EFFECT OF COCONUT-BASED AGROFORESTRY SYSTEMS ON PHYSICAL AND CHEMICAL PROPERTIES OF SOIL IN INTERMEDIATE ZONE OF SRI LANKA

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Introduction

Coconut (*Cocos nucifera* L.) is one of the major plantation crops in Sri Lanka, which accounts for 1.4% to the Sri Lankan GDP. Present, demand for coconut is continuously increasing, but not the production. However, scientists predict that yield reduction in coconut cultivation may cause due deterioration of soil quality. Therefore, factors that trigger the soil degradation must be reduced to obtain high yield from coconut cultivation. In this regard, knowing of relative level of soil degradation as a result of long term coconut cultivation is important. This research aims to find the soil quality changes as a result of long-term coconut cultivation in a mono-cropping system (CMS) in comparison with coconut-gliricidia integrated system (CGIS) and coconut- wild sunflower integrated system (CWIS) in same soil type.

Methodology

The study was carried out at Rathmalagara Estate, Madampe, in the intermediate zone of Sri Lanka. The soil type of the experimental site was Andigama soil series (Ferric acrisole-FAO classification). Soil samples were collected from four sites with different land use systems but approximately of same age (25 years) plantations. Selected sites were; long term coconut mono-cropping land, coconut integrated with double hedge row Gliricidia (*Gliricidia sepium*) cultivation, and coconut integrated with double hedge row wild sunflower (*Tithonia diversifolia*). For the comparison, natural forest adjacent to the coconut plantation was used as reference land use. At each site, samples were collected from three randomly selected locations of the centre of squire between coconut palms. From each location, samples were obtained at two depths (0-11 & 11-42 cm) for the determination of soil physical and chemical properties. Under the soil physical properties bulk density and soil moisture retention at field capacity (10 Kpa suction level) were determined using core sample method and standard pressure plate apparatus respectively. Aggregate size distribution was determined using dry sieving method. As the soil chemical properties, organic carbon content and cation exchange capacity were determined using Walky and Black method and Sodium acetate method respectively. The data were analysed as one-way ANOVA (Analysis of Variance) using the Statistical Analysing Software (SAS) version 9.0 and the tukey test was used for the mean separation.

Results and Discussion

Volumetric water content: **Volumetric water content at field capacity (FC) was higher in sub soil compared to that of top soil in all cropping systems (Figure 1). Considering both depths, the lowest moisture retention was reported in coconut mono-cropping system. This is related to low organic carbon content and less micro porosity (Table 1). Moreover, the results indicate that Gliricidia and Wild sunflower has an ability to improve the aeration status of the soil in CGIS and CWIS by improving macro porosity (Table 1). These results also supported by Vidhana Arachchi and Liyanage (1996) who**

reported that Gliricidia has the ability to improve aeration capacity and available water retention capacity of the soil, which resulted in increasing root growth and development of coconut.

Table1. Effect of different cropping systems on soil bulk density and porosity in 0-42 cm depth

Cropping system	Bulk Density (g/cm^3)	Total Porosity %	Microporosity %	Macroporosity %
Forest	1.5	43.31	13.06	30.26
Coconut monocrop	1.58	40.57	8.08	32.49
Coconut-gliricidia	1.48	44.17	8.68	35.49
Coconut-wild sunflower	1.49	43.89	8.64	35.25
LSD	0.1	3.72	1.25	3.83
CV%	5.33	7.07	10.66	9.38
Significance	NS	NS	***	*

Denote the significant difference at p<0.05; ***Denote the significant difference at p<0.0001; NS denote the non-significance

***Bulk Density*: According to the findings, the lower bulk densities were observed in CWIS and CGIS respectively while the highest values of bulk density were observed in CMS due to higher soil compaction. However, the bulk density was not significantly different between Gliricidia and Wild sunflower integrated systems. These results are also supported by Ilangamudali *et al*. (2014) and most recently who reported that there was no detectable impact of Gliricidia on bulk density of sub soil in both Rathmalagara and Pallama estates.**

***Mean weight diameter (MWD):* MWD of soil aggregate is the indicator of aggregation and it was significantly lower in crop-based systems compared to the adjoining forest. This might be due to higher organic matter content in forest soils which facilitate aggregate formation. Results showed sharp declining of MWD in CMS over the adjoining forest resulting in creation of poor-structured soil, which would ultimately affect on nutrient retention capacity as well. At the same time CGIS showed higher MWD (1.59 cm) over CMS (1.44 cm) may be due to frequently added green manure from periodic pruning of hedge-row trees. It may facilitate microbial growth resulting binding of soil particles together to form stable aggregates.**

***Organic carbon (OC):* The OC content of both top soil (depth 1) and sub soils (depth 2) were higher in CGIS and CWIS compared to CMS due to continuous addition of plant residue through the leaf falling and periodic pruning of hedge rows of Gliricidia and Wild sunflower. But, the values were significantly low compared to the typical fertile agricultural soils. The lowest mean was observed in CMS (Figure 2) may be due to continuous cultivation with chemical fertilizer application and not providing adequate organic manure to the soil. However, OC content of top soil in CGIS and CWISs were increased by 11% and 45% respectively in contrast to the CMS and, sub soil it was increased by 61 % and 50% respectively. As evident from the results, there was a general trend of increasing soil OC content with integration of agroforestry system to the coconut, instead for mono cropping. However, OC status of most coconut growing soils has been highly depleted in contrast to the virgin forest soil and the quantity of OC may vary on level of management specially, lopping frequency of Gliricidia and Wild sunflower.**

Cation exchange capacity (CEC): **Mean values of CEC in both depths were significantly ($p \leq 0.05$) higher in forest, compared to that of other three cropping systems and the lowest mean CEC was reported in CWIS (3.77 meq/100 g soil). According to the statistical analysis, it can be suggested that nutrient retention capacity of forest soil is two times higher compared to CWIS. The higher organic matter percentage in forest soil may be the reason for this observation. However, the results clearly showed that nutrient retention capacity of soils in coconut based cropping systems have been highly depleted compared to virgin forest soil due to continuous use of chemical fertilizers without providing adequate amount of organic/green manure to the soil.**

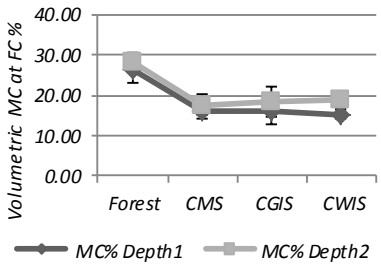

Figure1. Variation of volumetric water content at field capacity with respect to different cropping systems and soil depths

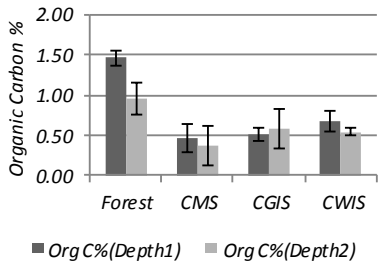

Figure2. Variation of soil organic carbon content with respect to different cropping systems and soil depths

Electrical conductivity (EC): **Electrical conductivity values of all soil tested, across the soil depths and cropping systems widely ranged from 21.4 to 104.5 µS/cm. Means of EC in both depths were significantly higher in forest, when compared to that of other three systems and the lowest was reported in sub soil of CMS. Higher EC values were observed in top soil compared to the sub soil in each system. Generally, top soil is more fertile due to addition of fertilizers and crop residues therefore; it improves the soil nutrient status and as a result ion concentration in top soil is high. However, EC was not significantly changed among two agroforestry systems and CMS.**

Soil pH: **Soil pH was not significantly ($p \geq 0.05$) different in studied cropping systems and the pH values of all tested soils ranged from 5.09 to 6.15.**

In summary, present study revealed that fields intercropped with Gliricidia and Wild sunflower have improved bulk density, water retention and organic carbon content while only Gliricidia integrated system showed positive influence on MWD and CEC over CMS. Moreover, this study also indicates the degree of which the soil fertility has declined through coconut cultivation in its comparison with natural forest on same soil type.

Conclusions

Most of the key soil properties of soil quality in CMS have been highly deteriorated compared to the adjoining forest. Soil fertility status of CGIS and CWIS were also lower compared to that of virgin forest soil but better than CMS. Therefore, coconut-based agroforestry systems (CGIS and CWIS) have positive effect on improving the soil quality for sustainable coconut production.

References

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