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Potassium Quantity-Intensity Relationship of Fauna Modified Soils of Abia State

[1]C.M. ldigbor, [2]D.O. Asawalam, [1]E.U.Onweremadu and [1]B.N. Ndukwu

[1]Federal University of Technology, P.M.B. 1526, Owerri, Nigeria
[2]Michael Okpara University of Agriculture, Umudike, P.M.B. 7267, Umuahia, Nigeria

Abstract: The Potassium (k) Quantity - Intensity (Q/l) relations of soils modified by termites (termite mound) and earthworms (earthworm casts) and non-modified soils (surface soils) were evaluated. Target soil sampling technique was used in field work. Each of the soil samples studied was collected from 6 different locations spread over Umudike in Abia State. Soil samples were subjected to both routine and special laboratory analyses. Soil data obtained was subjected to Analysis of variance (ANOVA), Means were separated using LSD (Least significant difference). Results obtained showed high K Activity Ratio (AR^K) in both the modified and non-modified soils with values varying from 12.54 to 16.14 $(ML^{-1})^{0.5}$ with a mean value of 14.47 $(ML^{-1})^{0.5}$. The PBC (Potassium Buffering Capacity) values ranged between 0.06 to 2,00 $cmolkg^{-1}$ $(ML^{-1})^{0.5}$ with a mean value of 0.56 $cmolkg^{-1}$ $(ML^{-1})^{0.5}$. The labile K varied from 0.26 to 2.83 $cmolkg^{-1}$ and fixed K from 0.73 to 1.18 $cmolkg^{-1}$. Parameters of K Q/l relations were correlated with some soil chemical and physical properties. A positive significant correlation ($P<0.05$) was observed between exchangeable K and AR^K (r = 0.89**). Organic matter and pH of the soils showed positive significant correlation with labile K (r = 0.58*, r = 0.82**). From the study, the Q/l parameters provided useful information for understanding K^+ status of the soils modified by termites and earthworms and non-modified soils.

Key words: Modified soils, Potassium quantity, Intensity, Activity ratio, Potassium buffering capacity, Labile k

INTRODUCTION

Finding solution to the problems of low and variability in K distribution in soils of Nigeria has been a major preoccupation of soil chemists in the last several years [1]. Potassium fertilizer use in most soils is below optimum and negative K^+ balance indicated soil K^+ depletion, which makes soil K^+ less readily available to crops [2]. However, it is generally recognized that K^+ in soil occurs in four different fractions: Potassium in the soil solution, exchangeable K^+, non exchangeable K and mineral or structural K which are in equilibrium with each other [3]. Soil solution K and exchangeable K are directly available to plants but in relatively small proportion. Plants absorb potassium from the soil solution which is buffered by the rapidly exchangeable forms. Evangelou *et al*.,[4] reported that uptake of K by plants from the soil solution is dependent on the concentration of calcium and magnesium ions. The non exchangeable K consists of slowly available K located in the interlayer spaces of 2:1 clay minerals.

Soluble K 6 Exchangeable K 6 fixed K

Potassium Q/l relations predict the K availability and supplying capacity of soil [5]. It is an approach that is known to be useful in understanding, characterizing and evaluating the potassium fertility status of the soil. The Potassium intensity factor is related to the concentration of potassium nutrient in the soil solution while the quantity factor refers to the adsorbed K. However, describing the K status of the termite mounds and earthworm cast requires specifying the current potential of K in the labile pool as well as the Q/l parameters in order to understand the K status of these soils.

Several works have been done on K Q/l relations of mineral soils [6,2], but little information is available on the K supplying capacity of termite mounds and earthworm cast using Q/I parameters. Consequently, the objective of this study was to determine K Q/I parameters of the soils modified by earthworms and termites.

Corresponding Author: E.U.Onweremadu, Federal University of Technology, P.M.B. 1526, Owerri, Nigeria

MATERIALS AND METHODS

Study Area: Umudike in Abia State of Southeastern Nigeria is located between the Latitude 5° 29’N and Longitude 7° 33’E. Soils are derived from coastal plain sands. It is a humid tropical environment with an average annual rainfall of about 2250mm and mean monthly temperature varying between 26° C to 27° C. Farming is a major socio-economic activity in the area. Land clearing is by slash-and-burn technique while soil fertility regeneration is by bush fallowing whose length has decreased due to anthropogenic activities.

Field Studies: Target soil sampling technique was used in field work. The soil samples (earthworm casts, cubitermes mound, macrotermes mound and top soils) for the study were collected from six (6) different locations spread over Umudike in Abia State. The samples were bulked together, air dried, crush and sieve through a 2 mm sieve.

Laboratory Analysis: Particle size distribution was determined by hydrometer method [7]. Soil pH was determined using 1:2.5 soil-liquid (water) ratio [8]. Organic matter was measured by wet digestion method [9]. Available P was determined using Bray ll method [10]. The soil exchangeable bases were determined by the neutral ammonium acetate procedure. Exchangeable acidity was measured in lN KCl [11]. Total nitrogen was determined by kjeldah digestion method [12]. The K Q/I relations were determined by equilibrating 5g of soil with 50ml of 0.01ML^{-1} $CaCI_2$ containing a range of potassium (KCI) concentration from 0 (nil) to $1x10^{-2}$ ML^{-1} for 2 hours. The changes in exchangeable K^+ ( ) K) were calculated from the difference in the initial and final equilibrated solutions. The activity ration (AR^K) in the solution was determined from the activities of K (ak), calcium (aCa) and magnesium (aMg) in the equilibrium solution.

$$\frac{ak}{(aCa + a\,Mg)_{0.5}}$$

The) k values were plotted in relation to the AR^K and the PBC^K was determined from the slope of the linear part of Potassium Q/I Isotherms. From the Isotherms, equilibrium labile K (KL) and fixed K (Kx) were estimated.

Data Analysis: Soil data were subjected to analysis of variance (ANOVA), Means were separated using Least Significant Difference (LSD). The K Q/I parameters were correlated with some soil properties using correlation analysis.

RESULTS AND DISCUSSION

The physical and chemical properties of the soils are shown in Table 1. The particle size analysis showed that the texture of the soils varied from sandy loam in cubitermes termite mounds and top soil, loam in earthworm casts to sandy clay loam in macrotermes termite mounds. Soils modified by earthworms and cubitermes termite had the highest pH value showing slightly acidic condition which is idea for crop production and encourages nutrient availability. The strong acidic condition observed in macrotermes termite mounds and surrounding top soils could lead to significant reduction in crop yield and in very severe cases crop failure [13]. However, high acidity which is one of the major soil critical challenges in Southeastern Nigeria may be ameliorated through the incorporation of the earthworm cast and cubitermes mound into the soil.

The organic matter content was significantly ($P<0.05$) higher in cubitermers mound and earthworm cast than in the macrotermes termite mounds and top soils. Mounds constructed by the macrotermes termites are believed to be formed of materials from the subsoil where organic matter content is low. On the other hand, earthworms and cubitermes termites forage from the upper layers of the soil and ingest large amount of organic materials that are incorporated into casts or mounds.

Potassium Q/I Parameters: The K Q/I Isotherm was shown in Fig 1 and is the representative of the Isotherms studied. From the Isotherms, the labile K (KL) which is the K^+ that is readily available to plants ranged between 0.26 $cmolkg^{-1}$ in macrotermes termite mounds to 2.83 $cmolkg^{-1}$ in earthworm cast with average value of 1.53 $cmolkg^{-1}$ (Table 2). These values were within the range reported by Ano *et al.*,[14] and Udo,[15] in some

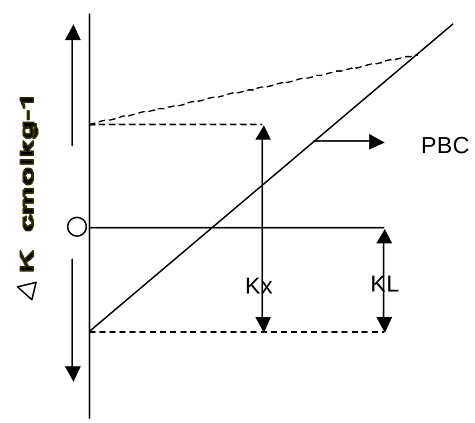

Fig 1: K Q/I Isotherm

Table 1: Physical and Chemical Properties of Soils

Soil materials	pH	%sand	%silt	%clay	Text class	%Om	Av.P mg/kg	%N	Ca	Mg	K	EA
									cmolkg^{-1}			
Cubitermes mound	6.40	75.90	9.36	14.74	SL	6.33	39.09	0.26	3.74	0.19	3.74	0.53
Earthworm cast	6.15	51.20	40.80	8.00	L	5.70	18.35	0.35	12.42	2.40	6.32	0.18
Macrotermes mound	3.81	59.20	8.80	32.00	SCL	0.93	8.35	0.05	1.94	1.94	0.12	0.35
Top soil	4.36	87.40	3.90	8.70	SL	1.73	9.00	0.07	1.92	1.28	0.19	0.34
LSD(0.5)	0.40	4.43	3.90	2.59		1.70	4.59	0.02	0.97	0.82	0.14	0.15

N = Nitrogen, Om = Organic matter, Ca = Calcium, Mg = Magnesium, EA = Exchangeable acidity, K = Potassium, text class = textural class, LSD = Least significant difference, Av.P = Available phosphorus

Table 2: Potassium Q/I Parameters

Soil materials	KL cmolkg^{-1}	Kx cmolkg^{-1}	Ex.K cmolkg^{-1}	PBC cmol/kg(ML^{-1})$^{0.5}$	AR (ML^{-1})$^{0.5}$
Cubitermes mound	2.63	1.18	3.35	0.08	15.00
Earthworm Cast	2.83	1.10	6.32	2.00	16.14
Macrotermes mound	0.26	0.73	0.12	0.06	12.54
Top soil	0.34	0.78	0.19	0.08	14.20
LSD(0.5)	0.27	Ns	0.14	0.09	5.15

KL= Labile potassium, Kx = Fixed potassium, AR = Activity ratio, Ex.K = Exchangeable potassium, PBC= Potassium buffering capacity, LSD = Least Significant difference

Table 3: Correlation between K Q/I parameters and some soil properties

K Q/I Parameters	Soil properties	Correlation coefficient (r)
Labile k	Ex.k	0.76**
Labile k	Ph	0.82**
Activity ratio	Clay	-0.59*
PBC	Organic matter	0.27^{ns}
Activity ratio	Ex.K	0.89**
Fixed k	Clay	-0.35^{ns}
Labile k	Silt	0.82**
PBC	Clay	0.01^{ns}
Labile k	Organic matter	0.58*

** correlation is significant at 1% (0.01) level of probability

* correlation is significant at 5% (0.05) level of probability,

Ex.k =Exchangeable potassium, PBC = Potassium buffering capacity

Nigerian soils but higher than the values reported by Mohsen, [2] in some calcareous soils of lran. High proportion of KL observed in earthworm casts and cubitermes termite mounds indicated a greater K^+ release into the soil solution leading to a large pool of exchangeable K. However, there was no significant difference ($p < 0.05$) between the KL observed in macrotermes termite mounds and non modified soils.

The significant low values of KL observed in top soils and macrotermes termite mounds showed low K status in these soils. The endowment of earthworm casts and cubitermes termite mounds with high readily available K is a reflection of the high exchangeable K and organic matter content of the worm cast and cubitermes mound which may be due to the incorporation of organic materials in these soils.

The labile K had significant positive correlation with exchangeable K (r = 0.76**) organic matter (r = 0.58*) and pH (r = 0.82**) of the soils respectively (Table 3), indicating that increase in the pH, exchangeable K and organic matter resulted to increase in labile K.

The exchangeable K ranged between 0.12 to 6.32 cmolkg^{-1} with a mean value of 2.50 cmolkg^{-1}. Earthworm cast had significantly ($p<0.05$) higher amount of exchangeable K compared to the soils modified by the two termite species and their corresponding non-modified soils. The least amount of exchangeable K was observed in soils modified by macrotermes termites.

The potassium buffering capacity (PBC), which is a measure of the ability of the soil to maintain the intensity of K^+ in the soil solution varied from 0.06 to 2.00 $cmolkg^{-1} (ML^{-1})^{0.5}$ with average of 0.56 $cmolkg^{-1} (ML^{-1})^{0.5}$. Generally, the PBC obtained from this study was low compared to the values reported by Sevage and BaIwant [16] in some soils of New South Wales. Low values of PBC observed in both the modified and non modified soils indicated the low Potassium supplying capacity of these soils and frequent fertilization for optimum crop yield. Consequently low PBC indicates that AR, K intensity in the soil solution and hence availability of K to plants will drop rapidly when the soils are cultivated or cropped.

The equilibrium AR^K in the soils varied from 12.54 in macrotermes termite mound to 16.14 $(ML^{-1})^{0.5}$ in earthworm cast with average of 14.47 $(ML^{-1})^{0.5}$ (Table 2). The values of the AR^K obtained in the study were higher than those reported by Ano et *al*.,[14] which fall within the range of 0.09 to 3.02 $(ML^{-1})^{0.5}$ in some Nigerian soils. Earthworm casts and cubitermes termite mounds contained higher amount of AR^K than the macrotermes termite mounds and top soils, indicating high intensity of the labile pool and suggests that any K residue would be loosely bound and readily available for crop uptake and leaching. According to Mohsen,[2], soils with higher clay contents usually have low AR values. The lower values of AR observed in macrotermes termite mound may be attributed to high clay content of the mounds.

Activity Ratio of K showed significant negative correlation (r = -0.59*) with clay (Table 3), indicating that increase in clay content of the soils resulted to decrease in AR. Similar observation was made by Ano *et al*., [14] in some soils of Eastern Nigeria and Mohsen, [2] in some soils of Iran.

Fixed K (Kx), the capacity of the edge sites which exhibit specific affinity for K ranged between 0.73 to 1.18 $cmolkg^{-1}$ with a mean value of 0.95 $cmolkg^{-1}$. There was no significant difference in the fixed K values of the soils.

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