



RELATIONSHIPS BETWEEN POTASSIUM FORMS AND SELECTED PHYSICO-CHEMICAL PROPERTIES OF SOME GHANAIAN SOILS ALONG A TOPOSEQUENCE

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ABSTRACT

A study was conducted to determine the distribution of forms of K (water soluble K, exchangeable K, non exchangeable K, and total K) of potassium in some Ghanaian soils occurring along toposequence using standard laboratory procedures. The soils were the Edina, Atabadzi, Benya, Udu and Kakum series (Acrisols), which form the Edina catena. The concentrations of total K in the soils ranged from 0.64 to 2.37 (cmol (+) kg⁻¹) with Kakum series showing the lowest ($P < 0.05$) value. Water soluble K and exchangeable K concentrations in the soils ranged from 0.05 to 0.25 c mol (+) kg⁻¹, and 0.26 to 0.89 cmol (+) kg⁻¹, respectively, with the Kakum series again showing the lowest values ($P < 0.05$) for both K forms. The Edina series, occurring at the summit of the catena, showed the highest concentrations of both water soluble and exchangeable K. In the study non-exchangeable K concentrations measured in the soils varied between 0.20 and 1.25 cmol (+) kg⁻¹. The study showed that exchangeable K constituted the highest proportion of the total K measured in the soils, while the proportion of water soluble K in the total K measured was the lowest. Pooling all the data obtained in the study, water soluble K and exchangeable K concentrations positively correlated with organic matter, cation exchange capacity and percentage bas saturation.

Keywords: potassium forms, water soluble K, exchangeable K, non exchangeable K, total K, organic matter, cation exchange capacity.

INTRODUCTION

Potassium (K), which a major constituent in all living cells is required in large amounts by plants, animals and humans (Hamdallah, 2004) because it plays a critical role in plant nutrition and physiology. Uptake of K by many plants is frequently greater than of nitrogen and phosphorus. This macronutrient is extracted in large quantities by intensive cropping systems (Panaullah *et al.*, 2006). The effect of potassium on resistance of plants on stress factors, such as pathogens, pests, and draught, cannot be overestimated (Kozak *et al.*, 2005). K promotes photosynthesis, controls stomata opening, improves N utilization and promotes assimilate transport to increase crop yields. Also, K influences the microbial population in the rhizosphere and plays key roles in the nutrition and health of man and livestock (Lauchli and Pfluger, 1979; Romheld and Neumann, 2006).

There is a general assumption that most tropical soils contain adequate amounts of K to sustain crop growth most probably due to the dominance of K bearing minerals such as illite etc, but the increase in intensity of cropping, leaching and introduction of high yielding varieties in various cropping systems (Moshen, 2007; Yadvinder *et al.*, 2005) have resulted in considerable drain of soil K reserves and crops are becoming responsive to K fertilization (Bukhsh *et al.*, 2012).

Soil K originates from the disintegration and decomposition of rocks containing K bearing minerals. Soil K may be classified according to their availability to plants into relatively unavailable, readily available and slowly available or exchangeable K forms. According to Olaitan and Lombin (1984) over 95% of K in tropical soils occur as relatively unavailable forms contained in primary

and secondary minerals including feldspars, muscovites, biotites and illites. This agrees with Hoefl *et al.* (2000) who pointed out that 90-98% of all soil K occurs in minerals as relatively unavailable forms. Defoer *et al.* (1998) noted that these minerals are quite resistant to weathering and so they release K very slowly. Tisdale and Nelson (1993) reported that the slowly available K form consists of those fixed within clay minerals such as illite, vermiculite and chlorite, which are made up of sheets of silica and alumina that traps K in the soil. Hoefl *et al.* (2000) further estimated that readily available K constitute only 1- 2% of the total soil K. They explained that readily available soil K exists as water soluble K in the soil solution and as exchangeable K held on soil colloidal surface.

According to Jones (1982) soil K can be lost through leaching in drainage waters, crop removal and utilization by living organisms. Furthermore, continuous cropping, which is practiced in most of sub-Saharan Africa agricultural systems results in excessive uptake of K by plants, especially from the labile K pool. The labile K pool is made up of the water soluble and exchangeable K forms. In some soils the exchangeable K, which is held onto the soil colloidal surface may be released for plant uptake when the labile K pool is exhausted, but Bhaskarachary (2011) noted that the release of exchangeable K is not fast enough to meet the requirement of rapidly growing crops.

Therefore, plants depend mostly on the soluble K and exchangeable K pools to satisfy their nutritional requirements. However, these K pools are slowly depleted after prolonged periods of agricultural production and removal of produce. Once these K pools are exhausted,



plants can only rely on the release of fixed K to recharge the exchangeable and soluble pools, but Mikkelsen (2008) found that the size of the fixed potassium pool in many soils, or the rate at which it is released, is insufficient to meet plant demand particularly, where crop production is intensive and/ or when high-yielding production systems are established. Therefore, a clearer understanding of the distribution of K forms in Ghanaian soils is required to enable effective management of potassium supply and use in Ghanaian soils.

Acquaye (1973) found that in Ghana, there is usually a lack of response to K fertilization a few years after soils are brought into cultivation from the fallow state. Furthermore, due to the paucity of information regarding K behaviour in agro-environments, many Ghanaian farmers do not apply K fertilizers even under continuous cropping systems and the few who do, apply K fertilizers in quantities that render crop production unsustainable (Yawson *et al.*, 2006). Indeed, a significant number of Ghanaian farmers cultivate root and tuber crops, which are heavy K feeders. Therefore, an improved understanding the distribution of K forms in Ghanaian

soils is critical to sustaining crop production, particularly, root and tuber crops.

The objective of the study was to determine the distribution of K forms in some soils along a toposequence and examine the relationships existing between the K forms and selected physicochemical properties of the soils.

MATERIALS AND METHODS

Soils

The soils (0-20 cm) used for the study were collected along a toposequence at the University of Cape Coast Research and Teaching farm in the coastal savanna agroecological zone of Ghana. The soils are the Edina, Atabadzi, Benya, Udu and Kakum series, which form the Edina Catena. The soils were all developed on sandstones, shales and conglomerates and are classified as Haplic Acrisol (FAO, 1977). The high intensity of weathering coupled with leaching of bases has given rise to soils that are generally acidic, low in ECEC and dominated by kaolinitic clays and sesquioxides (Asamoah, 1973).

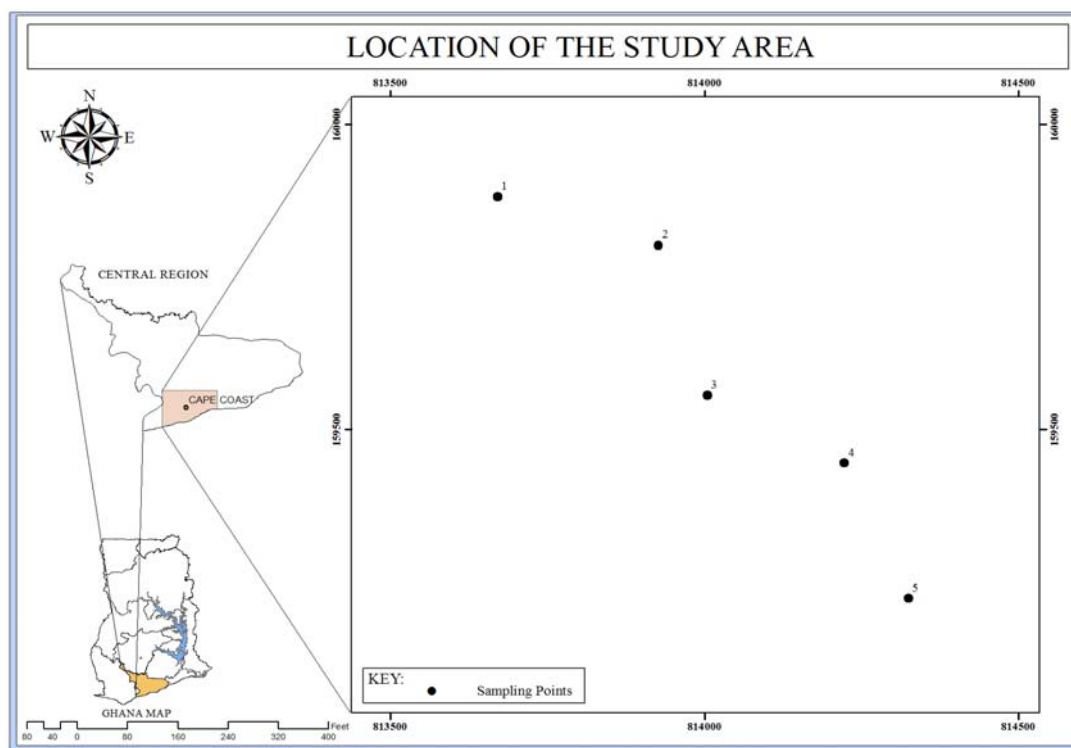


Figure-1. Location map of the study area.

Soil sampling and laboratory analyses

In each of the five series, five soil samples were randomly collected and thoroughly mixed to form the composite sample. The samples were bagged and labeled accordingly. The soil samples were air-dried for 48 hours, crushed and passed through a 2 mm mesh sieve. The fine earth fractions (<2mm) were used for laboratory analyses.

Laboratory analyses

Particle size analysis was carried out by the Bouyoucos hydrometer method after hydrogen peroxide (H_2O_2) treatment (to burn off organic matter in the soil samples) and dispersion with 5% Sodium hexametaphosphate (Anderson and Ingram, 1989). The soil pH was determined in both distilled water and in 1M KCl at a soil: water/KCl solution ratio of 1:2.5 with a pH



glass electrode (Model 520 A, Orion, Boston, MA, USA). Soil organic carbon concentration was determined by the Walkley-Black method (1934). The procedure involved oxidation of organic carbon using $K_2Cr_2O_7$ and Conc. H_2SO_4 . The digest was then titrated with 0.5M Ferrous Ammonium Sulphate using diphenylamine as indicator after addition of Phosphoric acid and 0.2g NaF. The available P was determined by Bray -1 method. Available P in the soils was extracted with 0.3M Ammonium Fluoride in 0.5MHC1 extract and their concentrations were estimated using the ascorbic acid method. In this method the standard P stock solution was prepared using monobasic potassium phosphate and the absorbance of the blue colour developed was measured with at 882 nm with a spectrophotometer (Spectrum 23 A) (Bray and Kurtz, 1945). The exchangeable bases (Mg^{2+} , Ca^{2+} , Na^+ , K^+) in the soils were extracted with 1.0M Ammonium Acetate at pH 7.0. The concentrations of calcium and magnesium ions were determined by complexometric titration with EDTA, using cal red indicator for calcium and erichrome black T indicator for calcium plus magnesium. Magnesium concentration was estimated by subtraction. Concentrations of potassium and sodium ions in the extract were determined by flame photometry (Motsara and Roy, 2006). Exchangeable acidity was extracted from the soil samples with 1N KCl. Aluminium and hydrogen ions were determined with 0.025M NaOH, using phenolphthalein as indicator for both Al^{3+} and H^+ . Sodium fluoride was then added after which H^+ was determined (McLean, 1965).

Determination of soil K forms

The total K was determined by HF - H_2SO_4 digestion as described by Jackson (1964). Water-soluble K was extracted by shaking 2 g soil with 20 ml distilled water. Exchangeable K was extracted from the same soil samples used in extracting soil K with 20 ml 1.0 M NH_4OAc at pH 7.0 Non-exchangeable K was determined by the use of 1 N boiling HNO_3 as an extractant (Haylock, 1956), with a soil: solution ratio of 1:10. All the K forms in the extract were determined by flame photometry (Motsara and Roy, 2006).

Statistical analysis

Data analyses were performed with the SPSS 11.0 statistical package (Windows Microsoft, 2006). Differences between the means of the different K forms measured in the same soil series, and differences between specific K forms measured in the different soil series were compared using Tukey's least significant difference (LSD) test. The GeNie software (Decision Systems Laboratory, Copyright (c) 1996-2006) was used to establish the cross-correlation matrix between the various forms of K and the selected physico-chemical soil properties.

RESULTS AND DISCUSSIONS

Physical properties of the soils

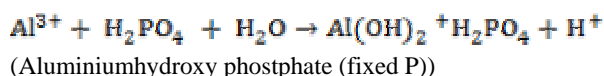
Selected physicochemical properties determined in the soils are summarized in Table-1.

The proportions of sand, silt and clay measured in the soil series varied from 22.2 to 62.5, 4.8 to 15.3 and 28.4 to 62.5%, respectively. The results indicated that most of the soils contained relatively higher proportions of sand compared to clay, but among the series studied, the Kakum series contained the highest ($P < 0.05$) clay and the lowest ($P < 0.05$) sand contents, respectively (Table-1). The gravimetric moisture content measured in the soils increased down the slope, with the Kakum series showing the highest ($P < 0.05$) gravimetric moisture content of 71.1%.

Chemical properties of the soils

The soils were all found to be acidic as the soil pH (H_2O) and pH KCl measured in the study ranged from 3.9 to 6.87 and 3.5 to 6.3 respectively (Table-1). The study also showed that the basic cation concentrations increased with increasing soil pH but there was trend of decreasing exchange acidity with increasing soil pH. Percentage organic carbon measured in the soil ranged from 2.09 to 1.18 and was observed to increase with increasing pH. The effective cation exchange capacity (ECEC) values which varied from 9.56 to 5.62 $cmol (+) kg^{-1}$ also increased with increasing soil pH (Van Diest, 1978).

The results showed that available P concentrations measured in the soils decreased as their pH decreased. In highly weathered, low pH, tropical soil, the concentration of the P-sorbing Al^{3+} ion is usually high. This was supported by the high exchange acidity values in the low pH soils used in the study. Therefore, the inverse relationship that was found between soil pH and soil available P concentrations indicate the high presence of Al^{3+} ions, which would have promoted P sorption, thus making it unavailable (Moody and Cong, 2008). This observation is schematically presented in the chemical reaction below:



Therefore, that the study has demonstrated that soil reaction is an important factor affecting P availability in these soils. In the study Percentage Base Saturation was found to increase with increasing soil pH possibly due to increasing basic cations concentrations as pH increased.

Forms of potassium in the soils

Data showing the concentrations of the various forms of K determined in the soils are presented in Table-2.

In accordance with Ghiri *et al.* (2011) the results indicated that the distribution of the different K forms in the soils varied considerably. This variation may be attributed to the differences in the chemical properties of the soils and possibly the extent to which K salts in the



different soil series have leached (Jones, 1982) because the gravimetric moisture content measured in the soils were found to increase down the slope.

In the study total K values ranged from 0.64 to 2.37 cmol(+) kg⁻¹. The Kakum series, which had the highest (P < 0.05) percentage clay content and the lowest soil pH, showed the lowest (P<0.05) total K content. This is in good agreement with Suddhiprakarn (2010) who noted that high soil clay contents with low soil pH are often associated with low total K concentration.

Water soluble K and exchangeable K measured in the soils ranged from 0.05 to 0.24 cmol (+) kg⁻¹ and 0.26 to 0.89 cmol (+) kg⁻¹, respectively. Similar to the low total K concentrations measured in the soils, the water soluble and exchangeable K concentrations, which according to Patterson (2002) constitute the available K were lowest (P<0.05) in the Kakum series. This observation can be attributed to the low soil pH and high Al³⁺ concentration (6.45 cmol (+) kg⁻¹) measured in the Kakum series. The high Al³⁺ concentration found in the Kakum series suggests a high Al³⁺ presence at the colloidal surface, which would have promoted K fixation leading to low water soluble and exchangeable K availability in the soil (Brady, 1990). Moreover, because the exchange complex is saturated with Al³⁺ ions, most of the K⁺ ions are displaced into the soil solution, and coupled with the high moisture content, most of the K⁺ ions are leached out, leading to low water soluble and exchangeable K concentrations in the Kakum series. The higher available K concentration measured in the higher pH (pH-H₂O 6.8, and pH-KCl 6.3) and lower exchangeable acidity (0.5 cmol (+) kg⁻¹) Edina series appears to confirm this conclusion.

The non-exchangeable K measured in the soils varied from 0.02 to 1.25 cmol (+) kg⁻¹. The results indicated that water soluble K concentrations measured in the soils accounted for 7.83 to 18.46% of total K concentrations; exchangeable K concentrations measured in the soils represented 37.61 to 65.44%, while non-exchangeable K accounted for 16 to 53.41% of the total K concentrations, respectively, indicative that the exchangeable K concentrations in the soils constituted the highest proportion of the total K, while the water soluble K accounted for the lowest proportion of the total K.

Considering the proportions of all the various forms of K to the total K in the Kakum series, the value for the non-exchangeable K pool was the highest (51.31%, P < 0.05). This observation might also be explained by the soil low pH and high exchange acidity in the Kakum series.

The K - saturation percentage (KSP) calculated for the soils studied ranged from 2.7 to 15.8%, with a mean of 9.9%. Thus, all soils recorded KSP values higher than the critical value (2.0) proposed by Webster and Wilson (1980).

Relationship between some forms of k and some selected soil properties

Results of simple correlation analysis between different forms of K and the various soil chemical properties are given in Table-3.

All the K forms positively correlated (P < 0.05) with organic carbon. This observation contradicts the findings of Acquaye (1973) who found no significant correlation of K with percentage organic carbon. Soluble and exchangeable K forms positively correlated with organic matter, with correlation coefficients (r) of 0.567 and 0.701 for water soluble K and exchangeable K respectively. This observation may be attributed to the fact that, tropical soils are often characterized by a variable charge systems (i.e., pH dependent charges) (Van Ranst, 2006), indicative that the creation of charges on tropical soil colloids depends on soil pH. Thus, the charge generated could either be positive or negative depending on the pH of the soil. Soil colloids acquire their charges either by dissociation of H⁺ from or onto the active functional group (Van Ranst, 2006) and as the pH of the soil increases, the H⁺ ions on the functional groups of organic matter dissociate, resulting in the creation of negative charges on the organic matter. The negative charges created therefore have affinity for K⁺ ions, hence the positive correlation between organic carbon and the K forms observed.

Negative correlation was observed between the K forms and Al³⁺, with correlation coefficients of -0.740, -0.957, -0.965, and -0.973, for total K, water soluble K, exchangeable K, and available K, respectively. This may be attributed to the fact that, at low pH, Al³⁺ becomes preponderant in the soil solution and therefore saturates the exchange complex (McCaughey, 2009). This is in good agreement with Brady (1990) who pointed out that the concentration of Al³⁺ increases as soil pH decreases making K unavailable. Furthermore, the positive charges created under high Al³⁺ and low pH conditions are likely to repel the positively charged K⁺ ions, and under intensive rainfall, there is the tendency that the K⁺ ions in solution will be lost of through leaching.

The above conclusion is further confirmed by the observation that the water soluble K, exchangeable K and available K concentrations significantly (P < 0.05) correlated positively with soil pH. The observed correlation coefficients (r) between the K forms and soil pH were (r = 0.867, 0.782 and 0.808 between water soluble, exchangeable K and available K and pH-H₂O respectively; r = 0.818, 0.693 and 0.728 between water soluble, exchangeable K and available K and pH-KCl respectively (Table-3). The positive correlation observed between soil pH and K forms (water soluble, exchangeable K and available K) has previously been reported by Kozak *et al.*, (2005) and Domska *et al.* (1998), but other authors found no obvious relationship between soil pH and exchangeable potassium (Cimrin, *et al.* 2004 and Kaskar, *et al.*, 2001)] or between pH and available K (Akbari, *et al.*, 2003 and Kaskar, *et al.*, 2001). In another study, Panwar *et al.* (2002) found a negative correlation between



pH value of soil and water soluble potassium. The observation made by Panwar *et al.* (2002) may be attributed to the nature of the parent material enriched with K-bearing minerals such as micas (muscovite and biotite) and feldspar (orthoclase and microcline) (Samadi *et al.*, 2010).

Additionally, the study demonstrated that water soluble K and exchangeable K significantly ($P < 0.05$) correlated positively with cation exchange capacity (CEC) ($r = 0.945$ and 0.915 respectively) and percentage base saturation (%BS) ($r = 0.806$ and 0.664 , respectively). However water soluble K and exchangeable K significantly ($P < 0.05$) correlated negatively with the effective cation exchange capacity (ECEC) ($r = -0.843$, and -0.968 respectively). Furthermore, water soluble K and exchangeable K significantly ($P < 0.05$) correlated negatively with moisture content ($r = -0.787$, and -0.827 respectively). Our finding corroborated with the finding of Barber (1978) who observed that, high moisture content adversely affects the mobility of K into the soil solution. The study showed that the Kakum series with 62.5% clay, which had the highest percentage gravimetric soil moisture content (71.1%), recorded the lowest levels of all the K forms determined. This was in accordance with Greg *et al.* (2011) who affirmed that there is less mobility of potassium from the exchangeable site into the soil solution in fine textured soil with high soil moisture content. However, this observation is in contrast with the findings made by Singh and Singh (2004) and Zeng and Brown (2000) who found a positive correlation between moisture content and K availability in soils. Thus, further research is needed to clarify the relationship between soil moisture content and available K concentrations in tropical soils.

In agreement with Samadi *et al.* (2010) the study showed significantly ($P < 0.05$) positive correlation ($r = 0.946$) between water soluble K and exchangeable, and between water soluble K and available K ($r = 0.967$, $P < 0.05$). This observation was not unexpected because exchangeable potassium is usually released into the soil solution from the exchange complex when plants deplete the soluble potassium, indicative that the size of the exchangeable potassium pool will determine the effectiveness of K re-supply, as well as the concentration of K in the soil solution.

Similar to findings made by Ghiri *et al.* (2011), exchangeable K concentrations in the soils positively correlated with available K ($r = 0.997$, $P < 0.05$) and non exchangeable K ($r = 0.630$, $P < 0.05$), and available K positively correlated ($r = 0.599$, $P < 0.05$) with non exchangeable K. Samadi *et al.* (2010) also made similar observations to confirm the positive correlation previously found between exchangeable and available forms of potassium by Kasker *et al.* (2001) and Kozak *et al.* (2005).

CONCLUSIONS

The study showed that the exchangeable and non-exchangeable K constituted over 75% of the total K in the soils. However, the non-exchangeable K pool in the soil can serve as K reserves, which can slowly release

available K to satisfy crops requirements when the soluble and exchangeable K pools becomes depleted. The study also demonstrated that the water soluble and exchangeable K concentrations in the soils were positively influenced by increasing organic carbon content and percentage base saturation, while low soil pH and high exchangeable acidity negatively affected K availability in the soils.

Percentage K saturation values found in the soils also were high, but the overall low CEC values measured in the soil suggest that the soils are not adequately supplied with available K. It can therefore be concluded that potash fertilization would be required for sustainable crop production in the soils studied.

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**Table-1.** Selected physicochemical properties of the soils.

Soil Series	pH		OC (%)	Available P (mg/kg)	Exch. Acidity (cmol (+) kg ⁻¹)	Exch. Bases (cmol (+) kg ⁻¹)				ECEC (cmol (+) kg ⁻¹)	% BS	% Sand	% Silt	% Clay	Texture	% MC
	H ₂ O	KCl				Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺							
Edina	6.8	6.3	1.33	10.53	0.5	4.8	1.23	0.14	0.83	7.00	93.2	56.8	4.8	38.4	Sandy clay	5.7
Atabadzi	5.3	4.5	2	7.00	1.5	2.43	0.69	0.11	0.89	5.62	73.28	56.8	8.7	34.5	Sandy clay loam	5
Benya	5.5	4.9	2.09	1.75	1.5	3.04	0.88	0.11	0.88	6.41	76.55	48.7	12.9	38.4	Sandy clay	8
Udu	4.9	4.4	1.61	2.19	5.3	2.05	0.89	0.07	0.48	8.79	39.8	62.5	9.1	28.4	Sandy clay loam	9.1
Kakum	3.9	3.5	1.18	3.5	6.45	2.17	0.63	0.06	0.26	9.56	32.52	22.2	15.3	62.5	Clay	71.1

Table-2. Levels of the various forms of potassium in the studied soils.

Soil series	Total K (cmol (+) kg ⁻¹)	Water Soluble K (cmol (+) kg ⁻¹)	% of Total K	Exch. K (cmol (+) kg ⁻¹)	% of Total K	Non-Exch. K	% of Total K	% K Saturation	Available K (cmol (+) kg ⁻¹)
Edina	1.26 (0.01) a	0.23 (0.01) a	18.46 (0.02)	0.83 (0.03) a	65.44 (0.03)	0.20 (0.01) a	16.10 (0.01)	11.9 (0.01)	1.06 (0.00) a
Atabadzi	2.30 (0.03) b	0.18 (0.03) b	7.99 (0.00)	0.89 (0.03) a	38.61 (0.04)	1.23 (0.03) b	53.41 (0.02)	15.8 (0.02)	1.07 (0.00) a
Benya	2.37 (0.01) c	0.24 (0.00) c	10.12 (0.02)	0.88 (0.01) b	37.27 (0.02)	1.25 (0.03) c	52.60 (0.03)	13.7 (0.03)	1.12 (0.01) b
Udu	0.90 (0.03) d	0.11 (0.03) d	11.93 (0.02)	0.48 (0.03) b	53.16 (0.02)	0.31 (0.00) d	34.19 (0.01)	5.5 (0.00)	0.59 (0.00) c
Kakum	0.64 (0.01) e	0.05 (0.01) d	7.83 (0.01)	0.26 (0.00) c	40.86 (0.00)	0.33 (0.00) d	51.31 (0.01)	2.7 (0.01)	0.31 (0.03) d

Means in the same rows with different letters are significantly different at $P < 0.05$ by LSD. Values in parenthesis represent ± 1 standard error.

**Table-3.** Cross - correlation matrix between the forms of potassium and some selected soil properties.

	pH-H ₂ O	pH-KCl	% O C	Available P(mg/kg)	Al ³⁺	CEC	ECEC	% BS	% MC	Total K	Water soluble K	Exch. K	Available K	Non-Exch. K
pH-H ₂ O	1													
pH-KCl	.990(**)	1												
% Organic C (OC)	.167	.051	1											
Available P (mg/kg)	.696(*)	.688(*)	-.283	1										
Al ³⁺	-.883(**)	-.819(**)	-.496	-.600(*)	1									
CEC	.954(**)	.973(**)	-.025	.727(*)	-.823(**)	1								
ECEC	-.631(*)	-.520	-.757	-.395	.906(**)	-.505	1							
% Base saturation (BS)	.922(**)	.877(**)	.366	.662(*)	-.988(**)	.897(**)	-.833(**)	1						
% Moisture content (MC)	-.755(*)	-.684(*)	-.642	-.272	.749(*)	-.534	.737(*)	-.692(*)	1					
Total K	.375	.258	.913(**)	.035	-.740(*)	.253	-.926(**)	.641(*)	-.614(*)	1				
Water soluble K	.867(**)	.818(**)	.567	.392	-.957(**)	.806(**)	-.843(**)	.945(**)	-.787(*)	.747(*)	1			
Exch. K	.782(*)	.693(*)	.701(*)	.424	-.965(**)	.664(*)	-.968(**)	.915(**)	-.827(**)	.867(**)	.946(**)	1		
Available K	.808(**)	.728(*)	.677(*)	.421	-.973(**)	.702(*)	-.949(**)	.931(**)	-.826(**)	.849(**)	.967(**)	.997(**)	1	
Non-Exch. K	.014	.107	.917(**)	-.235	-.454	-.097	-.751	.332	-.364	.932(**)	.468	.630(*)	.599(*)	1

*Denotes significant at P<0.05

** Denotes highly significant at P<0.05