POTASSIUM STATUS OF MAJOR SOILS OF TANZANIA

JOSEPH D.J. MBOGONI
Agricultural Research Institute Mlingano
P.O. Box 5088, TANGA

Presented at the First National Potash Symposium, Protea Hotel Court Yard,
Dar es salaam, 28-29th July 2015

INTRODUCTION

- **The agriculture sector supports approximately 80% of Tanzanians**
- **It is dominated by smallholder farmers who own farms of between 0.5ha and 3ha.**
- **The smallholder farmers cultivate over 5 million hectares annually and about 85% of the produce account for food crops.**
- **There has been a gradual decrease of land productivity during recent decades.**
- **Research evidence show land degradation in the form of soil erosion and nutrient mining to be one of the causes.**

ITRODUCTION (contd)

- **Nutrient mining is caused by continuous cropping without replenishment of nutrients.**
- **Some of the sustainable approaches for reversing the trend involve promoting the use of improved technologies.**
- **A good soil data bank detailing on soil properties and site characteristics is required for meaningful research on soil management and for transferability of technologies from one area to another.**

ITRODUCTION (contd)

- Nutrient elements are released into the soil following weathering of rocks and minerals.
- The rate of nutrient release depends on the nature of parent materials and other soil forming factors.
- Therefore, levels of nutrients in soils will differ depending on their parent materials and extent of weathering (Trohel and Thompsons, 1993).
- For instance, inorganic P is released after disintegration of the rocks containing apatites (Uriyo et al., 1979).
- On the other hand, disintegration of dolomite, gypsum, calcite, feldspar and amphiboles, apart from other nutrients, contribute significantly to soil calcium (Foth, 1990).
- Sandy soils derived from sandstone consisting mainly of quartz are very deficient in potassium.
- Sandy soils of young volcanic origin may have a high content of available potassium (Boyer, 1972).

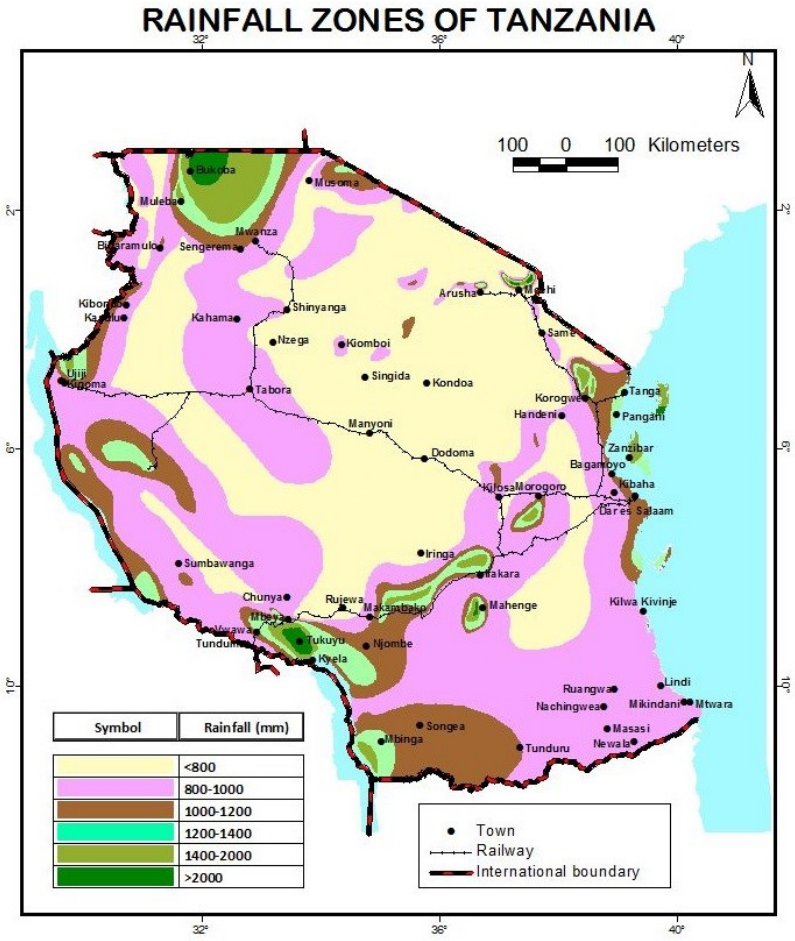
ITRODUCTION (contd)

- Potassium controls plant respiration and the transportation of photosynthesis products.
- Potassium activates several enzymes involved in carbohydrate metabolism.
- Potassium concentrates in the straw of cereal grains, meaning that if the straw is harvested along with the grain, the soil may face a shortage of potassium.
- Deficiency is apparent as slow growth, a poorly developed root system, and a grayish tinge to the plant.
- This paper describes the major soils that occur extensively in Tanzania and discusses the important properties that influence availability of nutrients to plants.

Rainfall in Tanzania

- **Figure 1 present rainfall zones of Tanzania.**
- **There are wide variations in rainfall conditions that are related to the complex topographic setting of the country.**
- **Rainfall for the coastal plain south of Dar es Salaam is lower than for the coastal zone on the northern part.**
- **These complex climatic and physiographic settings, among other factors, have had great influence on the characteristics of soils in Tanzania.**

Figure 1. Rainfall zones of Tanzania



Influence of soil moisture availability

- **Soil moisture status influences potassium availability to plants as potassium is transported to roots by diffusion (Nye, 1972).**
- **In moist soils, the diffusion rate is higher, potassium depletion greater and distance of potassium movement longer than in drier soils (Grimme et al, 1971).**
- **Generally soils of the humid areas have less of available potassium than those in semi-arid areas.**
- **This is caused by more intensive weathering, leaching of nutrients into lower layers, or their complete loss (Pagel, 1972).**
- **In climatically uniform region, the soil potassium status varies according to the composition of the parent material.**

APPROACH

- Base map -The Soils and Physiography of Tanzania at 1:2,000,000 scale (De Pauw, 1983)
- The basic soil bodies for the map are the soil units and physiographic sections
- Legacy data identification and collection
- Data selection
- Database development
- Data harmonization
- Classification of exchangeable potassium levels in soils

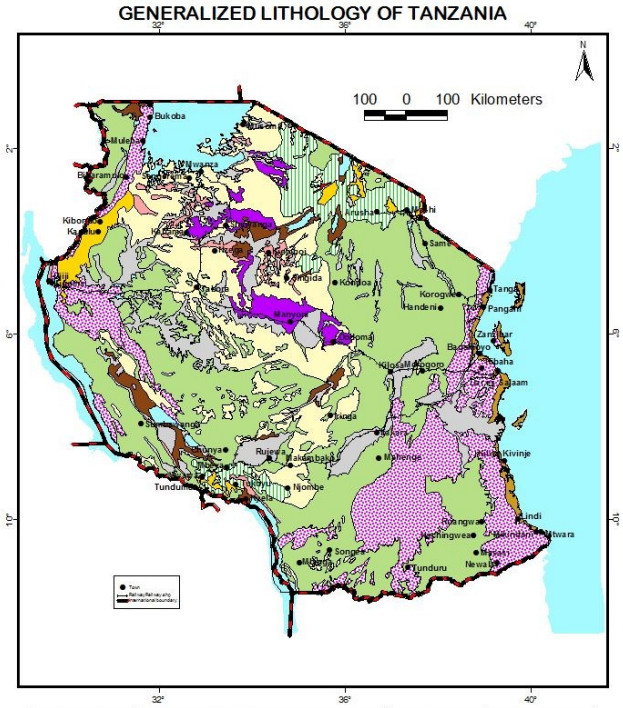
Table 1. Guide for rating K content of soils

cmol/kg	Very low	Low	Medium	High	Very high
K (clayey soils)	<0.20	0.20-0.40	0.41-1.20	1.21-2.00	>2.00
K (loamy soils)	<0.13	0.13-0.25	0.26-0.80	0.81-1.35	>1.35
K (sandy soils)	<0.05	0.05-0.10	0.11-0.40	0.41-0.70	>0.70

Compilation of soil data

- **The soil information of Tanzania has been identified and organized into Physiographic sections.**
- **A physiographic section is an area which all parts are similar in geologic structure and climate at a relatively small scale and which has consequently had a unified geomorphic history, and whose pattern of relief or landforms differ significantly from that of adjacent areas (Neuendorf et al., 2005).**

Figure Lithology of Tanzania

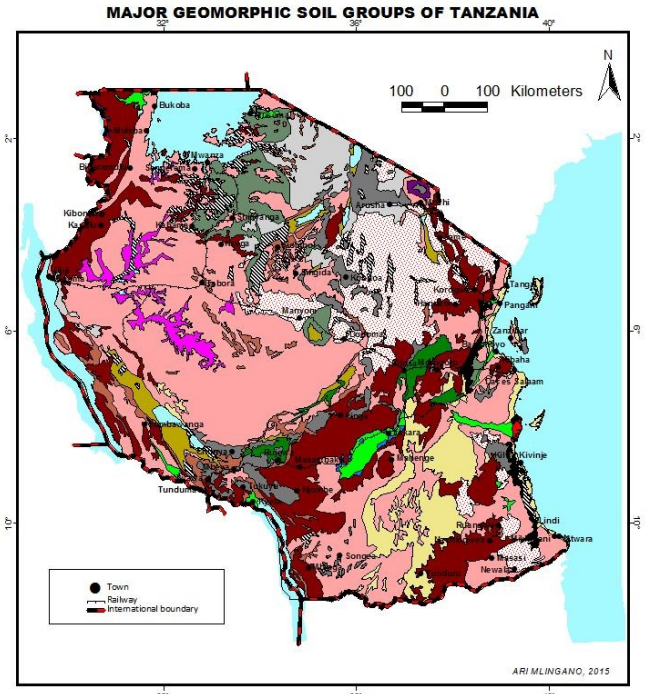


Symbol	Description	Sq_km	Percent
1	Acid igneous	155099.4	16.3
2	Basic igneous	17107.4	1.8
3	Acid metamorphic	365946.8	38.5
4	Basic metamorphic	12706.6	1.3
5	Clastic sediments	138073.8	14.5
6	Organic sediments	9761.4	1.0
7	Unconsolidated colluvium	24240.5	2.5
8	Unconsolidated eolian	232.6	0.0
9	Unconsolidated fluvial	101282.4	10.7
	Unconsolidated lacustrine	19754.9	2.1
11	Unconsolidated marine	396.0	0.0
12	Unconsolidated organic	710.3	0.1
13	Unconsolidated pyroclastic	45749.4	4.8

Table 2. Geormophic soil groups

SYMBOL	DRAINAGE	DRAINAGE	SOIL_DESCR	SQ_KM	PERCENT
111	1	Well to excessive	Slightly bleached soils	39130	4.1
112	1	Well to excessive	Moderately bleached soils	349726	36.8
113	1	Well to excessive	Strongly bleached soils	152479	16.0
121	1	Well to excessive	Immature soils	43400	4.6
122	1	Well to excessive	Paleosols	89326	9.4
211	2	Moderate to poor	Bleached sandy soils	56530	5.9
212	2	Moderate to poor	Dark cracking clays on slopes	5948	0.6
221	2	Moderate to poor	Bleached sands - old basins	1223	0.1
222	2	Moderate to poor	Greyish mottled loams to clays	18568	2.0
223	2	Moderate to poor	Dark cracking clays - depressions	26480	2.8
224	2	Moderate to poor	Hardpan soils	31889	3.4
231	2	Moderate to poor	Young alluvial soils	13754	1.4
232	2	Moderate to poor	Old alluvial soils	11582	1.2
233	2	Moderate to poor	Salt affected soils	17778	1.9
240	2	Moderate to poor	Peats	2062	0.2
250	2	Moderate to poor	Acid sulphate clays	939	0.1

Figure Geomorphic soil groups of Tanzania



Symbol	Drainage	Soil description	Sq_km	Percent
111	Well to excessive	Slightly bleached soils	39130	4.1
112	Well to excessive	Moderately bleached soils	349726	36.8
113	Well to excessive	Strongly bleached soils	152479	16.0
121	Well to excessive	Immature soils	43400	4.6
122	Well to excessive	Paleosols	89326	9.4
211	Moderate to poor	Bleached sandy soils	56530	5.9
221	Moderate to poor	Dark cracking clays on slopes	5948	0.6
222	Moderate to poor	Bleached sands - old basins	1223	0.1
223	Moderate to poor	Greyish mottled loams to clays	18568	2.0
225	Moderate to poor	Dark cracking clays - depressions	26480	2.8
224	Moderate to poor	Hardpan soils	31889	3.4
231	Moderate to poor	Young alluvial soils	13754	1.4
232	Moderate to poor	Old alluvial soils	11582	1.2
233	Moderate to poor	Salt affected soils	17778	1.9
240	Moderate to poor	Peats	2062	0.2
250	Moderate to poor	Acid sulphate clays	939	0.1

1 WELL DRAINED SOILS

- **1.1 Well drained zonal soils**
- **1.1.1 Slightly leached soils**
  - **Phaeozems**
  - **Chernozems**
  - **Solonetz**
  - **Solonchaks**

Phaeozems (PH) (22190.10 km^2; 2.34%)

- **Occurrence: Kilimanjaro, Mara, Arusha, Manyara, Dodoma, Shinyanga and Morogoro regions.**
- **Shallow to deep, dark brown, dark grey sandy loams, loams, silty loams and clay loams, weak to moderate structure, may be calcareous, moderate to high natural fertility, developed on volcanic ash.**
- **Current use: Cultivation of maize, beans, coffee, vegetables.**
- **Susceptible to erosion, salinity and sodicity especially with irrigation without adequate drainage.**

Solonetz (SN) (19626.46 km^2; 2.07%)

- **Occurrence: Mara, Arusha, Kilimanjaro, Singida, Dodoma, Iringa, Mbeya and Rukwa regions.**
- **Deep, dark brown or black clay loams and clays, with prismatic or columnar structure, poor natural fertility due to sodicity and subsoil salinity, developed on volcanic ash.**
- **Current use: Extensive grazing, some horticulture.**

1 WELL DRAINED SOILS (contd)

- **1.1.2 Moderately leached soils**
  - **Nitisols**
  - **Cambisols**
  - **Luvisols**

Nitisols (NT) (21001.11 km^2; 2.22%)

- **Occurrence: Mbeya, Iringa, Manyara, Kilimanjaro and Mara regions and some parts of Usambara mountains .**
- **Deep, dark reddish brown, reddish friable or firm clays with diffuse horizon boundaries and a subsurface horizon with more than 30% clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric (nutty) elements, developed on volcanic ash and lava, have high organic matter content and high natural fertility, susceptible to slope induced erosion.**
- **Current use: Plantation crops such as tea, coffee, rubber and pineapple, and are also widely used for food crop production on smallholdings.**

Cambisols (CM) (337,353.69 km^2; 35.64%)

- **Occurrence: The most extensive soils in the country, occur mainly in the semi- humid mid-western and south-eastern parts of the country.**
- **Moderately deep to deep, red, yellowish red, black and very dark grey sands, loamy sands and sandy loams, very weak structure , very low natural fertility status, moderate risk of erosion, have tendency to form surface sealing, may be underlain by ironstone, developed on sediments, granites and acid gneisses. (Ferralic and Rhodic Cambisols).**
- **Current use: Planted to a variety of annual and perennial crops or are used as grazing land.**

Luvisols (LV) (68706.15 km^2; 7.26%)

- **Occurrence: Important soils in Morogoro, Dodoma, Arusha, Manyara, Kilimanjaro, Tanga and Ruvuma regions.**
- **Moderately deep to deep, dark red to red sandy clay loams to clays, moderate to strong structure, subsoils are yellowish red and red clays with clay skins and clay balls, have moderate natural fertility.**
- **Parent materials: A wide variety of unconsolidated materials, calcareous materials, intermediate metamorphic rocks, etc.**
- **Current use: Luvisols are fertile soils and suitable for a wide range of agricultural uses.**

1 WELL DRAINED SOILS (contd)

- **1.1.3 Strongly leached soils**
  - **Acrisols**
  - **Ferralsols**
  - **Lixisols**

Acrisols (AC) (81642.50 km^2; 8.63%)

- **Occurrence: Acrisols are the second most extensive soils in the country and occur in Mara, Tabora, Singida, Dodoma, Tanga, Kilimanjaro, Morogoro, Iringa, Mbeya, Ruvuma, Lindi and Mtwara regions.**
- **Moderately deep to deep, dark reddish brown, brown, reddish, sandy loam, sandy clay loam, sandy clay topsoils on reddish or yellowish sandy clay loam and sandy clay with accumulation of low activity clays and low base saturation.**
- **Current use: Shifting cultivation of annuals, pineapple, cashew, rubber, oil palm.**

Ferralsols (FR) (59852.62 km^2; 6.32%)

- **Occurrence: Ferralsols are scattered throughout the country but occur mainly in Kigoma, Rukwa, Mbeya, Morogoro, Tanga, Kilimanjaro, Dar es Salaam and Mtwara regions.**
- **Moderately deep to very deep, brown, or reddish strongly weathered red ferralitic clays with kaolinite and (hydr)oxides of iron and aluminium, have diffuse horizon boundaries, in some areas subsoils have gravely (stoneline) layers with 40-60 % quartz gravel, low to very low natural fertility, very strong subsoil acidity, moderate organic matter, (very) low K content, developed on intermediate metamorphic rocks.**
- **Current use: Sedentary subsistence farming and shifting cultivation with a variety of annual and perennial crops, low volume grazing, fruit trees, large scale sisal.**

Lixisols (LX) (46888.61 km^2; 4.95%)

- **Occurrence: Important soils in Iringa, Mbeya, Ruvuma, Lindi and Mtwara regions.**
- **Deep to very deep, red, yellowish red, strongly weathered sandy clay loams and clays in which clay has washed out of an eluvial horizon down to an *argic* subsurface horizon that has low activity clays and a moderate to high base saturation level.**
- **Current use: Low volume grazing, perennial crops, woodlots (Pine, Cyprus, Eucalyptus, etc).**

1 WELL DRAINED SOILS (contd)

- **1.2 Well drained azonal soils**
- **1.2.1 Immature soils**
  - **Leptosols**
  - **Regosols**
  - **Andosols**

Leptosols (LP) (76,738.02 km²; 8.11%)

- **Occurrence: The third largest soils in terms of coverage in the country and are mostly associated with mountainous landscapes and steep terrains in Kagera, Arusha, Singida, Dodoma, Mbeya, Rukwa, Iringa and Lindi regions.**
- **Very shallow, excessively drained, rocky and stony, in some areas with pockets of moderately deep, sandy loam, sandy clay loam and clay loam topsoils, the major constraints are rockiness, stoniness and the very high risk of erosion.**

- **Current use: Extensive grazing , stone quarrying, forestry and nature conservation.**

Andosols (AN) (15904.46 km^2; 1.68%)

- **Occurrence: Andosols occur in Arusha, Mara and Mbeya regions.**
- **Deep, well drained, dark grey or brown loamy sands, sandy loams and loams rich in allophanic clays with weak structure, low bulk density, very low natural fertility, developed on volcanic ash and pumice .**

- **Current use: Planted to a wide variety of crops including sugarcane, tobacco, sweet potato (tolerant of low phosphate levels), tea, vegetables, wheat and orchard crops. Paddy rice cultivation is a major landuse on Andosols in lowlands with shallow groundwater.**

2 POORLY DRAINED SOILS

- **2.1 Soils without prolonged water logging**
- **2.1.1 Bleached sandy soils**
- **2.1.2 Dark cracking clays on slopes**

- **2.2 Soils with ponded drainage**
- **2.2.1 Bleached sandy soils**
- **2.2.2 Greyish mottled clays (Gleysols)**
- **2.2.3 Dark cracking clays of topographical depressions**
- **2.2.4 Planosols (PL)**

Vertisols (VR) (47497.85 km^2; 5.02%)

- **Occurrence: Mwanza, Shinyanga, Mara, Tabora, Kigoma, Coast and Lindi regions.**
- **Shallow to deep, moderately well to imperfectly drained, black, dark grey or brown calcareous cracking clays with a high proportion of swelling 2:1 lattice clays, often overlying paler subsoil with ephemeral structure and high natural fertility, soil depth is restricted by impervious and sodic subsoil.**
- **Current use: Cultivation of rice, maize, cotton, sugarcane and vegetables.**

Gleysols (GL) (1486.19 km^2; 0.16%)

- **Occurrence: Scattered.**
- **Deep, imperfectly to poorly drained, non-calcareous, gray or brown friable sandy loams to sandy clays with strongly mottled and compact subsoils, moderately leached, moderate natural fertility.**
- **Current use: Horticulture, grazing.**

2 POORLY DRAINED SOILS (contd)

- **2.3 Soils with variable drainage and flooding conditions**
  - **2.3.1 Young alluvial soils**
  - **2.3.2 Old alluvial soils**
  - **2.3.3 Salt affected soils**

- **2.4 Peats**
- **2.5 Acid sulphate soils**

Fluvisols (FL) (26223.13 km^2; 2.77%)

- **Occurrence: Important river plains such as the Rufiji basin, Ruaha basin, Ruvu basin, Kilombero basin and Wami basin.**
- **Deep, moderately well, imperfectly to poorly drained, almost pure bleached sands, brownish fine sands to sandy clay loams with high texture variability over short distances, highly stratified, high natural fertility, high content of weatherable minerals.**
- **Current use: Cultivation of rice, maize, sugarcane, vegetables, fruit trees.**

Histosols (HS) or Peats (3791.45 km^2; 0.40%)

- They occur in Kigoma, Shinyanga, Kagera and Kilimanjaro regions.
- They are confined to poorly drained basins, depressions, swamps and marshlands with shallow groundwater, and highland areas with a high precipitation/evapotranspiration ratio.
- Developed in incompletely decomposed plant remains, with or without admixtures of sand, silt or clay.
- Current use: farmers struggling to drain, lime and fertilize to ensure satisfactory crop growth of annuals and vegetables.

Figure Potassium levels in summits and upper slope positions

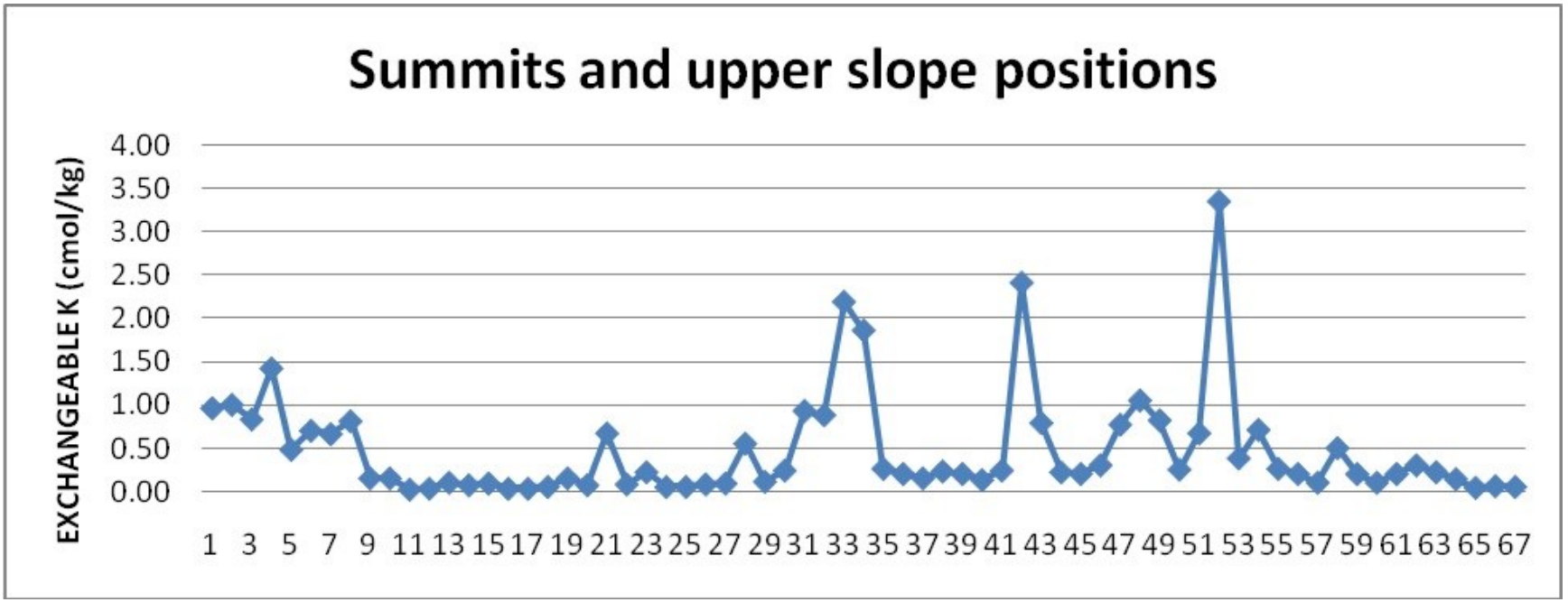


Figure Potassium levels in lower slope positions

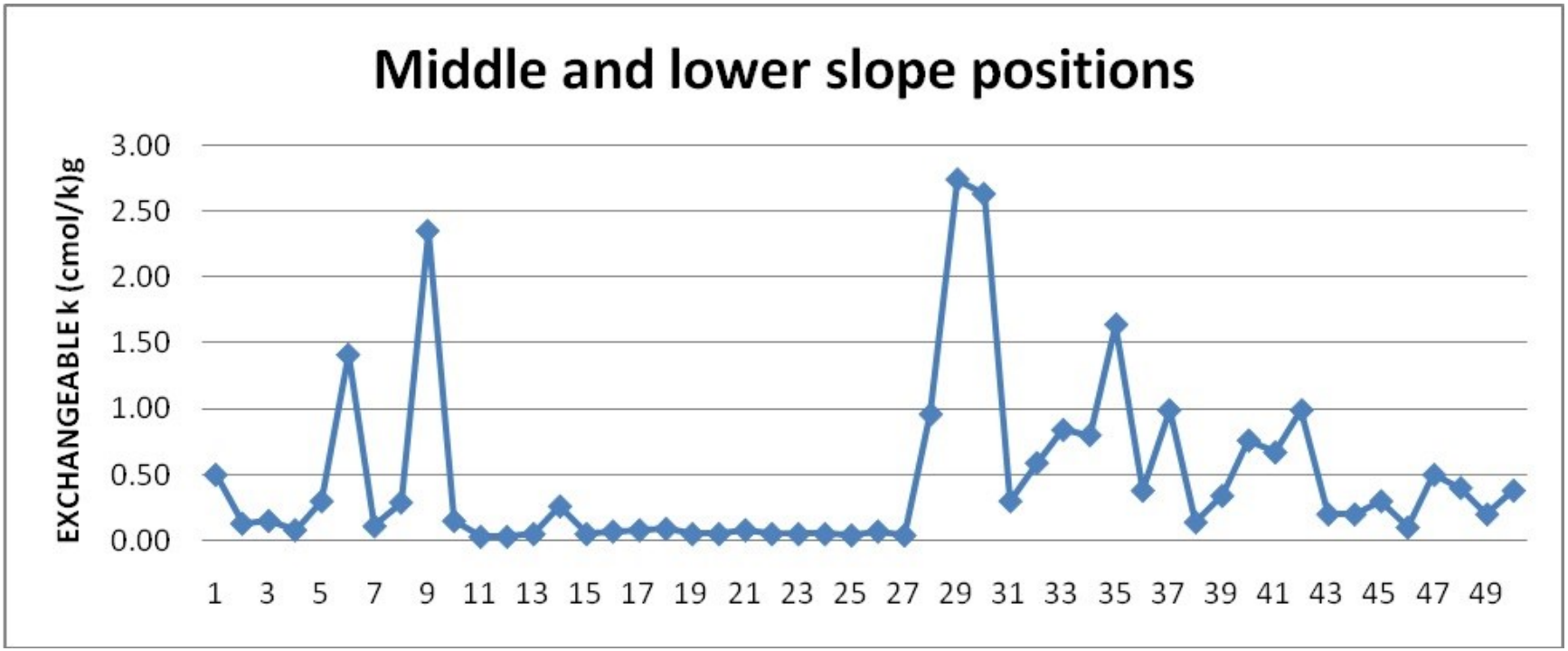
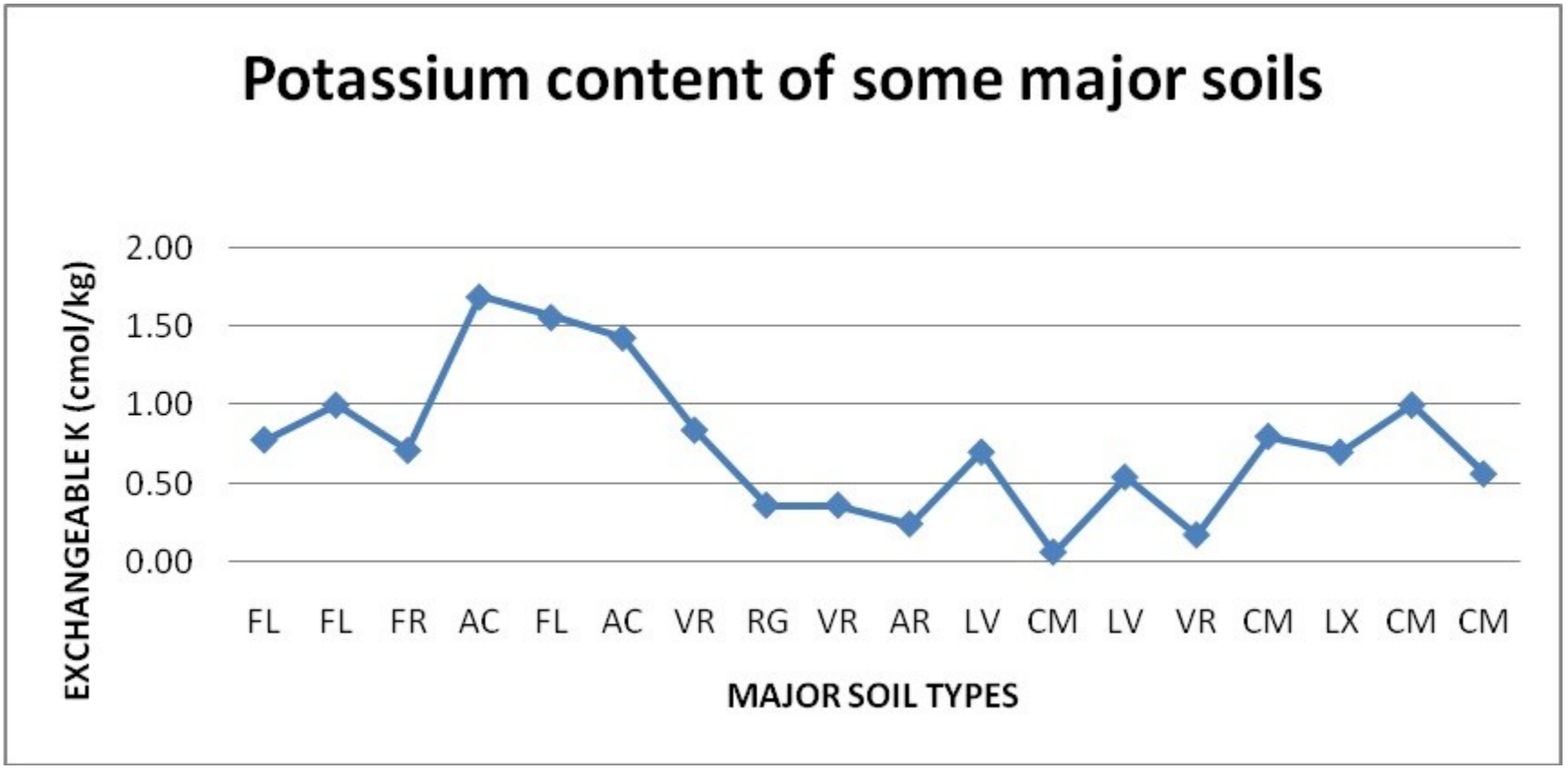


Figure potassium in major soils



Discussion

- **The nature and amount of nutrients released into soils depends on the nature of parent materials and other soil forming factors.**
- **Natural processes are in balance between nutrient release into soils and depletion.**
- **Human activities accelerate depletion of nutrients from soils.**
- **Nutrient mining is accelerating loss of nutrients from soils.**
- **Imbalanced fertilization is steering nutrient imbalance.**
- **This is why potassium has become deficient in many soils.**

Challenges

- **Inadequate soils information for assessing the potassium status of soils.**
- **The available soils information was generated from tailor-made soil mapping or soil sampling activities, with different sampling intensities.**
- **The available soils information is not harmonized in terms of units of measurement, sampling standards, soil classification, etc.**
- **The represented soils may not be on the ground at present due to soil erosion.**

CONCLUSIONS

- **Research on potassium status of soils in Tanzania has to be undertaken**
- **Research on balanced nutrition of plants including potassium has to be launched.**

THANK YOU FOR LISTENING