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POTASSIUM SUPPLYING CAPACITY OF SOME LOW ACTIVITY CLAY SOILS IN BENUE STATE

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ABSTRACT

Laboratory and pot experiments were conducted with some low activity Clay Soils in Benue State to evaluate their potassium (K) supplying capacity using equilibrium parameters as measured by quantity, intensity and activity indices. The soils were Daudu, Tse-Kough, Tse-Agbakor and Mbachor. Farmers' fields were used to verify the findings of these experiments. Routine Soil analysis was done using standard procedures. K fractions were estimated using the procedure of Pratt, (1965). The Total K content of the Soils varied from 57.06 C mol Kg-1 at Daudu to 64.63 C mol Kg-1 at Mbachor with the non-exchangeable K constituting 57.16%, 0.40% and 0.13% respectively of the total K in the Soils. The potassium buffer capacity (PBC) which measures the ability of the Soils to maintain K intensity in solution ranged from 1.98 at Daudu to 3.56 at Mbachor indicating a slow release of K in these Soils. The specifically bonded K which constituted the bulk of the labile K (KL) was generally low. Response of Soybean (Glycine max merr. (L) to K application was observed in all the Soils studied and the critical K value for optimum yield of the crop using the procedure of Cate and Nelson , (1965) was determined to be 0.33 C mol Kg-1. Available K and fixed K showed no relationship with the parameters studied. A positive and significant relationship was observed between Non Exchangeable K and Available K (r = 0.989*). Mineral K showed a Positive and significant relationship (0.993**) with Available K. Total K had a positive and significant relationship (r = 0.986*) with below ground tissue K. It was concluded that response of Soybean to K application would be probable in the Daudu and Tse-Kough Soils while response to K application will not be probable with the Tse-Agbakor and Mbachor Soils.

Keywords: Clay Soils, Tse-Kough, Tse-Agbakor, potassium (K)

1. INTRODUCTION

Potassium is one of the primary macro-nutrient elements and is a limiting factor for the growth and yield of many crops in Benue State. Clay minerals are primary sources of potassium in the soil. They hold the bulk of mobile potassium and release it when its concentration in the soil solution falls due to plant uptake or to an increase in soil moisture content (Pal and SubbaRao, 1997;Datta and Sastry, 1993). Potassium is released from the edge and wedge zones of micaceous minerals and feldspars, because weathering of these minerals start from the edge of the crystal and does not proceed on the whole surfaces. In feldspars the exchange front penetrates further into the particle as weathering proceeds, this portion of K is relatively, weakly bound compared to interlayer K (Bolt *et al.*, 1963).

The presence of K from these various sources has given rise to different forms of K in the soil and these are: (1) water soluble K which is taken up directly by plants, (2) exchangeable K held by negative charges on clay particles and is releasable to plants. (3) “Fixed “K, trapped in between layers of expanding lattice clay during weathering and lattice K or mineral K which is an integral part of primary K bearing minerals (Vantaskesh and Satyarana, 1994; Adhikari and Gosh, 1993; Mengel and Kirby, 1987). All these forms of K play important roles in the K supplying capacity of soil. However the extent of contribution of each varies with soil type. Consequently K supply capacity is conceived to include K supplied from soil solution K, exchangeable K and Non-exchangeable K forms (Pal and Mukhopadhyay, 1992). These forms have given rise to different indices of measuring K availability and there is a dynamic equilibrium existing between them (Udo, 1982).

These indices have been variously described by Quantity (Q), Intensity (I) and Capacity factors (Beckett, 1964a, b). The quantity factor is the total amount of K in the soil, which the plant could draw its K from. Intensity factor is the amount of K that is readily available to the plant while buffering capacity factor is the ability of the soil to release K from non- exchangeable to exchangeable and soluble form, when the intensity factor is depleted by crop uptake.

Many soils in Nigeria are deficient in K. Thus, accurate soil test is required to be able to diagnose which of the soils are deficient and which are not. However, many workers have observed that at times, some soils that test high may respond to K application contrary to expectation. This anomaly is an indication that there are other forms of K other than the exchangeable K contributing to K needs of crops(Adepetu*et al.*, 1992).

Non-exchangeable K has been shown to also contribute significantly to plant uptake; this has often been ascribed to the “fixed” K”. However recent studies in West – Indies (Sanchez and Buol, 1974) and in Nigeria (Agboola and Omueti, 1983; Adetunji and Adepetu, 1993) have shown that this phenomenon also occurs in tropical soils.The mechanism for such has not been elucidated. Therefore in assessing the K supplying capacity, the readily released K and the slow released K portions must be assessed. The use of intensity and quantity factors then becomes imperative.

This work intends to characterize the K - supplying capacity of somesoils in Benue state using quantity, intensity and buffering capacity factors.

2. MATERIALS AND METHODS

Four benchmark soils were collected from Daudu, TseKough, TseAgbakor and Mbachor at a depth of 0-20 cm. These soils were earlier classified as Alfisols and Inceptisols Table1 (FDALR, 1990). The samples were air dried and sieved through 4 and 2 mm sieve for potandlaboratory and pot experiments.

Table 1.Description of Sampled Locations

S/NO	Locations	GPS coordinates	Taxonomic classification
1	Daudu	N 7^0 55.06', E 8^0 35.74'	TypicPaleustalf (USDA) OrthicLuvisol (FAO)
2	Tsekough	N 7^0 28.83', E 8^0 E 8^0 37.35	TypicHaplustalf (USDA) OrthicLuvisol (FAO)
3	Tseagbakor	N 7^0 27.94', E 8^0 35.73'	TypicTropaquept (USDA) GleyicCambisol (FAO)
4	Mbachor	N 7^0 56.68', E 8^0 34.84'	OxicUstropept (USDA) EutricCambisol (FAO)

Source: FDALR, 1990

Laboratory Analysis

Particle size analysis was determined by the hydrometer method (Bouyoucous, 1951), pH was determined by glass electrode in a 1:1 soil – water ratio (Page, 1982). The titrable acidity was extracted with KCl solution and determined by titration with 0.1N NaOH solution (Maclean, 1965). Organic matter was determined by wet acid digestion suggested by Walkley and Black (1934). Exchangeable sodium, potassium, calcium, and magnesium in the soil samples were extracted with neutral 1M NH_4OAC. Extractable K and Na were determined by flame photometry while Ca and Mg were determined by Atomic Absorption Spectrophotometry (Page, 1982). Total K in the samples was digested with a mixture of HNO_3 and H_2SO_4 (1:1). Potassium content in the digest was determined using a flame photometer. Fixed K was extracted from the soil by 1N HNO_3 and estimated as described by Pratt, (1965).

Determination of Quantity-Intensity Parameters

The quantity – intensity parameters of the soils was measured according to the procedure of Beckett, (1964c). Five grams of the samples was weighed; 50ml of 0.01M $CaCl_2$ was added to the soil which already contained KCl. The concentration of KCl ranged between 0.06M and 0.2M. The soil suspension was shaken on a reciprocal shaker for 12 hours and allowed to stand overnight before filtering. The equilibrium solution was analyzed for K and Na using flame photometer. Ca and Mg were determined titrimetrically using 0.2M EDTA. The amount of K adsorbed or released by the soils ($\pm \Delta$ K) was obtained from the change in the concentration of K in solution (i.e difference of initial status of K and final solution).

Pot Experiment Four Kg of the 4mm sieved soils was weighed into each pot. Two rates of K (0 and 200 $mgkg^{-1}$) were applied to the pots. All treatments received an initial 20 mg Nkg^{-1} as NH_4NO_3 and 100 mg P kg^{-1} as $NaHPO_4.12H_2O$ and the pots were arranged in a Completely Randomized Design (CRD) and replicated three times giving a total of 24 experimental pots.

Three seeds of soybean, variety 1935 – 3F were planted into each pot and later thinned to two. Two cycles of the crop of four weeks each was grown. At the end of each cycle the whole plant tops was harvested and oven dried at 60^0 C for 48 hours. A portion of the plant tissue was milled and digested with H_2SO_4-H_2O_2 mixture and K content was determined by the use of flame photometer.

Farmers' Field

The results obtained from the pot experiment were verified on farmers' field. A plot of 5m x 5m each of soybean farms was selected at those points where the soil samples were collected. The samples wereanalyzed for all K forms and grains were harvested to determine the yield per hectare. K forms of the plot were correlated with yield.

Critical Level

The critical level of K was determined to predict K fertilizer needs of the soil samples using the graphical procedure described by Cate and Nelson (1971). Increase in yield (ΔY max) as a result of fertilizer application was used for the statistical analysis.

4. RESULTS AND DISCUSSION

Properties of the studied soils are shown on Table 2. The pH of the soils varied from 5.00 to 6.86 with a mean value of 6.10. The organic carbon content ranged from 8.30g kg^{-1} at Tse Agbakor to 9.50g kg^{-1} at Daudu. Available K ranged from 0.24 c mol kg^{-1} for soils in Tse-Agbakor to 0.29 c mol kg^{-1} in Tse-kough .Response to K fertilization was thus probable.

Potassium (K) Fractions

The K fractions of the experimental locations are presented on Table 3. Total K in the soils was highest in all locations with a value of 64.63 c mol kg^{-1} at Mbachor and 58.07 c mol kg^{-1} in Agbakor soils. Daudu and Tsekough had 57.06cmol kg^{-1} and 58.40 cmol kg^{-1} respectively. This was followed by the non-exchangeable K fraction with a value 63.72 cmol kg^{-1} in Mbachor and 57.62 cmol kg^{-1} in Agbakor, whearas Daudu and Tsekough have their values at 54.20 cmol kg^{-1} and 53.10 cmol kg^{-1} respectively. The mineral K fraction in Mbachor and Agbakor have the values of 62.16 cmo lkg^{-1} and 55.48 cmol kg^{-1} while Daudu and Tsekough have the values of 53.40 cmol kg^{-1} and 51.30 cmol kg^{-1} respectively. The available K values were 0.64 cmol kg^{-1}, 0.46 cmol kg^{-1}, 0.37 cmol kg^{-1}, and 0.32 for Mbachor, Agbakor, Daudu, and Tsekough in that order. The exchangeable K fraction in Mbachor soil was 0.60 cmol kg^{-1} and that in Agbakor soil was 0.43 cmol kg^{-1},Daudu had 0.33 cmol kg^{-1} and Tsekough 0.23 cmol kg^{-1}. The Mbachor soil had fixed K value of 0.18 c mol kg-1, Agbakor 0.16 c mol kg-1 while Daudu and Tsekough has 0.14 c mol kg-1 and 0.11 c mol kg-1 respectively. The least value recorded was that of the solution K. Mbachor has the value of 0.04 c mol kg-1, Agbakor 0.55 c mol kg-1, Daudu 0.32 c mol kg-1 and Tsekough 0.10 c mol kg-1.

Table 2:Properties of the Experimental Soils

Sites	pH	Clay g kg^{-1}	Textural class	Organic C g kg^{-1}	Organic matter g kg^{-1}	N g kg^{-1}	Available P cmolmgkg^{-1}	K cmol kg^{-1}	Na cmol kg^{-1}	Cacmol kg^{-1}	Mg cmol kg^{-1}	Exchange acidity cmol kg^{-1}	CEC cmol kg^{-1}
Daudu	5.00	173.2	SL	9.50	16.4	0.91	6.01	0.27	0.69	3.75	1.50	0.02	6.22
Tsekough	5.98	139.0	SL	9.30	16.1	0.97	5.20	0.29	0.58	3.57	1.54	0.02	6.20
TseAgbakor	6.50	132.0	SL	8.30	14.4	0.80	12.50	0.25	0.48	3.07	1.37	0.01	5.90
Mbachor	6.86	122.0	SL	8.70	15.1	0.70	12.42	0.24	0.55	2.77	1.30	0.02	5.40

Table 3:Potassium fractions in the experimental soils (cmol kg-1)

Forms of K	Status of the forms of K			
	Mbachor	Agbakor	Daudu	TseKough
Available K	0.64	0.46	0.37	0.32
Exchangeable K	0.60	0.43	0.33	0.23
Solution K	0.04	0.05	0.32	0.1O
Mineral K	62.16	55.48	53.40	51.30
Fixed K	0.18	0.16	0.14	0.11
Non-exchangeable K	63.72	57.62	54.20	53.10
Total K	64.63	58.070.	57.06	58.40
Mean	27.42	24.61	23.69	23.37

The K buffering capacities of the soils (Table 4) ranged from -3.564 in Mbachor to 1.9834 in Daudu. TseKough and TseAgbakor had 1.8365 and 1.7579 respectively.

Table 4: Potential K Buffering Capacities of the Soils

Soil Location	PBC (c mol kg^{-1})
TseAgbakor	1.7579
Daudu	1.9834
TseKough	1.8365
Mbachor	-3.564

The fresh below ground biomass yield of the crop is shown on Table 5. In the Daudu soil, cycle 1, 0.67g pot-1 was obtained at the control. Upon addition of 200mg kg-1 KCl the yield increased to 0.80g pot-1. This was significantly higher than the yield obtained at the control. In cycle 2, 0.73g pot-1 was obtained at the control while 0.83g pot-1 was obtained when the KCl treatment was applied. This was also significantly higher than the yield obtained at the control.

In Tse-Agbakor soil, a significant increase in yield was also recorded as fertilization increased from 0 to 200mg Kg -1KCl per pot. In cycle one, a yield of 0.70g pot-1 was recorded for the control while a yield of 0.80g pot-1 was recorded when 200mg kg-1KCl was supplied. In cycle two 0.73g pot-1 was recorded as K fertilization was increased to 200mg kg-1KCl. per pot.

Mbachor soil also exhibited the same trend of increase in yield as fertilization increased. In the first cycle, a yield of 0.67g pot-1 was recorded for the control and 0.87g pot-1yield was obtained when 200mg kg-1KCl was added. In cycle two a yield of 0.73g pot-1 was obtained for the control while 0.87g pot-1 was recorded when 200mg kg-1KCl was applied showing significant increase in yield to increase in fertilization.

There was also significant increase in yield with increase in fertilization in TseKough soil. 0.63g pot-1yield was recorded for the control and 0.77g pot-1 was obtained when K fertilizer was added in the first cycle while 0.70g pot-1 was recorded in the absence of K fertilizer and 0.87g pot-1 was recorded as K fertilizer was increased to 200mg kg-1 per pot in cycle two.

Table 5:Fresh weight of below ground plant biomass (g) of soybean

Treatments	Daudu		TseAgbakor		Mbachor		TseKough	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2
0 mg Kg^{-1}KCl	0.67	0.73	0.70	0.73	0.67	0.73	0.63	0.70
200 mg Kg^{-1}KCl	0.80	0.83	0.80	0.90	0.87	0.87	0.77	0.87
Mean	0.74	0.78	0.75	0.82	0.77	0.80	0.70	0.79

The fresh weight of above ground biomass yield of the crop is shown on Table 6. In the Daudu soil, 0.73g pot-1 was obtained in cycle one which is the control. Upon addition of 200mg kg-1 KCl, the yield increased to 0.90g pot-1. This is significantly higher than the yield obtained at the control. In cycle 2, 0.80g pot-1 was obtained at the control while 0.90g pot-1 was obtained when the KCl treatment was applied. This was also significantly higher than the yield obtained at the control.

In TseAgbakor soil, there was also an increase in yield with increase in fertilization from 0.77g pot-1 to 0.90g pot-1 in cycle one, and 0.80g pot-1 and 0.98g pot-1 in cycle two. This shows a significant increase indicating the need for K fertilization if higher yields are to be recorded.

Mbachor soils manifest the same increase in yield as K fertilization increases from the control to 200mg kg-1. In cycle one 0.77g pot -1 was recorded as the control and 0.97g pot-1 was recorded when 200mg kg -1 were supplied. In cycle two recorded an increase from 0.80g pot-1 to 0.93g pot-1 for control and fertilized pots

There was also a significant increase in yield with increase in fertilization in TseKough soil. 0.73g pot-1yeild was obtained in the absence of K fertilizer, but a yield of 0.90g pot-1 was recorded as 200mg kg-1KCl was added in cycle one. Cycle two has an increase as fertilization increases with the values 0.80g pot-1 for control and 0.98g pot-1 as 200mg kg-1KCl was supplied.

Table 6: Fresh weight of above ground Biomass (g) of Soybean

Treatments	**Daudu**		**TseAgbakor**		**Mbachor**		**TseKough**	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2
0 mg Kg^{-1}KCl	0.73	0.80	0.77	0.80	0.77	0.80	0.73	0.80
200 mg Kg^{-1}KCl	0.90	0.90	0.90	0.98	0.97	0.93	0.90	0.98

The K content of below ground plant tissue of the crop harvested in both cycles one and two are shown on Table 7. The Daudu soil showed no increase in K uptake even as K supply was increased from 0 to 200 mg kg-1KCl per pot. In cycle two however, there was an increase in K uptake from 0.22 C mol kg-1 to 0.24 C mol kg-1 as fertilization was increased from the control (0 mg kg-1 KCl) to200 mg Kg-1KCl. In TseAgbakor increase in K uptake was recorded in both cycles one and two with the value of K ranging from 0.20 to 0.21 and 0.23 to 0. 25 C mol kg-1 respectively.Mbachor soil also recorded an increase in cycle one as the plant tissue was analysed with a shift from the value 0.22 C mol kg-1 to 0.24 C mol kg K uptake,. however, cycle two recorded a decrease from 0.26 C mol kg-1 to 0.24 C mol kg-1 K uptake as fertilization was increased from 0 to 200 mg kg-1KCl per pot. In Tsekough soil, K uptake shows no change even as fertilization was increased from 0 to 200 mg kg-1KClwith same value of 0.22 C mol kg-1 recorded. Cycle two recorded an increase from 0.22 to 0.23 C mol kg-1 K uptake as fertilization was increased from 0 to 200 mg kg-1KCl per pot.

Table 7: Potassium content of below ground plant tissue (Cmol kg^{-1})

Treatments	**Daudu**		**TseAgbakor**		**Mbachor**		**TseKough**	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2
0 mg Kg^{-1}KCl	0.22	0.22	0.20	0.23	0.22	0.26	0.22	0.22
200 mg Kg^{-1}KCl	0.22	0.24	0.21	0.25	0.24	0.24	0.22	0.23
Mean	0.22	0.23	0.21	0.24	0.23	0.25	0.22	0.23

The K content of the above ground biomass of plant tissue is shown on Table 8. When fertilization was increased from 0 to 200 mg kg-1KCl per pot cycle one and two in Daudu soil shows no increase in K uptake with same value of 0.24 and 0.25 cmol kg-1 K respectively. TseAgbakor recorded an increase in K uptake in both cycles as fertilization increases from 0 to 200 mg kg-1KCl per pot with the K uptake values ranging from 0.22 to 0.23 C mol kg-1 in cycle one and 0.27 to 0.28 cmol kg-1 in cycle two. Cycle one in Mbachor soil show no increase in K uptake with increase in fertilization from 0 to 200 mg kg-1KCl per pot with a constant value of 0.24 cmol kg-1 at both levels of fertilization. In cycle two an increase from 0.24 to o.25 cmol kg-1 K uptake was observed as fertilization increases from 0 to 200 mg kg-1KCl per pot. In Tsekough soil, there was a corresponding increase in K uptake as fertilization increases from 0 to 200 mg kg-1 per pot. Cycle one has an increase from 0.23 to 0.24 cmol kg-1 and cycle two has an increase from 0.24 to 0.27 cmol kg-1 K uptake

Table 8:Potassium content of above ground plant tissue (Cmolkg-1)

Treatments	**Daudu**		**TseAgbakor**		**Mbachor**		**TseKough**	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2
0 mg Kg^{-1}KCl	0.24	0.25	0.22	0.27	0.24	0.24	0.23	0.24
200 mg Kg^{-1}KCl	0.24	0.25	0.23	0.28	0.24	0.25	0.24	0.27
Mean	0.24	0.25	0.23	0.28	0.24	0.25	0.24	0.26

Table 9, indicates that the yield of soybeans on the farmers plot ranged from between 1.00 t ha-1 at Tse Kough to 2.46 t ha-1 in Tse Agbakor. Daudu and Mbachor had 1.51 t ha-1 and 2.24 t ha-1 respectively. The available K on the farmers' field ranged from 0.28 mg Kg-1 in TseKough to 0.59 mg Kg-1 in Mbachor soils. The available K in Daudu soil was 0.31 mg Kg-1 and Tse Agbakor has its value to be 0.37 mg Kg-1. Total K content was highest in all the locations. The potassium buffering capacity was highest in the Daudu soil and was followed by Tsekough, TseAgbakor and Mbachor. The fresh below ground biomass followed the same trend with the buffering capacities of the Soils indicating that the more strongly buffered a soil is the more sustained availability of K throughout the growth period. However, the degree of response to fertilization in terms of change in yield was greatest with the poorly buffered Soils. The K content in the above ground plant parts also exhibited the same trend with the buffering capacities.

Yield on the famers' field however was highest at Mbachor and was followed by TseAgbakor, Daudu and Tsekough. The available K values also showed the same trend. This indicate that though the Daudu and TseKough Soils were more strongly buffered, K fixation could have probably occurred here leading to conversion to non-available forms thus affecting yield.Many workers have observed that at times, some soils that test high may respond to K application contrary to expectation. This anomaly is an indication that there are other forms of K other than the exchangeable K contributing to K needs of crops(Adepetuet al., 1992). It was thus concluded that the Daudu and Tse-Kough soils had less K supplying capacity while the Tse-Agbakor and Mbachor soils had a greater capacity to supply K.

Table 9: Yield and available K Fraction on farmers' field

Location	**Yield (t ha^{-1})**	**Available K (c $molkg^{-1}$)**
Daudu	1.51	0.31
TseKough	1.00	0.28
TseAgbakor	2.46	0.37
Mbachor	2.24	0.59

Relationships between K fractions of the experimental soils and the K tissue content as well as the yield parameters studied are shown on Table 10. Exchangeable K related positively and significantly with Available K. This indicates that as exchangeable K increases, more K that will be made available for plant uptake thus implying that the exchangeable K which belongs to the non labile K fraction is loosely held on the colloidal complex and is easily converted to the labile pool as the concentration of the latter decreases. This replenishment is necessary so as to maintain a relatively stable concentration of labile pool for optimum growth and yield of the crop. A dynamic equilibrium between the exchangeable (non labile pool) and Available K (labile) is thus possible. Vantaskesh and Satyarana, 1994; Adhikari and Gosh, 1993 had earlier reported that Exchangeable K is held by negative charges on clay particles which is releasable to plants. Solution K which is the form of K taken up by plants directly correlated negatively and significantly with the above ground plant biomass (r = -0.984*). Total K had a positive and significant relationship (r = 0.986*) with below ground tissue K; that is, the higher the total K content the more K that will be taken up by the below ground plant tissues. Similarly positive and significant correlation was obtained between non-exchangeable K and available K (r = 0.989*). Non –exchangeable K often contributes to plant uptake when all the K in available forms has been used. Non-exchangeable K is as important as exchangeable K when assessing the potassium supplying capacity of the soil as it contributes significantly to plant uptake over a longer period (Pal and Subbarao, 1997).

Table 10: Relationships between K fractions, K tissue content and yield parameters

K Fractions	KBC	BGB	AGB	KCon B	KCon A	Yield	Avail K (Field)
Available K	-0.918	0.853	0.537	0.911	-0.253	0.766	0.988
Exchangeable K	-0.861	0.894	0.450	0.856	-0.226	0.831	0.960*
Solution K	0.475	-0.577	-0.984*	-0.445	-0.485	-0.468	-0.515
Mineral K	-0.936	0.815	0.489	0.932	-0.333	0.726	0.993**
Fixed K	-0.731	0.934	0.315	0.726	-0.146	0.910	0.875
Non-exchangeable K	-0.923	0.850	0.579	0.915	-0.229	0.758	0.989*
Total K	-990	0.564	0.656	0.986*	-0.413	0.418	0.98

*KBC = Potassium buffering capacity; BGB = Below ground biomass; AGB = Above ground biomass; KCon B = Below ground K tissue concentration; KCon A = Above ground K tissue concentration.

CONCLUSION

The Daudu and TseKough Soils were more strongly buffered than the Tse-Agbakor and Mbachor Soils. Response of Soybean to K application would be probable in the Daudu and Tse-Kough Soils while response to K application will not be probable with the Tse-Agbakor and Mbachor Soils.

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