to the north and

Cameroon Republic to the east (Usman, 2005). The climate of the study area is typical of the West African Savanna climate. Temperature in this climatic region is high because of the radiation income, and is relatively evenly distributed. However, there is usually a seasonal change in the temperature with gradual increase in temperature from January to April, followed by a distinct drop in temperature at the onset of rains due to cloud cover effect. A slight increase after the cessation of rain (October to November) is common before the onset of harmattan in December as the temperature in Yola reaches 40°C particularly in April while minimum temperature can be as low as 18°C in the south to 27.8°C in the northeastern part in December (Adebayo and Tukur, 2012). The soil is typically Alfisols and Inceptisols, with commonly cultivated crops being maize, sorghum, millet, groundnut and beans (Musa *et al.*, 2007).

Soil Sampling and Analysis

Using grid technique of sampling, 23 composite samples were collected in a 30 hectares New Teaching and Research Farm, Modibbo Adama University, Yola. The collected samples were prepared in the laboratory by drying, sieving and bagging for physical, chemical and micronutrient analysis (Nafiu, *et al.*, 2012).

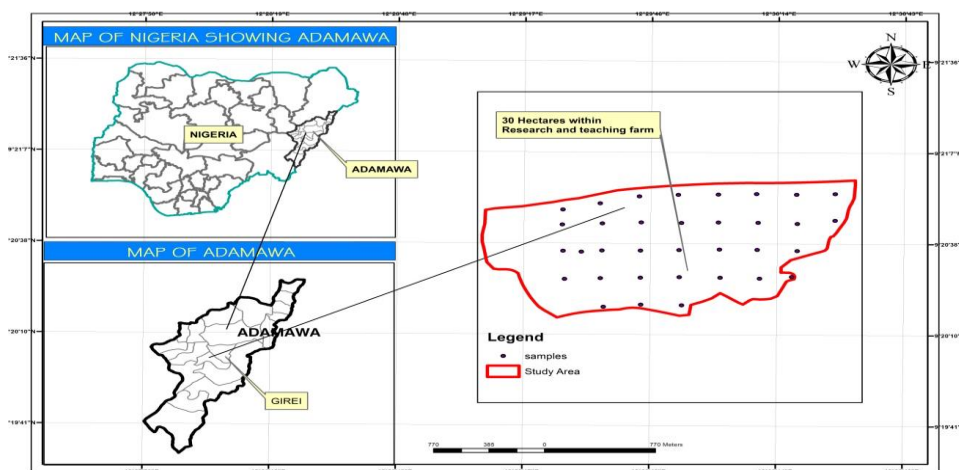


Figure 1: Map of the Study Area

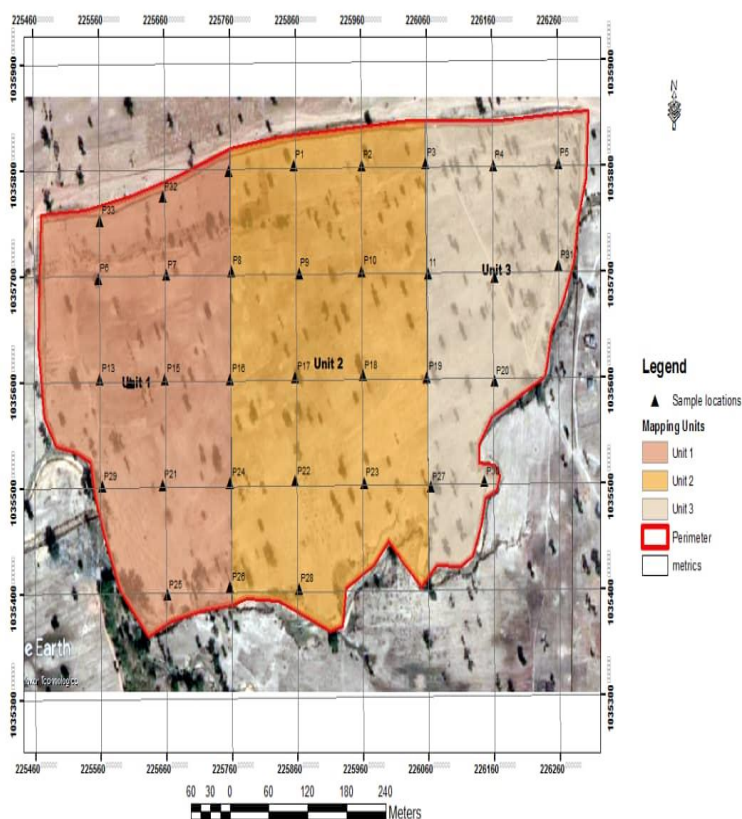


Figure 2: Study Area Showing Grid Sampling points

Soil texture was determined by the Bouyoucos hydrometer method. Soil pH was measured using pH meter in a 1:2.5 soil-water suspension. Organic carbon and total nitrogen were determined by Walkey-Black oxidation and Micro-Kjeldahl distillation methods, respectively. Available P was determined by Bray 1 method. Exchangeable cations were analysed using EDTA (diethylene triamine penta acetic acid) titrimetric method (FAO, 2020).

RESULTS AND DISCUSSIONS

Physical Properties

Physical parameters presented in (Table 1) indicates that the top soil of the study area was dominated with sand particles. The particles ranged from 71.00 to 93.00%

with the mean of 87.83%, largest sand particles of 93.40% were observed in locations P1 and P2. Silt particles ranged from 2.40 to 18.40% with the mean of 7.88%. Highest silt particles of 18.40% were observed on location P16 of the study area. Clay particle also ranged from 2.20 to 10.20% with the mean of 4.29%. Largest clay content of 10.20% was observed in location P16. This corroborated the report of Ibrahim and Zata (2022) for the soils of Girei, Adamawa State, Nigeria. Soils with predominantly sand particles retain less water and nutrients due to high porosity and little clay content thereby rendering the soils to be of low fertility status (Bapetel *et al.*, 2021). The particle density of the soils ranged between 2.13 to 2.51 gcm^{-3} with the mean of

2.39gcm⁻³. Bulk density for the soils of the study area also ranged between 1.58 to 1.72gcm⁻³ with the mean of 1.60gcm⁻³. The values of bulk density is higher than the mean of 1.51gcm⁻³ earlier reported by Maunde *et al.*, (2016) for soils of the area. However, the high mean bulk density observed in this study

is within the critical level of 1.65gcm⁻³ (Esu, 1991) and is within the range earlier reported for soils of north eastern Nigeria (Ezeaku *et al.*, 2022) and is not expected to develop hard pan that prevents water and air circulation as well as root penetration.

Table 1: Physical Properties for Soils of the Study Area

Locations	Sand (%)	Silt (%)	Clay (%)	P.D. (g/cm ⁻³)	B.D. (g/cm ⁻³)	Textural Class
P1	93.40	4.40	2.20	2.42	1.62	Sand
P2	93.40	4.40	2.20	2.51	1.68	Sand
P3	91.40	6.40	2.20	2.13	1.43	Sandy Loam
P4	79.40	10.40	10.20	2.17	1.46	Loamy Sand
P5	89.40	6.40	4.20	2.47	1.66	Loamy Sand
P6	89.40	6.40	4.20	2.39	1.60	Sand
P7	85.40	10.40	4.20	2.46	1.65	Loamy Sand
P8	95.40	2.40	2.20	2.56	1.72	Sand
P9	83.40	10.40	6.20	2.36	1.59	Loamy Sand
P10	89.40	6.40	4.20	2.45	1.65	Sand
P11	91.40	6.40	2.20	2.44	1.64	Sand
P12	81.40	12.40	6.20	2.39	1.60	Loamy Sand
P13	83.40	10.40	6.20	2.39	1.60	Loamy Sand
P14	91.40	6.40	2.20	2.51	1.68	Sand
P15	79.40	14.40	6.20	2.39	1.60	Loamy Sand
P16	71.40	18.40	10.20	2.04	1.37	Sandy Loam
P17	93.40	4.40	2.20	2.40	1.61	Sand
P19	83.40	10.40	6.20	2.41	1.62	Loamy Sand
P20	93.40	4.40	2.20	2.46	1.65	Sand
P21	89.40	8.40	2.20	2.36	1.58	Sand
P21	87.40	8.40	4.20	2.19	1.47	Sand
P22	93.40	4.40	2.20	2.60	1.75	Sand
P23	91.40	4.40	4.20	2.44	1.64	Sand
Mean	87.83	7.88	4.29	2.39	1.60	

Chemical Properties

Soil reaction (pH) for soils of the study area ranged from 5.15 to 6.94, with the mean of 5.99. Slightly acidic to neutral soil reaction, Landon, (1984), which normally provides appropriate medium for maximum microbial activities with higher rate of bio-

recycling of organic material allow for good nutrient availability and uptake by crops (Alexandra and Jose, 2005). Organic carbon for the soil of the study area ranged between 0.47 to 1.31gkg⁻¹ and has the mean of 0.94gkg⁻¹, based on ranking for organic carbon in soils Adamawa region, the organic

content was classified as low (Usman, 2005). The organic carbon level recorded is within the range earlier reported for top soils of northern guinea savanna (Jimoh *et al.*, 2016). Low organic carbon content could be related to very low return of crop residues into the soil due to competitive use as fodder, building materials, bush burning and degradation due to high tropical (Sani, *et al.*, 2019). Total nitrogen ranged between 0.28 to 0.84gkg⁻¹ with the mean of 0.47gkg⁻¹. The total nitrogen of the area is classified as very low (Esu, 1991), and as was reported for soils of Sudan Savanna Zones of Nigeria (Oyetola *et al.*, 2021; Tahir *et al.*, 2022). Low total nitrogen could be attributed to the inherent sandy nature of the soil, crop removal due to intensive crop cultivation in the area and imbalance fertilizer application (Osujieke *et al.* 2018). Available phosphorus ranged between 1.05 to 4.20mgkg⁻¹ with the mean of 2.64mgkg⁻¹, and classified as very low, and lower than what was earlier reported soils of north eastern Nigeria (Tahir *et al.*, 2022), but is consistent with some reports of phosphorus deficiencies in soils of tropical regions with low soil pH (Tsado, *et al.*, 2012). Low phosphorus availability could be a factor that limits plant growth, due to its importance in photosynthesis, respiration, metabolism and

cell division (Richard and Robert, 2018). Calcium ranged from 0.73 to 8.40cmolkg⁻¹ with the mean of 1.85cmolkg⁻¹, magnesium ranged from 0.11 to 0.34cmolkg⁻¹ with the mean of 0.17cmolkg⁻¹, sodium ranged from 0.13 to 2.56 with the mean of 1.10cmolkg⁻¹ and potassium ranged from 0.17 to 2.10cmolkg⁻¹ with the mean of 0.56cmolkg⁻¹ the exchangeable bases observed are all within the range earlier for the soils of the area (Bapetel *et al.*, 2021; Tahir *et al.*, 2022). Exchangeable calcium was the dominant cation in the exchange complex of the soils (Alhassan *et al.*, 2018). Values for the total exchangeable bases ranged from 1.45 to 5.00cmolkg⁻¹ and classified as low (Usman, 2005). Total exchangeable acidity ranged from 0.30 to 1.01cmolkg⁻¹ with the mean of 0.44cmolkg⁻¹ also classified as low (Esu, 1991). Effective cation exchange capacity ranged from 2.12 to 6.43cmolkg⁻¹ with the mean of 3.67cmolkg⁻¹ and classified as very low. The low ECEC in the soils could be associated with low chemical weathering activity of the soil, leaching, acidity and dominant clay minerals of the area (Hassan *et al.*, 2011; Osujieke *et al.* 2018). Percentage base saturation ranged from 76.14 to 92.16% with the mean of 88.42% and regarded as high, according to Landon (1991).

Table 2: Chemical properties for soils of the study area

Sampling points	pHw (1:2)	Organic Carbon (gkg ⁻¹)	Total Nitrogen gkg ⁻¹	Available Phosphorus (mgkg ⁻¹)	Exchangeable Bases (cmolk ⁻¹)							
					Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	TEB	TEA	ECEC	PBS (%)
P1	5.72	0.87	0.70	4.20	1.46	0.15	0.17	1.69	3.47	0.40	3.24	89.30
P2	6.22	1.01	0.56	2.03	1.70	0.13	0.22	2.10	4.15	0.40	4.43	90.98
P3	6.13	1.01	0.42	3.15	2.67	0.24	0.17	0.18	3.26	0.30	3.35	91.04
P4	6.56	1.14	0.42	1.61	2.67	0.13	0.17	2.03	5.00	0.50	5.38	90.71
P5	6.51	1.23	0.28	1.96	0.97	0.13	0.17	0.90	2.17	0.30	2.36	87.26
P6	6.61	0.81	0.42	3.92	1.70	0.24	0.13	0.95	3.02	0.30	3.10	90.32
P7	5.41	0.65	0.28	3.01	0.73	0.15	0.17	0.40	1.45	1.01	2.12	85.82
P8	5.73	1.04	0.56	1.05	1.21	0.11	0.13	0.46	1.91	0.30	2.12	85.32
P9	6.94	1.11	0.28	1.68	1.70	0.32	0.22	1.23	3.47	0.50	3.68	86.41
P10	5.21	0.66	0.56	3.50	1.70	0.13	1.23	0.22	3.28	0.40	3.56	88.76
P11	6.00	0.96	0.84	1.40	6.73	0.13	1.00	0.17	8.03	0.60	2.30	76.14
P12	5.61	1.31	0.28	8.40	1.46	0.20	2.54	0.22	4.42	0.40	4.63	91.36
P13	6.03	0.77	0.56	1.26	1.46	0.13	2.56	0.22	4.37	0.40	4.65	91.40
P14	6.20	0.92	0.28	2.24	3.40	0.11	2.31	0.22	6.04	0.50	6.43	92.23
P15	5.33	1.07	0.28	1.26	2.18	0.20	0.82	0.22	3.42	0.70	3.94	82.24
P16	5.90	0.78	0.28	1.61	2.18	0.24	1.26	0.22	3.90	0.50	4.18	88.05
P17	5.15	0.92	0.56	2.80	0.97	0.15	2.56	0.22	3.90	0.40	4.17	90.40
P19	6.27	1.13	0.21	6.30	1.46	0.31	1.82	0.22	3.81	0.30	3.83	92.16
P20	5.89	0.47	0.70	2.03	1.21	0.12	0.82	0.17	2.32	0.30	2.52	88.10
P21	5.41	0.81	0.42	1.05	1.94	0.15	0.87	0.17	3.13	0.40	3.40	88.24
P21	6.91	1.11	0.42	2.24	0.73	0.27	2.03	0.22	3.25	0.40	3.40	88.23
P22	6.48	0.84	0.70	2.03	1.21	0.13	1.97	0.22	3.53	0.40	3.82	89.52
P23	5.66	0.89	0.80	2.05	1.22	0.14	1.98	0.24	3.56	0.44	3.89	89.60
Mean	5.99	0.94	0.47	2.64	1.85	0.17	1.10	0.56	3.69	0.44	3.67	88.42

Pearson Correlation among the Parameters

The Pearson correlation presented in Table 3 indicates positive correlation of available phosphorus with effective cation exchange capacity, magnesium and organic carbon. There was stronger positive correlation between magnesium (*0.35) compared to effective cation capacity and organic carbon. This is an indication that increase in available phosphorus help in the increase of effective cation capacity, similar relationship was earlier by Bapetel (2021) for soils of Geriyo Irrigation Scheme. Calcium was positively correlated with effective cation capacity, organic carbon and pH, the correlation was relatively stronger with effective cation exchange capacity (0.089) compared to organic carbon and pH. Clay

was positively correlated with effective cation exchange capacity, potassium, magnesium, organic carbon and pH. This indicates that clay was positively correlated with all the parameters except calcium Table 3. The correlation was stronger with magnesium (0.39) then followed by effective cation exchange capacity (0.35), with potassium showing the least correlation (0.16). Strong of clay with magnesium in an indication that the soil solution is dominated with magnesium bearing clay particles. Effective cation capacity was also positively correlated with potassium, organic carbon and pH. The correlation was stronger with organic carbon (0.22) compared to potassium and pH. Potassium was positively correlated with organic carbon and pH, the correlation was stronger with pH compared to organic carbon (Table 3).

Table 3: Correlation Coefficient between Clay and soil Macronutrients

	AVP	Ca	Clay	ECEC	K	Mg	OC
Ca	-0.191						
Clay	0.084	-0.046					
ECEC	0.110	0.089	0.353				
K	-0.059	-0.052	0.162	0.145			
Mg	0.345	-0.124	0.389	-0.008	-0.059		
OC	0.284	0.072	0.253	0.218	0.257	0.035	
pH	-0.097	0.046	0.187	0.104	0.373	0.417	0.368

CONCLUSION

Using grid soil sampling technique, twenty-three composite surface soil (0-20cm) samples were collected from the new Teaching and Research Farm, Modibbo Adama University of Technology, Yola. Physical and chemical properties were analyzed using recommended procedures. The result obtained indicated that the top soil was predominantly sandy, with sand particles exceeding 80.00%, the bulk density was within the normal range (60.0gcm^{-3}). Soil reaction (pH) ranged from slightly acidic to neutral (5.15 to 6.94), organic carbon was low (0.47 to 1.31gkg^{-1}), total nitrogen was

very low, ranging between 0.28 to 0.84gkg^{-1} , available phosphorus was also low (1.05 to 4.20mgkg^{-1}). Similarly, the exchangeable bases were all low, with calcium dominating the exchange complex of the soils. Total exchangeable bases, total exchangeable acidity and effective cation exchange capacity were also low. Fertility status for the soil of new Teaching and Research Farm was rated as very low. For any meaningful research on the fields, application of the inorganic and organic amendments for the improvement of sandy texture, water-holding capacity and supply of soil essential nutrients could be recommended.

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