# Levels of Macronutrients of Leaves of Selected Plants from Highlands East of Mount Kenya

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## Abstract

*Fast growth in population has led to small scale farming as a result of land sub-division. The small pieces of land are under cultivation throughout which has led to reduction in soil fertility. The use of commercial inorganic fertilizers in these small pieces of land tends to be the ultimate solution in maintaining high yields. Too much use of inorganic fertilizers has led to low amount of organic matter in soil and low soil pH which leads to low rate of decomposition of the little organic matter present. Also, poor peasant farmers do not afford the inorganic fertilizers and do not know which plants have leaves that have high levels of macronutrients which can improve soil fertility so that their farm produce can be high. This study was aimed at investigating levels of macronutrients in leaves of selected plant found on highlands east of Mount Kenya. The percentage of the macronutrients on the leaves ranged from 0.037 to 1.605 for nitrogen, 0.152 to 0.792 for phosphorous, 0.044 to 1.331 for potassium, 0.354 to 2.034 for calcium, 0.073 to 0.977 for magnesium and 0.883 to 1.153 for sulphur. It was found that species of plants such as Helianthus annus (sunflower), Markhamia lutea (muu), Cordial africana (muringa), Croton macrostachyus (mutuntu) and Tithonia diversifolia (mexican sunflower) from the species studied contains leaves with high percentages of macronutrients. It is recommended that these plants be planted by farmers so that their leaves may be used to make compost manure, make bedding materials for animals (which results to farm yard manure) and/or simply be spread in farms which will improve soil fertility.*

**Key words:** Inorganic fertilizers, organic fertilizers, macronutrients

## *1. Introduction*

A few decades ago, Kenyan farmers practiced shifting cultivation. This is where a certain piece of land was left fallow for several seasons to regain fertility so cultivation was done when the piece of land was fertile. There was no need of applying fertilizers since pieces of land were big relative to the population. These days, the available pieces of land have been sub-divided to many smaller pieces and are under cultivation throughout. To ensure that the land pieces produce high yield, fertilizers are applied.

There are two types of fertilizers: inorganic and organic. Inorganic fertilizers are applied to farms in the form that can be absorbed quickly if water is present. However, they are expensive and increase soil acidity. Organic manure does not make the land to regain fertility very fast so the crops response to its application may not be as fast as when inorganic fertilizers are applied.

There are thirteen essential minerals to plants. Six of these are referred to as macronutrients because they are required in relatively higher quantities than others. These are nitrogen, phosphorous, sulphur, potassium, calcium and magnesium (Muchukuri *et*, *al*., 2004). Nitrogen, phosphorous and potassium are referred to as major macronutrients and are applied as fertilizer for almost all crops on most soils.

Nitrogen is an important component of chlorophyll and is associated with high photosynthetic activity, vigorous vegetative growth and dark green colour. Lack of nitrogen is the most common cause of nutritional stress (Groot *et. al*., 1991) Lack of nitrogen leads to yellowish-green foliage (chlorosis). "Firing" or dying of the lower leaves is also observed. For most plants, the nitrate ion is the primary source of nitrogen (Marschner, 1986).

Phosphorous most essential function is energy storage and transfer. It is also necessary for all cell division, growth of root and short tissues and developing seed and kernels of grain. Lack of phosphorous lead to stunted growth, slow emergence and slow growth, petioles have purple colour, poor root development, less fruits and plant look spindly or stunted (Jungi *et. al*., 2005; Lampkin, 1990).

Potassium is associated with protein activity primarily in maintenance of positive ion balance to satisfy negative ion charges on the protein. It is also required in enzyme activations, provides osmotic regulation, regulate stomatal opening, production of high energy phosphate molecules. Lack of it leads to shortening of internodes, dwarfing, loss of green colour, marginal discolouration, premature death of older leaves, small size and quantity of fruits and developing of white spots on leaves (Ryoung *et. al*., 2006).

Magnesium is the only metallic constituent of chlorophyll molecule. It is an activator and component of many plant enzymes. It is a structural component of ribosomes, stabilizing them in the configuration necessary for protein synthesis. It is also required for maximal activity of almost every phosphate reactive groups (Muchukuri *et, al*., 2004).Lack of it leads to regular yellowish-white stripes on leaves and leaf curling in some plants (Ding *et. al*., 2006).

Calcium is a constituent part of cell walls and affects permeability of protoplasmic membranes that surrounds each living cell. It controls uptake of water by cell colloids, enhances nitrate-nitrogen uptake, is essential for cell elongation and division. However excess calcium may restrict trace element availability and should be avoided (Lampkin, 1990). Lack of it leads to failure of terminal buds to shoot and tips of roots to develop which causes plant growth to cease. Lack of it may also lead to tip ends of leaves to be glued together, root rotting, spotted and/or necrotic areas of on the leaves, die back to terminal buds, low fruit weight and low dry matter (Lampkin, 1990). Sulphur is required for synthesis of sulphur containing amino acids, cystine, cystein and methionine which are essential components of proteins. It is a component of S-containing substances like S-adenosylmethionine, formylmethionine, lipoic acid and sulfolipid. It is also required in synthesis of chlorophyll though not a constituent (Young, 1976). Lack of it leads to pronounced retardation and leads to diseases susceptibility (Dubius *et. al*., 2005).

When organic matter is added to soil it undergoes decomposition. The breakdown of complex organic structures leads to the formation of a variety of more simple inorganic products, process known as mineralization (Coleman, 1989; Ellis & Mellor, 1985). Plants take up nutrients primarily in the form of electrically charged ions ($NO_3^-$, $H_2PO_4^-$, $K^+$, $Mg^{2+}$, $Ca^{2+}$) (Dahlin *et. al*., 2005). The organic manures are important primarily because of their organic content. All soils require the supply of organic matter as a carrier of utilizable energy and nutrients for the soil organisms, as well as many other reasons (Muchukuri *et. al*., 2004, Cooke, 1982). Organic manure used in farms is mainly made of decayed plants. The quality of manure depends on the type of plants used to make it so there is need to find plants that would be suitable to provide high quality organic manure. There was need to investigate plants found in Kenya to find which have leaves that would be used to make high quality organic manure which would be used as alternative to inorganic fertilizers.

## *2. Problem Statement and Justification*

Continued application of inorganic fertilizers in farms is expensive, lead to increased soil acidity and also lead low organic matter in soil. If plants with leaves that have high content macronutrients are identified, they can be planted by farmers who would use leaves from these plants to make organic manure to use in their farms which would lead to increased yield.

## *3. Objective*

The objective of this study was to determine the levels of macronutrients in leaves of selected plants from highlands east of Mount Kenya

## *4. Materials and methods*

The samples were collected from Meru South and Maara districts of Eastern Province in Kenya. Plants that are found in most farms were identified and classified as either exotic (E), local indigenous (L) or fodder &fruit trees (F). The plants are given in Table 1.

**Table 1: Species of Plants Sampled**

| Symbol | Scientific name | English name | Local name (Chuka name) |
|---|---|---|---|
| E1 | *Pinus patula* Schleditendal & Chamisso | Mexican weeping pine | - |
| E2 | *Casuarina equisetifolia* L. | Sea pine/whistling pine | - |
| E3 | *Cassia spectabilis* DC | Cassia | *Mubangua mweru* |
| E4 | *Grevillea robusta* A. Cum | Silky oak | *Mukima* |
| E5 | *Cupressus lusitanica* Mill | Mexican cypress | *Mutarakwe* |
| E6 | *Eucalyptus saligna* Sm | Sydney blue gum | *Mubau maguta* |
| E7 | *Jacaranda mimosifolia* D. Don | Jacaranda | *Mucakaranda* |
| F1 | *Macadamia tetraphylla* L.A.S Johnson | Macandamia nut | *Mukandania* |
| F2 | *Mangifera indica* L | Mango | *Mwembe* |
| F3 | *Persea americana* Miller | Avocado | *Mukondobia* |
| F4 | *Manihot esculenta* Ccrankz | Cassava | *Mwanga* |
| F5 | *Musa sapientum* L | Banana | *Irigu* |
| F6 | *Cajanus cajan* (L) Mill sp | Pigeon pea | *Ncugu* |
| F7 | *Carica papaya* L | Paw paw | *Mubabai* |
| F8 | *Helianthus annus* L | Sunflower | *Mbembe cia nguku* |
| F9 | *Pennisetum purpureum* Schumach | Napier grass | *Muthara* |
| L1 | *Newtonia buchananii* (Bak) Gilb & Bont | - | *Mukui* |
| L2 | *Bridelia micrantha* (Hochst) Baill | - | *Mukwego* |
| L3 | *Markhamia lutea* (Benth) K. Schum | - | *Muu* |
| L4 | *Cordia africana* Lam | - | *Muringa* |
| L5 | *Croton macrostachyus* Del | - | *Mutuntu* |
| L6 | *Vitex keniensis* Turril | Meru Oak | *Muburu* |
| L7 | *Sapium ellipticum* (Krauss) pax | - | *Muthatha* |
| L8 | *Albizia gummifera* (JFGel) C.A. Sm | Peacock flower | *Mukorwe* |
| L9 | *Tithonia diversifolia* (Hernst) A. Gray | Mexican sunflower | *Mugana/araka* |
| L10 | *Lantana camara* L | Lantan (Tick berry) | *Mucimoro* |
| L11 | *Rauvolfia caffra* Sond | - | *Muthuba* |

Samples were collected in the month of August and September. Yellowing leaves and those that had just fallen were picked, sun dried and later washed then dried. Some leaves were ground to fine powder which was later digested for analysis to determine the percentage of nitrogen, phosphorous, potassium, calcium, magnesium and sulphur.

The stock solutions of different elements were prepared in advance from which standard solutions were prepared just before analysis by serial dilution. Atomic absorption spectrometry was used to determine concentration of magnesium and calcium in wet-digest. Flame photometry was used to determine concentration of potassium and UV/visible spectrophotometry was used to determine concentration of nitrate-N, sulphate–S and phosphate–P.

## 5. Results and Discussion

The levels of macronutrients were determined by UV/visible spectrometry for nitrogen, phosphorus and sulphur, AAS for calcium and magnesium and flame photometry for potassium. The results of mean percentages of the macronutrients based on dry weight are given in Table 2.

**Table 2: Percentage of Macronutrients in Leaves (n=3)**

| Sample | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|
| E1 | 0.237+0.001 | 0.683±0.003 | 0.044±0.002 | 0.495±0.004 | 0.208±0.003 | 1.139±0.001 |
| E2 | 0.615+0.004 | 0.438±0.438 | 0.151±0.004 | 1.981±0.001 | 0.242±0.004 | 0.944±0.004 |
| E3 | 1.125±0.002 | 0.426±0.004 | 0.312±0.003 | 0.939±0.004 | 0.160±0.001 | 1.060±0.004 |
| E4 | 0.870±0.001 | 0.607±0.004 | 0.258±0.001 | 0.905±0.002 | 0.093±0.002 | 1.153±0.003 |
| E5 | 0.702±0.004 | 0.650±0.001 | 0.419±0.004 | 0.872±0.004 | 0.147±0.004 | 0.986±0.001 |
| E6 | 0.622±0.001 | 0.571±0.001 | 0.151±0.003 | 1.786±0.001 | 0.170±0.001 | 1.079±0.004 |
| E7 | 1.463±0.003 | 0.474±0.004 | 0.580±0.004 | 0.421±0.004 | 0.190±0.004 | 1.023±0.001 |
| F1 | 0.284±0.001 | 0.696±0.002 | 0.151±0.002 | 0.475±0.002 | 0.073±0.003 | 0.967±0.004 |
| F2 | 0.703±0.001 | 0.603±0.004 | 0.097±0.004 | 0.905±0.004 | 0.244±0.002 | 1.032±0.003 |
| F3 | 0.562±0.002 | 0.677±0.001 | 0.097±0.004 | 0.885±0.001 | 0.471±0.004 | 1.102±0.001 |
| F4 | 1.591±0.004 | 0.152±0.004 | 0.365±0.002 | 1.228±0.004 | 0.300±0.002 | 1.186±0.004 |
| F5 | 0.048±0.002 | 0.383±0.002 | 0.044±0.004 | 0.643±0.004 | 0.231±0.004 | 0.907±0.004 |
| F6 | 0.524±0.004 | 0.762±0.004 | 0.044±0.001 | 0.684±0.002 | 0.252±0.001 | 1.018±0.002 |
| F7 | 0.969±0.003 | 0.598±0.001 | 0.634±0.004 | 1.571±0.001 | 0.977±0.004 | 1.060±0.004 |
| F8 | 0.617±0.001 | 0.497±0.004 | 0.902±0.003 | 2.034±0.003 | 0.744±0.003 | 0.991±0.001 |
| F9 | 0.321±0.002 | 0.355±0.001 | 0.526±0.003 | 0.112±0.002 | 0.247±0.004 | 1.000±0.003 |
| L1 | 1.018±0.001 | 0.564±0.002 | 0.205±0.004 | 0.354±0.004 | 0.127±0.001 | 0.981±0.004 |
| L2 | 0.151±0.003 | 0.493±0.003 | 0.205±0.001 | 0.986±0.002 | 0.310±0.003 | 1.004±0.002 |
| L3 | 0.867±0.004 | 0.677±0.004 | 0.687±0.004 | 0.838±0.004 | 0.249±0.004 | 0.809±0.004 |
| L4 | 0.859±0.001 | 0.546±0.004 | 0.995±0.002 | 0.845±0.001 | 0.265±0.004 | 0.976±0.001 |
| L5 | 0.831±0.004 | 0.623±0.002 | 0.151±0.003 | 1.429±0.004 | 0.622±0.002 | 0.907±0.004 |
| L6 | 0.999±0.001 | 0.749±0.004 | 0.205±0.001 | 1.288±0.002 | 0.561±0.004 | 0.986±0.002 |
| L7 | 0.037±0.004 | 0.472±0.003 | 0.312±0.004 | 0.704±0.004 | 0.257±0.003 | 0.944±0.004 |
| L8 | 1.331±0.002 | 0.533±0.001 | 0.634±0.002 | 0.354±0.001 | 0.321±0.003 | 1.097±0.001 |
| L9 | 1.119±0.003 | 0.527±0.003 | 0.526±0.004 | 2.095±0.004 | 0.515±0.004 | 0.911±0.002 |
| L10 | 1.605±0.004 | 0.792±0.002 | 0.526±0.003 | 0.502±0.004 | 0.390±0.003 | 0.883±0.004 |
| L11 | 0.640±0.001 | 0.603±0.004 | 1.331±0.001 | 1.416±0.003 | 0.433±0.002 | 1.097±0.004 |
| $\bar{X}$ | 0.767±0.437 | 0.561±0.140 | 0.389±0.320 | 0.991±0.548 | 0.356±0.209 | 1.009±0.089 |

The nitrogen content was in the range of 0.037% to 1.605% with a mean percentage content of 0.767±0.437. This shows that different species of leaves have different levels of nitrogen. Cassia (E3), jacaranda (E7), cassava (F4), *Newtonian buchananii* (L1), peacock flower (L8), mexican sunflower (L9) and lantan (L10) had a percentage above 1. This study agrees with what is reported by Monicah (2003) that mexican sunflower nitrogen content is high and comparable to that found in nitrogen – fixing leguminous shrubs and trees.

The phosphorus percentage ranged from 0.152 to 0.792 with lantan (L10) having the highest percentage and cassava (F4) the lowest. The mean percentage of phosphorus was 0.561± 0.140. Percentage of potassium was found to range from 0.044 to 1.331 with a mean value of 0.389± 0.320. The highest value of potassium was found in *Rauvolfia caffra* (L11) while the lowest value in mexican weeping pine (E1), banana (F5) and pigeon pea (F6).

The percentage content of calcium was found to range from 0.112 to 2.034 with a mean of 0.991 ± 0.548. Sunflower ( F8) had the highest percentage of calcium and napier grass (F9) had the least. The range of magnesium percentage was 0.127 to 0.997 with a mean of 0.356±0.209. The highest percentage of magnesium was found in pawpaw (F7) and the lowest in *Newtonia buchananii* (L1).

The range of sulphur percentage was found to range from 0.809% to 1.186% with a mean of 1.009±0.089. Cassava (F4) had the highest sulphur content while *Markhamia lutea (*L3) had the lowest.

The levels of sulphur in this study was found to be very close for all species (approximately equal to 1%) which concurs with the findings of Murungi (1990) who found that different species had almost equal levels of sulphur.

The levels of nitrogen, phosphorus and potassium were found to agree closely with those of Lawrence (1975) who reported percentage values of nitrogen ranging from 0.53 to 4.15, phosphates from 0.10 to 1.50, potash from 0.10 to 2.70 from various plants. Lal (1995) and Njoroge (1999) also reported values close to those found in the study. The slightly higher levels of mexican sunflower (3.6 % N, 0.3 % P and 4.3 % K) reported by Gichuru *et al.*, (2003) and those reported by Jama *et. al.* (1999) was due to the fact that they reported levels in dry matter of plants whereas this study worked with fallen and yellowing leaves only.

From this study jacaranda (E7), cassava (F4), pawpaw (F7), sunflower (F8), *Markhamia lutea* (L3), *Cordia africana* (L4), peacock flower(L8), mexican sunflower (L9), lantan (L10) and *Rauvolfia caffra* (L11) are good for making bedding material in cowsheds resulting in organic manure because they have high total percentage of major macronutrients (N, P, K above 2%). These species also may be used for the same purpose because they contain total levels of macronutrients which is high that is above 4 %.

However, mexican weeping pine (E1), macadamia (F1), banana (F5), napier grass (F9) and *Sapium ellipticum* (L7) have low levels of macronutrients and are not therefore suitable for making organic manure.

## 6. Conclusions

This study found out that different species of plants produce leaves with different percentages of macronutrients. The plant species which have high percentage of macronutrients are; *Jacaranda mimosifolia* (jacaranda), *Manihot esculenta* (cassava), *Carica papaya* (paw paw), *Helianthus annus* (sunflower), *Markhamia lutea* (muu), *Cordia africana* (muringa), *Croton macrostachyus* (mutuntu), *Tithonia diversifolia* (mexican sunflower) and *Rauvolfia caffra* (muthuba). These species of plants are therefore appropriate for planting by farmers so that their leaves can be used to improve soil fertility.

## 7. Recommendations

Since the cost of inorganic fertilizers is high and the inorganic fertilizers increase acidity of the soil, farmers are advised to plant the species of plant that produce leaves which have high percentage of macronutrients. The farmers will then be using leaves from these plants as bedding materials of animals, spreading them in farms or even making compost manure. This will reduce the farming input and so farmers will have higher returns of their labour.

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