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COMMUNICATION II

Potassium Supplying Capacity of Representative Soils of South Western Nigeria as Measured by Intensity, Quantity and Capacity Factors.

ABSTRAK

Kajian-kajian telah dilakukan dimakmal dan rumah tanaman untuk mempastikan kegunaan faktor-faktor kuantiti, keamatan dan keupayaan K bagi menilai keupayaan-keupayaan bekalan K, dan dalam meramalkan pengambilan K oleh jagung dalam 14 tanah terpilih di Selatan Barat Daya Nigeria. Keputusannya menunjukkan bahawa nisbah aktiviti adalah satu indeks yang lemah bagi K yang boleh digunakan, dan tidak berkemampuan dalam peramalan yang tepat bagi pengambilan K semasa penanaman yang panjang. Potensi keupayaan penampanan adalah lebih tinggi dalam tanah-tanah pada kompleks paling bawah daripada mendakan azal, menunjukkan bahawa pengosongan K terhadap tanaman akan lebih cepat dalam tanah yang diambil daripada bantuan mendak daripada tanah-tanah pada kompleks paling bawah. Keputusan tersebut juga menunjukkan bahawa ketetapan K, faktor kuantiti dan potensi keupayaan penampanan akan memberikan maklumat yang berguna untuk menyatakan perbezaan tabiat penampanan tanah.

ABSTRACT

Laboratory and greenhouse studies were undertaken to determine the usefulness of K Quantity, Intensity and Capacity factors in evaluating K supply capacities and in predicting K uptake by maize in 14 representative soils of South Western Nigeria. The results showed that the activity ratio was a poor index of the available K and was incapable of correct prediction of K uptake during prolonged cropping. The potential Buffer Capacity was higher in the soils on basement complex than in soils derived from sedimentary origin, indicating that depletion of K on cropping will be faster in soils derived from sedimentary rocks than those on the basement complex. The results also showed that the 'fixed K', Quantity factor and the Potential Buffer Capacity could provide useful information in characterising the differential Buffer behaviour of soils.

INTRODUCTION

Several researchers (Unamba-Oparah, 1985; Udo and Ogunwale, 1978; Fagbami *et al.* 1985) have shown that potassium deficiencies occur in many Nigerian soils, especially in acid sands. The exact levels of soil K at which deficiencies will occur in many Nigerian soils under continuous cropping still cannot be predicted accurately. Quantification of K needs under continuous corpping requires knowledge of the soil K buffer capacity. The nature of the k buffer capacity is determined by the K quantity-Intensity relationships as well as the character of the non exchangeable K in the soil. In order to improve the reliability of predicting soil K so that sound K management decisions can be made, indices of K availability should be carefully considered.

The present study was conducted to examine the K supplying potential of South Western Nigerian soil by evaluating the major soil K supplying indices.

MATERIALS AND METHODS

Soil

Bulk samples from surface 15 cm soil were collected from 14 locations of different agroecological zones of South Western Nigeria. The soil samples were air dried and sieved to pass through 2mm sieve. A portion was retained for laboratory analysis and the remainder was used for the greenhouse trials.

Soil Analysis

Exchangeable Na, K, Ca, and Mg in the soil samples were extracted with neutral 1M NH_4OAC. K and Na in the extract were determined by flame photometry while Ca and Mg were determined by atomic absorption sepctrophotometry. The K released from the non-exchangeable form ('fixed' - K) plus the exchangeable K in the samples were extracted by boiling in HNO_3 and determined by flame photometry. The K released from the non-ex changeable forms ('fixed' K) was estimated by difference (Wood and De Turk, 1941;). Particle size analysis of the soils was determined by the hydrometer method. Soil pH was measured by the glass electrodes in a 1:1 Soil - Water ratio. Organic matter was determined by the wet digestion suggested by Walkley and Black (1935). The total K in the soil samples was digested with a mixture of HF and $HClO_4$. The K in the digest was further dissolved in 6N HCL and determined with a flame photometer. The intensity factor (ARO^K), the quantity factor (Δ K) and the Potential Buffer Capacity (PBC), were estimated according to the procedure of Beckett (1964).

Greenhouse Studies

Two kg soil was weighed into each of several pots; K was applied at 2 levels , 0 and 100 mg kg-1 soil. The pots were arranged in the greenhouse in a randomised complete block design with 3 replicates. All treatments received initially 100mg Nkg^{-1} N as NH_4NO_3 and 50 mg ρkg^{-1} as Na_2HPO_4 $12H_2O$. Each pot contained 3 seed of maize (*Zea Mays L*) which were later thinned to 2 seedlings per pot. Five cycles of the crop of 4 weeks each were studied. Whole plant tops were harvested at the end of each cycle, oven dried at 70°C for 72 hours and weighed. A portion of the plant tissue was milled and digested with H_2SO_4 - H_2O_2 mixture; the K content of the digest was determined by flame photometry. The K response was calculated from the uptake data as:

$$\frac{\text{Uptake of Plus K plots - uptake of minus K}}{\text{plots uptake of minus K plot.}}$$

RESULTS AND DISCUSSION

Table 1 shows properties of the soils used in this experiment. Table 2 shows the K status of the 14 soils studied .

The intensity factors (ARo^K) (Table 2) varied widely among soils and showed no definite trend. No relationship was found between ARo^K values and any of the soil properties. However, the Quantity factor (ΔK) and the Potential Buffer Capacity (PBC) appeared to be related to the parent material; PBC values were found to be lower in soils derived from sedimentary rocks than in soils on the basement complex. The PBC and ΔK values correlated significantly with the soil clay content ($r = 0.969$*** and 0.979*** respectively). The dynamic equilibrium between exchangeable and non exchangeable K determines the ability of a soil to buffer K supply to

TABLE 1
Some properties of the experimental soils

		Exchangeable cations meg/ 100g.					Mechanical Analysis (%)				
		K	Ca	Na	Mg	Ex Acidity	Sand	Silt	Clay	Organic Matter %	pH in Water
Soils derived from Basement complex	Ile-Ife	0.354	2.8	0.007	0.83	0.3	66.8	14.7	18.5	2.48	5.9
	Modakeke	0.573	2.0	0.004	0.87	1.0	72.2	14.8	13.0	2.08	6.0
	Ise-Ijesha	.564	5.6	0.026	0.73	1.0	58.4	16.8	24.8	1.88	6.1
	Ibodi	.449	3.2	0.013	0.33	1.0	48.5	16.9	34.6	2.15	5.7
	Eduabon	.462	3.6	0.022	0.77	0.8	81.0	12.6	6.4	1.07	5.8
	Ede	.449	4.0	0.022	1.52	0.7	79.2	8.0	12.8	2.88	6.2
	Ikare	.585	0.9	-	0.33	0.8	68.4	20.5	10.1	0.54	6.3
	Efon	.237	1.4	-	0.12	0.9	80.2	8.8	11.0	4.19	5.3
	Ado Ekiti	.500	2.8	0.007	0.73	1.0	65.0	12.6	22.4	1.27	6.1
	IyinEkiti	.179	3.0	0.035	-	1.4	71.0	12.2	16.8	1.81	6.2
Soils derived from Sedimentary origin	Owode	.147	2.0	0.035	0.83	0.8	74.6	10.2	15.2	1.34	6.4
	Odogbolu	.173	1.7	0.017	0.50	0.9	72.9	16.0	11.1	2.01	5.7
	Ilaro	.128	0.6	-	0.64	0.8	71.6	6.0	22.4	1.68	5.1
	Iperu	.115	2.1	0.004	0.81	0.8	72.5	17.4	10.1	1.74	6.1

crops; and this is dependent on the amount and type of clay (Beckett, 1964). Illite and vermiculite are know to be the major K fixers in the soil.

However, these Nigerian soils do not contain appreciable amounts of clay minerals. Some workers (Adepetu *et al.* 1990) have observed a phenomenon similar to the K fixation tendency found in South Western Nigerian soils where illite and vermiculite probably do not influence the soil content. These workers observed that the zone of K depletion about the plant root is a portion of the non exchangeable K ('fixed' K) that contributes to soil available K. The rate of release of this 'fixed' K depends on the buffer capacity of the soil which is characterised by the Quantity factor and the Potential Buffer Capacity. Thus the depletion of K on cropping should be faster in soils derived from sedimentary rocks than in soils on the basement complex.

Table 3 shows the results of the correlations of some of the indices studied with crop uptake. They show that the exchangeable K is the dominant contributor to the K available for uptake by the crop. However, this contribution decreased with cropping. while 97% of variation in uptake (R^2 = 0.97) is due to exchangeable K alone in the first crop; its cumulative contribution accounts for 72% after the 4th crop. This relationship could be used to predict cumulative uptake after 4 croppings according to the following regression equation:

$$\text{Uptake} + 0.79 + 35.96 \text{ exch-K}$$

The contribution of 'fixed' K was insignificant in the first two crops; however, its contribution increased with cropping. After the 4^{th} crop its cumulative contribution increased by 33%. This may indicate that the 'fixed' K is a potentially important buffer of available K in these soils, although it does not appear to represent a definite fraction of the labile K in the soils studied. The contribution of the activity ratio ARo^K was found to be insignificant and erratic. This shows that ARo^K is a poor index of the available K and is an unreliable predictor of K uptake at initial or after prolonged cropping. The Quantity factor (ΔK), on the other hand,

TABLE 2
Potassium station and quantity-intensity relationships of potassium in the experimental soils

	Soil	K Status in C mole (+) Kg^{-1} Exch.K.	Fixco K.	Exch + fixed K	Mineral K	Total K	ARo^k (ML^{-1}) $X10^3$	K C mole (+) Kg^{-1}	IBC CM(+) (ML^{-1}) $X10^3$
Soils on Basement Complex	Ile-Ife	.358	0.236	0.588	40.437	41.026	5.7	0.14	24.4
	Modakeke	.573	1.462	2.035	51.176	53.205	3.8	0.15	40.0
	Ise-Ijesha	.564	0.744	1.308	46.769	48.077	3.2	0.20	63.2
	Ibodi	.449	0.314	0.762	37.699	38.461	2.0	0.14	70.6
	Edunabon	.462	0.868	1.329	49.952	51.282	10.0	0.10	9.8
	Ede	.449	0.314	0.762	30.006	30.769	5.6	0.13	23.1
	Ikare	.385	0.868	1.765	30.286	32.051	4.8	0.10	21.0
	Efon	.237	0.026	0.263	4.224	4.467	6.1	0.10	16.4
	Ado Ekiti	.500	0.917	1.417	65.891	67.308	2.8	0.18	64.5
	Iyin-Ekiti	.179	0.823	1.003	50.279	51.282	3.6	0.11	30.6
	Mean	0.415	0.708	1.124	38.107	39.231	4.7	.14	36.4
Soils from sedimentary origin	Owode	.147	0.071	0.218	40.167	40.385	2.6	0.08	30.4
	Odogbolu	.173	0.110	0.283	34.973	35.256	2.0	0.05	25.0
	Ilaro	.128	0.090	0.218	36.321	36.538	1.6	0.04	25.0
	Iperu	.115	0.103	0.244	37.577	37.821	6.2	0.10	
	Mean	0.141	0.093	0.241	37.259	37.50	3.1	0.09	24.1
	Grand Mean	0.337	0.533	0.871	37.865	38.736	4.3	0.12	32.9

TABLE 3
Relationships between K uptake and K status indices (cummulative).

Factor	1st Crop	1st & 2nd Crop	1st to 3rd Crop	1st to 4th Crop
Exch.K	0.985***	0.864***	0.846***	0.850***
Fixed K	0.311	0.400	0.585*	0.580*
Exch. + fixed K	0.620*	0.686**	0.744**	0.700**
ARo^k	0.110	-0.320	-0.186	0.040
K	0.620*	0.588*	0.720**	0.878***
PBC	0.462	0.642*	0.585*	0.542*

* Significant at 5% level of probability
** Significant at 1% level of probability
*** Signigicant at 0.1% level of probability

related significantly to the K uptake and its contribution increased rapidly with cropping; after the 4th crop its cumulative contribution to crop uptake was 78% which can be demonstrated by the regression equation: Uptake = 14.986 - 12.43K. The capacity factor (PBC) showed no significant relationship with crop uptake at the first crop but was significant and essentially constant thereafter, indicating that the capacity of the soils to replenish depleted K in solution and on the exchange, varies widely according to cropping dependent on the status of the cropping. The rate of repletion tends to increase with prolonged cropping.

These results indicate that 'fixed' K, exchangeable K, K Quantity and K capacity can provide useful information in characterising the differential buffer behaviour of individual soils of South Western Nigeria. However, further work is needed to verify the practical usefulness of this information under field conditions.

M.T. ADETUNJI
J.A. ADEPETU

Department of Soil Science and Agric. Mechanisation, University of Agriculture, Abeokuta, Nigeria.

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