Society & Change
Vol. XVII, No.3, July-September 2023
ISSN: 1997-1052 (Print), 2227-202X (Online)

Comparative and States of Soil Health as Supported By Nature-Based Solutions under Organic and Conventional Tea Lands in Upper Highlands, Sri Lanka

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Abstract

Conventional approach of tea cultivation using agrochemicals is negatively affecting soil natural fertility. Excessive and unbalanced use of agro-chemicals has led to increased production costs but decline in farm productivity. Organic sources may reduce the dependency on chemical fertilizers. An organic system uses compost, animal manure, green manuring, biofertilizer (liquid fertilizer), tree lopping, and leguminous plants. Organic tea fields use a mulching system using rice straw, weed barrier, and defoliate leaves. Also, use deep drains and rainwater harvesting systems to conserve soil moisture. The sustainable Agriculture network (SAN) promotes the social and environmental sustainability of agricultural activities. A certification body certifies farmers of group administrators that comply with SAN standards and policies. The present

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study was planned with an overall objective of comparing soil health including soil pH, soil moisture and soil microbial activity under organic, sustainable agriculture standards and conventional systems. The experiment was carried out at smallholder organic tea fields and conventional tea fields in the Upper highlands in Sri Lanka. Minimum and maximum temperatures are 18°C and 34°C respectively. Soil microbial activity is determined by analyzing the amount of CO2 released using Anderson method. Also soil pH was measured using pH meter. The data of biological and chemical parameters of tea soils exposed to organic and conventional practices of tea were analyzed by SAS package. A questionnaire was given to tea farmers in order to gain information on cost for tea cultivation, income status, yield, problems and social satisfaction. The presence and action of all fauna and flora in soils is exhibited as biological activity. Organic tea soil has a significant difference with Natural forests, Pinus, Eucalyptus and vegetable soils. The reason for the lower value of soil biological activity may be due to the reduction of soil organisms as a result of excessive fertilizer applications in conventional fields. Soil moisture retention capacity is influenced by texture, structure, organic matter and soil depth. According to Duncan's Multiple Range Test soil moisture of organic and conventional has a significant difference. Conventional practices in tea cause the lower soil moisture of organic practices and enhance that by ensuring soil health. Organic tea fields use a mulching system using rice straw, weed barrier and defoliate leaves. Also use deep drains and rain water harvesting systems to conserve soil moisture. Both the organic and conventional tea soils are within recommended pH range for tea growth (4.5-5.5). However, long term exposure to organic tea cultivation will result in increased pH which is considered a limitation. The organic lands in Upper highlands are yet in the preliminary stage and would later experience high pH levels. There is an enhancement of biological and chemical properties in organically maintained soils in upper highlands compared to those under conventional practices. Organic soils are in a good range caused by good biological, chemical, cultural, and traditional methods. Organic farmers use environmentally friendly manures and fertilizers to improve their yield.

Keywords: Conventional tea, Organic tea, Soil microbial activity, Soil moisture, Soil pH

Introduction

Tea plays a major role in the Sri Lankan economy since James Taylor undertook the first commercial planting of tea in Sri Lanka in 1867. Tea (Camellia sinensis) is growing as a tree in many parts of the world with a wide adaptability. The Sri Lankan economy is largely sustained by the ten industries due to provision of employment directly or indirectly to over one million people. The total area planted with tea in Sri Lanka is about 188,175 ha and total production is 300 kg million per year (Sri Lanka tea board, 2022). Organic tea cultivation was undertaken in Sri Lanka 1983 and in the year 2000 about 336 MT of organic tea were produced in the country (Mohotti, 2002). At present Sri Lanka caters to many strong international markets with organic tea. Organic teas fetch 3-4 fold prices of conventional teas. In this respect it can be regarded as working more deeply with nature. It attempts to strengthen the support we get from the cosmos, firstly by the use of special preparations, and secondly by the use of a calendar which enables us to manage each particular crop under the most beneficial influences (Smith, 2007). The sustainable Agriculture network (SAN) promotes the social and environmental sustainability of agricultural activities. A certification body certifies farmers of SAN group administrators that comply with SAN standards and policies. Farmers can apply for use of the "Rainforest Alliance Certification (RAC)" certified trademark for products grown on SAN farms in Sri Lanka. The mission of SAN is to "Promote efficient agriculture, biodiversity conservation and sustainable community development"(SAN, 2010). Sri Lankan researchers have been studying the soil health of organic and conventional tea fields in Upper highlands, Sri Lanka. The aim of the study was to compare soil health including soil pH, soil moisture and soil microbial activity under organic, sustainable agriculture standards and those using agrochemicals.

Main Objectives

1. To study environmentally, economically and social sustainability of organic and conventional tea farming.
2. Examine the soil characteristics in organic and conventional tea farming practices.
3. Compare the factors affecting soil health in organic and conventional tea farming.
4. Analyze the most compatible farming method to sustain the soil health.

Material and methods

Experimental site

The experiment was carried out at organic and conventional tea fields in Upper highlands, Sri lanka. Maps were studied using Google Earth to retrieve data covering the entire area. All together, 239 samples were collected from all four zones.

	Sample count					
Zone	Organic tea	Conventional tea	Natural forests	Eucalyptus plots	Pinus plots	Vegetable plots
Madhuwelpathana	56	10	03	03	03	03
Wegoda	38	20	03	03	03	03
Halpe	31	10	03	03	03	03
Heeloya	10	06	03	03	03	03

Table 1: Sample count of all four zones

Both laboratory and field experiments were carried out to fulfill the overall objectives of comparing soil pH, soil moisture and soil microbial activity of organic tea field, conventional tea fields, Pinus forests, Eucalyptus forests, natural forests and vegetable plots.

Soil sampling

Field soil samples were drawn randomly to a depth 0-15 cm from each organic and conventional tea lands. Samples from 04 places in each location were taken with an auger. Pooled together and well mixed, composite soil samples were kept under cool and humid conditions until used for the experiments. Soil samples from Pinus forests, Eucalyptus forests, natural forests and vegetable plots were also drawn in the same manner to be compared with organic and conventional tea soils for soil biological and chemical parameters. The analysis was done to determine the following biological and chemical parameters of tea soils exposed to organic and conventional practices in Upper highlands.

Determination of soil biological properties

Soil microbial activity measurement

Soil respiration of different treatment plots were determined by using the method described by Anderson (1982). A mass of 10g of soil for each treatment plot was placed in a reagent bottle, 3.5ml of distilled water was added and mixed well. An ignition tube containing 3ml of 0.5N NaOH was hung upright in each bottle and the reagent bottle was sealed tightly using para film. After two days the content of each ignition tube was washed into 200ml of beaker using distilled water. Then 7.5ml of 2N $BaCl_2$ and a few drops of phenolphthalein were added as an indicator. This was titrated against 0.5N HCl and the amount of CO_2 released during seal period was determined using following equation.

Amount of released $CO_2 = (3-V_1) \times 22 \times 0.001$mg / day / 10g of soil

Where V_1 (Volume of NaOH not neutralized by CO_2 released) = $(N_2 \times V_2)/N_1$

N_2 = Normality of HCl

N_1 = Normality of NaOH

V_2 = Volume of HCl

Soil moisture

Of all the gravimetric techniques for determining soil moisture, oven drying is perhaps the most popular and is frequently used to calibrate other soil moisture determinations. With this technique, a soil sample is over-dried at 105 °C until a constant weight is produced. Typically, this weight is produced in 24 hours, but larger samples require longer drying times. Before oven drying, the soil sample's wet weight (10g) is recorded. The sample's moisture content can be computed and reported as a percentage of the dry soil weight, allowing the amount of water in the sample to be identified (Schmugge et al., 1980). The gravimetric value is multiplied by the bulk density of the soil if the volumetric water content is required:

$SM = (10g - W_d)/10g * 100\%$

Where,

SM = Soil moisture (%)

W_d = dry weight of soil (g)

Determination of soil chemical properties

Soil pH

A mass of 10g of fresh soil was weighted and placed in a 50ml pH cup. Then, a volume of 25ml of distilled water was added (soil 1: water 2.5), stirred well using a plastic rode. The suspension was left for 30 minutes. It was stirred well and the pH was measured using pH meter.

Data analysis

The data of biological and chemical parameters of tea soils exposed to organic and conventional practices of tea were analyzed by SAS package.

Results and Discussions

Soil Microbial activity

The presence and action of all fauna and flora in soils is exhibited as biological activity. Data generated in tea soils exposed to organic and conventional practices in Upper highlands and undisturbed natural forest soil, Pinus soil, Eucalyptus soil and vegetable soil are presented in figure 1.

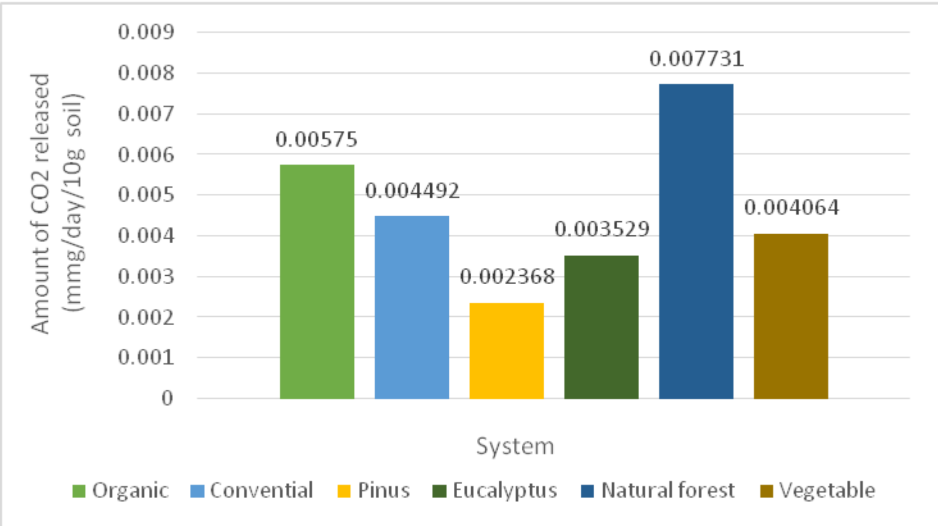

Figure 1: Biological activity of organic and conventional tea soils, undisturbed forest soil, Pinus, Eucalyptus, and vegetable soils

Data showed that both conventional and organic tea lands had statistically significant soil microbial activity ($P \leq 0.05$). According to Duncan's Multiple Range Test Microbial activity of organic and conventional has a significant difference. Also Organic tea soil has a significant difference with Natural forests, Pinus, Eucalyptus and vegetable soils. Microbial activity of conventional tea soil has a significant difference with Natural forests and Pinus soils but conventional tea soil has no significant difference with Eucalyptus and vegetable soils. The highest biological activity was recorded in the forest sample (7.75µg/day/10g of soil) while it was more closely to that of organic tea soils (5.875µg/day/10g of soil).

The presence and action of all fauna and flora in soils is exhibited as biological activity. Organic tea soil has a significant difference with Natural forests, Pinus, Eucalyptus and vegetable soils. The reason for the lower value of soil biological activity may be due to the reduction of soil organisms as a result of excessive fertilizer applications.

Soil moisture

Soil moisture retention capacity is influenced by texture, structure, organic matter and soil depth. In general, greater the percentage of pore spaces in a soil of given texture, the greater will be the water retention capacity. Data generated in tea soils exposed to organic and conventional practices in Upper highlands and undisturbed natural forest soil, Pinus soil, Eucalyptus soil and vegetable soil are presented in figure 2.

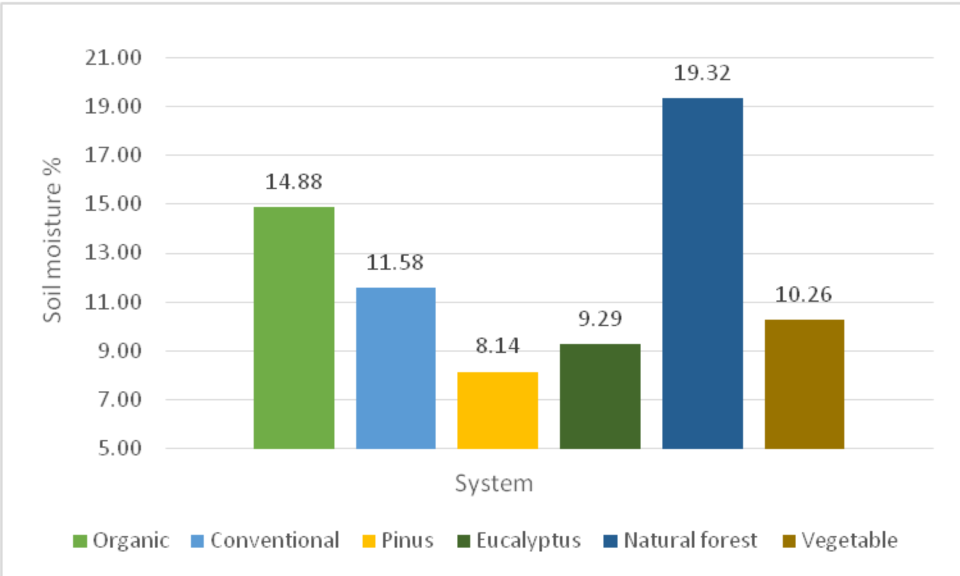

Figure 2: Soil moisture of organic and conventional tea soils, undisturbed forest soil, Pinus, Eucalyptus, and vegetable soils

Data showed that both conventional and organic tea lands had statistically significant soil moisture ($P \leq 0.05$). According to Duncan's Multiple Range Test soil moisture of organic and conventional has a significant difference. Also Organic tea soil and conventional tea soil have a significant difference with Natural forests, Pinus, Eucalyptus and vegetable soils. Organic tea soil is 22.17% more healthy than conventional tea soil in Upper highlands. Organic tea fields use a mulching system using rice straw, weed barrier and defoliate leaves. Also use deep drains and rain water harvesting systems to conserve soil moisture.

Soil pH

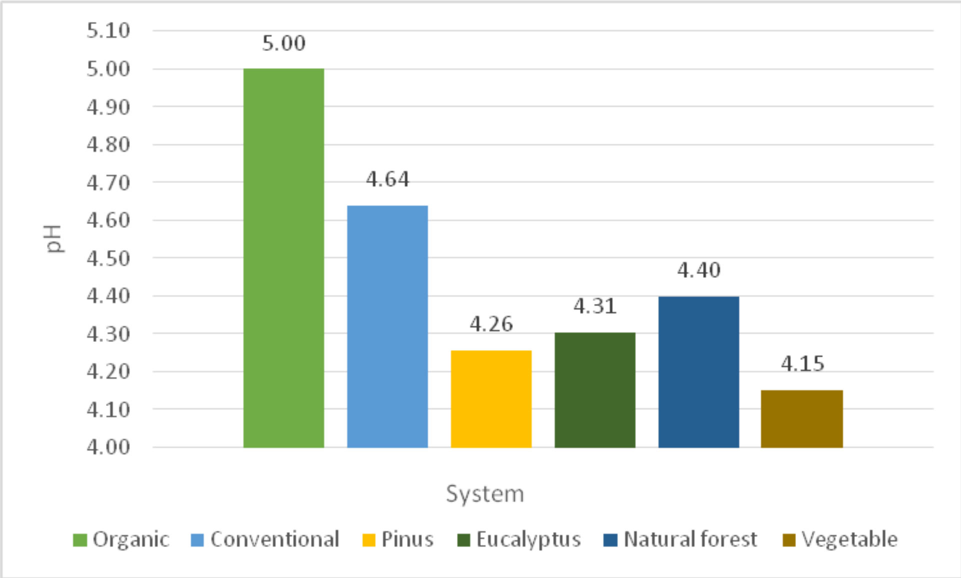

Figure 3: Soil pH of organic and conventional tea soils, undisturbed forest soil, Pinus, Eucalyptus, and vegetable soils

As shown in figure 3, Data showed that both conventional and organic tea lands had statistically significant difference in soil pH ($P \leq 0.05$). According to Duncan's Multiple Range Test soil pH of organic and conventional has a significant difference. Soil pH of Organic forests, Pinus, Eucalyptus and vegetable soils have no significant difference between each other. Long-term exposure to organic tea cultivation will result in increased pH which is considered a limitation. Organic lands in Upper highlands are yet in the preliminary stage and would later experience high pH levels.

Estimated yield

The estimated yield (Kg/Month/ha) of organic and conventional tea is presented in figure 4.

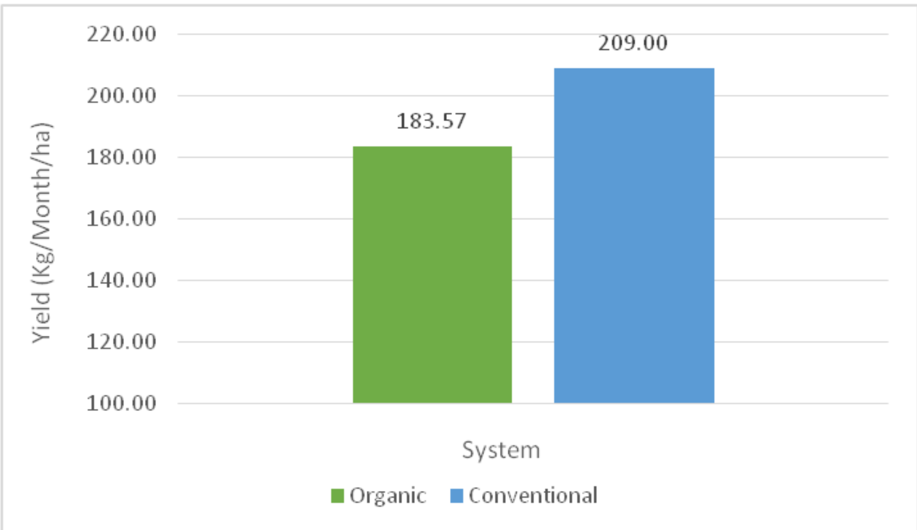

Figure 4: Estimated yield of organic and conventional tea lands (Kg/Month/ha)

Even though the majority of organic tea farmers had a negative opinion of the productivity of the organic system compared to conventional tea, the results of the socioeconomic survey did not show a statistically significant (P=0.2252) difference in yield (Kg/Month/ha), according to the findings shown in figure 4. Organic tea yield is 183.57Kg/Month/ha and conventional tea yield is 209.00 Kg/Month/ha. A Higher number of Conventional tea fields are located in Upper highlands than organic tea fields. But as shown in figure 4, the estimated yield of organic and conventional tea has not changed much because chemical fertilizers are prevented by the government and available fertilizer stocks are too expensive.

Conclusion

The present study was carried out in Upper highlands in Sri lanka, with an aim of conducting a comparative evaluation of organic and conventional tea systems to have a perception of evaluating soil biological and chemical properties and socio-economic status which represents the actual scenario of organic tea cultivation in the country in practice.

The overall results revealed that there is an enhancement of biological and chemical properties in organically maintained soils in Upper highlands which are statistically significant in situations under conventional practices. It can be concluded from the findings of the soil analysis that the soil biological parameters such as soil microbial activity and soil moisture water retention capacity are significantly higher in organically maintained tea soils than in conventional tea soils. Enhancement of biological properties of tea soil ensures the soil health together with chemical and physical properties which may affect the sustainable productivity. Both organic and conventional soils are in a good range caused by good biological, chemical, cultural, and traditional methods.

Based on the social survey, it can be concluded that the farmers perception on conventional tea yields have become lower because of a chemical fertilizer prohibition from the government. Therefore, available chemical fertilizers and manures are limited and more expensive. Therefore, farmers have restricted of using fertilizer due to the shortage. Organic farmers use eco-friendly manures like compost, chicken manure and bio fertilizers to improve their yield.

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