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Potential of Potassium Supply in Locally Available Soil Amendments for Use in Coconut Plantations

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ABSTRACT

Potassium (K) is an essential macro nutrient which plays a vital role in crop growth and development. Most of the tropical soils are having low level of potassium and crops grown on these soils are heavily dependent on mineral fertilizers for the supply of potassium. Organic growers are in need of locally available natural source of potassium as they have restrictions on use of synthetic fertilizers. A pot experiment was conducted on sandy regosol to investigate the potassium supplying ability to soil from locally available potassium containing materials. The treatments were, T1-Control (no amendments added), ground mica (T2), feldspar (T3), coconut husk ash (T4), *Tithonia diversifolia* (T5), muriate of potash (T6) for comparison. Materials were analyzed for nutrient content and applied at the rate equivalent to recommended K level for adult coconut palm. Soil samples were extracted from each pot at one-month interval for analysis. Results show that higher exchangeable K level has been maintained (1.5-3.8 meq/100g soil) by T4 during the experimental period while T1, T2, T3 and T6 had significantly lower (<0.05 meq/100g soil) exchangeable K. In addition, T4 has increased soil pH towards neutral level and higher exchangeable Mg and available P. Treatments T5 and T4 also showed significantly higher exchangeable K than T1, T2 and T3. The results indicate that coconut husk ash and *Tithonia diversifolia* have a greater potential to be used as a source of potassium with additional advantage of enhanced availability of other nutrients.

Keywords: Organic cultivation, Soil nutrient availability, Soil potassium

INTRODUCTION

Potassium is a major plant nutrient taken up by plants through roots from soil. As potassium is associated with many functions in plants like transportation of nutrients, carbohydrates and water, if potassium is not adequately supplied, plant growth get retarded (Oosterhuis *et. al*, 2013; Wakeel, 2013). A larger area of agricultural lands around the world is deficient in potassium (Rengel and Damon, 2008). The supply of K from the soil is often insufficient to meet the demand in many agricultural systems (White, 2013). Therefore, most of the cropping systems on highly weathered soils, especially in tropics, are heavily depend on mineral fertilizers for supply of potassium. Such soils commonly occur in developing countries (Manning, 2010).

Furthermore, in organic cultivation systems, application of synthetic fertilizers is not allowed. Animal manure and compost made from plant residues and animal waste consist of considerable amounts of nitrogen and phosphorus, however low amount of potassium. Therefore, growers are in need

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of alternative sources of potassium for these systems. This is common among coconut (*Cocos nusifera*) growers as coconut is a high potassium demanding crop. Nuts and husk of coconut contain higher amount of potassium than other parts and in general, harvested nuts are taken away from the field for processing or consumption. Therefore, there is a continuous flow of potassium moving out from the plantation making coconut growing soils low in potassium. Moreover, the present high cost of conventional potassium fertilizers further justifies investigation of alternative potassium sources.

Mica and Feldspar are considered as a naturally occurring mineral sources of K. The lower solubility of K from these materials limits their use (Cooray *et.al.,* 1992). Some plant materials such as *Tithonia diversifolia* are considered to be rich in K. *Tithonia diversifolia* is a species of flowering plant in the Asteraceae family that is commonly known as wild sunflower, tree marigold or Mexican sunflower. In some large-scale coconut plantations growers tend to plant them. *Tithonia diversifolia* has shown great potential in raising the soil fertility in soils depleted in nutrients (Jama *et al*., 2000). This plant grows wildly in some areas of Sri Lanka and considers as a weed.

Coconut husk is another source of potassium and it is recommended to apply the mature husk back into coconut fields for moisture conservation and as a nutrient source. However, most of the growers are reluctant to apply them to the field due to various reasons.

Therefore, the objective of this study was to evaluate potassium supplying potential of locally available soil amendments to be used in coconut plantations. Commonly use K fertilizer source, Muriate of Potash (MOP) was used as a treatment for comparison purpose. This study further evaluates the changes in soil pH and the availability of other nutrients as a result of applying the same soil amendments.

MATERIALS AND METHODS

Experimental Location and Soil Type

This research study was conducted as a pot experiment under a greenhouse condition using a common coconut growing Sandy Regosol (USDA: Aquic Quartzipsamments, uncoated sandy, non calcarious; FAO: Orthridystric Regosols). Soil samples were collected from 5-20cm depth of a matured coconut plantation in the Intermediate Zone of Sri Lanka. Soils were air-dried for one week and passed through 5mm mesh to remove any stones, rock pieces and plant debris. Then the pots (20cm diameter and 35cm height) were filled with 5kg of soil and treatments were applied.

Treatments and Experimental Design

Locally available sources known to be rich in potassium were used as treatments in this experiment (Table1). Muriate of potash

(MOP), the common potassium supplying fertilizer used in coconut cultivation in Sri Lanka was also used as treatment for comparison purposes.

Table 1: Treatments of the experiment, potassium contents and the rates of application

Treatment	Amendment added	Amount of K (% K_2O)	Amount applied per pot (g)
T1	No amendment added		0
T2	Mica powder	8.26	29
T3	Feldspar (ground)	8.95	26
T4	Coconut husk ash	17.91	13
T5	Tithonia (air dried and ground)	3.08	78
T6	Muriate of Potash	60	4

Potassium application rate was decided based on K levels of the treatment materials and the K application rate recommended by Coconut Research Institute of Sri Lanka for adult coconut in their manure circle (48g K_2O/100kg of soil in the manure circle). The experimental was designed as a Completely Randomized Design with three replicates per each treatment.

Collection of Treatment Material and Application

Samples of phlogopite mica powder [K $(Mg)_3$ $AlSi_3$ O_{10} $(OH, F)_2$] were collected from a mica processing centre, Matale, Sri Lanka and K-feldspar [$K(Al,Si)_3O_8$] in ground form was collected from a feldspar deposit at Kaikawala, Sri Lanka. Coconut husk ash was produced by burning dried mature coconut husk in open fire allowing full burn in an earth pit. The coconut husks were collected from Bandirippuwa Estate, Lunuwila in the Intermediate Zone of Sri Lanka. *Tithonia diversifolia,* commonly known in Sri Lanka as wild sunflower (immature to semi-hard woody branches with leaves) was collected from Madampe area the Intermediate Zone of Sri Lanka. These branches and leaves were allowed to dry under atmospheric conditions for one week and applied in ground form. Muriate of Potash (MOP) fertilizer was obtained from retail market. After application, the treatment materials were well incorporated to soil within 30cm depth using a spade. The pots were watered once in every two days with equal amount of water. It was assured not to apply water beyond saturation as to avoid leaching losses of nutrients. Soil samples were extracted at 15cm depth from the surface of each pot in one-month intervals. The experiment was continued for 5 months.

Analysis of Treatment Materials and Soil Samples

Treatment materials were analyzed for their potassium content. The soil used for filling up pots were initially analyzed for the chemical properties. The collected soil samples were analyzed every month for exchangeable potassium using NH_4OAc extraction method. For other chemical parameters soil samples were analyzed at 1st, 3rd and 5th month after treatment application. The other chemical properties tested were soil pH (1:2.5 Soil: water) using glass electrode, exchangeable magnesium (NH_4OAc extraction) and available phosphorus using Olsen method (Olsen *et al.*, 1954).

RESULTS AND DISCUSSION

Chemical properties of soil before application of treatments are given in the Table 2. Soil has an acidic soil pH and very low level of exchangeable potassium and magnesium. The soil has available phosphorus content less than 10 ppm and it is considered as a low phosphorus level.

Table 2: Initial properties of soil used in the experiment

Parameter	Value (Mean ± SD)
Soil pH	4.33±0.08 (1:2.5 soil: water)
Exchangeable K	0.04±0.003 meq/100g
Available P	6.29±0.07 ppm
Exchangeable Mg	0.036±0.007 meq/100g

Soil pH

The soil pH was significantly increased in the coconut husk ash added treatment and also in the wild sunflower added treatments. However, there were no significant difference in soil pH of control, mica, feldspar and MOP added treatments throughout the experimental period (Table 3). The treatment with added coconut husk ash has been able to bring its soil pH to a neutral level and maintained in a neutral range (7.06-6.91) throughout the experimental period. This would be useful to make other major nutrients available as most macro nutrients increase their availability in the neutral pH levels.

Table 3: Soil pH after application of treatments

Treatment	pH value (1: 2.5 soil: water)		
	1 month	3 months	5 months
Control	4.32 c	4.30 c	4.38 c
Mica	4.31 c	4.38 c	4.40 c
Feldspar	4.38 c	4.33 c	4.42 c
Coconut husk ash	7.06 a	6.96 a	6.91 a
Tithonia	5.89 b	5.67 b	5.61 b
Muriate of Potash	4.33 c	4.40 c	4.41 c

Note: Mean values indicated by same letter along the columns are not significantly different at α =0.01

Soil Exchangeable Potassium

Soil exchangeable potassium content was significantly higher in coconut husk ash treatment compared to all other treatments in all samplings except the sampling at 2nd month after treatment application (MATA). The highest exchangeable K content of 3.8 meq/100g of soil was given by coconut husk ash treatment at 4 MATA (Figure 1). These results show that the coconut husk ash has a great potential of supplying K.

The reason for having higher K content than MOP would be the increase of soil pH towards the neutral level.

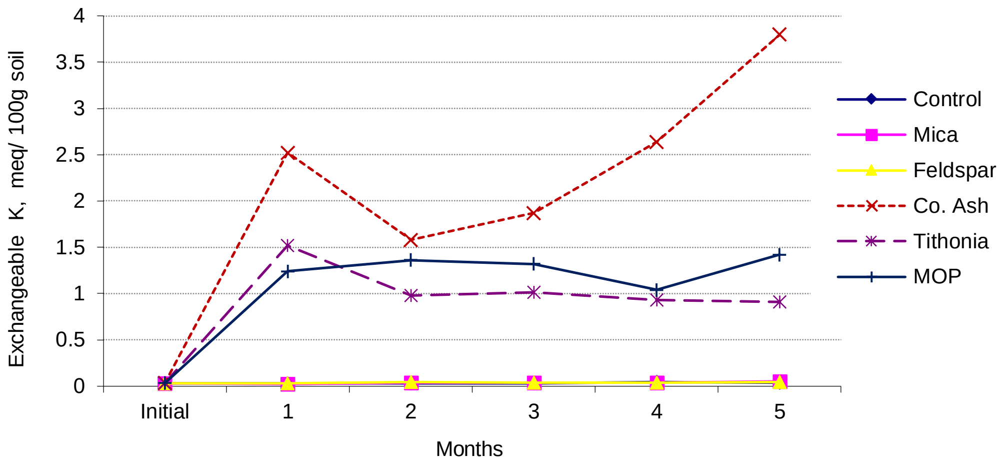

Figure 1: Variation in soil exchangeable potassium of different treatments over the experimental period

According to the K content of coconut husk ash, annual K need of adult coconut palm can be met by adding 5.36kg of husk ash. This will also have the advantage of increasing soil pH in acidic soils.

The lowest K content was observed in the control, mica and feldspar treatments recording less than 0.05 meq/100g exchangeable K levels in soil throughout the experimental period. This fact indicates that the release of K from mica and feldspar has not been happened during the experimental period. Cooray *et al*. (1992) have also observed low availability of K from application mica. The wild sunflower treatment (T5) showed significantly higher exchangeable K content than control, mica and feldspar treatments but significantly lower than T4. There was no significant difference in soil exchangeable K between T6 and T5 at 1 and 4 MATA. This fact *Tithonia diversifolia* to be used as a source of potassium.

When the amount of *T.diversifolia* needed to supply annual K requirement is calculated, it rises to a value of 31.16 kg for one adult cocopalm which may seem to be a practically difficult amount for application. Being an organic manure, application of *T. diversifolia* has an added advantage of enhancing soil organic matter which leads to multiple benefits with respect to soil fertility.

Soil Exchangeable Magnesium

A significantly higher exchangeable Mg contents were observed in coconut husk ash treatment and *T. diversifolia* treatment compared to all other treatments throughout the experimental period. This can be considered as an advantage of T2 and T3 to have a higher K and Mg content.

Table 4: Changes in soil exchangeable Magnesium after application of treatments

Treatment	Soil exchangeable Mg (meq/100g of soil)		
	1 month	3 months	5 months
Control	0.04 [b]	0.04 [b]	0.05 [b]
Mica	0.07 [b]	0.07 [b]	0.08 [b]
Feldspar	0.04 [b]	0.05 [b]	0.04 [b]
Coconut husk ash	0.34 [a]	0.42 [a]	0.44 [a]
Tithonia	0.33 [a]	0.36 [a]	0.35 [a]
Muriate of Potash	0.05 [b]	0.04 [b]	0.05 [b]

Note: Mean values indicated by same letter along the columns are not significantly different at α = 0.01

Even though mica has Mg in its chemical formula, release of Mg to exchangeable pool has not been happened during the experimental period (Table 4).

Soil Available Phosphorus

It was observed that the available phosphorus content significantly increased in T4, the coconut husk ash treatment compared to all other treatments. The T5 treatment also showed increment in available P than T1, T2, T3 and T6 but lower than T4. This could be mainly due to the increase of pH to a neutral level. The phosphorus availability in soil is generally limited both in acidic and alkaline pH conditions (Table 5).

Table 5: Changes in soil available Phosphorus after application of treatments

Treatment	Soil Available P (ppm)		
	1 month	3 months	5 months
Control	6.32 [c]	6.30 [c]	7.38 [c]
Mica	6.21 [c]	7.38 [c]	7.40 [c]
Feldspar	7.38 [c]	6.33 [c]	7.42 [c]
Coconut husk ash	12.06 [a]	11.96 [a]	11.91 [a]
Tithonia	8.89 [b]	9.67 [b]	9.61 [b]
Muriate of Potash	4.33 [c]	4.40 [c]	4.41 [c]

Note: Mean values indicated by same letter along columns are not significantly different at α = 0.01

CONCLUSION

Coconut husk ash has a greater potential of supplying potassium with providing additional advantages of increasing the availability of Mg and P, and also by enhancing soil pH to a neutral pH range. The coconut husk ash needed for complete replacement of K requirement of an adult coconut palm is calculated as 5.36 kg. Coconut husks are in demand for various other industries which may limit the use of them for this purpose.

Next to Coconut husk ash, *Tithonia diversifolia* has a potential to use as an amendment rich in K with its enhanced availability of providing phosphorus and exchangeable Mg. The needed amount of *Tithonia diversifolia* to meet annual K requirement for an adult coconut palm was calculated to be 31.16 kg. As *Tithonia* *diversifolia* has proven ability to thrive in relatively low fertile soils, there is a potential to use it in coconut plantations by cultivating them in underutilized land pockets with proper land use planning.

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