SOIL FERTILITY STATUS AND AVAILABILITY OF MICRONUTRIENTS IN SOILS OF JALINGO, NORTH EASTERN Nigeria

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ABSTRACT

Research was conducted in 2021 on Teaching and Research Farm, Taraba State College of Agriculture Jalingo. Using grid system the area was divided in three sections. Ten composite samples were taken from each of the sections and analysed for physical, chemical and micronutrient contents. The top soil was predominantly sandy with highest mean of exceeding 90%. The soil has large pore spaces with low water-holding capacity. Soil reaction was slightly acidic to neutral with the overall mean of 6.44 recorded in section A. Electrical conductivity was low in all the three sections and less than 0.4dSm^{-1}, similarly all the sections were low in organic carbon (8.06gkg^{-1}) and total nitrogen (0.88gkg^{-1}), but medium in available phosphorus (8.30mgkg^{-1}), exchangeable bases (8.02cmolkg-1) and high in percentage base saturation (82.14%). Highest mean of copper (1.26mgkg^{-1}), iron (3.53mgkg^{-1}), manganese (3.48mgkg^{-1}) and Zinc (2.41mgkg^{-1}) were all recorded in section A of the study area. The fertility status of the soil could be rated from low to medium. For sustainable production of staple crops, combined application of organic and inorganic fertilizers (integrated nutrient management) could be recommended.

Key words: Soil fertility, micronutrients, north eastern Nigeria

Introduction

Soil fertility is the quality that enables particular soil to provide plant nutrients in adequate amounts and proper balance, for the growth of specified plants (John and Heiniger, 2020). Seventeen nutrients are essential to plant growth, the amount required by the plants vary and as such are divided in to macro or micro nutrients (Sela, 2021). When plant nutrient concentration is deficient enough to reduce plant growth severely, distinct visual deficiency symptoms appear, extreme deficiencies can result in stunted and finally plant death (Singh *et al*., 2015). Plant nutrient concentration above which plant growth or yield is not increased is the critical range (FAO, 2020). Critical nutrient ranges vary among plants, but always occur in the transition between nutrient deficiency and sufficiency (Salman, 2015). Sufficiency or luxury consumption is the concentration range where added nutrient does not increase yield but increases nutrient concentration (John and Heiniger, 2020). Nutrient concentration is considered excessive or toxic when plant growth and yield are reduced (Singh *et al*., 2015). Soil deficient in plant essential nutrient is supplemented through application of fertilizer following soil, plant test or both (Bhatt, 2014).

Declining soil fertility is a major agricultural production constraint in the Nigerian Savanna regions. Soil of north eastern Nigeria, are mostly low in organic carbon, nitrogen and phosphorus (Bapetel *et al*., 2021). Improving soil fertility management among smallholder farmers is widely recognized as a critical approach to addressing enhanced crop yields and poverty alleviation, especially in northeastern Nigeria, where the majority of the populations earn their livelihood as smallholder farmers (Tarfa, *et al*., 2017). Application of

6.9) with low organic carbon, total N, available P and CEC but medium in ESP and PBS. The soil of the area was classified as Alfisols (Ezeaku *et al.*, 2022).

Soil Sampling and Analysis

Using land use the area was divided in three sections (sites A, B and C). Ninety surface soil (0-20cm) samples were collected and composited into thirty prepared in the soil science laboratory by drying, sieving and bagging for physical, chemical and micronutrient analysis (Nafiu, *et al.*, 2012).

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 DISCUSSION

Physical Properties

Sand separates dominated the particle distribution of the three sections of the study area. Highest sand particles were observed on locations 2 and 4 in section B, similarly, largest mean of 89.19% was observed in same section. In earlier studies Osujieke *et al.*, (2018) reported higher sand particles for soil surface of Wukari metropolis, similar result was also obtained by Ezeaku *et al.*, (2022) who reported that soil surfaces of three pedons in Taraba State University Teaching and Research Farm were dominated by sand particles. Jimoh *et al.* (2016) attributed the dominance of sand contents in soils of Northern Nigeria to sorting of materials by clay eluviation. Larger porosity (40.0%) and less water content (11.00%) of the soils could also be attributed to the dominance of sand particles on the soil surface. Soils with sandy surfaces and larger pores may contain less water and nutrient probably due leaching and evaporation (Bapetel *et al.*, 2021).

Chemical Properties

Soil reaction (pH) of the area was slightly acidic to neutral acidic (Hazelton and Murphy, 2007). Section A of the study area recorded comparatively highest pH mean of 6.44. Neutral soil reaction recorded could be attributed to the effects of calcium and magnesium applied as impurity along with synthetic fertilizers. Neutral soil reaction provides appropriate medium for maximum microorganism activities with higher rate of bio-recycling of organic materials (Lawal, *et al.*, 2020). Electrical conductivity for all the sections were low and has less tendency for excess salts accumulation on the soil surface horizons (Alhassan *et al.*, 2018). The soils contain low organic carbon, the highest of 9.75gkg^{-1} was observed in section A location 1. The organic carbon level is within the range earlier reported for top soils of northern guinea savanna (Jimoh *et al.*, 2016). Low organic carbon content could be as a result of less return of crop residues back to the soil due to competitive use as fodder and building materials. The low organic carbon is usually associated with savanna soils and may be attributed to fast degradation due to high tropical temperatures, burning and lack of balanced fertilizer application (Sani, *et al.*, 2019). Total nitrogen was less than 1.15g/kg in all the sections and rated as very low (Osujieke *et al.* 2018; Ezeaku *et al.* 2022). Low total nitrogen could be attributed to crop removal due to intensive crop cultivation in the area. Section A location 1 recorded the highest available phosphorus of 12.14mgkg^{-1}, which was rated as medium and but within the range for soils of

Sudan savannah zone of Nigeria (Shehu, *et al*., 2015). Exchangeable calcium, magnesium and potassium were medium; while exchangeable was high. The exchange complex of soils indicates that sodium was the dominant cation. Highest total exchangeable cations of 8.02cmolkg^{-1} was observed in section A and rated as medium (Ricardo and Michelle, 2014). Total exchangeable acidity is moderate and similar with earlier report (Osujieke *et al*. 2018). Effective cation exchange capacity and exchangeable sodium percentage were low. Low effective cation exchange capacity level implies that the soils were dominated by low activity clays and sesquioxides (Shehu *et al*., 2015).

Micronutrients

Copper concentration for the three sections of the study area presented in Table 4 indicates that the concentration ranged from 0.20 to 1.52mgkg^{-1}. Section A recorded comparatively higher mean of 1.26mgkg^{-1}. The amount Cu is considered to be medium (Dan'azumi *et al*. 2018), and slightly higher than the range of 0.19 and 0.45mgkg^{-1} earlier reported for some soils of north eastern Nigeria (Mulima *et al*., 2015). Medium levels of Cu observed could be due to the nature of the parent material. Iron content of the sections were relatively low, highest mean of 3.53mgkg^{-1} was recorded in A is below the critical value of 4mgkg^{-1} (Augie, 2020), low iron content could be attributed to relatively low organic matter content of the area and neutral soil reaction. Addition of iron containing fertilizer for sustainable crop cultivation could be considered in future fertilization plan. Manganese level of the soil is considered to be medium with section A recorded highest mean of 3.48mgkg^{-1} and is within the range for soils of northeastern Nigerian savanna (Biwe, 2012). Zinc status of the soil is considered to be medium (Gabasaw *et al*., 2016), with highest mean of 2.41mgkg^{-1} also recorded in section A of the area. Similar value for mean zinc concentration of 2.32mgkg^{-1} was reported for soils along a Challawa-Gorge micro watershed, Kano, northern guinea savanna of Nigeria (Dan'azumi *et al*. 2018).

CONCLUSION

Thirty composite soil samples were obtained from the study area using grid system of soil sampling. The samples were air dried, crush, sieved and bagged. Soil physical, chemical and micronutrient status were determined using standard procedure. The top soil was predominantly sandy with highest mean of about 90%. The soil has large pore spaces with low water-holding capacity. Soil reaction was slightly acidic to neutral with the overall mean of 6.44 recorded in section A. Electrical conductivity was low in all the three sections and less than 0.4dSm^{-1}, similarly all the sections were low in organic carbon (8.06gkg^{-1}) and total nitrogen (0.88gkg^{-1}), but medium in available phosphorus (8.30mgkg^{-1}), exchangeable bases (8.02cmolkg-1) and high in percentage base saturation (82.14%). Highest mean of copper (1.26mgkg^{-1}), iron (3.53mgkg^{-1}), manganese (3.48mgkg^{-1}) and Zinc (2.41mgkg^{-1}) were all recorded in section A of the study area. The fertility status of the soil could be rated from low to medium. For sustainable production of staple crops, combined application of organic and inorganic fertilizers (integrated nutrient management) could be recommended.

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Table 1: Physical Properties for Soils of Collage of Agriculture Teaching and Research Farm, Jalingo

Parameter	Sand (%)			Silt (%)			Clay (%)			Porosity (%)			WHC (%)		
Location/Site	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	87.50	88.91	87.81	7.29	7.98	10.98	5.21	3.11	1.21	23.44	24.10	24.64	8.01	10.10	8.00
2	88.50	90.91	90.74	10.45	7.88	7.65	1.05	1.11	1.61	19.87	28.77	32.96	7.00	7.00	10.00
3	88.50	88.91	88.70	9.69	8.98	8.45	1.81	2.11	2.81	22.25	37.59	28.71	9.00	7.31	8.00
4	90.50	90.91	85.79	4.09	7.10	12.00	5.41	6.98	2.21	32.74	23.32	28.17	7.01	7.00	6.33
5	86.50	88.92	89.74	8.29	7.17	8.45	5.21	3.91	1.81	40.09	21.39	31.21	8.00	8.10	8.67
6	90.50	89.11	88.79	6.29	9.78	5.40	3.21	1.11	5.81	19.92	29.05	21.55	7.01	7.03	6.00
7	88.50	87.81	88.81	9.69	9.98	5.97	1.81	2.21	5.21	22.25	24.80	31.94	9.10	8.00	7.00
8	90.50	89.81	89.81	7.15	6.98	9.14	5.41	3.21	1.05	32.74	23.10	29.69	7.30	7.10	4.00
9	86.50	86.51	86.50	8.29	7.98	9.98	5.21	1.21	1.81	40.09	20.85	23.72	8.01	7.20	8.02
10	90.50	89.82	88.22	6.29	8.97	6.37	3.21	1.21	5.41	19.92	33.93	30.98	7.30	7.01	11.00
Mean	**88.94**	**89.19**	**88.57**	**7.80**	**8.31**	**8.16**	**3.59**	**2.56**	**3.08**	**27.76**	**26.98**	**28.77**	**7.75**	**7.31**	**7.67**

All values with same letters are not significantly different at 0.05% confidence level according to Duncan Multiple Range Tes t
WHC = Water-Holding Capacity

Table 2: Soil Reaction (pH), Electrical Conductivity, Organic Carbon, Total Nitrogen and Available Phosphorus for the Soils of the Study Area

Parameter	pH(w)			Electrical Conductivity (dS/m)			Organic Carbon (g/kg)			Total Nitrogen (g/kg)			Available Phosphorus (mg/kg)		
Location/Site	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	6.72	6.61	5.51	0.40	0.60	1.80	9.75	8.65	8.65	1.04	0.90	0.85	12.14	6.97	8.17
2	6.31	6.81	6.74	0.30	0.90	0.63	8.15	9.40	7.70	0.82	0.95	0.80	7.62	8.93	7.21
3	6.11	6.51	5.61	0.40	0.60	0.67	7.35	6.85	8.75	0.72	0.70	0.90	8.34	7.57	8.12
4	6.51	5.61	6.11	0.50	1.20	1.00	7.40	6.85	7.70	0.72	1.20	0.75	7.81	7.64	6.19
5	6.41	5.92	6.94	0.50	0.50	0.40	9.05	9.55	6.55	0.11	1.00	0.65	7.38	6.24	8.67
6	6.71	6.15	6.31	0.40	1.03	0.30	8.60	9.75	8.80	0.82	1.10	0.90	8.69	6.85	7.84
7	6.51	6.21	5.71	0.30	0.80	0.70	8.25	7.51	8.69	0.67	0.75	0.87	7.34	9.32	8.25
8	6.63	5.81	6.61	0.40	0.83	0.67	7.10	6.63	5.63	0.49	0.67	0.57	8.16	8.34	7.06
9	6.24	5.51	5.91	0.40	1.40	0.47	7.20	6.23	6.23	0.87	0.62	0.63	6.27	6.42	7.05
10	6.21	6.61	5.61	0.70	2.40	1.50	7.35	9.13	8.13	0.57	0.92	0.82	9.23	9.15	7.49
Mean	**6.44**	**6.18**	**6.11**	**0.43**	**1.03**	**0.81**	**8.02**	**8.06**	**7.68**	**0.68**	**0.88**	**0.77**	**8.30**	**7.74**	**7.61**

All values with same letters are not significantly different at 0.05% confidence level according to Duncan Multiple Range Tes t

Table 3: Exchangeable Calcium, Magnesium, Potassium, Sodium and Total Exchangeable Bases (TEB) for Soils of the Study Area

Parameter	Ca^{2+} (cmol/kg)			Mg^{2+} (cmol/kg)			K^{+} (cmol/kg)			Na^{+} (cmol/kg)			TEB (cmol/kg)		
Location/Site	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	4.48	4.49	4.76	2.01	1.04	2.55	0.26	0.23	0.24	0.87	0.61	0.75	7.62	6.37	8.23
2	5.21	4.35	4.81	1.69	2.53	2.72	0.36	0.18	0.19	0.63	0.68	0.36	7.79	7.74	8.08
3	5.61	5.76	5.17	2.42	2.05	1.84	0.04	0.26	0.33	0.38	0.49	0.66	8.45	8.56	8.00
4	6.43	4.45	4.36	2.30	1.62	2.22	0.05	0.31	0.29	0.49	0.81	0.49	9.27	7.19	7.36
5	5.80	4.19	3.57	2.90	1.72	1.78	0.09	0.36	0.26	0.06	0.71	0.98	8.85	6.98	6.59
6	4.16	5.12	4.58	1.69	2.52	2.51	0.04	0.05	0.19	0.79	0.25	0.15	6.68	7.94	7.43
7	4.65	4.25	4.41	1.05	2.39	2.87	0.04	0.31	0.26	0.79	0.92	0.78	6.53	7.87	8.32
8	5.18	4.23	5.85	2.22	2.32	2.22	0.22	0.04	0.17	0.94	0.27	0.33	8.56	6.86	8.57
9	5.56	4.39	4.79	2.67	1.69	1.29	0.32	0.13	0.13	0.61	0.84	0.27	9.19	7.05	6.48
10	5.06	4.99	4.64	1.77	2.45	2.14	0.13	0.22	0.13	0.25	0.64	0.21	7.21	8.23	7.12
Mean	**5.21**	**4.62**	**4.69**	**2.07**	**2.03**	**2.21**	**0.16**	**0.21**	**0.22**	**0.58**	**0.62**	**0.50**	**8.02**	**7.48**	**7.62**

All values with same letters are not significantly different at 0.05% confidence level according to Duncan Multiple Range Tes t
Where: TEB = Total Exchangeable Bases

Table 4: Total Exchangeable Acidity, Effective Cation Exchange Capacity , Percentage Bases Saturation and Exchangeable Sodium Percentage for the Soils of the Study Area

Parameter	Total Exchangeable Acidity (cmol/kg)			Effective Cation Exchange Capacity (cmol/kg)			Percentage Bases Saturation (%)			Exchangeable Sodium Percentage (%)		
Location/Site	A	B	C	A	B	C	A	B	C	A	B	C
1	1.44	1.57	1.64	9.05	7.80	9.72	84.17	81.57	85.20	2.88	2.92	2.36
2	2.43	2.43	2.36	10.17	10.16	10.44	87.17	76.16	77.42	2.56	1.81	1.83
3	1.93	0.95	1.93	10.36	9.49	9.91	81.42	90.01	80.59	0.43	2.63	3.31
4	2.42	2.92	1.44	11.68	10.10	8.69	79.29	71.10	83.45	0.39	3.08	2.20
5	1.93	1.39	1.44	10.76	8.27	8.02	82.11	83.22	82.07	0.82	4.36	3.19
6	0.94	2.45	1.85	7.67	10.36	8.86	87.79	76.41	83.76	0.57	0.43	2.15
7	1.93	2.17	2.77	7.95	10.04	11.07	82.09	78.36	75.11	0.55	3.08	2.38
8	2.43	1.93	2.43	10.98	8.73	10.25	82.09	79.36	76.11	1.98	0.50	1.70
9	2.46	1.44	1.83	11.96	8.48	8.30	79.47	83.06	77.93	2.19	1.57	1.58
10	2.31	1.46	1.43	9.53	9.76	8.55	75.84	85.02	83.24	1.37	2.28	1.55
Mean	**2.02**	**1.87**	**1.91**	**10.01**	**9.32**	**9.38**	**82.14**	**80.43**	**80.49**	**1.37**	**2.27**	**2.23**

All values with same letters are not significantly different at 0.05% confidence level according to Duncan Multiple Range Test

Table 4: Copper, Iron, Manganese and Zinc for Soils of the Study Area

Parameter		Copper			Iron			Manganese			Zinc	
Location/Site	A	B	C	A	B	C	A	B	C	A	B	C
1	1.52	0.85	0.58	3.41	3.12	2.48	1.83	1.76	1.88	3.79	3.68	2.01
2	1.69	1.02	0.67	1.68	1.03	1.99	3.21	2.78	2.06	2.87	2.27	1.64
3	0.91	0.71	0.22	4.15	3.68	5.96	2.57	1.80	0.21	2.67	1.97	0.98
4	1.27	0.87	0.90	3.73	3.56	3.83	2.93	2.86	2.99	2.50	1.52	1.85
5	1.26	0.93	0.74	2.09	1.54	2.08	3.97	3.44	3.61	1.19	0.26	1.75
6	1.13	0.50	0.67	5.83	5.70	1.99	5.71	5.04	2.06	1.34	0.97	1.64
7	1.20	0.74	0.32	3.19	4.09	5.23	2.80	2.67	0.30	2.60	2.43	1.53
8	1.57	0.86	1.23	4.00	3.80	3.70	3.97	3.40	3.67	2.77	2.00	2.63
9	1.27	0.99	0.20	2.83	1.93	2.67	2.56	2.59	3.50	3.00	1.40	1.87
10	0.73	0.53	0.67	4.40	5.30	2.07	5.27	5.20	2.70	1.40	1.37	2.33
Mean	**1.26**	**0.80**	**0.62**	**3.53**	**3.38**	**3.20**	**3.48**	**3.15**	**2.30**	**2.41**	**1.79**	**1.82**

All values with same letters are not significantly different at 0.05% confidence level according to Duncan Multiple Range Tes t