Direct Research Journal of Agriculture and Food Science

Vol. 12(3), Pp. 18-24, October 2024,

https://journals.directresearchpublisher.org/index.php/drjafs

Research Article
ISSN: 2354-4147

Forms and Status of Potassium in Soils Supporting Rubber (*Havea brasiliensis*) Plantations in three Locations in Akwa Ibom State, Nigeria

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ABSTRACT

The status of the various forms of potassium in soils supporting rubber (Havea brasiliensis) plantations in three locations in Akwa Ibom state was investigated. Soils samples were collected from three rubber plantations (Obio-Akpa, Ntak-inyang and IkotObioEkpung) at the depth of 0 - 15, 15-30, 30-45 and 45-60cm. The results indicated that the soils were loamy sand in texture, acidic with mean pH value of 4.38, low nitrogen (0.16%), exchangeable K (0.09 cmolkg-1), exchangeable Na (0.11 cmolkg^{-1}) with high content of organic matter (4.80%), calcium (5.68 cmolkg^{-1}) and magnesium (5.14 cmolkg^{-1}). The results also revealed that water soluble K ranged from 0.02 to 0.06 cmolkg^{-1}, available K from 0.05 to 0.15 cmolkg^{-1}, exchangeable K from 0.03 to 0.10 cmol/kg-1, difficultly K from 0.01 to 0.15 cmol/kg^{-1}, acid-soluble K from 0.03 to 0.08 cmolkg^{-1} and total K from 0.15 to 0.25cmolkg^{-1}. The different forms of K correlated positively and significantly among each other and with some soil properties, thus an increase in one form lead to a corresponding increase in the other. In all the soils, the content of all forms of K was generally low. The low levels of total K indicate that soils supporting rubber in Obio-Akpa, Ntak-Inyang and IkotObioEkpung in Akwa Ibom State are deficient in K contents and may not meet the needs of K demanding crops like rubber. Therefore, adequate K fertilization is suggested as a possible means of improving the soils for rubber cultivation in the area.

Keywords: *Rubber plantation, potassium, soil properties*

Article information
Received 2 June 2024;
Accepted 20 September 2024;
Published 4 October2024
DOI: https://doi.org/10.26765/DRJAFS36328545

Citation: Ijah, C. J., Iyanam, M. V., Essien, G. E., Robson, M. S., and Effiong, I. B. (2024).Forms and Status of Potassium in Soils Supporting Rubber (*Havea brasiliensis*) Plantations in three Locations in Akwa Ibom State, Nigeria. Direct Research Journal of Agriculture and Food Science: Vol. 12(3), Pp. 18-24. https://doi.org/10.26765/DRJAFS36328545.

INTRODUCTION

Potassium (K) is one of the essential nutrients needed by rubber (*Havea brasiliensis***)** for its growth and development. Sufficient levels of K in the soil acts on the activation of enzyme system related to photosynthesis and respiration (Ashraf *et al*., 2001; Cakmak *et al*., 2005; Ahmad *et al*., 2012). K enhances the synthesis of protein (Ashraf *et al*., 2001) and adenosine triphosphate (ATP) Pettigrew (2008) and regulates water loss from opening and closing of stomata (Aquero, 2006; Ahmad *et al*., (2012). In addition, K increase the leaf area and dry matter accumulation in rubber (Ahmad *et al.,*(2012). However, K deficiency leads to a decrease in plant growth (Pettigrew, 2008), size of internodes, apical dominance, delay fruiting and smaller fruits with less intense colours.

Chemically, Potassium exist in soil in three forms: relatively unavailable, slowly available and readily available (Tsidale and Nelson, 1975). Readily available K is a combination of water soluble and exchangeable K and is present either in the soil solution or is held by the exchange fraction of the soil. Slowly available K is K that is gradually taken up by plants. The unavailable form of K occurs as a part of the crystal structure of weathered or only slightly weathered primary and secondary micaceous and feldspathic minerals (Tsidale and Nelson, 1975). According to Yagodin (1984) Total K include various forms of K compounds namely: water soluble K, exchangeable K, mobile K (water soluble plus exchangeable K, usually regarded as the available K) removed from the soil with a salt extract, non-exchangeable hydrolysable K (difficultly exchangeable K) which serves as the nearest nutrient reserve, acid-soluble K combining all of the four forms, and non-exchangeable K (different between total and acid soluble ones). Water soluble K constitutes about 0.5 – 2% of the overall K reserved in the soil (Yagodin, 1984). About 98% of K comprises of the structure of primary and secondary minerals and is in the unavailable forms Spark (2000). Several reports Periaswam y*et al*.,(1983); Enwezor*et al.,*(1988); FPDD, (1990); Iren and Amalu, (2012) indicated that total K is found more on surface soil than in subsurface soil because of the increase in carbonate content with depth. Fassbender, (1994) estimated that the concentration of K ranged from 0.9 to 19 g/kg^{-1} in tropical soils. The concentration may vary depending on the degree of moisture content in the soil and mineralogical composition of the source of K (Shaikh *et al.,* 2017).

Rubber (*Hevea brasiliensis*) is an important cash crop which belongs to the family Euphorbiacease in the genus Hevea. The latex from rubber tree is the raw materials used for the production of rubber in the world especially in the tire industry (Nogueria *et al*., 2015) and wood used in furniture industry. The seeds contain oil used in making paints and soap. Diniz *et al.,* 2015 and Blagodatsk *et al*., (2016) indicated that this crop can store large amount of carbon (C) in the soil and is also considered as a good alternative for increasing carbon levels in the soil. The state of Akwa Ibom is one of the top rubber-producing states in Nigeria, along with seventeen others. Despite widespread cultivation of rubber, the yields are often low due to poor soil fertility. As a result, this study aims to evaluate the different forms of potassium present in the soils that support rubber plantations in Akwa Ibom State. This research could potentially lead to improvements in soil fertility and subsequently increase rubber yields in the region.

MATERIALS AND METHODS

The study was conducted in Akwa Ibom State, Nigeria. Akwa Ibom State lies between latitudes$4^0 30^1$and $5^0 30N^1$ and longitudes $7^0 30^1$ and $8^0 20^1$E. The climate of the study area is humid tropical with mean annual rainfall of 2500 – 3000mm with 1-3 dry months in the year.Mean annual temperature varies between 27ºC – 28ºC with relative humidity of 75-80%. The soils are highly weathered with low activity clays such as kaolinite and the amorphous oxides of Fe and Al (Petters*et al*., 1989).

This study was carried out in three (3) rubber plantations in Akwa Ibom State, namely; Obio Akpa in OrukAnam Local Government Area L.G.A), Ntak Inyang in Itu L.G.A and Ikot Obio Ekpung in MkpatEnin L.G.A., respectively, (Figure 1). The soil samples for this study were obtained from rubber plantations using a soil auger. We collected samples at depths of 0-15, 15-30, 30-45, and 45-60cm, resulting in a total of thirty-six (36) soil samples for laboratory analysis. The soil samples were air dried, ground, and pass through a 2mm sieve to remove debris and were later subjected to the following analysis: Particle size analysis was determined by the Bouyoucos hydrometer methods using Calgon as a dispensing agent (Gee and Or, 2002).Soil pH was determined in a 1:2.5 soil/ water suspension using a glass electrode pH meter (Maclean, 1982).Organic carbon of the soils was determined by Walkley and Black wet oxidation method (Nelson and Sommers 1996). Organic matter was computed by multiplying the organic carbon value by Van Bemmelen factor of 1.723. Total nitrogen (N) was determined by the modified micro – kjeldhal distillation procedure as outlined by Bremner (1996). Available phosphorus was extracted with Bray- 1 method (Kuo, 1996) and the P in the extract was determined spectrometrically. Exchangeable K, Ca, Mg and Na were extracted with 1 N ammonium acetate (Udo *et al*., 2009). Potassium (K) and Na were read with flame photometer while Ca and Mg were determined using Atomic Absorption Spectrometer (AAS). Exchangeable acidity was measured titrimetrically using 1N KCL against 0.05N Sodium hydroxide (Maclean, 1982) while effective cation exchange capacity was calculated from the summation of all the exchangeable bases and total exchangeable acidity. Base saturation (BS) was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and the multiplied by 100.

Water-soluble K was determined by extraction with deionized water in 1:10 soil- water suspension. Exchangeable K was determined by extraction with 1N ammonium acetate (NH_4OAC) buffered at pH 7.0 in 1:10 soil- salt solution suspension (Pratt, 1965). Available K was determined by summation of water- soluble K and

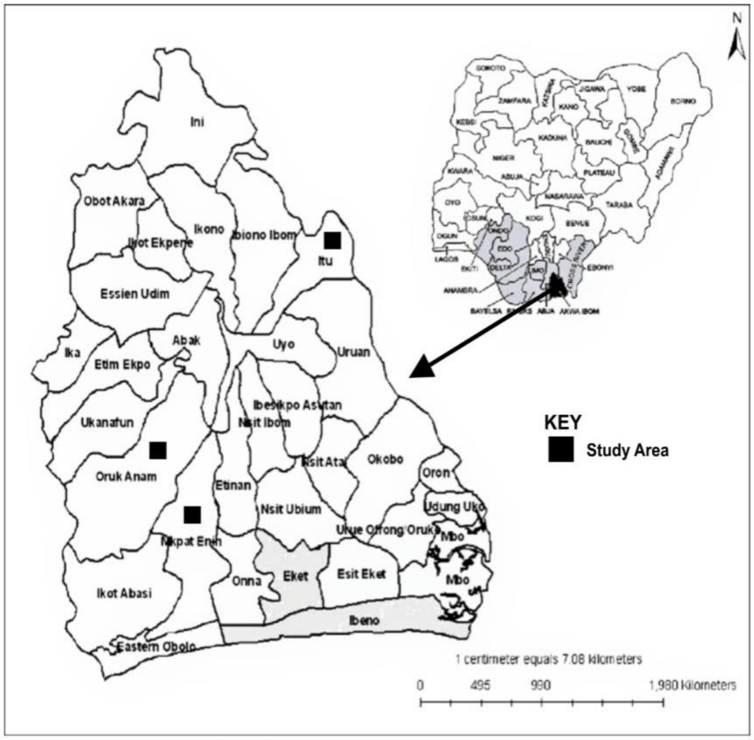

Figure 1. Map of Akwa Ibom State showing Study Area

nitric acid (HNO_3) exchangeable K. Difficultly exchangeable K was determined by extraction with 1N HNO_3 in 1:10 soil- acid suspension after boiling for one hour. (Pratt, 1965).The difference between 1N HNO_3-extractable K and that of exchangeable K was considered as the difficultly exchangeable K. Acid-soluble K was determined by extraction with 1N hydrochloric acid (HCl) in 1:10 soil-acid suspension after boiling for 1hour. The difference between 1N HCl- extractable K and that of exchangeable K will be taken as the aid soluble K.Total K was determined using the method of (Pratt, 1965). One-gram (g) of soil was completely digested in Hydrofluoric (HF) and perchloric acid ($HClO_4$) mixtures under a fume hood. The filtrate was brought to volume in a100-ml volumetric flask, and total K content was determined with a flame photometer.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA), mean separation was done using Fishers Least Significant difference (F-LSD) at 5% level of probability. Correlation between some soil properties and forms of K were determined using SPSS statistics 17.0 and Stat Point, (2005).

RESULTS AND DISCUSSION

Physico-chemical properties of soils of the study area

Particle size analysis (Table 1) indicated that the soils of Obio Akpa, Ntak Inyang and Ikot Obio Ekpung rubber plantations were loamy sand in texture with very high sand fractions. The sand fractions ranged from 67.26 g/kg to 83.80 g/kg with a mean of 79.19 g/kg, silt ranged from 5.90 g/kg to 10.68 g/kg with a mean of 7.053 g/kg and clay ranged from 8.24 g/kg to 22.06 g/kg with a mean of 13.59 g/kg, respectively. The loamy sand texture of the soils falls within the recommended texture of loam to silty loam recommended by Asawalam and Ugwa (1993) for rubber production. The soils were acidic in nature with pH values ranging from 3.27 to 5.46 with a mean of 4.38 except at Ntak-Inyang at the depth of 0 – 15cm where the pH increased to 6.13. The low pH values recorded at Obio Akpa and Ikot Obio Ekpung rubber plantations is in agreement with the observation of (Ijah *et al*, 2021) on soils developed under coastal plain sand parent materials. The high acidity could be attributed to high amount of rainfall which might have contributed to leaching (Ijah *et al.,* 2021) of exchangeable bases from the top soils.. Electrical conductivity (EC) of soils across

Table 1: Physico-chemical properties of the soil supporting rubber plantation in Akwa Ibom State.

Sample Location	Depth	Particle Size Analysis				pH	EC		OC	OM	TN		AVP	K	Ca		Mg	Na	EA	ECEC	BS
	(Cm)	Sand	Silt	Clay	TC	(H_20)	dS/m		%	%	%		mg/kg	Cmolkg^{-1}							%
		g/Kg																			
Ntak-inyang	0-15	83.80	6.14	10.06	LS	6.13	1.39		2.79	4.81	0.09		22.01	0.08	9.12		3.60	0.01	1.76	14.6	87.74
	15-30	81.68	6.02	12.30	LS	5.17	0.08		2.29`	3.95	0.12		16.01	0.08	5.36		4.08	0.01	1.44	11.0	93.44
	30-45	77.38	6.02	16.60	LS	5.46	0.07		1.82	3.14	0.08		7.02	0.09	4.32		3.84	0.01	1.76	10.02	82.44
	45-60	81.62	5.90	12.48	LS	4.89	0.40		1.09	1.88	0.22		4.67	0.09	2.88		7.20	0.01	0.96	11.14	91.38
IkotObioEkpung	0-15	77.32	6.56	16.12	LS	4.29	0.21		4.50	7.75	0.15		34.68	0.05	7.68		4.32	0.04	1.92	14.01	86.29
	15-30	79.44	6.32	14.24	LS	3.84	0.13		3.11	5.36	0.18		24.68	0.05	6.24		6.24	0.02	2.72	15.27	82.19
	30-45	71.26	8.44	20.30	LS	5.11	0.06		2.51	4.32	0.15		18.02	0.05	6.24		6.48	0.01	2.24	15.02	85.09
	45-60	67.26	10.68	22.06	LS	3.54	0.06		2.31	3.98	0.15		12.67	0.05	3.36		4.08	0.02	2.56	10.07	74.58
ObioAkpa	0-15	81.50	8.14	10.36	LS	3.65	0.09		4.49	7.74	0.19		10.67	0.15	2.88		7.68	0.02	1.76	12.49	85.91
	15-30	83.62	8.14	8.24	LS	3.27	0.06		3.49	6.01	0.19		8.00	0.14	3.36		6.00	0.02	3.36	12.88	99.84
	30-45	83.74	6.14	10.12	LS	3.81	0.02		2.99	5.15	0.17		4.08	0.15	4.80		5.52	0.02	2.88	13.37	78.46
	45-60	81.68	8.14	10.18	LS	3.37	0.15		1.99	3.42	0.17		3.34	0.14	1.92		2.64	0.02	1.76	6.35	74.33
Range		16.54	4.78	13.82		2.86	1.334		3.27	8.73	0.14		38.68	13.44	4.56		0.03	0.10	2.42	14.55	25.51
X (Mean)		79.19	7.053	13.59		4.38	0.23		2.79	4.80	0.16		13.8	0.09	5.68		5.14	0.11	2.09	13.01	85.14
SD		5.198	1.493	4.377		0.942	0.48		0.956	0.047	2.434		12.85	0.041	3.734		1.591	0.092	0.67	3.58	5.863
CV			6.56	21.17	32.21		21.507	208.7	26.26	30.32	42.04	82.57	44.30	65.74	30.95	87.43	32.01	27.52	6.89		

Where x = mean; SD = Standard deviation; CV = Coefficient of variances; EC=Electrical Conductivity, OC = Organic Carbon, OM = Organic matter, TN = Total Nitrogen, Av. P = Available phosphorus, K = Potassium, Mg = Magnesium, Na = Sodium, EA = Exchangeable acidity, ECEC = Effective cation exchange capacity, BS=Base saturation

the three rubber plantations were generally low ranging from 0.02 dSm^{-1} to 1.39 dSm^{-1} with a mean of 4.38dSm^{-1}. Organic carbon (OC) ranged between1.09 to 4.50% with a mean of 2.79% in the soils across the three-rubber plantation. The organic matter (OM) content was found to be high in all the locations and decreased with increasing depth, except at Ntak Inyang, where it was low (1.88%) at a depth of 45-60cm. The high soil organic matter concentration especially at the surface soils could be attributed to biomass return to the surface soils by the crop. The content of total nitrogen (TN) was low and ranged from 0.08 to 0.19 with a mean of 0.16% as characteristics of tropical soils. According to Hartz (2007), soils with less than 0.07% total nitrogen has limited mineralization potentials whereas those higher

Table 2: Forms of (K) in soils of selected rubber plantations in Akwa Ibom State.

Sample locations	Depth (cm)	Water soluble k cmolkg^{-1}	Exchangeable k cmolkg^{-1}	Available k cmolkg^{-1}	Difficulty k cmolkg^{-1}	Acid soluble k cmolkg^{-1}	Total k cmolkg^{-1}
NtakInyang	0-15	0.03	0.05	0.08	0.04	0.08	0.18
	15-30	0.03	0.05	0.08	0.06	0.07	0.21
	30-45	0.03	0.06	0.09	0.06	0.07	0.23
	45-60	0.03	0.06	0.09	0.05	0.07	0.20
IkotObioEkpung	0-15	0.02	0.03	0.05	0.04	0.07	0.15
	15-30	0.02	0.03	0.05	0.05	0.06	0.17
	30-45	0.02	0.03	0.05	0.05	0.07	0.18
	45-60	0.02	0.03	0.05	0.06	0.07	0.18
ObioAkpa	0-15	0.06	0.03	0.15	0.02	0.03	0.25
	15-30	0.05	0.09	0.14	0.02	0.05	0.24
	30-45	0.06	0.10	0.15	0.01	0.05	0.24
	45-60	0.05	0.09	0.14	0.03	0.06	0.24
Range		0.04	0.07	0.1	0.05	0.05	0.1
X (Mean)		0.035	0.059	0.093	0.49	0.75	0.206
SD		0.0158	0.027	0.0412	0.47	0.68	0.0337
CV		45.143	45.76	44.76	0.96	1,39	16.36

Where X = mean, SD = Standard deviation, CV = Coefficient of Variance

than 0.15% are expected to mineralize sufficient nitrogen. The soil available phosphorus ranged from 3.34 mgkg^{-1} to 34.68 mgkg^{-1} with a mean of 13.8mgkg^{-1}. The available phosphorus of the soil was generally medium to high at the surface soils and decreased with increase in depth. Low available phosphorous (P) in tropical soils has been attributed to the nature of the chemical forms of P and the high content of oxides of iron and aluminum associated with high P fixation. The exchangeable calcium (Ca) content of the soil ranged from 1.92 to 9.12 cmolkg^{-1} with a mean of 5.68 cmolkg^{-1} and Exchangeable magnesium ranged from 2.64 to 7.68 cmolkg^{-1} with a mean of 5.14 cmolkg-^{1}. The content of exchangeable calcium and magnesium in the soil were generally high in all the location except calcium in Obio Akpa where it decreases with increase in depth. The exchangeable potassium content was generally low in all the locations and ranged from 0.05 to 0.15 cmolkg^{-1} with a mean of 0.09 cmolkg$^{-1.}$ Potassium deficiency in the soil could be due to high exchange acidity leading to K fixation. Exchangeable sodium content ranged from 0.01 cmolkg^{-1} to 0.02 cmolkg^{-1} with a mean of 0.11 cmolkg^{-1}.and was generally low in all the rubber plantations. Exchangeable acidity ranged from 0.96 to 2.88 cmolkg^{-1} with a mean of 2.09 cmolkg^{-1}. However, high acidity in the soils can be ameliorated by liming the soils and application of organic manure. Effective cation exchange capacity (ECEC) ranged from 6.35 to 15.27 cmolkg^{-1} with a mean of 13.01cmolkg^{-1}. However, the medium to high ECEC suggest that the soils have the ability to withstand heavy leaching loss of nutrients for tropical soils (Sanchez, 1976). Base saturation was high and ranged from 74.30% to 99.84% with a mean of 85.14%.

Forms of Potassium (K) in soils of selected rubber plantations

The status of the different forms of potassium in each of the selected rubber plantations is outlined in (Table 2). The water-soluble K values of all the soils ranged from 0.02 to 0.06 cmolkg^{-1} with a mean of 0.04 cmolkg^{-1}. These values are low and compare well with the report of Iren and Amalu, (2012) for selected soils supporting oil palm in Cross River State, Nigeria but less than the ranged of 0.01 – 1.25cmolkg^{-1} reported by Akinyede (1988) for selected soils of Nigeria. The exchangeable K values of the soils ranged from 0.03 to 0.10 cmolkg^{-1}a mean of 0.06cmolkg^{-1}. The exchangeable K values are low when compared with the range of 0.15 to 1.92 cmolkg^{-1} obtained by Akinyede (1988) for soils formed on different parent materials in Nigeria but falls within the range of 0.03 to 1.03 cmolkg^{-1} obtained by Amalu (1989) for some soil supporting Coconuts. Soil exchangeable K less than 0.13 are considered very poor in K and those that contain 0.13 to 0.31 cmolkg^{-1} are moderately endowed with K while those that contain more than 0.31cmolkg^{-1} are rated as high in exchangeable K content (Amalu, 1989).

The available K ranged from 0.05 to 0.15 cmolkg^{-1} with a mean of 0.09. The levels of available K in all the rubber plantations were generally low. The low content of the available K could be attributed to K fixation in these soils and leaching of basic cations which are characteristics of tropical soils. The difficultly exchangeable K values ranged from 0.01 to 0.15 cmolkg^{-1} with a mean of 0.49 cmolkg^{-1}. Soils that have less than 0.31 cmolkg^{-1} of difficultly K are considered as K deficient soils, those with 0.31 to 0.49cmolkg^{-1} are considered moderate and those with more than 0.49cmolkg^{-1} are rated as adequate (Amalu, 1989). The soils in this study generally exhibited low levels of exchangeable potassium. This finding aligns with the range of 0.03 to 0.64 cmol/kg reported by Unamba-Oparah (1985) for sandy soils in southeastern Nigeria. The acid soluble K ranged from 0.03 to 0.08 cmolkg^{-1} with a mean of 0.75 cmolkg^{-1}. Generally, soils formed on acidic sandstones and Aeolian materials

Table 3: Relationship between Soil Properties and Forms of K.

	W.k	Ex.K	Av.K	Dk	AsK	Tk	Sand	Silt	Clay	pH	EC	OC	OM	Av.P	Ca	Mg	EA	ECEC	BS
W.K	1																		
Ex.K	0.994**	1																	
Av.K	0.997 **	0.999**	1																
DK	0.982**	0.982**	0.985**	1															
ASK	0.997**	0.986**	** 0.991	0.996**	1														
TK	0.994**	0.995**	0.996**	0.995**	0.985**	1													
Sand	0.262	0.241	0.249	0.220	0.278	0.234	1												
Silt	0.559	-0.559	-0.560	-0.552	-0.611	-0.558	-0.684*	1											
Clay	-0.100	-0.074	-0.083	-0.051	-0.110	-0.066	-0.970	0.453	1										
pH	0.763 **	0.739**	0.749**	0.700**	0.780**	0.733**	-0.067	-0.435	0.226	1									
EC	0.426	0.366	0.388	0.269	0.485	0.346	0.269	-0.214	-0,243	0.571	1								
OC	-0.555	-0.514	-0.529	-0.545	-0.574	-0.562	-0.106	0.286	0.016	-0.538*	0.590	1							
OM	-0.171	-0.150	-0.158	-0.185	-0.574	-0.186	0.649*	-0.434	-0.657*	-0.298	-0.229	0.54	1						
Av.P	-0.323	0.346	0.338	-0.342	-0.270	-0.340	-0.834**	0.618*	0.760**	0.134	0.029	0.099	-0.547	1					
Ca	0.435	0.355	0.384	0.448	0.461	0.417	0.119	-0.426	-0.003	0.520	0.292	-0.436	-0.175	0.060	1				
Mg	-0.201	-0.167	-0.180	-0.215	-0.184	-0.209	0.198	-0.107	-0.229	-0.045	-0.241	0.514	0.623*	-0.050	-0.310	1			
EA	-0.686*	-0.682*	-0.684*	-0.698	0.647*	0.682*	-0.184	0.394	0.067	-0.523	-0.073	0.095	-0.185	0.311	-0.419	0.055	1		
ECEC	0.268	0.198	0.223	0.279	0.322	0.248	0.114	-0.393	-0.027	0.455	0.178	-0.232	0.018	0.172	0.884**	0.100	-0.235	1	
BS	0.343	0.323	0.33	0.330	0.324	0.325	0.413	-0.310	-0.391	0.177	0.125	0.027	0.403	-0.240	0.341	0.340	-0.320	0.551	1

Where Wk = Water Soluble K, Ex.K = Exchangeable K, Av. K = Available K, Dk = Difficulty K, As.K = Acid soluble K, Tk = Total K, EC=Electrical conductivity, OC = Organic carbon, OM = Organic matter, Av. P = Available phosphorus, Mg = magnesium, EA = Exchangeable acidity, ECEC = Effective cation exchange capacity, BS=Base saturation
* correlation is significant at 0.05 level
** correlation is significant at 0.01 level

contain low amounts of weathered mica and hence low fixed K reserved (acid soluble K) as reported by FPDD, (1990). According to Amalu, (1989), soils that have less than 0.51 cmolkg^{-1} been considered as low, those having 0.51 to 1.02cmol/kg^{-1} are considered moderate and soils having more than1.02cmolkg^{-1} are rated as high in K reserve. The total K values of the soils ranged from 0.15 to 0.25cmolkg^{-1} with a mean of 0.206cmolkg-^{1}. The total K values in all the locations are less than the range values of 3.83 to 81.84 cmolkg^{-1} obtained by Amalu (1989) for soils of Southern Nigeria. Soils with less than 5.12cmol/kg^{-1} are considered very low in total K levels, soils between 5.12 to 25.58cmolkg^{-1} as rated as low, 25.58 to 40.92cmolkg^{-1} are moderate and soils that have more than40.92cmolkg^{-1} are high in K (Amalu, 1989).

Correlation between some soil properties and forms of K

Correlation between some soil properties and forms of K are presented in (Table 3). Water soluble K correlated positively and significantly with exchangeable K (r = 0.994**), available K (r = 0.997**), difficultly K (r = 0.982**), acid soluble K (r = 0.997**), total K (r = 0.994**), pH (r = 0.763**) and exchangeable acidity (0.686*). Exchangeable K correlated positively with available K (r = 0.999**), difficultly K (r = 0.982**), acid soluble K (r = 0.986**), total K (r = 0.995**) and pH (r = 0.739**). Available K correlated positively with difficultly K (r = 0.985**), acid soluble K (r = 0.991**), total K (r = 0.996**) and pH (r = 0.749**). Difficultly K correlated with acid soluble K (r = 0.966**), total K (r = 0.995**), pH (r = 0.700**). Acid soluble K correlated positively with total K (r = 0.985**), pH (r = 0. 780**), and exchangeable acidity (r = 0.647**). Total K correlated positively (r = 0.733**) and exchangeable acidity (r = 0.682**). The results indicated that, an increased in one form of K significantly lead to a corresponding increase in other forms of K and some soil properties. These findings are in agreement with the study of Prabha *et al.,* (2020).

Conclusion and Recommendation

In conclusion, the soils supporting rubber in Obio-Akpa, Ntak-inyang and Ikot Obio Ekpung in Akwa Ibom State are deficient in total K content and may not meet the long term K- demanding crops like rubber. The continued removal of soil

K either by erosion, leaching, K-fixation and absence of applied K would affect crop growth or yield. Therefore, to increase the levels of K in these soils, the use of organic and inorganic K fertilizers is recommended for the continuous production of rubber in these soils. In addition, maintenance of good crop cover would reduce erosion and leaching losses of basic cations.

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