COMPARISON OF THE EFFECTS OF ORGANIC FERTILIZERS WITH INORGANIC FERTILIZERS ON THE GROWTH OF EIGHT MONTHS OLD COCONUT SEEDLINGS AND THE NUTRIENT AVAILABILITY AND SOIL MICROBIAL ACTIVITY OF SOILS

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Abstract

The study was planned to find out the effect of different fertilizers on the growth of coconut seedlings, availability of some nutrients and soil microbial activities with the aim of developing a fertilizer mixture that supports the plant growth with simultaneous improvement of soil health. Eight months old coconut seedlings of CRIC 65 cultivar was planted in large pots and kept inside a green house. Six treatments: control (T1), inorganic fertilizer (T2), BioGold® (T3), cattle manure (T4), Kochchikade biofertilizer (T5) and compost (T6) were selected. Biweekly measurements of growth parameters, soil chemical parameters: pH, electrical conductivity, levels of K, P, Mg, and soil microbial parameters: biomass carbon and CO_2 evolution were taken. The experiment design was a Complete Randomized with three replicates. The data were analyzed by analysis of variance (ANOVA) using the MINITAB statistical package. No significant differences ($P<0.05$) were observed in growth parameters, soil pH and EC throughout the research period in any of the treatments. The highest P level and lowest K level were observed in inorganic treatment after a six months period. Cattle manure contributed a high level of Mg to the soil. And hence possible to recommend cattle manure as a good source of Mg. Significantly improved microbial activity was observed in BioGold® and the compost treatments. This implies that organic fertilizers are more environmental friendly compared to inorganic fertilizers.

Keywords: inorganic fertilizers, organic fertilizers, biofertilizers, soil nutrients, microbial activity, coconut

1. INTRODUCTION

Fertilizer application is one of the most popular and common method among the coconut farmers, on increasing the production of coconut lands. However, many coconut farmers are experiencing a rapid deterioration of soil health in many lands. It is suspected repeated application of chemical fertilisers play a major role in this deterioration of soil health. Especially these chemicals affect adversely on naturally inherent soil micro flora.

As a result of this problem, the importance of developing better eco friendly fertilizers was emphasized during the last few years. Therefore, this research was designed with the major objective of developing a low cost, eco-friendly and effective fertilizer. As the planting material for this research, a new coconut variety is selected name in CRIC 65 variety. Two biofertilizers available in the market; Biogold® and Kochchikade biofertiliser , along with four other organic fertilizers were select as six treatments in this study.

2. MATERIALS AND METHODS

2.1. TREATMENT STRUCTURE

Experiment was conducted in a green house at Coconut Research Institute (CRI) Lunuwila. The coconut cultivar CRIC 65, which is a cross between dwarf and tall (Dwarf x Tall) varieties introduced by the CRI of Sri Lanka was employed in this research. Eight months old Dwarf x Tall (D x T) poly bagged seedlings obtained from Ambakele Seed Nursery, were planted in plastic pots (45 cm x 55 cm) and kept in a green house. Each pot was filled with Madampe series soils of Latosols which belongs to land suitability class S_1 of coconut growing soils.

Seven fertilizer treatments were employed as given in the Table 01. Dolomite (1000 g/per pot) was applied as the basal dressing for all the treatments. Treatments were arranged in a Completely Randomized Design (CRD) with three replicates for each treatment. Three groups of parameters were measured during the experimental period. Growth parameters measured were leaf area, plant girth, plant height and number of leaves per plant at 8 month after planting. Soil parameters were categorized into two as chemical and microbial. Available P, Exchangeable K and Mg, pH and EC constituted the chemical parameters while microbial biomass measurements were taken as denoted by biomass carbon and CO_2 evolution from soil.

Table 01: Fertilizer treatments employed in the study

Treatment	Fertilizer type and quantities applied to a pot
T1	Control (Only Soil)
T2	Inorganic Fertilizer (Urea 250 g, ERP 750 g ,MOP 250 g)
T3	BioGold®(55ml/2.5 l/)+ERP (750 g)+ MOP 250 g
T4	Cattle Manure (10 Kg)+ ERP (750 g)+MOP 250 g
T5	Kochchikade Biofertilizer
T6	Compost (10 Kg) +ERP 750 g

Note: ERP and MOP denotes Eppawala Rock Phosphate and Muriate of Pottash, respectively.

2.2. FERTILIZER ANALYSIS

All organic fertilizers (cattle manure and compost) and biofertilizers (BioGold® and Kochchikade biofertilizer) were analyzed according to methods in laboratory manual (2000) of CRI to find out the contents of N, P, K and Mg. It was assumed that the percentages of N, P, K and Mg in Urea, ERP, MOP and Dolomite were present at standard levels as: 46% N in Urea, 30% P in ERP, 60% K in MOP and 20% Mg in Dolomite.

2.3. MEASUREMENT OF GROWTH PARAMETERS

Seedling girth, seedling height, number of leaves/seedlings and the leaf area were used as growth parameters and were recorded prior and ten weeks after application of treatments. The seedling girth measurement was taken at the 5 cm height from the soil level and seedling height was measured from the soil level to the tip of the longest leaf of the seedling. The number of leaves was recorded by counting. Four measurements were taken to calculate the leaf area of the seedlings: height of the leaf from the starting point below to the leaf tip, width of the one part of the leaf at the place where leaf separates in to two, the distance between the two tips of the same leaf, the length of the leaf from the place where leaf separates into two to the leaf tip.

2.4. SOIL SAMPLE COLLECTION

Madampe series soils of Latosol which belongs to land suitability class S_1 was selected as the soil type for this study. Soil sampling was carried out from the pots, before and after application of treatments at two weeks interval by using a PVC pipe (diameter 2.9 cm x 29 cm) at a depth of 0-19.5 cm. Two samples were taken from each pot at 8 cm distance away from the stem to the right side and to the left side and the samples were composited. After removing larger particles and debris, soil was air dried and sieved through a 2 mm sieve to be used in the chemical analyses. Samples for microbial analysis were immediately send to the refrigerator maintained at 4 ^{0}C, packed in polythene bags, leaving a 2/3 air pack from the total volume of the bag.

2.5.MEASUREMENT OF SOIL PARAMETERS

2.5.1SOIL CHEMICAL PARAMETERS

Available P, K, Mg, pH and EC were measured for the soil chemical analysis. Murphy and Riley (1982) method was used for the determination of available phosphorous while Atomic Absorption Spectrophotometry was employed in the quantification of exchangeable K and Mg with Ammonium Acetate as the extracting solution. A soil suspension of soil: water in the ratio of 1:5 was used to measure electrical conductivity (EC) and soil pH (Tropical soil and leaf analytical methods, 2000).

2.5.2 SOIL MICROBIAL PARAMETERS

Two soil microbial parameters: biomass carbon (C) and CO_2 evolution was used to ascertain the microbial density of soil.

Microbial biomass quantification was done by weighing 25 g of fresh soil sieved by a 2 mm sieve into a conical flask, moistening with 2- 4 ml of water and fumigating with alcohol free $CHCl_3$ for 5 minutes with an evacuated desiccator. A small vial containing 20 ml of 0.1 M KOH was placed in the conical flask after fumigation. The system was sealed with a rubber cap and incubated for 7 days. The residual KOH was titrated in the vial with 0.1 M HCl using Phenolphthalein as an indicator. Carbonate ions in the solution was stabilized by precipitating with saturated $BaCl_2$ before the titration. Blank reading was taken without using the soil (Jenkinson and Powlson, 1976; Parkinson and Paul, 1982; Anderson and Ingram, 1989). Biomass C amount was calculated using the formula.

$$Biomass\ C = F/\ K_C$$

Where, F = (Volume of 0.1 M HCl needed for the blank) - (Volume of 0.1 M HCl needed for the sample), K_C = Portion of biomass C mineralized to CO_2 (= 0.45).

For the measurement of CO_2 Evolution, 250 g of fresh soil sieved through a 2 mm sieve was taken into a glass container, moistened with distilled water and mixed thoroughly. Then 50 ml of 0.1 M NaOH was taken into a small beaker and placed in the air proof glass container having the soil sample. A blank was set up with no soil and both sets were incubated for 7 days at room temperature. Then a few drops of $BaCl_2$ solution and phenolphthalein was added to the NaOH solution and titrated against 0.1 M HCl (Anderson and Ingram, 1989). CO_2 reacts with the base and form CO_3^{-2} which is stabilized by forming a precipitate with $BaCl_2$. Milligrams of C or CO_2 can be calculated using the equation.

$$Milligrams\ of\ C\ or\ CO_2 = (B\text{-}V)\ NE$$

Where B- Volume of acid required to titrate the blank NaOH solution, V-Volume of acid required to titrate the sample NaOH solution, N-Normality of the acid used for the titration, E-Equivalent weight (E= 6 if expressed as C or E= 22 if expressed as CO_2). CO_2 evolution can be expressed in terms of µg g-1 of soil day $^{-1}$. Amount of evolved CO_2 is proportional to the amount of active microorganism in the soil.

2.6. STATISTICAL ANALYSIS OF RESULTS
One-way and Two-way ANOVAs were employed as appropriate using MINITAB 15 version to determine the treatment effects. The significant means were compared using LSD at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. FERTILIZER ANALYSIS
According to the fertiliser analysis, the highest N content was recorded in the BioGold® biofertiliser sample followed by cattle manure. Available P level was comparatively high in cattle manure. BioGold® biofertilizer which comes as a pelleted form showed the least moisture content which was 8.7%. Compost and Kochchikade biofertilizer have shown a comparatively high moisture percentage than the other fertilizers.

3.2. GROWTH PARAMETERS

Table 02: Mean values of growth parameters after six months.

Treatment	Leaf area (cm^2)	Seedling girth (cm)	Seedling height (cm)	No of leaves/ seedlings
TI	3.3 ($\pm$0.25)^{a}	15.2 ($\pm$0.62)^{a}	110.9 ($\pm$0.73)^{a}	6 ($\pm$0.02)^{a}
T2	3.4 ($\pm$0.32)^{a}	14.8 ($\pm$0.52)^{a}	112.0 ($\pm$0.62)^{a}	6 ($\pm$0.02)^{a}
T3	2.9 ($\pm$0.12)^{a}	14.7 ($\pm$0.52)^{a}	112.2 ($\pm$0.62)^{a}	5 ($\pm$0.12)^{a}
T4	3.1 ($\pm$0.31)^{a}	15.1 ($\pm$0.42)^{a}	111.59 ($\pm$0.41)^{a}	6 ($\pm$0.32)^{a}
T5	4.0 ($\pm$0.42)^{a}	15.0 ($\pm$0.62)^{a}	110.9 ($\pm$0.35)^{a}	0 ($\pm$(0.2)^{a}
T6	3.5 ($\pm$0.22)^{a}	15.1 ($\pm$0.32)^{a}	110.9 ($\pm$0.32)^{a}	0 ($\pm$0.2)^{a}

There were no significant differences ($P \geq 0.005$) between treatments in any of the growth parameters tested after a period of six months after planting (Table 02).

3.3. SOIL PARAMETERS

3.3.1 PHOSPHOROUS (P) AND POTASSIUM (K) LEVEL
Changes in the soil P and K levels due to the fertiliser treatment have followed two different patterns as shown in Figure 01 and 02.

Available P level in all treatments was significantly increased ($P = 0.000$) with the application of inorganic fertilizer (T2). This high availability of P within a short period of time could be due to the quick release of P from ERP. With the organic treatment and biofertilizer treatments it was expected to convert insoluble inorganic P sources in soil in to available forms. As this is a slow and long lasting process releasing only limited quantities over time, a sharp increase cannot be expected as in the case of inorganic fertilizer application. This fact was also supported by the data obtained, with a higher P level over the control except BioGold®.

Availability of ERP is normally increased in soils with low pH (Samanthi, 2009). Therefore, if the pH of Latosolic soil could be increased by any other treatment, a significant increase in P level would have been resulted in other treatments as well. As a P supplier, 750 g of ERP was added to all the treatments except for compost treatment. Hence, a similar increment in P level is expected with all such treatments. In contrast to the expectation, only inorganic fertilizer treatment showed a significantly high increase in a shorter time period. It has been showed that ERP solubilization increasing with a lowering of soil pH. In this treatment urea is added, which can be utilized by soil microorganisms.

Urea causes soil acidification when it is broken down to form ammonium and the subsequent conversion of ammonium to nitrate, which is the predominant form of nitrogen taken up by the roots of a plant (Chvyl *et al.,* 2006). This leads to acidification of soil and help the P availability. But this pH reduction was not observed in soil pH levels in this research. This implies the process of soil acidification in soil is a temporary activity and not persists for a long period.

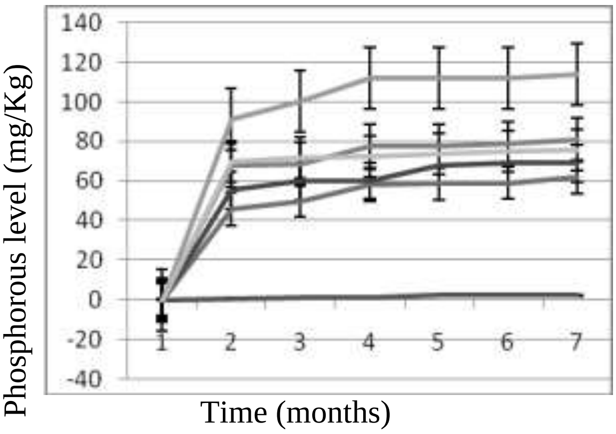


Figure 01: Variation of available P level over time for different treatments

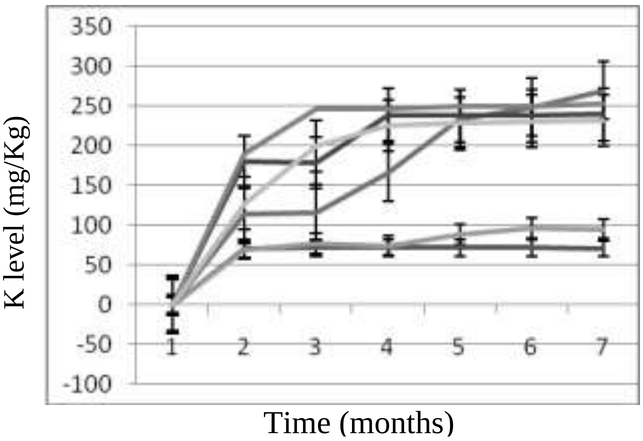
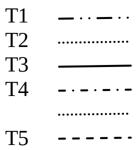


Figure 02: Variation of available K level over time for different treatments



The results have shown the quick availability of P by inorganic fertilizer application. Therefore, farmers prefer to apply inorganic fertilizer, since it gives quick results compared to organic fertilizer after the application. Though it gives out short term economical benefit, organic fertilizers are more beneficial in environmental aspect. Since Organic fertilizers are having natural origin it makes least damage to the environment and this showed that it can release P needed for the plant persistently. This also reduces P leaching minimizing environmental problems. Therefore, use of organic fertilizers is more beneficial in long term. But still most of the coconut farmers depend on applying inorganic fertilizers expecting quick results. But now it is mentioned application of inorganic and organic fertilizers together in favourable composition is more economical and environmental friendly in every aspect.

Except the inorganic fertiliser treatment, all the other treatments have given highest K levels with compared to the other treatments. However, the lowest contribution was resulted from T2 at all time points which are also lower than that of control. But these results are unexpected. In the inorganic treatment, MOP has been added at the beginning. But the results showed it to be lower than the control even. So this result can not be accepted. This might have happened due to a practical mistake. Although the K analysis were expected to repeat to obtain the correct data, it was failed due to the time constrain. Reason for the high increment of K^+ in soil, treated with organic matter can be discussed as the high binding ability of organic matter which increase the cation exchange capacity of a soil.

3.3.2 MAGNESIUM (MG) LEVEL

From the analyzed data, cattle manure treatments showed a significant increment in the Mg level in soil than all the other treatments (Figure 03).
These results showed that the highest amount of Mg had been released from cattle manure during the experimental period.

All the treatments except cattle manure treatment showed a similar increment pattern throughout the period. The high increment of Mg level has been shown in the T4 treatment from the first month after fertilizer application.

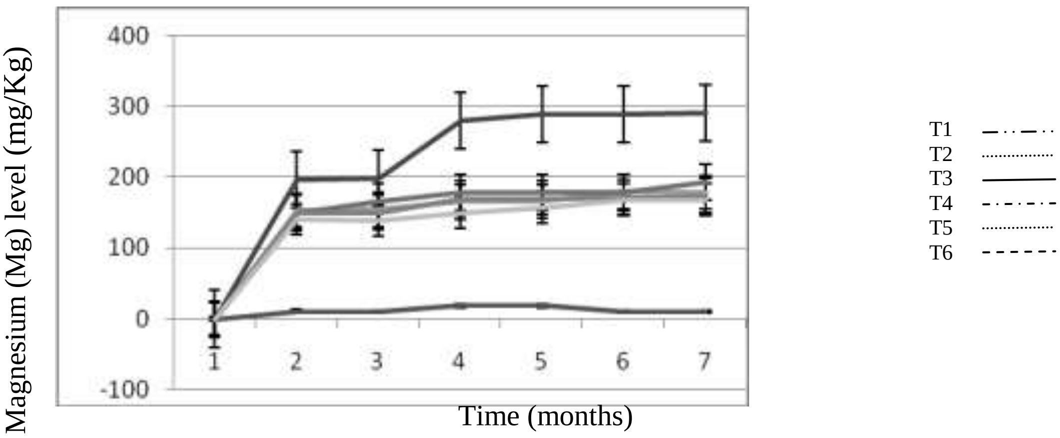


Figure 03: Variation of Mg level over time for different treatments

3.3.3 SOIL MICROBIAL PARAMETERS

When the biomass C and CO_2 evolution rates were considered, they reflect a similar pattern. i.e. The highest significant increase in soil microbial activity was recorded by the compost treatment in both parameters.

Mean biomass C level and Microbial Biomass level were almost similar in the control and the T2 treatment throughout the research period (Figure 04 and 05). This confirms the positive effect of BioGold® and Compost in increasing the soil microbial population by providing nutritive sources for the growth of soil microbes. The producers of the BioGold®, 'BioPower Lanka (pvt) Ltd' says that their product contains two microorganisms named *Azotobacter chrococum* and *Psedudomonas fluorescens*. Considering the BioGold® and compost, it is shown that the microorganisms in compost mixture and *Azotobacter chrococum* and *Psedudomonas fluorescens* in BioGold® have actively participated in enhancing the microbial population in the soil.

The original density of the microbial population in the soil has been increased significantly due to the application of BioGold® and Compost. Since both these treatments are adding a significant number of microorganisms to the soil this increment can be expected in the soil microbial population. Although cattle manure (T4) and Kochchikade fertilizer (T5) treatment was significantly different from (T1) control treatment, there was no significant difference between the two treatments at each time point. This revealed that Kochchikade biofertilizer has the same effect as cattle manure treatment in relation to microbial activities.

Further studies are needed to confirm the long-term effect of such applications on other agricultural aspects such as plant vigour, yield etc. before making a curriculum on this matter.

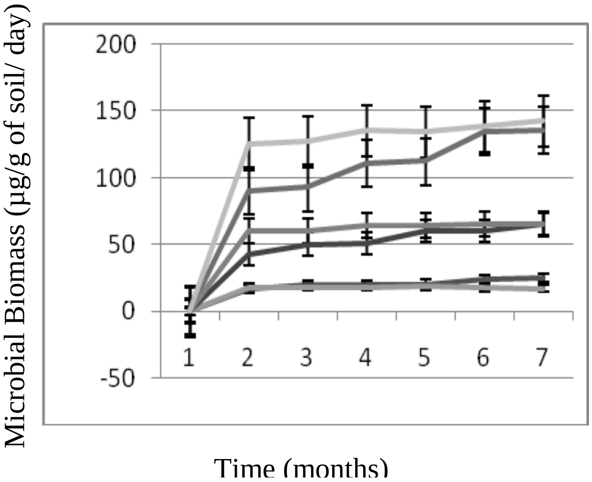


Figure 04: Variation of Microbial Biomass C level over time for different treatments

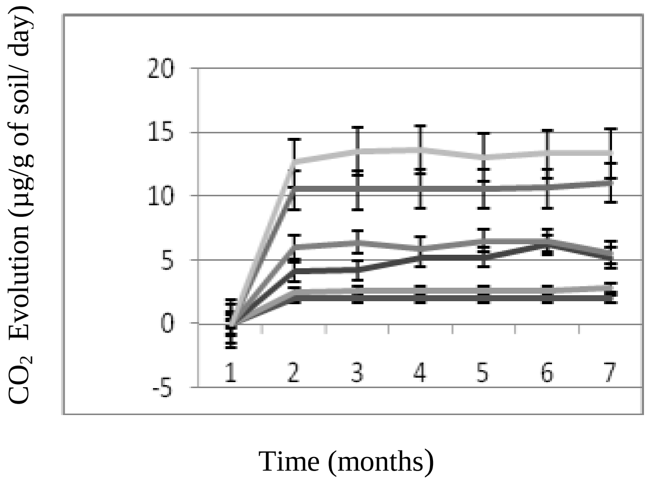


Figure 05: Variation of CO2 Evolution level over time for different treatments

T1
T2
T3
T4
T5
T6

3.3.4 PH LEVEL AND ELECTRICAL CONDUCTIVITY

The average pH range preferred by the coconut palm is 6.1-7.5 (CRI Fertilizer Recommendations, 2005). The average pH value of the soil used for this research was 7.53. Within the whole experimental period, there was no significant change (P =0.499) observed for pH levels among all the treatments indicating the maintenance of good soil pH by all the fertilizers engaged in the study. The variation of EC and pH over the experimental period is presented in Figure 01.In the EC levels a significant difference (P= 0.100) was not observed at any time point during the after six months period. Therefore, by applying any of the above treatments EC levels in soil cannot be changed significantly. According to the soil properties, Latosolic soil has low clay particles. Therefore retention of cations might be low in the soil particles. This might affect the low mean values of EC in this soil. However, it is surprising as in inorganic fertilizer treatment application, a considerable amount of ions are expected to be released during a short time period.

4. CONCLUSIONS

Increment of soil K level from all the treatments were more or less similar and had reached the critical K level range at the end of six months. Further, the Mg contribution from cattle manure was higher than that of all the other treatments. A significant effect on seedling growth was not observed with any of the fertilizers used in the study. Hence, none can be recommended for better seedling development of coconut within six months of period.

During the experiment period, there were no significant differences in soil pH and EC among all treatments. Hence, the results showed that there was no significant effect of all the treatments on soil pH and EC. Organic fertilizers including biofertilizers have been able to increase soil microbial activities considerably while inorganic fertilizers showed no effect. As soil microflora is an essential component of soil that are responsible for soil mineral nutrient transformations and organic matter degradation, it is of high importance to maintain a good soil health. Organic fertilizers as expected can improve soil microbial activities considerably. As a whole all the fertilizers investigated were capable of releasing nutrients above the critical level. Organic fertilizers improved soil health with respect to microbial activities.

But, organic fertilizers are bulky and need to put in large quantities to get the same effect as with inorganic fertilizers. Considering all these factors, it can be recommended that an effective fertilizer combination has to be adopted in order to have long term beneficial effects and organic fertilizers can play a significant role in such formulations. As the time duration did not permit long term studies, the results are inclusive for this period.

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