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Nutrient status and forms of potassium in farmed soils at University of Benin

Estado nutricional y formas del potasio en los suelos cultivados de la Universidad de Benin

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Abstract

This study was conducted to determine the nutrient status and forms of potassium in farmed soils at the University of Benin. The soil sample was collected from the Experimental Farm Site and control site at a depth of 0 cm - 15 cm, 15 cm - 30 cm, and 30 cm - 45 cm using a soil auger. Soils collected from each depth were air-dried, crushed, and sieved. The sieved samples were analyzed for some physical and chemical properties using standard laboratory procedures. The data obtained were analyzed by Genstat computer package at a 5 % probability. The result showed that the sand (833.9 g.kg^{-1}) fraction was predominant in the experimental farm site. The pH (4.58) result was recorded in the experimental farm site compared to the control site (4.35). The result showed that (0.13 mg.kg^{-1}) water soluble potassium (H_2OK) was recorded in soil depth of 0 cm - 15 cm. The result showed that exchangeable potassium (Exch K) (0.17 mg.kg^{-1}) at the Experimental Farm site is superior to the control site (0.12 mg.kg^{-1}). The mean result of HCl K (0.37 mg.kg^{-1}), Acid K (0.13 mg.kg^{-1}), Residual K (0.45 mg.kg^{-1}), and Total K (1.35 mg.kg^{-1}) of the Experimental Farm site were superior to the control site HCl K (0.3 mg.kg^{-1}), Acid K (0.12 mg.kg^{-1}), Residual K (0.39 mg.kg^{-1}) and Total K (1.18 mg.kg^{-1}) respectively. The result showed that forms of potassium, H_2O K, exch K, HCl K, acid K, residual K, and total K exhibited positive correlations with EC, organic matter (O.M), total nitrogen (T. N), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and average phosphorus (Av. P).

Key Word: soil nutrients, land use, and forms of potassium.

Resumen

Este estudio se llevó a cabo para determinar el estado nutricional y las formas del potasio en suelos cultivados en la Universidad de Benin. Se recogieron muestras de suelo de la granja experimental y de la zona de control a una profundidad de 0 cm a 15 cm, de 15 cm a 30 cm y de 30 cm a 45 cm utilizando un medidor de suelo. Los suelos recogidos de cada profundidad se secaron al aire, se trituraron y se tamizaron. Las muestras tamizadas se analizaron para determinar algunas propiedades físicas y químicas mediante procedimientos de laboratorio estándar. Los datos obtenidos se analizaron mediante el paquete informático Genstat con un nivel de probabilidad del 5 %. El resultado mostró que la fracción de arena (833.9 g.kg^{-1}) era predominante en el sitio de la granja experimental. El pH (4.58) se registró en la explotación experimental en comparación con el control (4.35). El resultado mostró que (0.13 mg.kg^{-1}) potasio soluble en agua (H_2OK) fue registrado en la profundidad del suelo

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de 0 cm - 15 cm. El resultado mostró que el potasio intercambiable (K) (0.17 mg.kg^{-1}) en el sitio de la Granja Experimental es superior al sitio control (0.12 mg.kg^{-1}). El resultado medio de HCl K (0.37 mg.kg^{-1}), K ácido (0.13 mg.kg^{-1}), K residual (0.45 mg.kg^{-1}) y K total (1.35 mg.kg^{-1}) del sitio de la granja experimental fueron superiores al sitio de control HCl K (0.3 mg.kg^{-1}), K ácido (0.12 mg.kg^{-1}), K residual (0.39 mg.kg^{-1}) y K total (1.18 mg.kg^{-1}) respectivamente. El resultado mostró que las formas de potasio, H_2O K, K intercambiado, HCl K, K ácido, K residual, y K total exhibieron correlaciones positivas con CE, materia orgánica (M.O), nitrógeno total (T. N), sodio (Na), potasio (K), calcio (Ca), magnesio (Mg), y fósforo medio (prom. P).

Palabra clave: nutrientes del suelo, uso de la tierra, formas de potasio.

Introduction

Nutrient supply to plants is key to crop productivity and food sufficiency. Potassium has been reported to be one of the essential nutrient requirements for plant growth. The ability of soil to supply potassium to a crop depends on its forms and distribution as influenced by soil physicochemical properties (Ndukwu et al., 2012). To comprehend the impacts of land use and management practices on soil properties and nutrient supply, it is necessary to conduct a detailed study of both qualitative and quantitative changes in soil properties. Land use encompasses the type and manner of utilization of the land in its current state, which is typically represented by one of the following land use categories: agriculture, garden, forest, pasture, meadow, residential, industry, and mine. One of the measures that can affect the soil quality is the land use change. The impact of the type of land use on the soil performance in the ecosystem would be possible by studying and investigating the changes in soil quality indices. (Doran et al., 1996).

Potassium occurs in different forms in the soils such as water-soluble, exchangeable, non-exchangeable, in mineral form. The different forms are in equilibrium with one another and vary with location (Ndukwu et al., 2012). Potassium is one of the major nutrient elements and the most abundant elemental constituent of the soil (Lalitha & Dhakshinamoorthy, 2014). Potassium is a metallic element found naturally in various salts and clay minerals in soils (Strivastava, 2007). Available potassium is a limiting factor in many agricultural and environmental soils. There are equilibrium and kinetic factors between these forms that affect the level of soluble potassium at any particular time, and thus the amounts that are readily available to plants (Jalali & Khanlari, 2014).

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Materials and method

Study Area

The study was carried out in the Experimental Field of the Faculty of Agriculture, University of Benin, Benin City. Benin City localized at approximately latitude 06° 19' 00" E to 6° 21' 00" E and longitude 5° 34' 00" E to 5° 44' 00" E with an average elevation of 77.8 m above sea level,is a pre-colonial city, the capital of defunct Bendel State and the present-day Edo State. This city is underlain by sedimentary formation of the Miocene-Pleistocene-age often referred to as the Benin formation and is located in the humid tropical rainforest belt of Nigeria. The rainy season in Benin begins in March/April and ends in October/November. Rainfalls are of high intensity and usually double maxima with a dry little spell in August usually referred to as 'August Break'.

Soil Sampling

The soil sample was collected from the Experimental Farm Site and control site at a depth of 0 cm - 15 cm, 15 cm - 30 cm, and 30 cm - 45 cm using a soil auger. The soil sample was Air-dried under a shade and analyzed for its chemical and physical properties and the forms of K.

Laboratory Analysis

Soils collected from each depth were air-dried, crushed, and passed through a 2mm sieve. The sieved samples were analyzed for some physical and chemical properties using standard laboratory procedures.

Soil pH was determined using the soil: water (1:1) method (Udo et al., 2006). The particle size distribution was determined using the hydrometer method (Gee & Or, 2002). Organic carbon was carried out via wet oxidation methods (Walkley & Black, 1934). Organic matter was determined by a multiplication factor of 2.0 (Pribyl, 2010). The exchange acidity was determined using Jackson (1962) method. Exchangeable cations were determined using ammonium acetate solution (1N NH_4OAc) buffered at pH 7.0. Ca and Mg were determined from the extract of 0.01 m EDTA, while K and Na were determined using a photometer (Jackson, 1962). Total nitrogen and available phosphorous were determined using Bremner & Mulvaney (1982) method. The forms of Potassium: Water-soluble K was determined by extraction with deionized water in 1:10 soil–water suspension. Exchangeable K was determined by extraction with 1 N 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 nitric acid (HNO_3)– exchangeable K. Difficultly exchangeable K was determined by extraction with 1 N HNO_3 in 1:10 soil–acid suspension after boiling for 10 min (Pratt, 1965). The difference between 1 N HNO_3–extractable K and that of exchangeable K was considered the difficultly exchangeable K. Acid-soluble K was determined by extraction with 1 N hydrochloric acid (HCl) in 1:10 soil–acid suspension after boiling for 1 h. The difference between 1 N HCl– extractable K and that of exchangeable K was taken as the acid-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 ($HClO_4$) acid mixtures under a fume hood. The filtrate was brought to volume in a 100 mL volumetric flask, and the total K was content determined with a flame photometer.

Statistical Analysis

The data obtained were analyzed by Genstat computer package. The difference between the means was separated using the Duncan multiple range test at a 5 % level of probability.

Results and discussion

Physical properties of soil at different depth in two locations

The result of the physical properties of soil at different depths in the two locations is presented in Table 1. The result shows that clay soil was significantly ($p<0.05$) different across the depth (0 cm - 15 cm, 15 cm - 30 cm, and 30 cm - 45 cm) in the Experimental Farm Site. The high percentage of sand observed in all the two study areas could be attributed to the parent material, which is coaster plain sands (Table 1) as characterized by sandy soils over a wide expanse of land (Akamigbo & Ukaegbu, 2003). The highest clay (126.30 $g.kg^{-1}$) was recorded in a soil depth of 30-45 cm while the lowest clay (114.70 $g.kg^{-1}$) was recorded in a soil depth of 0 cm -1 5 cm. In the control site, the result shows that there was a significant ($p<0.05$) difference in the amount of clay soil between the soil depth. The increase in clay down the depth indicates the process of illuviation Niu *et al.* (2015).

Chemical properties of soil at different depth in two locations

The result of the pH of different soil depths at two different locations (Experimental Farm Site

Table 1: Physical Properties of soil at different depths in two locations

Location	Depth	Clay	Silt	Sand
		g.kg^{-1}		
Experimental Farm Site Treatment Site	0-15 cm	114.70c	48.67a	836.70a
	15-30 cm	120.00b	45.67b	834.30b
	30-45 cm	126.30a	43.00c	830.70c
	Mean	120.33	45.8	833.9
Control Site	0-15 cm	116.30c	42.33a	841.30a
	15-30 cm	129.30b	33.00ab	837.70b
	30-45 cm	139.30a	28.33b	832.30c
	Mean	128.3	34.6	837.1

Mean value(s) with the same letters(s) in the column are not significantly different from one another at 5 % level of probability.

Treatment Site and Control Site) is presented in Table 2. The result shows that the soil pH was significantly ($p < 0.05$) different across the depth (0 cm – 15 cm, 15 cm – 30 cm, and 30 cm – 45 cm) in the Experimental Farm Site. Indicating acidity from the study area, is in line with Crozier & Hardy (2003), who reported that in typical soil pH profiles, surface soils tend to be less acidic due to organic matter influence (Osmond et al., 2002). The observed pattern of increasing EC values as it moves closer to the soil surface in both sites is consistent with the known behavior of electrical conductivity, which often correlates with soil salinity. Higher EC in the Experimental Farm Site might be attributed to agricultural practices, such as irrigation, which can lead to salt accumulation (Nocco et al., 2019). Comparatively, lower EC in the Control Site suggests different factors influencing its soil salinity. The findings of higher organic matter content in the Experimental Farm Site compared to the Control Site align with (Curry & Good, 1992). Organic matter acts as a reservoir for nutrients and improves soil structure. The decline in organic matter with depth at both sites is consistent with soil development patterns (Lal, 1991). The significantly higher total nitrogen content in the Experimental Farm Site's soil is indicative of higher soil fertility, often associated with agricultural activities (Recous et al., 1995). Nitrogen is a key nutrient for plant growth, and higher values could be attributed to fertilizer applications or leguminous crops (Ladha et al., 2005). The higher sodium (Na) content in the Experimental Farm Site might be attributed to irrigation practices or soil amendments (Bauder & Brock, 2001). Sodium can affect soil structure and permeability when present in excess, leading to potential soil degradation. The decline in potassium content with increasing depth is consistent with soil nutrient dynamics (Bauder & Brock, 2001). Potassium is mobile in the

Table 2: Chemical Properties of soil at different depth in two locations

Location	Depth	pH	EC	org. M	T. N	EA	Na	K	Ca	Mg	Av. P
			µS.cm^{-1}		coml.kg^{-1}						
Experimental Farm	0-15 cm	5.13a	127.30a	20.37b	1.60a	0.63a	0.51a	0.13a	1.85a	1.23a	28.40a
	15-30 cm	4.46b	113.30b	21.20a	1.10b	0.66a	0.45b	0.10b	1.77b	1.11b	17.02b
	30-45 cm	4.16c	98.70c	16.66c	0.83c	0.53a	0.30c	0.09c	1.50c	0.97c	14.70c
	Mean	**4.58**	**113.4**	**19.4**	**1.17**	**0.61**	**0.42**	**0.1**	**1.7**	**1.1**	**20.04**
Control Site	0-15 cm	4.46a	85.70a	13.79a	0.66a	1.74a	0.34a	0.12a	0.81a	0.64a	10.98a
	15-30 cm	4.50a	67.59b	10.57b	0.50b	1.46b	0.26b	0.07b	0.74a	0.35b	10.49a
	30-45 cm	4.10b	50.75c	10.51b	0.30c	1.20c	0.21c	0.06b	0.66b	0.31b	8.35b
	Mean	**4.35**	**68**	**11.62**	**0.48**	**1.47**	**0.27**	**0.08**	**0.73**	**0.43**	**9.94**

Mean value(s) with the same letters(s) in the column are not significantly different from one another at a 5 % level of probability.

soil and can be leached from the upper layers. The differences in potassium content between the sites might reflect differences in land use and management practices. The depth-related variations in organic matter, nutrient content, and other properties correspond to the concept of soil depth development, where different layers have distinct characteristics (Phillip, 2022).

Forms of Potassium at different soil depths from two locations

The result of the forms of Potassium at different soil depths from two locations is presented in Table 3. The result showed that the highest (0.13 mg.kg^{-1}) Water-soluble potassium (H_2OK) was recorded in soil depth of 0 - 15 while 15 - 30 and 30 - 45 soil depth recorded the same amount (0.12 mg.kg^{-1}) of water-soluble potassium (H_2OK) at the Experimental Farm site. Also, higher (0.11 mg.kg^{-1}) Water soluble potassium (H_2OK) was recorded in 15 - 30 soil depth while the least (0.09 mg.kg^{-1}) was recorded in 0 - 15 and 30 - 45 soil depth in the control site. The mean result showed that Water soluble potassium (H_2OK) (0.12 mg.kg^{-1}) at the Experimental Farm site is superior to the control site (0.09 mg.kg^{-1}). The result of the exchangeable potassium presented in Table 3 indicated that there was no significant ($p > 0.05$) difference between the soil depth at the Experimental Farm site. Also, higher (0.14 mg.kg^{-1}) exchangeable potassium (Exch K) was recorded in 15 - 30 soil depth while the least (0.12 mg.kg^{-1}) was recorded in 0 - 15 and 30 - 45 soil depth in the control site. The mean result showed that exchangeable potassium (Exch K) (0.17 mg.kg^{-1}) at the Experimental Farm site is superior to the control site (0.12 mg.kg^{-1}). The mean result of HCl K (0.37 mg.kg^{-1}), acid K (0.13 mg.kg^{-1}), Residual K (0.45 mg.kg) and Total K (1.35 mg.kg^{-1}) of the Experimental Farm site were superior to the control site HCl K (0.3 mg.kg^{-1}), Acid K (0.12 mg.kg^{-1}), Residual K (0.39 mg.kg^{-1}) and Total K (1.18 mg.kg^{-1}) respectively. The findings of higher water-soluble potassium (H_2O K) content in the Experimental Farm Site, especially in the topsoil, could relate to the addition of potassium-containing fertilizers and organic matter. Simonsson et al., (2009) highlight the immediate availability of hydrolyzable forms of potassium due to their solubility. The higher exchangeable potassium (Exch K) content in the Experimental Farm Site indicates effective nutrient management practices that maintain a more consistent availability of this form of potassium. According to Ghiri & Abtahi (2011) maintaining an appropriate level of exchangeable potassium in the soil is crucial for plant health and productivity. The higher values of residual potassium and total potassium in the Experimental Farm Site suggest that the site has accumulated potassium over time. This can be due to repeated fertilizer applications, mineral weathering, and organic matter decomposition, which contribute to the build-up of less readily available forms of potassium. The differences between the Experimental Farm Site and the

Table 3: Forms of Potassium

		H_2O K	Exch K	Hl K	Acid K	Residual K	Total K
		mg.kg^{-1}					
Experimental Farm site	0-15	0.13a	0.17a	0.42a	0.2a	0.5a	1.57a
	0-30	0.12b	0.17a	0.37b	0.11b	0.45b	1.31b
	30-45	0.12b	0.17a	0.33c	0.09c	0.40c	1.17c
	Mean	**0.12**	**0.17**	**0.37**	**0.13**	**0.45**	**1.35**
Control Site	0-15	0.09b	0.12b	0.38a	0.15a	0.46a	1.27a
	15-30	0.11a	0.14a	0.27b	0.12b	0.40b	1.16b
	30-45	0.09b	0.12c	0.25c	0.11c	0.31c	1.11c
	Mean	**0.09**	**0.12**	**0.3**	**0.12**	**0.39**	**1.18**

Mean value(s) with the same letters(s) in the column are not significantly different from one another at a 5 % level of probability.

Control Site could be attributed to management practices at the experimental site compared to natural processes at the control site. These differences could include fertilizer application, irrigation practices, cropping patterns, and organic matter management. Total K in top soil of the Experimental Farm Site was higher compared to the Control Site. Nayan & Walia (1999) revealed that the total K was found more in sub-surface soils than the surface soils.

Correlation Between Some Soil Physical and Chemical Properties and Forms of Potassium in Experimental Farm and Control Farm Site.

Table 4 and Table 5 represent correlation matrices that show the relationships between various soil physical and chemical properties, as well as different forms of potassium, in the study area. Each cell in the matrix contains a correlation coefficient that indicates the strength and direction of the relationship between the two properties. The correlations range from -1 to 1, with positive values indicating a positive correlation (when one property increases, the other tends to increase) and negative values indicating a negative correlation (when one property increases, the other tends to decrease). The diagonal line of the matrix showed that the values are all 1 because they represent the correlation of each property with itself, which is a perfect positive correlation. Total K has a highly significant and positive correlation with clay (r = 0.83*) fraction showing that most of the Total-K is derived from the interlayer of clay structure and increase total-K with fineness of soils (Das et al., 1997). The results in the two sites, pH and electrical conductivity (EC) show a consistent relationship. Higher pH values generally have a relationship with higher EC values and increased levels of various forms of potassium. This aligns with Ferrarezi et al. (2022) who stated that pH affects the solubility and availability of nutrients, including potassium. The similar findings in both sites suggest a common relationship between pH, EC, and potassium availability (Atta et al., 2020).

Organic matter (org. M) and total nitrogen (T. N) indicated strong positive correlations with most forms of potassium in both sites. This is in line with Cornell University Cooperative Extension (CUCE) (2007) report which indicates that organic matter and nitrogen content enhance cation exchange capacity and nutrient retention, influencing the availability of essential elements like potassium. Sodium (Na) and potassium (K) have positive correlations with each other and various soil properties in both sites. This relationship can be attributed to their similar chemical behavior as alkali metals. However, the higher correlations observed in the control site might be related to the influence of management practices, irrigation, or natural conditions affecting sodium accumulation (Arienzo et al., 2012). The correlation of clay, silt, and sand with potassium levels suggests that soil texture plays a role in potassium retention and release. Higher clay content correlates with lower potassium levels, which could be due to increased fixation of potassium in clay-rich soils. Conversely, sand content shows a negative correlation with most forms of potassium, possibly indicating leaching effects in sandy soils (Simonsson et al., 2009). These findings align with Atta et al. (2020) who indicated that pH affects ion exchange, which in turn affects the availability of cations like potassium. The positive correlation between organic matter and potassium supports that highlights the role of organic matter in improving soil fertility and nutrient retention. Organic matter enhances the cation exchange capacity, leading to better nutrient availability. The correlations with soil texture resonate with Simonsson et al. (2009) about the impact of soil structure on nutrient-holding capacity. Clay-rich soils tend to have higher cation exchange capacity, which can lead to increased potassium retention. Ghosh & Mukhopadhyay (1996) also revealed that the total K has a highly positive and significant correlation with silt and clay fraction of soil indicating that substantial quantities of K-bearing minerals are present in silt and clay fractions of the soils under investigation. Sharma et al. (2006) found that total potassium was high in clay soil which shows that among the various particle-size fractions, clay is a principal host of K in these soils.

Table 4: Correlation between some Soil Physical and Chemical Properties and Forms of Potassium in Experimental Farm Site

	pH	*EC*	*org. m*	*Na*	*K*	*Ca*	*Mg*	*Av. P*	*Clay*	*Silt*	*Sand*	*H20 K*	*Exch K*	*Hcl K*	*Acid K*	*Residual K*	*Total K*
pH	1																
EC	0.956*	1															
org. m	0.264	0.383	1														
T. N	0.976*	0.982*	0.325														
Na	0.827*	0.950*	0.475	1													
K	0.982*	0.940*	0.235	0.812*	1												
Ca	0.823*	0.938*	0.437	0.930*	0.799*	1											
Mg	0.981*	0.988*	0.330	0.898*	0.971*	0.902*	1										
Av. P	0.956*	0.918*	0.231	0.790*	0.982*	0.781*	0.962*	1									
Clay	-0.836*	-0.899*	-0.331	-0.872*	-0.830*	-0.868*	-0.886*	-0.825*	1								
Silt	0.480	0.518*	0.586*	0.577*	0.496	0.394	0.465	0.410	-0.300	1							
Sand	0.338	0.362	-0.188	0.290	0.319	0.436	0.394	0.385	-0.628*	-0.553*	1						
H_2O K	0.964*	0.914*	0.206	0.781*	0.992*	0.770*	0.943*	0.958*	-0.801*	0.525*	0.271	1					
Exch K	0.982*	0.947*	0.244	0.823*	0.999*	0.814*	0.973*	0.976*	-0.836*	0.506*	0.317	0.993*	1				
HCl K	0.107	0.100	-0.109	0.174	0.091	-0.026	0.031	-0.048	-0.181	0.338	-0.117	0.149	0.103	1			
Acid K	0.126	0.127	-0.056	0.215	0.138	-0.023	0.055	-0.002	-0.124	0.532*	-0.324	0.205	0.150	0.958*	1		
Residual K	-0.183	-0.161	-0.315	-0.039	-0.188	-0.239	-0.236	-0.302	0.016	0.112	-0.106	-0.135	-0.177	0.930*	0.878*	1	
Total K	0.444	0.410	-0.083	0.417	0.446	0.244	0.364	0.315	-0.401	0.539*	-0.090	0.522*	0.469	0.901*	0.925*	0.747*	1

NB: * Significant at a 5 % level of probability.

Table 5: Correlation Between Some Soil Physical and Chemical Properties and Forms of Potassium in Control Site

	pH	*EC*	*org. m*	*T. N*	*Na*	*K*	*Ca*	*Mg*	*Av. P*	*Clay*	*Silt*	*Sand*	*H20 K*	*Exch K*	*Hcl K*	*Acid K*	*Residual K*	*Total K*
pH	1																	
EC	0.575*	1																
org. m	0.161	0.686*	1															
T. N	0.812*	0.921*	0.569*	1														
Na	0.474	0.985*	0.702*	0.874*	1													
K	0.260	0.928*	0.756*	0.768*	0.954*	1												
Ca	0.865*	0.782*	0.425	0.958*	0.730*	0.611*	1											
Mg	0.320	0.927*	0.772*	0.810*	0.959*	0.986*	0.687*	1										
Av. P	0.921*	0.843*	0.416	0.954*	0.775*	0.597*	0.918*	0.637*	1									
Clay	-0.272	-0.715*	-0.271	-0.581*	-0.772*	-0.699*	-0.471	-0.694*	-0.534*	1								
Silt	0.404	0.805*	0.467	0.734*	0.836*	0.783*	0.648*	0.797*	0.645*	-0.911*	1							
Sand	0.116	0.532*	0.058	0.361	0.603*	0.523*	0.247	0.502*	0.357	-0.931*	0.699*	1						
H_2O K	0.237	0.918*	0.759*	0.753*	0.947*	0.999*	0.597*	0.986*	0.577*	-0.694*	0.778*	0.519*	1					
Exch K	0.304	0.941*	0.756*	0.798*	0.963*	0.998*	0.650*	0.990*	0.632*	-0.699&	0.792*	0.515*	0.997*	1				
HCl K	0.020	-0.155	-0.322	-0.083	-0.128	-0.180	0.001	-0.162	-0.057	-0.284	0.393	0.146	-0.180	-0.174	1			
Acid K	0.287	0.270	-0.030	0.319	0.303	0.203	0.355	0.240	0.323	-0.583*	0.716*	0.381	0.199	0.216	0.888*	1		
Residual K	0.043	0.087	-0.288	0.052	0.146	0.057	0.060	0.056	0.090	-0.671*	0.607*	0.628*	0.055	0.056	0.855*	0.860*	1	
Total K	0.234	0.489	0.315	0.457	0.517*	0.494	0.418	0.502*	0.376	-0.725*	0.865*	0.495	0.492	0.500*	0.690*	0.816*	0.751*	1

NB: * Significant at a 5 % level of probability.

Conclusion

The study investigated soil properties and potassium forms in farmed soils at the University of Benin Experimental Farm. The Experimental Farm Site showed significant differences in pH, EC, organic matter, and total nitrogen across soil depths. Soil potassium (K), is one of the essential macronutrients required for plant growth and development. It plays a crucial role in various physiological and biochemical processes within plants. Potassium is vital for overall plant nutrition and is considered the third most important nutrient after nitrogen (N) and phosphorus (P).

Forms of Potassium in this study indicated significant differences in soil depth of both sites, with higher values recorded in the Experimental Farm Site. The result showed that forms of potassium, H_2O K, Exch K, HCl K, Acid K, Residual K, and Total K exhibited positive correlations with EC, organic matter (org. m), total nitrogen (T. N), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and average phosphorus (Av. P). It is therefore concluded that soil potassium is needed for a complete nutrient supply in farms.

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Authorship Contribution

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the Concept, Design, Data Collection, or Processing, Statistical Analyses, Literature Search, Writing, Review and Editing of the manuscript.

Conflicts of Interest

There is no conflict of interest between the article authors. We sought the permission of the University project farm management, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria before sampling. We declare that there is no conflict of interest between us as the article authors.

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References

Akamigbo, F.O.R., & Ukaegbu, C.E. (2003). The Rule of Soil Conservation in Nigeria, Agriculture in 21st Century. Invited paper to USDA Workshop, NRCRI

Arienzo M., Christen E.W., Jayawardane N.S., & Quayle W.C. (2012). The relative effects of sodium and potassium on soil hydraulic conductivity and implications for winery wastewater management. *Geoderma*, 173–174, 303–310 https://doi.org/10.1016/j.geoderma.2011.12.012

Atta A. A., Morgan K. T., Hamido S. A., & Kadyampakeni D. M. (2020). Effect of essential nutrients on root growth and lifespan of Huanglongbing affected citrus trees. *Plants,* 9(4), 1–20. https://doi.org/10.3390/plants9040483

Bauder, J. & Brock, T. (2001). Irrigation water quality, soil amendment, and crop effects on sodium leaching. *Arid Land Research and Management*, *15*(8),101–113. https://doi.org/10.1080/15324980151062724

Bremner J. M., & Mulvaney, C. S. (1982). Nitrogen-total. In A.L. Page, R.H. Miller & D.R. Keeney (Eds.), *Methods of soil analysis. Part 2. Chemical and microbiological properties* (pp. 595–624). American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin.

Cornell University Cooperative Extension (CUCE) (2007). Cation Exchange Capacity (CEC). Agronomy Fact Sheet Series # 22. Department of Crop and Soil Sciences, College of Agriculture and Life Sciences, Cornell University.

Crozier, C. R., & Hardy, D. H. (2003). Soil Facts: Soil Acidity and Liming—Basic Information for Farmers and Gardeners. *AG-439-51, North Carolina Cooperative Extension.*

Curry, J. P., & Good, J. A. (1992). Soil Faunal Degradation and Restoration. In: R. Lal & B.A. Stewart (Eds.), *Soil Restoration. Advances in Soil Science*, vol 17. Springer, New York, NY. https://doi.org/10.1007/978-1-4612-2820-2_7

Das, P. K., Sahu, G. S., & Das, N. (1997). Vertical distribution and release characteristics of potassium in some lateritic soils of Orissa. *Journal of Potassium Research, 13*(3), 105–110.

Doran, J. W., Sarrantonio, M., & Liebig, M. A. (1996). Soil health and sustainability. *Advances in Agronomy*, 56, 1–54. http://dx.doi.org/10.1016/S0065-2113(08)60178-9

Ferrarezi, R. S., Lin, X., Gonzalez, A. C., Tabay, F., Hu, H., Wang, X., Huang, J. H., & Fan, G. (2022). Substrate pH Influences the Nutrient Absorption and Rhizosphere Microbiome of Huanglongbing-Affected Grapefruit Plants. *Front. in Plant Science, 13*. https://doi.org/10.3389/fpls.2022.856937

Gee, G. W., & Or, D. (2002) Particle Size Analysis. In: J. H. Dane & G. C. Topp (Eds.), *Methods of Soil Analysis, Part 4, Physical Methods* (pp. 255–293). Soils Science Society of America.

Ghiri, M. N., & Abtahi, A. (2011). Potassium dynamics in calcareous vertisols of Southern Iran. *Arid Land Reserve Management, 25*(3), 257–274. https://doi.org/10.1080/15324982.2011.565857

Ghosh, B. N., & Mukhopadhyay, A. K. (1996). Potassium release characteristics of some soils of West Bengal and their relationship with forms of soil K and clay mineralogy. *Geoderma, 104*, 135–144.

Jackson, M. L. (1962). Soil chemical analysis. Prentice Hall, New York. 263–268.

Jalali, M., & Khanlari, Z. V. (2014). Kinetics of potassium release from calcareous soils under different land use. *Arid Land Research and Management*, 28, 1–13

Ladha, J. K., Pathak, H., Krupnik, T. J., Six, J., & Van Kessel, C. (2005). Efficiency of fertilizer nitrogen in cereal production: Retrospects and prospects. *Advance. Agronomy*, *87*, 85–156.

Lal, R. (1991). Soil conservation and biodiversity. In D.L. Hawksworth, (ed.), *The biodiversity of microorganisms and invertebrates: its role in sustainable agriculture* (pp. 89–103). Wallingford, UK, CAB International

Lalitha, M., & Dhakshinamoorthy, M. (2014). Forms of Potassium: A review National of Soil Survey and Land Use Planning. *Agricultural Review*, 560 024, 35, 1. https://doi.org/10.5958/j.0976-0741.35.1.008

Nayan, A., & Walia, C. S. (1999). Profile distribution of various forms of potassium in some landforms of Bundelkhand region. *J. Potassium Res., 15*, 1–4.

Ndukwu B. N., Chukwuma M. C., Idigbor C. M., & Obasi S. N. (2012). Forms and distribution of potassium in soils underlain by three lithologies Southeastern Nigeria.

INT'L Journal of Agriculture. and rural Development, 15(2), 1104.

Niu, D. F., Li, B. S., Wang, F. N., Wen, X. H., Ma, J. L., & Shu, P. X. (2015). Climate changes indicated by the clay minerals: A case of the Dishaogouwan section on the southeastern margin of the Mu Us Desert. *Journal of Fuzhou University (National Science Education), 43*, 345–351.

Nocco, M. A., Ruark, M. D., & Kucharik, C. (2019). Apparent electrical conductivity predicts the physical properties of coarse soils. *Geoderma, 335*, 1–11. https://doi.org/10.1016/j.geoderma.2018.07.047

Osmond, D.L., Crozier, & Hardy, D. H. (2002). SoilFacts: Careful Soil Sampling—The Key to Reliable Soil Test Information. AG-439-30, North Carolina Cooperative Extension.

Phillip, R. (2022). Reference Module in Earth Systems and Environmental Sciences.

Pratt, P. F. (1965). Potassium. In C. A. Black (Ed.), *'Methods of soil analysis, Part 2: chemical and microbiological properties* (pp. 1023–1031). American Society of Agronomy: Madison, Wisconsin.

Pribyl, D. W. (2010). A critical review of the conventional SOC to SOM conversion factor. *Geoderma. 156*(3),75–83. https://doi.org/10.1016/j.geoderma.2010.02.003

Recous, S., Robin, D., Darwis, D., & Mary, B. (1995). Soil inorganic nitrogen availability: Effect on maize residue decomposition. *Soil Biology. Biochem*, *27*, 1529–1538. https://doi.org/10.1016/0038-0717(95)00096-W

Sharma, B. D., Mukhopadhyay, S. S., & Sawhney, J. S., (2006). Distribution of potassium fractions in relation to landforms in a Himalayan catena. *Archives Agronomy Soil, 52*, 469–476. https://doi.org/10.1080/03650340600743717

Simonsson, M., Hillier, S., & Öborn I. (2009). Changes in clay minerals and potassium fixation capacity as a result of release and fixation of potassium in long-term field experiments. *Geoderma*, *151*(3–4),109–120 https://doi.org/10.1016/j.geoderma.2009.03.018

Strivastava, K. S. (2007). Academic Dictionary of Botany. First edition, (pp 201).

Udo, E. J, Ibia, T. O., Ogunwale J. A, Ano, A. O., Esu, I. E., Udoh, B. T., Ndaeya, N.U., & Harold, K.O. (2006). Fertility status and variability of some soils developed from parent material in the humid region of Nigeria. Proceedings of the 31st Annual Conference of Soil Science of Nigeria (SSSN), 13th – 17th November, 2006, Ahmadu Bello University, Zaria, 79 – 85.

Walkley, A., & Black I. A. (1934). An examination of the different methods for determining soil organic matter and the proposed modification of the chromic acid wet titration method. *Soil Science of America Journal*, 37, 29–38. http://dx.doi.org/10.1097/00010694-193401000-00003