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Performance of Eppawala Rock Phosphate with Organic Manure as a Phosphate Source for Adult Coconut Palms in Dry Zone (DL_3)

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ABSTRACT

The low solubility of locally available Eppawala Rock Phosphate (ERP) makes it unsuitable for direct application for Coconut palms in Dry Zone. In order to increase the solubility of ERP, it is suggested to incorporate organic manure (Goat Manure). Organic manure is believed to convert ERP into a more soluble form making it available to the palm. The present study was to identify the effect of the ERP with Organic Manure as a Phosphate source for Adult Coconut Palms in Dry Zone (DL_3). In sub soil, pH was significantly lower in TSP only treatment than all the other treatments. Also, TSP only treated soil released P to soil than other treatments such as ERP only, Organic manure only, Organic manure + TSP and Organic manure + ERP. The results of the study did not show an increase in available P when ERP is applied with organic manure. Adsorption of P by the soil and increased microbial activity with organic matter could be the reasons for it. Since this study was conducted only after a period of one year from the introduction of treatments, continuation of the experiment is needed to arrive at firm conclusions.

KEYWORDS: Available phosphorous, Eppawala rock phosphate, Organic matter, pH level

INTRODUCTION

Coconut (*Cocos nucifera* L) is a widely grown perennial tree crop in Sri Lanka and it is well adapted to the hot and humid conditions of the tropics. It contributes to 1.4% of the Gross Domestic Product (GDP) of the country annually (Anon, 2011). The total extent of coconut is nearly 394,900 ha (Anon, 2011). Coconut is grown widely in wet and intermediate climatic conditions.

Phosphorus (P) is a macronutrient in coconut. It increases leaf production and root density. The P requirement for cultivated plants is very high right from the beginning of the growth (Dayaratne *et al.*, 1984).

P is found in soils in several forms like soluble and insoluble, organic and inorganic compounds (Avnimelech and Chen, 1986). Inorganic P in the soil is made up of three fractions; in solution, exchangeable and non exchangeable. Most P in the soil is present in the solid phase with a very small amount dissolved in the soil water solution. It is only the P found in the soil solution that can be taken by the plant. The availability of inorganic P is largely determined by several factors, those are; soil pH, soluble Iron, Aluminum, Calcium, Manganese, amount of decomposed organic matter and activities of microorganisms. The soil pH drastically influences the reaction of P with the different ions and minerals (Brady, 1990).

The inorganic P, derived originally from the weathering of rocks containing the mineral apatite, will be present in a variety of combination with Iron, Aluminum, Calcium, Fluorine and other elements. Rock phosphate is the raw material for production of phosphate fertilizers. The Eppawala Rock Phosphate (ERP) is a phosphate deposit at Eppawala in Anuradhapura district in Sri Lanka. Compared with other soluble phosphates, ERP is low in solubility level (Anon, 1999a). But it has been reported that the solubility is increased in acidic media. In ERP the total P content was found to be about 30 % and the water soluble P content was about 0.02 % (Perera, 2007).

Direct application of Rock Phosphate could be agronomically feasible and economically more viable than the use of expensive soluble P fertilizers such as Single Super Phosphate and Triple Super Phosphate (TSP). Although it is well known that rock phosphate is often applied to slow growing crops such as coconut its' availability is low due to Alkalinity, high pH under drought stress, high bicarbonate in irrigation water and low organic matter (Hosscini *et al.*, 2010).

P availability can be increased through addition of organic residues *via* several mechanisms. Slow releasing of organic P during the decomposition of organic matter provides a continuous supply of P with a mineral exposure to the different fixation mechanisms. Moreover, the presence of organic matter in the soil effectively decreases the P fixation by the soil through the acidifying and chelating mechanisms. The decomposition of organic matter releases organic acids and CO_2, both tending to lower the soil pH in neutral and basic soils, thus to raise P availability. The added organic matter and its decomposition products have significant chelating capacity, lowering the activity of polyvalent cations (Ca, Fe, Al) that form insoluble salts with Phosphorus (Avnimelech and Chen, 1986).The researches have shown that rock phosphate application along with the activity of soil microorganisms can be effective (Kang *et al.,* 2002).

The application of organic matter stimulates the growth and activity of microbial population .The microorganisms can affect phosphate availability by forming chelates, organic acids or through the decomposition of phosphorus containing organic matter. Many microorganisms, especially those colonizing the rhizosphere, are capable of solubilizing calcium phosphate, a common insoluble form of phosphate in the soils. Acid and chelates producing organisms can increase phosphate solubility near the plant roots. The products which need to phosphate solubalization include both organic and inorganic acids are produced by heterotrophic organisms (Avnimelech and Chen, 1986). The organic matter content increased in goat dung treated soils providing energy reserves for microbial activity (Tennakoon, 1990).

In Sri Lanka ERP is used as a direct application fertilizer for Tea, Rubber and Coconut, grown on acid soils. The Coconut Research Institute has recommended 100 % of the P requirement of adult and young coconut palms in wet and intermediate zones with locally available ERP. At present P requirement of adult and young Coconut palms in Dry Zone is fulfilled with TSP. Therefore the objective of the study was to test the possibility of application of ERP with organic manure for Dry Zone.

MATERIALS AND METHODS

The research was conducted in the Soils and Plant Nutrition Division of the Coconut Research Institute, Lunuwila, Sri Lanka. The time period was January to April 2013. For this study, soil and leaf samples were collected from an ongoing experiment. The trial is located at the Ever Green Estate, Wanathawilluwa, in the Dry Zone of the country having Marvilluseries soil. This site belongs to the Great Soil Group of Red Yellow Latosols (RYL). Texture of the soil was Loamy sand and the nature of the soil was neutral to slightly alkaline. Soil and leaf samples were collected one year after introducing the treatments. The treatments tested are given below.

Treatments

T_1 - 400 g TSP palm/year
T_2 - 900 g ERP palm/year
T_3 - 25 kg Organic Manure (Goat Manure) palm/year
T_4 - 400 g TSP + 25 kg Organic Manure (Goat Manure) palm/year
T_5 - 900 g ERP + 25 kg Organic Manure (Goat Manure) palm/year

All the palms were treated with the basal dose of Nitrogen at the rate of 800 g of Urea, 1600 g of Potassium and 1000 g of Magnesium annually. The experiment was in Randomized Complete Block Design (RCBD) with five treatments with three replicates and six palms per each plot.

Collection and Preparation of Soil Samples

Soil samples were collected from the randomly selected four coconut palms in each plot. It was collected from the manure circle (mc) of the selected palms at 0 to 20 cm and 20 to 40 cm depths from the surface.

The collected soils were air dried (25-30 ^{0}C) for two to three days in the laboratory. Samples were passed through 2 mm sieve and stored for analysis.

Collection and Preparation of Leaf Samples

In order to determine the P nutritional status of the coconut palms in the sites where treatments were introduced, leaf samples were collected from the14th frond (count downward from the 1st fully opened frond as the 1st frond) of the selected palms in each plot. Collected leaf samples were washed in running tap water and then three times in distilled water and were put in the oven at 85 ^{0}C for a maximum of 72 hr. Then the samples were powdered using a hammer mill with stainless steel grinder and stored in plastic containers until the chemical analysis.

Analysis of Soil Samples

Determination of Soil pH

The soil pH samples were prepared for the determination of pH electrometrically using an Orion research model 410A plus pH meter after calibrating the instrument at pH 4 and pH 7 (Black,1965).

Determination of Available Phosphorus

The available phosphorus in the soil samples were determined by using Olsen bicarbonate method with 0.5M Sodium bicarbonate (Olsen *et al.,* 1954)

Determination of Soil Organic Carbon

Organic Carbon was estimated according to Walky- Black method (Hess, 1971).

Analysis of Leaf Samples

Determination of Phosphorus

Leaf samples were digested with 4:1mixture of HNO_3 and $HClO_4$ acid. The concentration of P in extracts was determined using Auto analyzer (Anon, 1982).

Determination of Nitrogen

Powdered leaf samples were digested with 0.4 % Selenium Sulphuric acid solution. The concentration of N was determined using Auto analyzer (Anon, 1982).

Statistical Analysis

Effect of treatments on leaf and soil data was analyzed by statistical analysis system (Anon, 1990b).

RESULTS AND DISCUSSION

Soil Parameters

The pH of the soils ranged from 6.58 to 7.24 and 6.32 to 6.84 among the treatments in top and sub soils, respectively (Table 1). The TSP only treatment (T1) recorded the lowest pH values whilst ERP + organic manure (T5) treatment recorded the highest values for both depths. This may be due to dissolving TSP leading to an increasing hydrogen ion concentration at the vicinity of the TSP granules and lowering the pH of the soil. In sub soil, pH was significantly lower in TSP only treatment (T1) than all the other treatments. Leaching of dissolved TSP could be the reason decreased pH in sub soil.T5 showed the highest pH value than other treatments. There was no significant difference between T2 and T5.Therefore the application of organic manure had not influenced the soil pH. The short time period between introducing treatments and collection of samples may be a reason for this. Organic matter requires a considerable period of time to show expected results. These findings can be supported by the fact that pH of the experimental site was at neutral to slightly alkaline conditions prior to introducing treatments.

Soil Organic Carbon

According to the analyzed data, OC ranged from 0.51 to 0.66 % in top soil and 0.59 to 0.78 % in sub soil (Table 1). There was no significant difference in OC among the treatments at both depths. A higher OC content was observed in all treatments in subsoil than in top soil. In this experimental site harrowing had been the weed management practice adopted before initiating the experiment. The turning of soil during the process may be the reason for higher OC in sub soil.

Table 1. pH and Organic Carbon Levels of Top soil and Sub soil

Treatments	pH		OC%	
	0-20 (cm)	20-40 (cm)	0-20 (cm)	20-40 (cm)
T1	6.58	6.32^{b}	0.51	0.59
T2	6.93	6.70^{a}	0.56	0.61
T3	6.62	6.57^{ab}	0.58	0.59
T4	6.84	6.77^{a}	0.64	0.78
T5	7.24	6.84^{a}	0.66	0.69
LSD<0.05	NS	0.01*	NS	NS

*Mean in a row followed by the same letters are not significantly different at 0.05 level *denotes 0.05 significant level and NS denotes not significant.*

Available Phosphorous

According to the analyzed data, Olsen bicarbonate P values ranged from 4.18 to 13.47 mg/kg in top soil and 3.17 to 7.6 mg/kg in sub soil respectively (Table 2). Significant differences were observed in Olsen P values in top soil among all the treatments tested. However, there were no significant differences in Olsen P values in sub soil among the treatments. T1 treatment recorded the highest Olsen P value in both depths. The lowest Olsen P values were recorded in T3 in top soil and T4 in sub soil. The critical Olsen P value for coconut growing soils is 8.5 $mgkg^{-1}$, thus in all treatments except in T1 the Olsen P value in the top soil was below the critical level. This result indicated that TSP only (T1) treated soil supplied sufficient P to soil than other treatments (T2, T3, T4 and T5).In treatment T4 and T5 relatively low availability of P could be due to microbial P immobilization in presence of phosphate sources with organic manure. Soil microorganisms act as sink and source of P which mediate key processes in the soil P cycle, e.g., P mineralization and immobilization (Oberson *and* Joner, 2005). Microbial P immobilization can affect P availability by removing inorganic P from the soil solution, especially when soluble Carbon is available for microbial growth (Bunemann *et al.*, 2004).

Kang *et al.* (2002) reported that rock phosphate application as a phosphate fertilizer along with the activity of soil microorganisms can be effective. Most soil microorganisms such as bacteria and fungi have the ability to change insoluble P to soluble forms (Hosseini *et al.*, 2010).

The results suggested that incorporating organic manure to either TSP or ERP has not significantly improved the available P against the TSP and ERP only treatments. This can be also explained by P adsorption mechanisms taking place in these soils. The maximum adsorption was 78 mg $kg^{-1}$of studied Mavillu series,. which was used for the study (Wijebandara, 2011). After maximum adsorption of P to the soil, P availability will increase. TSP is the only treatment which supplied enough P for saturate P adsorption sites comparing with other treatments. It can be argued that low adsorption levels could be one of the reasons for available P levels to be below the critical level. This is an ongoing experiment and the treatments had been introduced only one year ago and hence more time will be required to detect expected treatment responses.

Table 2. Available Phosphorous Levels of Top soil and Sub soil

Treatments	Available Phosphorous (mg/kg)	
	0-20 (cm)	20-40 (cm)
T1	13.47^{a}	7.6
T2	7.70^{ab}	3.56
T3	4.18^{b}	3.35
T4	6.27^{b}	3.17
T5	6.45^{b}	5.38
LSD<0.05	5.31*	NS

*Mean in a row followed by the same letters are not significantly different at 0.05 level *denotes 0.05 significant level* and NS *denotes not significant.*

Leaf Phosphorus

The P values ranged from 0.12 to 0.13 % (Table 3). The treatment different were not statically significant.

Leaf Nitrogen

Leaf N ranged from 2.05 to 2.11 % among the treatments (Table 3). The highest N value was evident in T5 whilst the lowest value was in T4. However the treatment differences were statistically not significant.

Table 3. Total phosphorous and Total Nitrogen of Coconut Leaf

Treatments	P%	N%
T1	0.13	2.06
T2	0.12	2.10
T3	0.13	2.07
T4	0.12	2.05
T5	0.13	2.11
LSD<0.05	NS	NS

NS *denotes not significant.*

CONCLUSIONS

The results of the experiment revealed that the soil pH was lowest in the TSP applied treatment. The highest Olsen P value was recorded in the only TSP treatment (T1) and organic manure treatment recorded the lowest (T3). The TSP only treated soil released sufficient P to soil than the other treatments such as ERP only treated, organic manure only, TSP + organic manure and ERP+ organic manure. The main objective of this experiment was to increase the solubility of ERP with addition of organic manure. The result of the present experiment did not show the expected results after application of ERP with organic manure. It may be that organic matter did not enhance the availability of P as expected due to high microbial activity utilizing available P, adsorption of P by the soil and the less time given for the treatments to respond.

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