Agricultural Research & Technology:
Open Access Journal
ISSN: 2471-6774

Research Article
Volume 2 Issue 1 - July 2016

Agri Res & Tech: Open Access J


# Potassium Fixing Capacities of Some Selected Soils in South Western Nigeria

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**Submission:** June 13, 2016; **Published:** July 02, 2016

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**Abstract**

Potassium fixation is a widespread phenomenon in most soils and accounts significantly for the availability of applied K to plants. Although this phenomenon is a direct consequence of the presence of 2:1 clay minerals, recent studies have shown that this phenomenon also occurs in tropical soils with insignificant content of 2:1 silicate clays. Also, the knowledge of potassium status of soils provides useful information for rational K fertilizer management. Therefore this study investigated the potassium fixation capacities as well as the potassium status of some soils of southwestern Nigeria. Potassium fixation in the soils was conducted by evaluating the effect of applied K on the extractability of K with time. A series of five K sorption treatment solution (0.11, 0.22, 0.45, 0.90 and 1.80 cmol/kg) were prepared and applied as KCl replicated three times. The first set of soil samples were extracted with 1N $NH_4OAc$ extractant for K after the first day of incubation. The second and third sets were extracted with the same extractant after 10 and 42 days of incubation respectively to determine the amount of K fixed. Correlation between applied K and fixed K was carried out. Potassium status of the soils was evaluated. Fixation increased with increase in the concentration of added K. There was also a linear relationship between the proportion of K fixed and the amount added at higher incubation periods. It was concluded that the soils have the ability to fix potassium. Therefore, fertilizer recommendation should take in to account the amount that is initially fixed.

**Keywords:** Fixation; Potassium; Sorption; Incubation

## Introduction

Potassium (K) is the third most essential nutrient element after nitrogen and phosphorus for plant nutrition. It is very instrumental in plant nutrition and physiology. Potassium has been found to activate over sixty (60) enzymes. It also promotes photosynthesis, controls stomata opening, improves the utilization of N, promotes the transport of assimilates and consequently increases crop yields. Also, K influences the microbial population in the rhizosphere and plays key roles in the nutrition and health of man and livestock [1,2]. Potassium exists in four forms in the soil. These include the solution, exchangeable, non-exchangeable or fixed and mineral or structural K forms [3-5]. Solution K constitutes about 2-5 mg/l except in recently K amended soils and is the form directly taken by plants and microbes and subject to leaching losses [5]. Exchangeable K is the form that is electrostatically bound to the outer surface of clay minerals and humic substances and which is readily exchangeable and available to plants. Non-exchangeable or fixed K represents the portion held between adjacent tetrahedral layers of 2:1 clay minerals such as micas and vermiculites and which is sparingly available to plants [6,3,4] while mineral or structural K consist about 90-98% of total soil potassium and constitutes the portion that is bonded within crystal structures of soil mineral particles [7].

Equilibrium and kinetic reactions exist between potassium forms in the soils and this affects their solution concentration and availability to plants [8,9]. Thus as soil solution potassium concentration is depleted through leaching and plant uptake, it is immediately replenished by the other forms especially the exchangeable and non-exchangeable fractions [10]. Availability of potassium in soil solution could therefore be influenced by the solution-exchangeable K dynamics, rate of K exchange in soils, K fixation and release from soil minerals and leaching [7,5]. Many researchers have observed that at times, some soils that test high may respond to K application contrary to expectation. This is an indication that there are other forms of K other than the exchangeable K contributing to K needs of crops. Non-exchangeable K has been shown to also contribute significantly to plant uptake, this has often been ascribed to the fixed K; step K [11,12]. Potassium fixation is a direct consequence of the presence of 2:1 clay minerals. However some studies in West-Indices and in Nigeria [13-17,34] have shown that this phenomenon also occurs in tropical soils with insignificant content of 2:1 silicate clays. Therefore in assessing the K supplying capacity, the readily released K and the slow released K portions must be assessed because of the dynamics of water and gas in the soil-plant system and rhizosphere processes, Reports of K deficiency in southwest Nigerian soils have been reported by [14] while the exact levels of soil K at which the deficiencies occur cannot be predicted accurately. Hence, in order to improve the reliability of predicting soil K, indices of K availability should be considered. Potassium status of our soils should be well understood to help formulate the right fertilizer mixtures to boost crop production. The objectives of this study were therefore to determine the K fixation capacities of some selected soils of the southwestern Nigeria.

## Materials and Methods

### Description of study sites

Experimental soil samples were collected from 6 different locations in Ogun, Osun and Oyo states based on parent rock materials; sedimentary rocks and basement complex rocks respectively as shown in Table 1.

**Table 1:** Sampling location coordinates and land use of the studied soils.

| S/N | Sampling location | Coordinates | Land use |
|---|---|---|---|
| 1 | Parry road | 3° 27' 10'' N<br>3° 53 20'' E | Uncultivated land |
| 2 | Technology road | 7° 26' 24'' N<br>3° 53' 20'' E | Land sown to Cassava |
| 3 | Apomu | 7° 21' 11'' N<br>4° 10' 58'' E | Plantain plantation |
| 4 | Ikoyi | 7° 21' 0'' N<br>4° 9' 21'' E | Forested land |
| 5 | Ilisan | 6° 53' 11'' N<br>3° 42' 11'' E | Land sown to Cassava |
| 6 | Ikenne | 6° 53' 0'' N<br>3° 42' 11'' E | Uncultivated land |

### Sample collection and preparation

Soil samples were randomly collected at a point from two depths (0-15cm and 15-30cm) at 6 different locations across the south-western region of Nigeria, giving a total of 12 samples. The collected soil samples were air-dried, crushed and sieved through 2 mm and 0.5 mm sieve (depending on the analysis to be carried out on the soils) respectively and fine earth fractions stored ready for analysis (Figure 1).

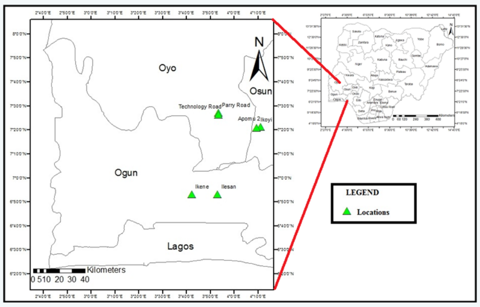


**Figure 1:** Map showing locations of experimental soil samples.

### Laboratory analysis

Soil pH was determined on a 1:10 (soil: water). Particle size was determined by hydrometer method [18]. Phosphorus was extracted with Bray P-1 solution and the P in the extract was determined by Molybdate blue colour method of [19] with Spectronic 20. Organic carbon was determined by the dichromate wet oxidation method as described by [20]. Exchangeable acidity was extracted with 1 N KCl and titrated against 0.01N NaOH. The effective cation exchange capacity (ECEC) was obtained by the sum of the total exchangeable bases (TEB) and total exchangeable acidity (TEA). Total Nitrogen was determined by Micro-Kjeldahl method as described by [21]. Micronutrient elements (Fe, Mn, Cu and Zn) were extracted with 0.1 N HCl and their concentrations read on the Atomic Absorption Spectrophotometer [20].

### Potassium fixation

A stock solution was prepared by dissolving 1.91 g KCl in 200 ml distilled water and the volume made up to 1 litre solution with distilled water. This gave a concentration of 1 g K/l (2.56 cmol/kg). A series of five sorption treatment solutions viz: 0.11, 0.22, 0.45, 0.90 and 1.80 cmol/kg [22], were prepared by diluting 21.48, 43.00, 87.89, 175.78 and 351.56 ml respectively of the stock solution to 500 ml. 2.5 g each of the 20 soil samples was weighed into custom laboratory cups in tray racks. A 2.5 ml portion of each treatment solution was added, in three sets, to the 20 soil samples contained in the custom laboratory cups. A control experiment was also set up. They were then covered with clean polythene sheets following 1, 10 and 42 days of incubation. The samples were kept moist to about field capacity with deionized water throughout the incubation period. The first set of soil samples were extracted with 1N NH4OAc extractant for K after one day of incubation. The second and third sets were extracted with the same extractant for K after 10 and 42 days of incubation, respectively. The extract was read using a flame photometer.

### Statistical analysis

Fixed K was calculated as follows:

(K added at rate R + K in control) – K recovered at rate R [23].

While Correlation between added K and different days of


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incubations were conducted using Genstat statistical package [24].

## Results and Discussion

### Soil physico-chemical properties

**Table 2:** Particle size distribution of the studied soils.

| Location | Soil depth (cm) | Sand (g/kg) | Silt (g/kg) | Clay (g/kg) | Textural Class |
|---|---|---|---|---|---|
| Parry road | 0-15 | 840 | 40 | 120 | SL |
| | 15-30 | 840 | 60 | 100 | SL |
| Tech. road | 0-15 | 840 | 40 | 120 | SL |
| | 15-30 | 840 | 40 | 120 | SL |
| Apomu | 0-15 | 880 | 53 | 67 | SL |
| | 15-30 | 760 | 60 | 180 | LS |
| Ikoyi | 0-15 | 880 | 53 | 67 | SL |
| | 15-30 | 880 | 20 | 100 | SL |
| Ilishan | 0-15 | 880 | 20 | 100 | SL |
| | 15-30 | 880 | 20 | 100 | SL |
| Ikenne | 0-15 | 860 | 20 | 120 | SL |
| | 15-30 | 880 | 53 | 67 | SL |

SL: Sandy loam; LS: Loamy sand

The physical properties of the soils are presented in Table 2. The sand, silt and clay contents varied from 760-880 mg/kg, 20-60 mg/kg and 67-180 mg/kg respectively. The major soil texture encountered was sandy loam which constituted 95% of the soils investigated. The sand fraction was higher than silt and clay fractions respectively in all the investigated soils, thus it can be inferred that the relatively high sand fraction would favors leaching and the creation of acidic condition. Soils were strongly acidic to slightly alkaline (pH 5.44 to 7.41) as shown in Table 3. The high acidity of soils has been ascribed to intense base leaching by high tropical rainfall [25]. Low pH values less than 5.50 indicate that the soils may suffer from aluminum toxicity. It has been reported that aluminum toxicity occur in soils with pH values less than 5.50 and increases in intensity as the pH decreases below 5.0 [26,27]. Mean values for Soil organic carbon in the different locations ranged from low (3.99 g/kg) at Parry road to very high (56.7 g/kg) at Apomu. Mean values of organic carbon was above the critical limit (10-14 g/kg) for all the locations except for Parry road (3.99 g/kg) [28]. Total nitrogen ranged from 0.42 g/kg (low) in soils from Parry road to 3.28 g/kg (very high) in Ikoyi soils. Except for parry road, all other locations had mean values above the critical limit (1.2-1.6 g/kg) [28]. Mean values for available P ranged from 5.06 mg/kg (low) in Parry road to 27.82 mg/kg (high) in Ikenne. Except for soils from Tech road (20% of the soils) with available P values below the critical level mean values for available P were above the critical limit (10-15 mg/kg) for P- Bray P-1 in all locations [29]. Mean values for exchangeable Calcium (Ca) ranged from 1.98 cmol/kg (low) at Parry road to 19.34 cmol/kg (high) at Ikenne. Only Parry road soils had mean values below the critical limit for Ca (5-10 cmol/kg) reported by [30], Mg values below the critical range (1.5-3 cmol/kg) reported by [30], were observed at Parry road and Ikoyi. Mean values of exchangeable potassium (K) ranged from 0.05 cmol/kg at Parry road, Ikenne and Ilisanto 0.17 cmol/kg at Tech road. 80% of the soils had K values below the critical range for K (0.3-0.6 cmol/kg) reported by [30], suggesting that there will be response to application of K fertilizer in these soils. Mean values for exchangeable Sodium (Na) ranged from 0.1-0.4 cmol/kg. 60% of the soils had values for Na below the critical range (0.3- 0.4 cmol/kg) reported by [30]. ECEC ranged from 3.3 cmol/kg in Parry road to 20.83 cmol/kg at Ikenne. With exception of Apomu (16.83 cmol/kg) and Ikenne (20.83 cmol/kg) all other locations (80% of the studied soils) had mean ECEC values less than 16 cmol/kg suggesting that they are predominantly kaolinitic 1:1 clay (low activity clay) [26]. % Base saturation ranged from 79% at Parry road to 99% at Ikenne. Mean values of Organic carbon, Nitrogen and Phosphorus in the soils are above critical limit [28], suggesting good fertility status of the various locations. Mean values of less than 16 cmol/kg ECEC in some of the soils suggests that they are dominantly of low activity clay [26].

**Table 3:** Some chemical properties of the soils studied.

| Location | Depth (Cm) | pH | Org. C (g/kg) | TN (g/kg) | Avail. P (mg/kg) | Ca (cmol/kg) | Mg (cmol/kg) | K (cmol/kg) | Na (cmol/kg) | EA (cmol/kg) | ECEC (cmol/kg) | BS % | Fe mg/kg | Cu mg/kg | Mn mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parry road | 0-15 | 5.91 | 3.99 | 0.42 | 12.25 | 2.22 | 0.58 | 0.05 | 0.11 | 0.4 | 3.36 | 88 | 301 | 4.68 | 11.3 |
| | 15-30 | 6.09 | 12.37 | 1.12 | 5.06 | 1.98 | 0.47 | 0.05 | 0.1 | 0.7 | 3.3 | 79 | 275 | 3.44 | 5.4 |
| Tech. road | 0-15 | 6.27 | 33.52 | 1.06 | 5.46 | 9.91 | 2.07 | 0.17 | 0.19 | 0.3 | 12.64 | 96 | 498 | 4.99 | 21.4 |
| | 15-30 | 6.95 | 18.75 | 2.16 | 7.06 | 6.48 | 2.02 | 0.14 | 0.1 | 0.3 | 9.05 | 97 | 487 | 5.22 | 23.9 |
| Apomu | 0-15 | 6.51 | 13.17 | 1.91 | 92.25 | 8.86 | 1.94 | 0.07 | 0.43 | 0.4 | 11.7 | 97 | 610 | 7.09 | 19.9 |
| | 15-30 | 6.68 | 24.74 | 1.82 | 63.76 | 6.9 | 1.18 | 0.07 | 0.29 | 0.6 | 9.04 | 93 | 633 | 7.25 | 27.6 |
| Ikoyi | 0-15 | 7.29 | 23.54 | 1.04 | 12.51 | 5.66 | 1.28 | 0.12 | 0.31 | 0.3 | 7.67 | 96 | 295 | 6.29 | 12.7 |
| | 15-30 | 7.02 | 33.52 | 3.28 | 11.18 | 6.7 | 1.38 | 0.16 | 0.3 | 0.6 | 9.14 | 93 | 518 | 5.81 | 22.9 |



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| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ilishan | 0-15 | 7.30 | 31.12 | 2.21 | 16.77 | 10.01 | 1.98 | 0.07 | 0.11 | 0.6 | 12.77 | 95 | 565 | 6.7 | 30.7 |
| | 15-30 | 7.41 | 18 | 2.75 | 18.9 | 10.29 | 1.33 | 0.04 | 0.13 | 0.7 | 12.49 | 94 | 593 | 7.16 | 25.2 |
| Ikenne | 0-15 | 6.50 | 5.59 | 1.46 | 13.84 | 5.56 | 3.99 | 0.06 | 0.15 | 0.7 | 10.46 | 93 | 563 | 6.98 | 19.2 |
| | 15-30 | 5.44 | 25.14 | 1.79 | 27.82 | 19.34 | 0.81 | 0.11 | 0.27 | 0.3 | 20.83 | 99 | 702 | 6.44 | 21.6 |

Org.C: Organic carbon; TN: Total nitrogen; Avail. P: Available phosphorus; EA: Exchangeable acidity

## Fixation capacity

Tables 4-9 show the proportion of K fixed in the different soils. Mean proportion of K fixed ranged from 0.02 cmol/kg in Ikoyi (15-30 cm) to I.72 cmol/kg in Apomu (0-15cm). Mean K fixation capacity ranged from 0.16-1.71, 0.03-1.63, 0.06-1.72, 0.09-1.28, 0.02-1.02 and 0.06-1.21 cmol/kg in Parry road, Tech. road, Apomu, Ikoyi, IIisan and Ikenne respectively. K fixation was best at 1.80 cmol/kg added K in all the soils and soils showed releasing properties at lower concentrations of added K. Variation in K fixation capacity has been reported to depend on the type of clay mineral and its charge density, degree of interlaying, moisture content, concentration of K ions as well as concentration of competing cations and pH of the ambient solution bathing the clay or soil [3].

## Parry road

Soils from Parry road (15-30 cm) showed releasing properties at 0.11, 0.22, 0.45 and 0.9 cmol/kg of added K. There was no fixation at 0.11, 0.22, and 0.45 cmol/kg application rates respectively. Mean K fixation varied as 0.41 and 1.33 cmol/kg at 0.9 and 1.8 cmol/kg respectively. Parry road (15-30 cm) soils showed releasing properties at 0.11 and 0.22 cmol/kg added K. Mean K fixation varied as 0.16, 0.28, 1.48, 1.00, and 1.71 cmol/kg at 0.11, 0.22, 0.45, 0.9 and 1.8 cmol/kg application rates respectively (Table 4).

**Table 4:** Amounts of potassium fixed by soils from Parry road following incubation for 1, 10 and 42 days of incubation**.**

| K added (cmol/kg) | Incubation time (Days) | (0 - 15 cm) K | | (15-30 cm) K | |
|---|---|---|---|---|---|
| | | Recovered (cmol/kg) | Fixed (cmol/kg) | Recovered (cmol/kg) | Fixed (cmol/kg) |
| 0.00 | 1 | 0.08- | | 0.05- | |
| | 10 | 0.14- | | 2.11 - | |
| | 42 | 0.05- | | 0.02- | |
| | Mean | 0.09 | - | 0.72 | - |
| 0.11 | 1 | 0.27 | -0.08 | 0.24 | -0.08 |
| | 10 | 0.72 | -0.47 | 1.65 | 0.57 |
| | 42 | 1.00 | -0.84 | 0.14 | -0.01 |
| | Mean | 0.66 | - | 0.68 | 0.16 |
| 0.22 | 1 | 0.46 | -0.16 | 0.46 | -0.19 |
| | 10 | 1.00 | -0.64 | 1.35 | 0.98 |
| | 42 | 0.25 | 0.02 | 0.18 | 0.06 |
| | Mean | 0.57 | - | 0.66 | 0.28 |
| 0.45 | 1 | 0.43 | 0.10 | 0.49 | 2.07 |
| | 10 | 1.37 | -0.78 | 0.48 | 2.08 |
| | 42 | 0.21 | 0.29 | 0.17 | 0.30 |
| | Mean | 0.67 | - | 0.38 | 1.48 |
| 0.90 | 1 | 0.46 | 0.52 | 0.61 | 0.34 |
| | 10 | 1.06 | -0.02 | 1.14 | 1.87 |
| | 42 | 0.21 | 0.74 | 0.13 | 0.79 |
| | Mean | 0.58 | 0.41 | 0.63 | 1.00 |
| 1.80 | 1 | 0.95 | 0.93 | 0.66 | 1.25 |
| | 10 | 0.70 | 1.24 | 1.29 | 2.62 |
| | 42 | 0.08 | 1.77 | 0.12 | 1.70 |
| | Mean | 0.58 | 1.33 | 0.69 | 1.71 |



**How to cite this article:** Thomas EY, Omueti J, Bandele B. Potassium Fixing Capacities of Some Selected Soils in South Western Nigeria. Agri Res & Tech: Open Access J. 2016; 2(1): 555577. DOI: 10.19080/ARTOAJ.2016.01.555577

## Technology road

Soils collected from the Technology road (0-15 cm) showed releasing properties at 0.11 and 0.45 cmol/kg levels of added K. Mean K fixation varied as 0.06, 0.64, 0.21, 0.96 and 1.63 cmol/kg at 0.11, 0.22, 0.45, 0.9 and 1.8 cmol/kg application rates respectively. At lower depth (15-30 cm), the soil showed releasing properties only at 0.11 cmol/kg added K. Mean K fixation varied as 0.03, 0.29, 0.44, 0.81 and 1.44 cmol/kg at 0.11, 0.22, 0.45, 0.9 and 1.8 cmol/kg application rates respectively (Table 5).

**Table 5:** Amounts of potassium fixed by soils from Technology road following incubation for 1, 10 and 42 days of incubation.

| K added (cmol/kg) | Incubation time (Days) | (0-15cm) K | | (15-30cm) K | |
|---|---|---|---|---|---|
| | | Recovered (cmol/kg) | Fixed (cmol/kg) | Recovered (cmol/kg) | Fixed (cmol/kg) |
| 0.00 | 1 | 0.72 | - | 0.51 - | - |
| | 10 | 1.41 | | 1.42- | - |
| | 42 | 0.23 | - | 0.05- | - |
| | Mean | 0.79 | - | 0.66 | - |
| 0.11 | 1 | 0.51 | 0.32 | 0.56 | 0.06 |
| | 10 | 1.70 | -0.18 | 1.45 | 0.08 |
| | 42 | 0.30 | 0.04 | 0.20 | -0.04 |
| | Mean | 0.83 | 0.06 | 0.74 | 0.03 |
| 0.22 | 1 | 0.12 | 0.82 | 0.13 | 0.60 |
| | 10 | 0.85 | 0.78 | 1.39 | 0.25 |
| | 42 | 0.12 | 0.33 | 0.24 | 0.03 |
| | Mean | 0.36 | 0.64 | 0.59 | 0.29 |
| 0.45 | 1 | 1.23 | -0.06 | 0.90 | 0.06 |
| | 10 | 1.87 | -0.01 | 0.89 | 0.98 |
| | 42 | 0.08 | 0.70 | 0.21 | 0.29 |
| | Mean | 1.06 | 0.21 | 0.67 | 0.44 |
| 0.90 | 1 | 0.77 | 0.85 | 0.51 | 0.90 |
| | 10 | 1.38 | 0.93 | 1.51 | 0.81 |
| | 42 | 0.07 | 1.10 | 0.23 | 0.72 |
| | Mean | 0.74 | 0.96 | 0.75 | 0.81 |
| 1.80 | 1 | 0.61 | 1.91 | 1.00 | 1.31 |
| | 10 | 2.14 | 1.07 | 1.96 | 1.26 |
| | 42 | 0.13 | 1.90 | 0.10 | 1.75 |
| | Mean | 0.96 | 1.63 | 1.02 | 1.44 |

## Apomu

Apomu soils (0-15 cm) showed some releasing properties at 0.11, 0.22 and 0.45 cmol/kg added K and there was no fixation at 0.11 cmol/kg level of added K. Mean K fixation varied as 0.12, 0.06, 0.52, 1.72 cmol/kg at 0.22, 0.45, 0.90 and 1.80 cmol/kg application rates respectively. Apomu soils (15-30) showed some releasing properties at 0.11, 0.22 and 0.45 cmol/kg added K with no fixation at those concentrations. Mean fixation varied as 0.49 and 0.87 at 0.9 and 1.8 cmol/kg application rates respectively (Table 6).

**Table 6:** Amounts of potassium fixed by soils from Apomu following incubation for 1, 10 and 42 days of incubation.

| K added (cmol/kg) | Incubation time (Days) | (0 - 15 cm) K | | (15 – 30cm) K | |
|---|---|---|---|---|---|
| | | Recovered (cmol/kg) | Fixed (cmol/kg) | Recovered (cmol/kg) | Fixed (cmol/kg) |
| 0.00 | 1 | 0.08 | | 0.06 | - |
| | 10 | 1.44 | - | 0.21 | - |
| | 42 | 0.04 | - | 0.04 - | |
| | Mean | 0.52 | - | 0.10 | - |


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| | | | | | |
|---|---|---|---|---|---|
| 0.11 | 1 | 0.38 | -0.19 | 0.46 | -0.29 |
| | 10 | 1.84 | -0.29 | 0.64 | -0.32 |
| | 42 | 0.04 | 0.11 | 0.18 | -0.03 |
| | Mean | 0.75 | - | 0.43 | - |
| 0.22 | 1 | 0.51 | -0.21 | 0.69 | -0.41 |
| | 10 | 1.17 | 0.49 | 0.13 | 0.30 |
| | 42 | 0.19 | 0.07 | 0.20 | 0.06 |
| | Mean | 0.62 | 0.12 | 0.34 | - |
| 0.45 | 1 | 0.43 | 0.10 | 0.72 | -0.21 |
| | 10 | 2.13 | -0.24 | 1.26 | -0.60 |
| | 42 | 0.18 | 0.31 | 0.22 | 0.27 |
| | Mean | 0.91 | 0.06 | 0.73 | - |
| 0.90 | 1 | 0.76 | 0.22 | 0.54 | 0.42 |
| | 10 | 1.76 | 0.58 | 0.79 | 0.32 |
| | 42 | 0.17 | 0.77 | 0.21 | 0.73 |
| | Mean | 0.90 | 0.52 | 0.51 | 0.49 |
| 1.80 | 1 | 1.07 | 0.81 | 1.00 | 0.86 |
| | 10 | 0.62 | 2.62 | 1.11 | 0.90 |
| | 42 | 0.10 | 1.74 | 1.00 | 0.84 |
| | Mean | 0.60 | 1.72 | 1.04 | 0.87 |

## Ikoyi

Ikoyi soil at the depth of 0-15 cm showed some releasing properties at 0.11, 0.22 and 0.45 cmol/kg added K. There was no fixation at 0.22 and 0.45 cmol/kg. Mean K fixation varied as 0.12, 0.25 and 0.86 cmol/kg at 0.11, 0.90 and 1.80 cmol/kg application rates respectively. Ikoyi soils (15-30 cm) showed some releasing properties at 0.11, 0.22, 0.45 and 0.9 cmol/kg and in Apomu soil showed some releasing properties at 0.11, 0.22 and 0.45 cmol/kg of added K. There was no fixation at 0.11 cmol/kg of added K. Mean fixation of K varied as 0.02, 0.12, 0.41 and 1.03 cmol/kg application rates respectively (Table 7).

**Table 7:** Amounts of potassium fixed by soils from Ikoyi following incubation for 1, 10 and 42 days of incubation.

| K added (cmol/kg) | Incubation time (Days) | (0 – 15cm) K | | (15 – 30cm) K | |
|---|---|---|---|---|---|
| | | Recovered (cmol/kg) | Fixed (cmol/kg) | Recovered (cmol/kg) | Fixed (cmol/kg) |
| 0.00 | 1 | 0.10 | - | 0.14 | - |
| | 10 | 1.01 | - | 0.45 | - |
| | 42 | 0.06 | - | 0.70 | - |
| | Mean | 0.39 | - | 0.43 | - |
| 0.11 | 1 | 0.51- | 0.30 | 0.46 | -0.21 |
| | 10 | 0.38 | 0.74 | 2.07 | -1.51 |
| | 42 | 0.24- | 0.07 | 0.77 | 0.03 |
| | Mean | 0.38 | 0.12 | 1.10- | |
| 0.22 | 1 | 0.56 | -0.24 | 0.04 | 0.32 |
| | 10 | 1.13 | 0.10 | 1.06 | -0.39 |
| | 42 | 0.75- | 0.47 | 0.78 | 0.14 |
| | Mean | 0.81 - | | 0.63 | 0.02 |
| 0.45 | 1 | 0.59 | -0.04 | 1.13 | -0.54 |
| | 10 | 1.53 | -0.07 | 0.44 | 0.46 |
| | 42 | 0.74 | -0.23 | 0.79 | 0.45 |
| | Mean | 0.95 | - | 0.85 | 0.12 |


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| | | | | | |
|---|---|---|---|---|---|
| 0.90 | 1 | 0.74 | 0.26 | 0.56 | 0.48 |
| | 10 | 1.58 | 0.33 | 1.39 | -0.04 |
| | 42 | 0.81 | 0.15 | 0.81 | 0.79 |
| | Mean | 1.04 | 0.25 | 0.92 | 0.41 |
| 1.80 | 1 | 1.10 | 0.80 | 0.51 | 1.43 |
| | 10 | 1.94 | 0.87 | 2.04 | 0.21 |
| | 42 | 0.94 | 0.92 | 1.05 | 1.45 |
| | Mean | 1.33 | 0.86 | 1.20 | 1.03 |

## Ilisan

Ilisan soils (0-15cm) showed some releasing properties at 0.11, 0.22, 0.45 cmol/kg added K. There was no fixation at 0.11 and 0.22 cmol/kg added K. Mean K fixation varied as 0.09, 0.82 and 1.28 cmol/kg at 0.45, 0.90 and 1.80 cmol/kg application rates respectively. Ilisan soils (15-30 cm) showed some releasing properties at 0.11, 0.22, and 0.45 cmol/kg added K. There was no fixation at 0.11 and 0.22 cmol/kg added K. Mean K fixation varied as 0.26, 0.54, and 1.02 cmol/kg at 0.45, 0.90 and 1.80 cmol/kg application rates respectively (Table 8).

**Table 8:** Amounts of potassium fixed by soils from Ilisan following incubation for 1, 10 and 42 days of incubation.

| K added (cmol/kg) | Incubation time (Days) | (0-15cm) K | | (15-30 cm) K | |
|---|---|---|---|---|---|
| | | Recovered (cmol/kg) | Fixed (cmol/kg) | Recovered (cmol/kg) | Fixed (cmol/kg) |
| 0.00 | 1 | 0.48 | - | 0.82 | - |
| | 10 | 0.93 | - | 0.26 | - |
| | 42 | 0.04 | - | 0.04 | - |
| | Mean | 0.48 | - | 0.37 | - |
| 0.11 | 1 | 0.51 | 0.08 | 0.43 | 0.50 |
| | 9 | 0.72 | 0.32 | 1.54 | -1.17 |
| | 42 | 0.70 | -0.55 | 0.25 | -0.10 |
| | Mean | 0.64 | - | 0.74 | - |
| 0.22 | 1 | 0.09 | 0.61 | 0.56 | 0.48 |
| | 9 | 2.07 | -0.92 | 1.25 | -0.77 |
| | 42 | 0.77 | -0.51 | 0.51 | -0.25 |
| | Mean | 1.00 | - | 0.77 | - |
| 0.45 | 1 | 1.25 | -0.32 | 0.51 | 0.76 |
| | 9 | 0.97 | 0.41 | 0.53 | 0.18 |
| | 42 | 0.30 | 0.19 | 0.65 | -0.16 |
| | Mean | 0.84 | 0.09 | 0.56 | 0.26 |
| 0.90 | 1 | 0.82 | 0.56 | 0.87 | 0.85 |
| | 9 | 0.85 | 0.98 | 0.72 | 0.44 |
| | 42 | 0.03 | 0.91 | 0.62 | 0.32 |
| | Mean | 0.57 | 0.82 | 0.74 | 0.54 |
| 1.80 | 1 | 0.74 | 1.54 | 1.23 | 1.39 |
| | 9 | 1.44 | 1.29 | 1.31 | 0.75 |
| | 42 | 0.84 | 1.00 | 0.93 | 0.91 |
| | Mean | 1.01 | 1.28 | 1.16 | 1.02 |

## Ikenne

Ikenne soils at (0-15 cm) showed some releasing properties at 0.11, 0.22, 0.45 and 1.80 cmol/kg levels of added K. There was no fixation at 0.11 cmol/kg added K. Mean K fixation varied as 0.44, 0.49, 1.20 and 1.21 cmol/kg at 0.22, 0.45, 0.90 and 1.80 cmol/kg application rates respectively. Ikenne (15-30 cm) showed some releasing properties at 0.11, 0.22, 0.45 and 1.80 cmol/kg levels of added K. There was no fixation at 0.11 and 0.45 cmol/kg added K. Mean K fixation varied as 0.06, 0.50 and 1.03 cmol/kg at 0.22, 0.90 and 1.80 cmol/kg application rates


**How to cite this article:** Thomas EY, Omueti J, Bandele B. Potassium Fixing Capacities of Some Selected Soils in South Western Nigeria. Agri Res & Tech: Open Access J. 2016; 2(1): 555577. DOI: 10.19080/ARTOAJ.2016.01.555577

respectively. The soils showed releasing properties more at the lowest level of added K (0.11 cmol/kg) than other levels of added K (Table 8). The soils showed releasing properties more at the lowest level of added K (0.11 cmol/kg) than other levels of added K (Table 9). The soils exhibited releasing properties rather than fixation at 0.11 cmol/kg of K added (Figure 2). At 0.22 cmol/kg K added, fixation was better on days 10 and 42 of incubation with day 42 recording the least. With 0.45 cmol/kg, 0.9 cmol/kg and 1.8 cmol/kg levels of K added, fixation was better on days 42 and 10 of incubation and least in day 1 (Figure 2). In general, higher levels of K fixation were observed in 10 and 42 days of incubation while incubation period of 1 gave the least. Fixation was best on day 42 of incubation (day 42 > day 10 > day 1). Fixation of K increased with increase in the concentration of added K during the incubation periods (Figure 2). There was high correlation between ($P < 0.01$) K added and K fixed in all the incubation periods (Table 10). The study indicated that the selected soils have the potential to fix applied K, this is in consonance with the findings of [23,29,31,32] who observed K fixation in tropical soils. The ability of these soils to fix K would not ordinarily be expected because they are predominantly kaolin tic 1:1 clay minerals, low external surface area, relatively no internal surface area and low in cation exchange capacity. Similar results have however also been reported for some other Nigerian soils [34]. This suggests the presence of specific adsorption sites for K in soils. The occurrence of specific adsorption sites may increase the retention of K in the soil; improve nutrient cycling and the residual effect of K fertilization [33] of K. Hence, any K fertilizer recommendation must take into account this amount that is initially fixed. The fixed portion could eventually be available for uptake by plants adapted to low levels of K in the soil solution. The high fixing capacities of some soils of this zone could be attributed to the type of soil as the latter affect K fixation [29]. Higher levels of K fixation observed in day 1 and 10 days of incubation in some of the soils and lower amount fixed at the 42 – day period of incubation are not uncommon as the fixation sites in the soil are first satisfied when a nutrient element is added before providing the excess for plant uptake. In this study, this was only observed at 0.22 cmol/kg level of K added as 0.45, 0.9 and 1.8 cmol/kg levels of K added recorded higher levels of K fixation in 42 and 10 days of incubation and lower amounts in day 1 of incubation.

**Table 9:** Amounts of potassium fixed by soils from Ikenne following incubation for 1, 10 and 42 days of incubation.

| K added (cmol/kg) | Incubation time (Days) | (0 – 15cm) K | | (15-30cm) K | |
|---|---|---|---|---|---|
| | | Recovered (cmol/kg) | Fixed (cmol/kg) | Recovered (cmol/kg) | Fixed (cmol/kg) |
| 0.00 | 1 | 0.05 - | | 0.16 | - |
| | 10 | 1.45- | | 0.70 | - |
| | 42 | 0.59 | - | 0.07 | - |
| | Mean | 0.70 | - | 0.31 | - |
| 0.11 | 1 | 0.64- | 0.48 | 1.07 | -0.80 |
| | 10 | 1.50 | 0.06 | 1.39 | -0.58 |
| | 42 | 0.72 | -0.02 | 0.25 | -0.07 |
| | Mean | 0.95 | - | 0.9 | - |
| 0.22 | 1 | 0.56- | 0.29 | 0.84 | -0.46 |
| | 10 | 0.83 | 0.84 | 0.65 | 0.27 |
| | 42 | 0.03 | 0.78 | 0.04 | 0.25 |
| | Mean | 0.47 | 0.44 | 0.51 | 0.06 |
| 0.45 | 1 | 0.59- | 0.09 | 1.34 | -0.73 |
| | 10 | 1.32 | 0.58 | 1.48- | 0.33 |
| | 42 | 0.05 | 0.99 | 0.12 | 0.4 |
| | Mean | 0.65 | 0.49 | 0.98 | - |
| 0.90 | 1 | 0.64 | 0.31 | 0.77 | 0.29 |
| | 10 | 0.37 | 1.98 | 1.31 | 0.29 |
| | 42 | 0.17 | 1.32 | 0.05 | 0.92 |
| | Mean | 0.39 | 1.20 | 0.71 | 0.50 |
| 1.80 | 1 | 1.99- | 0.14 | 1.51 | 0.45 |
| | 10 | 1.84 | 1.41 | 1.68 | 0.82 |
| | 42 | 0.03 | 2.36 | 0.04 | 1.83 |
| | Mean | 1.29 | 1.21 | 1.1 | 1.03 |


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**Table 10:** Correlation between K added and different days of incubation.

| | K added | Day 1 | Day 10 | Day 42 |
|---|---|---|---|---|
| K added | - | 0.657** | 0.603** | 0.865** |

** = significant P < 0.01

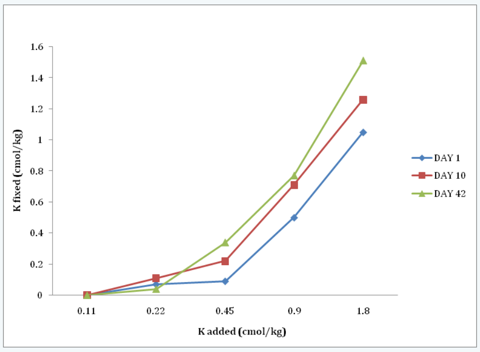


**Figure 2:** Relationship between K added and the amount of K fixed with time in the soils studied averaged over 12 samples (6 locations and 2 depths).

## Summary and Conclusion

The soils varied with respect to their properties but were generally coarse textured, slightly acidic to slightly alkaline and predominantly of low activity clay (ECEC < 15 cmol/kg). Although potassium and sodium levels were below the critical limit in most of the soils investigated, other nutrients (N, P, Organic Carbon, Ca, Mg) were above the critical range, suggesting little or no response to fertilizer application for those nutrients. Mean proportion of potassium (K) fixed ranged from 0.02 cmol/kg in soils from Ikoyi (15-30 cm) to I.72 cmol/kg in soils from Apomu (0-15 cm). Fixation increased with increase in the concentration of added K. There was also a linear relationship between the proportion of K fixed and the amount added at higher incubation periods. Fixation was affected by days of incubation, and best fixation was observed at 42 days of incubation for the varying concentrations of K added. There was significant correlation ($P \leq 0.01$) between K added and K fixed during all the incubation periods.

As revealed by the study, the studied soils of south-western Nigeria have the ability to fix potassium and fixation capacity increased with increasing supply of K as well as days of incubation. Fertilizer recommendation program must therefore take into account this amount that is initially fixed. In general, periodic evaluation of soil K status is necessary for rational K fertilizer management.

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