FORMS AND DISTRIBUTION OF POTASSIUM IN SOILS UNDERLAIN BY THREE LITHOLOGIES SOUTHEASTERN NIGERIA

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Abstract
We conducted a study to evaluate the forms and distributions of potassium(K^+) in soils derived from three lithological materials in Abia State, Southeastern Nigeria. A free survey technique guided by the geologic map of the study area was used in field sampling. Three pedons representing 3 lithologies: Shale (Bende), Lower Coal Measures (Ovim) and Upper Coal Measure (Nkwoagu) in 3 areas of Abia State were sunk. Soil samples were prepared and subjected to laboratory analysis using standard techniques. The degree of variability of physicochemical properties and forms of K^+ was estimated using coefficient of variation. The relationship between forms of K^+ was obtained using regression analysis. Results showed that the soils of the 3 lithologies had varying physicochemical properties with shale being the most fertile when compared to Lower Coal Measure (LCM) and Upper Coal Measure (UCM). On the forms and distribution of K^+, exchangeable K^+, non-exchangeable K^+ and K^+ supplying power of Shale were about 2 times higher than that of LCM and UCM, respectively. Exchangeable K^+ and non-exchangeable K^+ had positive significant ($p=0.05$) relationship with K^+ supplying power.

Keywords: Tropical soils, lithology, soil fertility, potassium.

Introduction
Variations in soils could be attributable to the nature_of parent material as it influences soil characteristics (Ibanga, 2006). Parent material has also been reported to influence nutrient content of soils (Giesleret *et al*, 2005; Onweremadu, 2007). Nutrient supply to plants is key to crop productivity and food sufficiency. Potassium has been reported to be one of the essential nutrient requirements for plant growth (Unamba Oparah, 1985). The ability of a soil to supply potassium to a crop depends on its forms and distribution as influenced by soil physicochemical properties (Chandra and Singh, 1985). Potassium occurs in different forms in the soils such as water soluble, exchangeable, non-exchangeable and in mineral form (Sparks and Huang, 1985). The different forms are in equilibrium with one another and vary with location (Ano, 1991). In Abia State, most studies on potassium have been concerned in the field (Odurukwe and Arene, 1980; Ano and Okeke, 1987, Oluri *et al*, 1987). Furthermore, there is little information (Ano, 1994) as regards physicochemical properties and different forms of potassium in Abia State soils, particularly in Bende, Ovim and Nkwoagu. It was on this premise therefore that this study aimed at investigating the forms and distribution of potassium in three lithological areas of Abia State, Southeastern Nigeria.

Materials and methods
Study Area: The study was carried out at three different locations in Abia State. These are Ovim in Isiukwuato Local Government Area (Latitudes 5^0 40' and 6^0 30' N and longitudes 7^0 20' and 7^0 35' E); Nkwoagu in Umunneochi Local Government Area (latitudes 5^0 50' and 6^0 04' N and longitudes 7^0 21' and 7^0 35' E) and Bende in Bende Local Government Area (latitudes 5^0 25' and 5^0 52' N and longitudes 7^0 28' and 7^0 45' E).The soils are derived from Lower Coal Measures , Upper Coal Measures and Shale, respectively. The sites have humid tropical climate with a mean annual rainfall ranging from 1800 to 2600 mm Temperature ranges between 26 to 32 ^{0}C with a relative humidity of 66.79 %. The sites have a rainforest vegetation, though they have been altered due to population increase and attendant conflictive land use including subsistence agriculture.

Field Studies: A free survey technique guided by the geologic map of Abia State was used in situating soil profile pits. Three pedons representing three lithological groups were sunk. Soil sampling was done based on the degree of horizon differentiation. Soil samples were later air-dried, gently crushed and made to pass through 2-mm sieve preparatory to laboratory analysis.

Laboratory Studies: Laboratory analysis were conducted for particle size distribution by hydrometer method (Gee and Or, 2002), soil pH by the use of pH meter (Hendershot *et al*., 1993), total carbon by wet digestion (Nelson and Sommers, 1982), and organic matter was got by multiplying organic carbon by 1.724, available phosphorus according to the procedure of Olson and Sommers (1990), exchangeable bases by ammonium acetate (McLean, 1982). Base saturation was obtained by calculations (Exchangeable bases/Effective cation exchange capacity x 100). Exchangeable potassium was determined using flame photometer (Mclean, 1982), potassium supplying power was estimated by extraction using IN HNO_3 (Haylock, 1956), potassium reserve was determined using 10 N HCI acid (Finck, 1962). Non-exchangeable potassium was obtained by the difference between potassium supplying power and exchangeable potassium.

Date Analysis: Soil generated data were analyzed using coefficient of variation and correlation and regression analysis. Variability among selected soil properties and various forms of potassium was ranked according to Aweto (1982).

Table 1: Some physical properties of studied pedons.

Depth	Sand	Silt	Clay	Silt: Clay Ratio	Texture Class
(cm)		($g\ kg^{-1}$)			
Lower Coal Measure (Ovim)					
0-30	858	90	130	0.07	Sandy loam
30-60	804	30	160	0.20	Sandy loam
60-90	828	30	140	0.20	Sandy loam
90-120	849	30	120	0.18	Loamy sand
Mean	**835**	**30**	**140**	**0.16**	
%CV	**2.86**	**4.33**	**12.16**		
Ranking	LV	MV	LV		
Shale (Bende)					
0-30	878	50	70	0.67	Sand
30-60	868	40	90	0.42	Loamy sand
60-90	883	10	100	0.14	Loamy sand
90-120	888	10	100	0.09	Loamy sand
Mean	**878**	**30**	**90**	**0.33**	
%CV	**0.97**	**69.69**	**15.30**		
Ranking	LV	HV	LV		
Nkwoagu (Upper Coal Measure)					
0-30	908	10	80	0.18	Sand
30-60	903	10	90	0.10	Sand
60-90	908	10	88	0.11	Sand
90-120	838	10	150	0.06	Sand
Mean	**889**	**10**	**100**	**0.11**	
%CV	**3.85**	**24.41**	**35.06**		
Ranking	LV	MV	MV		

LV=Little variation; MV=Moderate variation: HV=High variation

Table 2: Some chemical properties of studied pedons

Depth (cm)	pH H_2O	KC1	N	K	Mg	C_a	TEA	ECEC	BS	OM (gkg)	Av.P (mg kg)
			←		(cmol/ kg)			→			
Lower Coal Measure (Ovim)											
0-30	5.69	4.55	0.122	0.107	0.40	2.80	0.48	3.91	88.0	10.0	37
30-60	5.55	4.49	0.087	0.099	1.60	1.20	0.56	3.55	84.0	9.30	47
60-90	5.49	3.88	0.044	0.099	3.60	0.80	0.56	5.10	89.1	3.30	40
90-120	5.38	3.83	0.122	0.132	1.20	1.20	0.32	2.97	89.4	2.10	52
Mean	**5.50**	**4.10**	**0.09**	**0.110**	**1.70**	**1.50**	**0.48**	**3.88**	**87.54**	**6.20**	**44**
%CV	**2.32**	**9.20**	**39.51**	**14.30**	**80.08**	**59.13**	**23.57**	**23.17**	**2.65**	**65.62**	**15.14**
Ranking	LV	LV	MV	LV	HV	HV	MV	MV	LV	HV	LV
Shale (Bende)											
0.30	6.57	5.58	0.096	0.240	2.00	2.80	0.24	5.88	95.5	9.30	65
30-60	7.46	6.00	0.287	0.687	2.40	2.80	0.24	6.41	96.3	9.30	70
60-90	6.87	5.48	0.244	0.578	2.80	1.60	0.40	5.62	93.0	5.90	43
90-120	6.45	4.90	0.148	0.297	2.80	2.40	0.32	5.96	95.0	6.70	50
Mean	6.80	5.50	0.190	0.450	2.50	2.40	0.30	5.89	94.8	7.80	57
%CV	6.00	8.38	45.06	47.85	15.31	23.57	25.53	7.68	1.53	22.59	22.14
Ranking	LV	LV	MV	MV	LV	MV	MV	LV	LV	MV	MV
Upper Coal Measure (Nkwoagu)											
0-30	5.98	4.35	0.174	0.256	1.20	1.20	0.72	3.55	80.0	8.60	33
30-60	5.98	4.28	0.062	0.033	2.00	0.40	0.40	2.88	86.1	7.90	57
60-90	5.68	4.16	0.052	0.041	0.80	1.60	0.32	2.81	89.0	9.90	43
90-120	5.59	4.05	0.139	0.050	1.60	2.40	0.40	4.58	91.3	3.30	17
Mean	5.80	4.20	0.100	0.100	1.40	1.40	0.46	3.46	86.44	7.40	37.5
%CV	2.90	3.15	59.47	11.32	36.86	59.47	8.56	23.97	5.72	89.91	44.9
Ranking	LV	LV	HV	LV	MV	HV	LV	MV	LV	HV	MV

ECEC=Effective cation exchange capacity; BS=percent base saturation; OM=organic matter; Av.P=Available phosphorous; LV: Lower variation; MV: Moderate variation; HV: High variation.

Table 3. Correlation matrix among various forms of K^+

Properties	Exch K^+	Non-exch K^+	K^+ Supplying power	K^+reserve
Exch K^+	-			
Non- Exch K^+	0.52^{nd}	-		
K Supplying power	0.83^{++}	0.88^{++}	-	
K Reserve	0.16^{NS}	0.33^{NS}	0.28^{NS}	-

RESULTS AND DISCUSSION

Physical properties of the three studied pedons are shown in Table 1: Among the three pits, illuvial clay accumulation was noticed indicating clay lessivage (Eshett *et al.,*1990).The textural class of soils of the area ranged between sand and sandy loam. These implied that the soils are sandy. Jungerius and Levellt (1964) noted that soils of the area are generally sandy, this they attributed to the harsh whether conditions of the region. On the whole, the pedons had low silt:clay ratio (SCR) of <0.67. It has been observed that SCR as low as these imply that such soils are highly weathered (Wambeke, 1962)

Critically observation at the three pedons (Table 2) shows that pH both in water and KCI decreased which increase in depth for lower and upper Coal measures, but that of Shale did not follow any particular trend. Mean values of pH in water and KCl were highest in Shale (6.80 and 5.50 respectively), followed by Upper Coal Measure (5.80 and 4.20 respectively) and lastly, Lower Coal Measures (5.50 and 4.10, respectively).According to Landon (1991) pH range of 5.60 to 6.50 provides the most satisfactory plant nutrient levels for most crops. Thus, giving the pH of Shale (Bende) it can be asserted that the soils are more fertile and preferred for farming in relation to those of Lower and upper Coal Measures.

Table 4. Potassium fractionation of studied pedons

	Exch K^{-+}	Non-exch K^+	K^+ Supplying Power	K^+
	(cmol kg^{-4})			
	Lower Coal Measure (Ovim)			
0-30	0.107	0.051	0.153	0.059
30-60	0.099	0.071	0.256	0.02
60-90	0.044	0.134	0.256	0.131
90-120	0.122	0.12	0.22	0.09
Mean	**0.11**	**53.94**	**22.72**	**35.31**
%CV	**14.31**	**53.94**	**22.72**	**35.31**
Ranking	LV	HV	MV	MV
	Shale(Bende)			
0-30	0.096	0.237	0.333	0.052
30-60	0.287	0.395	0.639	0.105
60-90	0.244	0.440	0.384	0.046
90-120	0.448	0.133	0.281	0.046
Mean	**0.45**	**0.23**	**0.41**	**0.06**
%CV	**47.85**	**53.97**	**38.81**	**46.00**
Ranking	MV	HV	MV	MV
	(Upper Coal Measure)			
0-30	0.174	0.005	0.179	0.019
30-60	0.052	0.076	0.013	0.059
60-90	0.052	0.178	0.032	0.026
90-120	0.139	0.168	0.307	0.026
Mean	**0.10**	**0.11**	**0.21**	**0.030**
%CV	**81.2**	**76.73**	**36.19**	**55.30**
Ranking	HV	HV	MV	HV

LV=Little variation; MV=Moderate variation; HV=High variation

This is further buttressed by the effective cation exchange capacity, percent base saturation, organic matter and available P of Shale (Table 2) when compared to those of Lower and Upper Coal Measures as they increased with increase in pH. Thus, Shale had superior chemical properties which indicated good chemical edaphology for crop productivity. In this regards therefore, it (Shale) would require minimal fertilizer input when compared to Lower and Upper Coal Measures, respectively. Table 2 indicates that the three pedons had differentiated variability in relation to selected chemical properties.

Potassium fractions of the three pits are shown in Table 3. Among the three pedons, K^+ fractions did not show any particular trend both intrapedally and interpedally, except for non exchangeable K^+ and K^+ supplying power which decreased with increased depth in the pedon of Shale lithology. Exchangeable K^+ (0.45 cmolkg^{-1}), non exchangeable K^+ (0.23 cmolkg^{-1}) and K^+ supplying power (0.41 cmolkg^{-1}) were about 2times higher in Shale than for Lower and Upper Coal Measures, respectively. This further confers higher fertility status on soils of Shale than those of the rest two lithological groups. Also, soils having exchangeable K^+ values higher than 0.4 cmolkg^{-1} are regarded as better endowed with this form of K^+ (Unamba – Oparah, 1985 and Ano, 1987). The mean values of non-exchangeable K^+ obtained in this study compared favourably with a range of 0.1-0.46 cmolkg^{-1} reported by Unamba-Opara (1985) for soils of Northern Imo State of Nigeria. Soils with K^+ supply power value between 0.31 and 0.49 cmolkg^{-1} have been classified as having potential for response of K^+ fertilization especially if removal of K is intensive and if the soils are coarse textured (Ano e*t al.,* 1991). Therefore, Bende soils (Shale) have greater propensity for increased fertility for K^+ if supplied with minimal amounts of K_20 as against Lower and Upper Coal Measures which would require intense supply of K_2O. Exchangeable K^+ and non-exchangeable K^+, respectively had a positive significant (p=0.05) relationship with K^+ supplying power (Table 5), thus indicating a state of equilibrium among these forms of K^+ (Ano, 1991). On their variability, non-exchangeable K^+ had high variation among the three pedons. Similarly, K^+ supplying power had moderate variation among the three pits, but exchangeable K^+ and K^+ reserve did not show any particular trend in their variability (Table 3).

CONCLUSION

The forms and distribution of K^+ aPage 1107 pedons showed that Shale had hi
forms. Therefore, Shale would require minimal K_20 fertilization in order to boost its K^+ fertility status as compared with Lower and Upper Coal Measures, respectively.

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