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QUANTITIES OF POTASSIUM FERTILIZER REQUIRED TO RAISE THE SOIL TEST VALUE IN SOILS OF EDO STATE OF NIGERIA

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ABSTRACT

To determine nutrient requirement, it is necessary to know how much to the nutrient must be applied to overcome sorption effects and raise the test value to the desired level. A sorption study was conducted on a wide range of Edo State soils of Nigeria to establish this information for Potassium. Composite surface samples (0-15cm depth) from eight different sites were used. Composite surface soil from each site was treated with four levels of K and incubated for forty two days period.

Analysis for K using $1NH_40A_c$ (pH 7), showed that the quantity of applied K (Kg/ha) required to raise the soil test value by a unit amount (mg/L), i.e. the K fertilizer factor varied from 1.393 to 1.782 with a mean of 1.544. The level of K sorption was influenced by pH.

INTRODUCTION

Amao(1990) defined potassium fixation as applied potassium which is not immediately replaceable by the usual cation exchange reagents such as NH_4 - acetate. Potassium fixation depends on a number factors including the charge density of the mineral, the extent of the wedge zones, the moisture content, the concentration of K and the nature and competing cations in the surrounding medium (Rich, 1964 and Kittrick, 1966). Other factors that affect K fixation include soil pH, organic matter as well as the soil parent material.

Ataga (1974) evaluated the release and fixation of Potassium in some soils supporting the oil palm (Elaeis guineensis) in Nigeria. He found that substantial proportion of added Potassium (35-65%) was fixed by both the acid soils and soils derived from basement complex.

In soils exhibiting considerable Kfixation, Mclean(1978) proposed a factor to account for K fixation effect in computing sufficiency level for exchangeable K. The use of fertilizer factor has recently become a family procedure in fertilizer recommendation (Ayodele and Agboola, 1981). Agboola (1982), advanced the use of "fertilizer factor" for making fertilizer recommendation while investigating the prospect and problems of using soil testing programme for Ekiti-Akoko Agricultural Development project area in Nigeria. After extracting the soils with Bray's PI-DPTA (0.03N NH_4F + 0.25NHCI + 0.005MDPTA), appropriate fertilizer factor was used as multiplier having in mind the critical level of the nutrient in question and the economic factors of the farmers.

Wanku(1984) carriedout fixation studies of P and K on Ndop plain soils of the Republic of Cameroons. He also calculated the fertilizer factors for P and K to be 4.70 and3.20ppm, respectively. Amao (1990) carried out K fixation studies on basement complex soils of South Western Nigeria. He obtained 0.90 and 0.93 Meq/100g as K fertilizer factors for the forest and savanna soils, respectively.

Osemwota et. al. (1996) reported K deficiency in some ultisols of Bendel State of Nigeria. The normal approach to correcting K deficiency in the soil is to first determine the test vale on an extract of the soil, and from the known optimum level applicable to the particular crop, establish the deficit in terms of the test value. To calculate the mass of the nutrient required per unit area (e.g. Kg/ha), this deficit is then multiplied by a factor, termed here as K fertilizer factor. K requirement (Kg/ha) = (optimum soil K - Measure soil K) x K fertilizer factor x 2. The 2 is used as a multiplier in order to convert ppmk (mg/Kg) to Kg/ha. It is necessary to use accurate estimate of this factor for this approach to be successful.

There is no information on K fertilizer factor for Edo State soils of Nigeria. Hence the objective of this study is to carry out a detailed K fixation studies on these soils in order to determine their K fertilizer factor.

MATERIALS AND METHODS

The soil samples used for study were collected from eight different sites within Edo State of Nigeria. In all the sites, composite surface samples were taken by the use of auger at 0-15cm depth. Core soil samples were taken from different points about 5-10 metres apart and bulked into bags. Composite soil samples were air dried, thoroughly mixed, crushed and sieved through 2mm sieve and preserved in plastic containers for use. Potassium fixation studies was done by using the procedure described by Waugh and Fitts (1966). Particles size analysis of the soil samples was done by hydrometer method (Bouyoucos, 1951), with Calgon as the soil dispersing agent. Soil pH was determined with a Bechman pH meter using a glass electrode. Organic carbon was determined by dichromate wet oxidation method of Walkey and Black 91934). Exchangeable cations and Effective cation exchange capacity were determined by extracting the soil with $1NNH_40A_c$ (Schollenberger and Simon, 1945) at pH 7. Exchangeable N_a C_a and K were determined by flame photometer while exchangeable Mg was determined by atomic absorption spectrophotomter. Summation of exchangeable bases and exchangeable acidity gave the effective cation exchange capacity value.

RESULTS AND DISCUSSION

The results of K fixation studies are shown in Table 1 while the physico-chemical properties of the soil samples used for study are shown in Table 2.

Potassium Fertilizer Factor:
Fertilizer factor is defined as the amount of an element which is required to raise the soil test value of the element by 1ppm (1mg/L). The fertilizer factor is calculated from the following relationships (Agboola, 1982):

Table 1: Effects of K rate on K recovered. K fixation by soils and K fertilizer factor

Location	U.S. Taxonomy	K added to soil sample	K recovered after 42 days incubation	K fixed	% K fixed	Mean % fixed	Fertilizer factor	Fertilizer Factor mean value
		mg/kg					mg/kg	
Ehor	Rhodic Pale udult	0	89.0	-	-	-	-	-
		100	180.6	8.4	4.44	-	0.994	-
		400	338.6	150.4	30.76	24.0	1.603	1.443
		600	435.4	253.6	36.80	-	1.732	-
Irruekpen	Rhodic Pale udult	0	36.8	-	-	-	-	-
		100	116.1	20.7	15.13	-	1.261	-
		400	290.3	146.5	33.54	26.8	1.578	1.448
		600	435.4	201.4	31.63	-	1.505	-
Ugonoba	Rhodic Pale udult	0	32.9	-	-	-	-	-
		100	121.9	11.0	8.28	-	1.135	-
		400	290.3	142.6	32.94	24.1	1.554	1.393
		600	435.4	197.5	31.21	-	1.490	-
Fugar-Ayodo (About 5 km from Agenebode Road Junction)	Grossarenie Pale Ustalf	0	50.3	-	-	-	-	-
		100	137.4	12.9	8.58	-	1.147	-
		400	311.4	138.8	30.82	26.6	1.531	1.487
		600	387.0	263.3	40.49	-	1.782	-
Obayantor	Typic Pale udult	0	16.4	-	-	-	-	-
		100	89.98	26.4	22.69	-	1.359	-
		400	290.3	126.1	30.28	30.1	1.460	1.479
		600	387.0	229.4	37.22	-	1.618	-
Agenebode (West Bank of River Niger)	Typic Tropaqualt	0	96.7	-	-	-	-	-
		100	166.4	32.5	16.26	-	1.477	-
		400	290.3	208.4	41.79	31.91	2.088	1.782
		600	435.4	263.3	37.68	-	1.782	-
NIFOR	Rhode Pale udult	0	66.8	-	-	-	-	-
		100	135.5	31.30	18.76	-	1.456	-
		400	290.3	176.5	37.80	32.8	1.790	1.707
		600	387.0	279.8	41.96	-	1.874	-
About 51 Kilometres to Okeke on the Road from Auchi (Malina forest Reserve)	Lithic Treporthent	0	90.95	-	-	-	-	-
		100	158.7	32.25	16.89	-	1.471	-
		400	338.6	152.35	31.05	28.3	1.613	1.610
		600	435.4	255.55	36.99	-	1.742	-
Mean		-	-	-	-	28.1	-	1.544

Table 2: Physico-Chemical properties of Soil Samples used for study

Location	U.S. Taxonomy	Clay	Silt	Sand %	O.M	pH (H2O)	Exch. Bases K	Ca	Mg	Na	Exch. H	Acidity AL	ECEC	B. S.
							cmol/kg							%
NIFOR	Rhodic Pale udult	6.5	1.4	92.1	2.03	5.40	2.29	5.9	0.33	0.33	0.40	0.10	7.92	93.68
Ugonoba	Rhodic Pale udult	10.5	1.9	87.6	0.50	4.60	0.81	1.12	0.16	0.34	2.20	1.40	6.03	40.29
Obayantor	Typic Pale udult	8.0	1.4	90.6	1.81	4.60	0.09	1.92	0.40	0.36	2.40	0.40	5.57	49.73
Agenebode (River Bank)	Typic Tropaqualf	9.0	10.9	80.1	1.60	5.90	0.48	3.46	0.84	0.50	0.60	0.20	6.08	86.84
Fugar-Ayodo (About 5kms from Agenebode Road Junction	Grossarenic Pale ustalf	6.0	1.4	92.6	1.48	5.80	0.27	6.64	0.24	0.38	0.90	0.50	8.93	84.32
Malina Forest Reserve (About 51kms to Okene on the Rd from Auchi)	Lithic Troporthent	8.5	4.9	86.6	2.71	5.70	0.48	3.68	0.50	0.34	1.00	0.40	6.40	78.2
Ehor	Rhodic Pale udult	6.5	1.9	91.6	3.26	5.50	1.00	2.44	0.96	0.46	0.70	0.30	5.86	82.92
Irruekpen	Rhodic Pale udult	5.5	2.4	92.1	1.60	5.50	0.18	3.92	0.40	0.29	0.80	0.10	5.59	83.89

Fertilizer factor (F_f) =

$$\frac{\text{Amount of k added to soil}}{\text{amount recovered - amount in untreated}}$$

As shown in Table 2, the K fertilizer factor varied among the soils obtained from different sites. The soils collected from Ugonoba had the least fertilizer factor of 1.393 mg/kg while the Highest fertilizer factor of 1.782mg/kg was obtained from Agenebode (West bank of river Niger) soils. In general, the K fertilizer factor varied from 1.393 to 1.782 mg/Kg with a mean of 1.544 mg/Kg (Table 2).

The relationship between the amount of K added to soils and the amount recovered was best described by Linear regression equation:

$$Y = a + b x$$

where Y = amount of K recovered

X = rate of K addition

b = slope (proportion of the added K recoverable or fractional recovery (FR)

The following Linear regression equations were obtained for the eight different soils.

Table 3: Linear Regression equations for the relationship between extractable K and rates of K addition

Location	U.S. Taxonomy	Linear Regression equation (Y = a + bx)
Ehor	Rhodic Paleudult	Y = 97.25 + 0.58x
Ugonoba	Rhodic Paleudult	Y = 41.93 + 0.65x
Fugar - Ayodo (About 5kms from Agenebode Road Junction	Grossarenic Paleustalf	Y = 68.23 + 0.56x
Agenebode (West Bank of River Niger)	Typic Tropaqualf	Y = 100.80 + 0.53x
NIFOR	Rodic Paleusult	Y = 74.87 + 0.53x
Obayantor	Typic Paleudult	Y = 24.51 + 0.62x
Irruekpen	Rhodic Paleudult	Y = 41.93 + 0.65x
About 51 Kms to Okene on the Rd. from Auchi (Malina Forest Reserve	Lithic Troporthent	Y = 97.51 + 0.58x

Potassium Fixation:

Potassium fixation by the eight soils increased as a result of the additions of K fertilizer (Table 1). The highest fixation of applied K was observed in Agenebode River Bank and NIFOR soils. Potassium fixation in the Agenebode River Bank Soil increased from 32.3 mg/Kg k when it received 100 mg/Kg K to 263.3 mg/Kg K when it received 600 mg/Kg K.

Potassium fixation in NIFOR soil increased from 31.30 mg/Kg K when it received 100mg/Kg K to 279.8 mg/Kg K when it received 600 mg/Kg K (Table 2). Percent fixation of applied K varied among the different sites. In general, percent fixation of applied K varied from 24.00 to 32.8% with a mean of 28.1% (Table 1).

Potassium fixation by the eight soils increased as the amount of K added increased. This is in agreement with the theory of K fixation by soils (Volks, 1934). The decline in K fixation observed in some of the soils at high level of K applications may be due probably to the saturation of fixation sites (Table 1).

In order to identify some of the K fixation agents in these soils, Linear correlation between recovery (FR) of added K and soil physico-chemical properties at 42 days incubation period were calculated. Soil pH, silt and organic matter contents were negatively correlated with FR while the sand and clay fractions were positively correlated with FR. PH had significant but negative correlation of 0.66* at 42 days of incubation.

CONCLUSION

The quantity of potassium fertilizer required to raise the soil test value in Edo State soils of Nigeria was determined from sorption studies.

Percent fixation of applied K varied from 24 to 32.8% with a mean of 28.1%. The level of K fixation was influenced by pH. The fertilizer factor of 1.54ppm should be taken into account when computing sufficient level of available K in Edo State soils in order to overcome the effect of K sorption on the availability of K to growing crops.

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