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Residual Effect of Long-Term Organic and Inorganic Fertilizer Application to Coconut Measured by Major Nutrients and Some Soil Physical Parameters

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ABSTRACT

A research was conducted to assess the effect of long-term organic and inorganic fertilizer application for coconut by its residual properties in soil and leaves. Organic manure such as Cattle, Goat, Poultry, Gliricidia and inorganic fertilizer (Adult Palm Mixture) were used as treatments over the control. Soil analysis exhibited that residual amount of Phosphorus, Calcium, Magnesium and organic carbon were significantly higher in poultry manure and Goat manure applied soil than other treatments, and also they had favorable soil physical properties for coconut. Leaf analysis also reflected that, organic fertilizer treated palms had higher residuals of major nutrients (Nitrogen, Phosphorus, Magnesium and Potassium.) than control and inorganic treatments. Further it is confirmed that residuals of Nitrogen were not present within the sufficient levels in all treatments. Only Goat manure and Poultry manure showed sufficient level of Phosphorus while sufficient levels of Potassium residuals recorded in cattle manure treatment. Therefore Goat and poultry manure application reflected better performance over the other treatments for their nutrient residuals. This research work revealed that the application of organic manure for coconut soil has the better performance in keeping their nutrient residuals over the application of inorganic fertilizer.

KEYWORDS: Inorganic fertilizer, Major nutrients, Organic manure, Residual effect, Soil analysis

INTRODUCTION

Coconut (*Cocos nucifera* L.) which belongs to the family *Palmaceae,* has been Sri Lanka's third most important commercial crop (Kumar *et al.*, 2003) and ranking the 4th place in the world coconut cultivation (Anon, 2009) Coconut palm being a perennial with a life span of more than 60 years and requires a regular supply of plant nutrients to sustain its growth maintenance and yield production (Liyanage, 1999).

High amount of nutrients are removed through the harvest and different removing parts. It is estimated that coconut grown in one hectare, yielding 15,000 nuts per year, nutrients are removed about 50 kg of Nitrogen, 6 kg of Phosphorus, 106 kg of Potassium and 14 kg of Magnesium through nuts, fronds and inflorescence parts (Somasiri *et al.*, 2003) . These nutrients should be supplied by regular manuaring with organic or inorganic fertilizer.

Long-term applications of inorganic fertilizers deplete soil quality, destroy beneficial soil organisms and beneficial insects, making the crop more susceptible to pests and diseases and also reducing the soil fertility. Further, it may destroy the beneficial soil microorganisms such as Pseudomonas, Azotobactor and Bacillus as well as soil physical properties (Pushpakumari *et al.*, 2008). Therefore, it has been a growing trend to use organic fertilizers such as cattle manure, goat manure, poultry manure, *Gliricidia* leaves *etc.* for crop production.

Organic matter helps to improve the soil physical conditions such as soil aggregation stability and also it influence infiltration, water holding capacity, aeration, temperature and root penetration ability of the soil (Sharma, 1988). As a general rule, higher the organic matter content, microbial activity and availability of nutrients are also high (Biswas and Mukherjee, 1987). Further, adding of organic matter to the soil influence the microorganisms activity and also the organisms present in organic matter play important role in cultivated land by improving its soil properties.

However the major nutrients percentage (N, P, K and Mg) available in organic matter, which is preferred by coconut is comparatively less than inorganic fertilizers and it will take longer time to show the effect through the crop compared to the inorganic fertilizer applied crop (Sharma, 1988). Therefore it will take long time to evaluate the effect of organic fertilizers with a perennial crop such as coconut.

Organic manure is important source of plant nutrients to sustain soil fertility and

productivity especially for perennials such as coconut (Tennakoon *et al.*, 2004). Long term organic fertilizer addition will give sufficient level of micro nutrients to the coconut soil, (Kondagama *et al.*, 2009) and also it will give higher levels of macro nutrients, favorable soil physical properties and higher microbial biomass than the inorganic fertilizer application (Silva *et al.*, 2008).

Organic fertilizer can be applied to coconut with the recommended levels of inorganic fertilizer and it will give a better performance of yield and cost-effectiveness to the farmer. Therefore organic manure is an important source of nutrient for coconut lands which enhance the productivity and sustain the fertility of soil (Tennakoon and Bandara 2003).

Considering the above criteria CRI has designed a long-term research project at Rathmalagara estate, with organic and inorganic fertilizers treatment in 1997. The major objective of the present research work was to evaluate the residual effect of major nutrients and some physical properties of the treated soil after 13 years of treatment and 2 year rest period.

MATERIALS AND METHODS

Location

Research was conducted in soil and plant nutrition division at Coconut Research Institute (CRI) Lunuwila, from January to April 2013. Soil and leaf samples were collected from the experiment site at Rathmalagara estate which belongs to S_4 land suitability class and Boralu series. Treatments were arranged in randomized complete block design (RCBD) with three replicates and six plots per each replicate containing six palms per each plot.

Treatments were as follows;
T1-control (no fertilizer)
T2-3 kg APM (Adult palm mixture) +1 kg dolomite per palm
T3-35 kg cattle manure+1200 g MOP per palm
T4-25 kg goat dung+800 g MOP per palm
T5-30 kg poultry manure+250 g MOP per palm
T6-30 kg *Gliricidia* +750 g ERP+1500 g MOP+1 kg dolomite per palm

Sampling and Sample Preparation

Soil and Leaf Sampling

Soil samples were collected from the manure circle (MC) at the depth of 0-9"of three randomly selected coconut palms in each plot and made a composite sample per plot. A portion of each sample was dried at room temperature for three days. Dried samples were sieved by 2 mm sieve and stored for the chemical analysis. Composite Leaf samples were collected from the above randomly selected coconut palms. Leaf samples were taken from the leaflets arising from a 10 cm long mid portion of the 14th frond (counting from the 1st fully opened frond) from one palm. Leaf samples were dried at oven temperature of 85 °C and kept for chemical analysis.

Soil Chemical Analysis

Soil Physical Parameters

The soil electrical conductivity and pH were measured (1:5 w/w water) electrometrically (Black, 1965). Cation-exchange capacity (CEC) in soil was measured by extracting of 2.5 g soil sample with 1M ammonium acetate solution through 5 min centrifugation at 2000 rpm followed by analysis in Atomic absorption spectrophotometer (Lab manual CRI, 2000).

Total Soil Nitrogen

Powdered soil sample (0.5 g) were digested with 0.4 % selenium sulphuric solution and analyzed using Auto analyzer (Lab manual CRI, 2000).

Available Exchangeable Bases

Exchangeable bases of soil, Na, K, Ca and Mg were estimated by extraction of 5 g soil sample with 1M ammonium acetate and centrifuged for 5 min at 2000 rpm followed by analysis in Atomic absorption spectrophotometer (Lab manual CRI, 2000).

Available Soil Phosphorus

Available soil phosphorus (P) was measured by extraction of 2.5 g soil sample with acetic acid solution and observed the absorbance from the Atomic absorption spectrophotometer (Lab manual CRI, 2000).

Soil Organic Carbon Content

Soil organic Carbon (OC) was estimated by the titration method (Walkey-Black, 1934).

Leaf Chemical Analysis

Available Exchangeable Bases

Potassium (K) was estimated by 1:10 dilution with distilled water. Magnesium (Mg) was estimated by 2:25 dilution with 20000 ppm Lanthanum Chloride solution (Lab manual CRI, 2000).

Total Leaf Nitrogen

Powdered leaf sample (0.1 g) were digested with 0.4 % selenium Sulphuric solution and analyzed using Auto analyzer (Lab manual CRI, 2000).

Available Leaf Phosphorus

Oven dried, powdered leaf samples (0.1 g) were digested with Percloric ($HClO_4$) and Nitric (HNO_3) acid (1:4 v/v) and then mixed with 50% Hydrochloric acid (HCl) finally analyzed using Auto analyzer (Lab manual CRI, 2000).

Statistical Analysis

Data were analyzed using ANOVA procedure. (SAS 9.1 software)

RESULTS AND DISCUSSION

Soil Analysis

Soil Physical Parameters

pH of the treated soil were in the range of 6.17 to 6.56 as given in the Table 1 and the highest value (6.56) was recorded from goat manure which is not significantly different from inorganic and cattle manure. The lowest was observed from the control indicating that land is well suited for coconut (Biswas and Mukherjee, 1987).

Table 1. Treatment effect of some soil physical parameters

Treatments	Parameter		
	pH	CEC (meq/100g)	EC (µs/cm)
T1	6.17c	7.30	23.26
T2	6.42ab	7.20	29.26
T3	6.56a	7.82	24.40
T4	6.63a	8.34	25.16
T5	6.28c	8.74	29.96
T6	6.20bc	8.42	27.56
Level of significant	*	NS	NS
LSD < 0 .05	0.19	-	-

*Means with different letters within the same column represent significant difference at $p < 0.05$ level, *significant at $p < 0.05$, NS-not significant*

Soil CEC and the EC were not shown a significant difference among the treatments. The lowest values were observed from the control field for the both parameters.

Soil Total Nitrogen Content

A significant different was not identified among the treatments (Table 2). However all treatments had higher values than the control.

Available Soil Exchangeable Bases

Significant difference was not found among the treatments for Potassium (K) content in treated soil and it was ranging from 0.097 mg/kg to 0.189 mg/kg (Table 2).

Magnesium (Mg) had a significant difference with the treatments. *Gliricidia* treated soil showed the highest value (1.36 mg/kg) which was not significantly different with goat manure applied soil (1.21 mg/kg) where significant differences were found with all other treatments. The lowest value (0.73 mg/kg) was observed from the control field (Table 2).

Significant difference also recorded in Calcium (Ca) content (Table 2) which is very high (5.53 mg/kg^{-1}) in *Gliricidia* treated soil over the other treatments.

Available Soil Phosphorus

Phosphorus (P) content of all soils tested had significant differences having the highest with poultry applied soil (791.93 mg/kg). Lowest value was recorded in control field.

Soil organic Carbon Content

Goat manure treated soils showed significantly highest value (0.870 %) for organic carbon (OC %) yet not significantly different from poultry added soils (0.841 %).The lowest value (0.634 %) was observed from inorganic fertilizer added soils and it was not significantly different from the control field (0.674 %) (Table 2).

Soil OC is an important property for plant growth as a trigger for nutrient availability through mineralization and it has an ability to increase water retention capacity of soil that may useful to coconut as it is highly sensitive to soil water level (Anon, 2011).

Leaf Analysis

Total Leaf Nitrogen

Analyzed data showed that the total Nitrogen (N) content in leaves was not significantly different among treatments (Table 3). All the treatments were below the critical level (N; 1.9%-2.1%) (Liyanage, 1999) revealing that the residual N content in coconut palms are not enough for production.

Available Leaf Mg and K Contents

Mg level of coconut palms in all treated soils were significantly different while the highest and lowest values were observed in poultry applied palms and control palms respectively. Further all the values were within the sufficient level (0.25% - 0.35%) according to Liyanage (1999).

Significant difference could also be observed in K level of treated coconut palms. The highest value (1.470%) was recorded in cattle manure applied palms and it was not significantly different from goat and Gliricidia applied palms. All treatments showed deficiency levels of K except cattle manure treated soil.

Table 2. Treatment effect of soil nutrients

Treatments	Parameter					
	N (mg Kg^{-1})	P (mg Kg^{-1})	K (mg Kg^{-1})	Mg (mg Kg^{-1})	Ca (mg Kg^{-1})	OC %
T1	376	184.40e	0.097	0.73c	2.09d	0.674c
T2	623	666.60b	0.155	0.97bc	2.44cd	0.634c
T3	465	417.07d	0.131	0.96bc	2.53cd	0.785ab
T4	555	544.07c	0.136	1.21ab	3.38bc	0.870a
T5	715	791.93a	0.111	0.79c	4.56ab	0.841a
T6	545	683.57b	0.189	1.36a	5.53a	0.729bc
CV %	25.42	23.82	23.82	10.65	19.99	7.785
Level of significant	NS	*	NS	*	*	*
LSD < 0 .05	-	106.25	-	0.37	1.24	0.107

*Means with different letters within the same column represent significant difference at p < 0.05 level, *significant at p < 0.05, NS-not significant*

Available Leaf Phosphorus

Significant difference could also be observed in P levels (Table 3). The highest value (0.18%) was observed for poultry treatment and it was not significantly different from *Gliricidia*. Control, inorganic and cattle manure treated palms were under deficiency levels of P (sufficient level for P is 0.12%-0.13%) (Liyanage, 1999).

Table 3. Treatment effect of major leaf nutrients

Treatments	Parameter			
	N %	Mg%	P %	K %
T1	1.506	0.280	0.101c	0.506b
T2	1.890	0.306	0.113c	0.700b
T3	1.823	0.303	0.115c	1.470a
T4	1.896	0.350	0.153b	0.980ab
T5	1.866	0.390	0.180a	0.630b
T6	1.796	0.290	0.167ab	1.050ab
CV %	8.9	13.44	8.8	34.5
Level of significant	NS	NS	*	*
LSD < 0 .05	-	-	0.022	0.558

*Means with different letters within the same column represent significant difference at p < 0.05 level, *significant at p < 0.05, NS-not significant*

The present research work reflected that Poultry and Goat manure treated soil perform better in terms of residual properties of major soil nutrients and organic carbon over the other treatments. Leaf analysis showed poor residual properties of control and inorganic fertilizer treated palms while other treatments performed well. Further it is confirmed that the residuals of Nitrogen was not within the sufficient levels in all treatments. However, goat and poultry treatments showed sufficiency level of Phosphorus while cattle manure reflected the sufficient levels of Potassium. When all treatments are considered, goat and poultry manure reflected better performance though it limits the residual of Nitrogen and Potassium. If it is possible to improve goat/poultry manure to retain their N and K residuals at higher level than the critical levels, farmers would have been able to maintain their fields under adequate residual nutrients for two years after application. That will reduce the cost for organic fertilizer application for at least two years. Present recommendation of CRI is to apply organic manure (poultry, goat, cattle and *Gliricidia*) annually to the coconut field.

CONCLUSIONS

Long-term application of organic fertilizer demonstrated higher residual properties of major nutrients, Organic Carbon prercentage and the favorable physical properties of soil required for the coconut than the APM application. Even though Goat and poultry were the well performed fertilizer among the organic fertilizers, they were deficient in K and N residual levels. Hence the field cannot be recommended to keep under residual condition as N and K are highly required nutrients for coconut. So the experiment urged to study the improvement of goat and poultry manure for keeping its nutrient residuals further. It is suggested to extend the present research with a new treatment having a mixture of organic fertilizers to evaluate the above organic fertilizer's residual habits well.

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