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Manurial effect of wood ash and refuse tea on nutrient status and yield of tea (*Camellia sinensis* L.)

L.H.M.G., Gunathilaka[1,]*., G.P., Gunarathne[2], L.P.Vidhana Arachchi[1,2]

[1]*Department of Export Agriculture, Faculty of Agriculture Science, Sabaragamuwa University of Sri Lanka*

[2]*Soil and Plant Nutrition Division, Tea Research Institute of Sri Lanka, Talawakelle*

Abstract

A field experiment was carried out to determine the effects of wood ash and refuse tea with urea on yield and nutrient status of tea. Experimental plots were located in the St Coombs Estate, Tea Research Institute, Talawakelle, Sri Lanka. Six treatments (1 ton wood ash plus 20 ton refuse tea ha^{-1} $year^{-1}$\{T_1\}, 2 ton wood ash plus 20 ton refuse tea ha^{-1} $year^{-1}$\{T_2\}, 1 ton wood ash plus 20 ton refuse tea plus 587 kg urea ha^{-1} $year^{-1}$\{T_3\}, 2 ton wood ash plus 20 ton refuse tea plus 587 kg urea ha^{-1} $year^{-1}$\{T_3\}, present TRI fertilizer mixture\{T_3\}, and control\{T_3\}, without any fertilization) were arranged according to Randomized Complete Block Design with three replicates. Macro and micro nutrient contents in soil and leaf were analyzed5 months after applying treatments and yield was recorded in weekly intervals.T_2 applied plots indicated significant positive effect ($p<0.05$) on the yield and significantly ($p<0.05$) higher Potassium and Calcium content in the soil. Significant effect ($p<0.05$) of Nitrogen and Carbon content in the soil was given by T_1. Electrical conductivity and pH changes in soil were not any significantly different among all the treatments whilst higher macro and micro-nutrient concentration was observed in the soil, treated with T_1,T_2,$T_3$and T_4. It is evident from results that wood ash, refuse tea with urea can be successfully used to promote sustainable tea cultivation in the Mattakelle soil series (Rhodudults/Tropudults;USDA classification) which having high buffering capacity.

Keywords:Buffering capacity, Soil nutrient, Sustainable tea production

1. Introduction

Tea (Camellia sinensis (L) O Kuntze) is very important plantation crop in Sri Lanka. The immature shoots of tea are plucked at regular intervals and removed a certain amount of various elements from the plant-soil system1.

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Therefore, fertilization acts as a major role in tea sector to enrich its economical yield factors such as vigor, flush yield, and growth.

Production cost of tea was highest in Sri Lanka in compare to other competitive tea producing countries. Syntheticfertilizer is affecting the natural environment harmfully by many ways. Then, throughout the world, there is an increasing demand for organic tea, which is free of pesticide and other chemical residues2.

The use of solid waste such as wood ash and refuse tea has enabled an alternative form of fertilization and a way to replace nutrients in the soil, consequently affecting the crop. Tea industry, also has waste product such as refuse tea coming from made tea production while ash coming from fire wood. This residue contains varying concentrations of minerals and, once in the soil, works as a corrective fertilizer improving the soil fertility.

Several researches had publicized that when synthetic fertilizers were not applied, the use of wood ash produced significant effects on the growth and yield of many crops, but dearth of information of effect of application of wood ash on tea plant growth and yield. This study was initiated to find out and recommend wood ash more rationally to the tea plantation stakeholders in eco-friendly and cost-efficient way.

2. Methodology

The experimental plots were located at the Tea Research Institute of Sri Lanka (latitude 6o80' N, longitude 80o 40'E; and altitude 1382 m AMSL) of the Mattakelle series which belongs to the great soil groups Red Yellow Podsolic (Rhodudults/Tropudults; USDA classification) in up-country wet zone;WU2. Average annual rainfall of the area is about 2250 mm and annual average minimum, maximum temperatures were 14.2oC and 22.8oC, respectively.

The field trial was carried out trench planted spacing of 4x 2 feet in1965. Each individual plots contained 40 bushes. The following six treatments (Table 1) were arranged in the Randomized Complete Block Design with three replicates (n=3). Eighteen plots were marked out and each plot was surrounded by a guard raw which separated the treated area in order to prevent treatment effect in any adjacent plots.

The initial nutrient content (%) available in wood ash and refuse tea were analyzed by using following stranded methods. Soil (0-6 and 6-12cm depth) and leaf sampling was undertaken before the 1st treatment application and after 5 months. Electrical conductivity and pH were determined using pH meter (ORION 510A model, USA) and Conductivity meter (model CDM 83), respectively.

Soil and leaf nutrients content, including C, N, P, K, Mg, Ca, Mn, Fe, Zn and Cu measured by analysis of soil and fresh leaves using Walkley- Black method, Kjldal method3, Determination of Borax [Na2B4O7.12H2O] extractable phosphorous4, Determination of total potassium, magnesium, calcium in soil, and determination of D.T.P.A extractable (Zn, Cu, Mn, Fe)Trace element in Soil respectively. Total yieldin each plot also obtained from sum of ten times plucking.

Data were analyzed using the Statistical Analysis System and Microsoft Excel version 6 package. Mean comparison of treatments were performed using Least Significant Difference (LSD) test at 0.05 probability level ($p<0.05$).

Table 1. Treatments details.

Treatment	Details
Treatment 1 (T_1)	wood ash3.2 kg (1t/ha/yr) + refuse tea32 kg(20 t/ha/yr) per each plot/yr
Treatment 2 (T_2)	wood ash 6.4 kg (2t/ha/yr) + refuse tea32 kg (20 t/ha/yr) per each plot/yr
Treatment 3 (T_3)	wood ash 3.2 kg (1t/ha/yr) + refuse tea32 kg (20 t/ha/yr) per each plot/yr +urea 469g (587kg/ha/yr) per each plot /3 months
Treatment 4 (T_4)	wood ash6.4 kg (2t/ha/yr) + refuse tea32 kg (20 t/ha/yr) per each plot/yr + urea469g (587kg/ha/yr) per each plot /3 months
Treatment 5 (T_5)	Present TRI ground fertilizer recommendation
Treatment 6 (T_6)	No any fertilizer application (control)

3. Results and Discussion

The effect of six treatments on the experimental traits is showed in Table 2. Combination of wood ash, refuse tea and urea treated soils were positively significant ($p<0.05$) on the yield. Based on results, T4 was the best treatment for increasing of yield (Table 2). Wood ash contains varying concentrations of minerals except nitrogen. Then, after incorporation this residues to the soil, it works as a corrective fertilizer. Then, application of other nitrogen source (urea and refuse tea) with wood ash is vital to improve the tea yield. Further, present inorganic fertilizer mixture and the control treatments have shown the lowest yield. Most of nutrients were lost many ways such as leaching, evaporation, and wash out. Therefore, combination of organic and inorganic fertilizers provides the ideal environmental conditions for the crop with improving soil properties.

The changes of pH and EC in soil with respect to six different treatments during research period were not significantly ($p>0.05$) different. It can be concluded that application of wood ash for soil series having high pH buffering capacity (Mattakelle series, Nuwaraeliya series etc.) may not harmful, although tea is a acidity condition loving plants. Because that type of soil can resistance to change in the concentration of any ion in the soil solution5. Soil pH is one of the most important soil properties influencing tea growth while pH of 4.5 - 5.5 is considered to be the optimum for the utilization of nutrients. All treatments application plots have been showed above correct pH range (Table 2).

There was a significant ($p<0.05$) difference among the treatments for responding to the soil nitrogen. Besides, all the treatments which were treated with refuse tea have been noticed higher nitrogen concentration (Table 2). Krishnapillai6 also suggested that refuse tea was known to contain a higher percentage of nitrogen. Although urea release considerable amount of the nitrogen to soil, most of them were lost by many ways.

Soil phosphorous content was not significant ($p\geqslant0.05$) with treatments while, potassium was significant ($p<0.05$) difference among the treatments. Wood ash usually presents a relatively high concentration of potassium. There was a significant ($p<0.05$) difference organic carbon content among six different treatments in soil. The highest carbon concentration was observed in plots which are treated with the wood ash with refuse tea (Table 2). There was no any significant ($p\geqslant0.05$) difference in soil magnesium whilst, there was a significantly ($p\leqslant0.05$) different in soil calcium content among the six treatments. Calcium and magnesium carbonate or oxides are present in comparatively large quantities giving the wood ash.

Results further suggested that, there was a significant ($p<0.05$) difference in soil copper content while, there was no any significant ($p\geqslant0.05$) difference in soil ferrous, zinc, and manganese content among the six treatments. Wood ash contains high concentrations of micronutrients. The higher ferrous content has showed among all the treatments in (Table 2). It can be assumed that, Mattakelle series belongs to the great soil group red yellow podsolic which inherited high in the ferrous content.

There was no any significant ($p \geqslant 0.05$) difference among nitrogen or potassium composition in the mother leaves treated in six different ways. Magnesium composition in the mother leaves were significantly ($p \leqslant 0.05$) higher in six different treatments. However, there was not any significantly different among the treatments for phosphorous. Magnesium is the only mineral constituent in the chlorophyll molecule that regulates photosynthesis. In addition, it acts as an activator of many enzyme systems1. There was a significant ($p<0.05$) difference in zinc, whilst no any significant ($p \geqslant 0.05$) difference in copper and ferrous composition in the mother leaves (Table 2). Zinc is necessary for the synthesis of IAA, which is responsible for active shoot growth1.

It is evident from the results, wood ash, refuse tea and urea can be used as integrated fertilizer mixture in tea cultivation in Mattakelle soil series. Two ton wood ash plus 20 ton refuse tea plus 587 kg of urea ha-1 year-1 treatment can be consider as superior over the other tested treatments in respect to soil available nutrient concentration and tea yield for high buffering capacity soils.

Table 1. Effect of treatments on the yield, soil and leaf nutrients.

Treatments	Total yield (Made tea kg/ha)	pH	EC(µS/cm)	C %	N %		K		P		Mg		Ca (ppm)	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)	
					Soil	Leaf	Soil (ppm)	Leaf %	Soil (ppm)	Leaf %	Soil (ppm)	Leaf %		Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf
Wood ash 1000kg/ha/y + refuse tea	762 ab	5.31 a	19 bc	2.70 a	0.40 a	3.41 a	710 a	1.32 a	38 ab	0.06 a	127 a	0.24 a	582 bcd	22 a	42 a	3.50 a	15 a	4.35 a	343 a	1.79 a	13 a
Wood ash 2000kg/ha/yr + refuse tea	785 ab	5.28 a	21 abc	2.67 a	0.40 a	3.47 a	722 a	1.27 a	39 ab	0.06 a	128 a	0.25 a	885 a	21 a	37 a	2.09 abc	14 a	4.92 a	274 ab	1.67 a	14 a
Wood ash 1000kg/ha/yr + refuse tea +urea	821 a	4.70 a	42 a	2.68 a	0.40 a	3.42 a	723 a	1.27 a	40 ab	0.08 a	129 a	0.22 a	698 abc	26 a	46 a	2.78 abc	15 a	4.53 a	145 bc	1.28 ab	15 a
Wood ash 2000kg/ha/yr + refuse tea +urea	835 a	5.10 ab	31 ab	2.53 a	0.40 a	3.4 a	724 a	1.43 a	44 ab	0.06 a	94 a	0.26a	745 ab	19 a	49 a	2.98 ab	15 a	4.96 a	218 abc	1.35 ab	15 a
TRI recommendation	698 bc	4.69 b	32 ab	1.87 b	0.40 a	3.02 ab	725 a	1.20 a	24 b	0.05 a	101 a	0.153 b	457 cd	18 a	67 a	1.94 bc	12 b	1.92 ab	244 abc	0.67 b	13 a
Control	608 c	4.92 ab	5 c	1.64 b	0.40 a	2.87 b	726 a	1.1533 a	21 b	0.05 a	84 a	0.166 c	414 d	19 a	15 a	1.45 c	11 b	0.71 b	89 c	0.67 b	13 a
LSD(P<0.05)	102.97	0.57	21.6	0.3665	0.077	0.48	27.966	0.285	30.2	0.029	51.36	0.074	282.13	9.138	45	1.443	2.269	3.133	174.2	0.753	3.708
Prob. Level	0.0051	0.12	0.04	0.0002	0.028	0.08	0.0006	0.414	0.161	0.023	0.356	0.038	0.0289	0.499	0.3	0.081	0.004	0.052	0.085	0.03	0.674
CV%	7.5316	6.27	47.7	8.5815	11.06	8.13	27.966	8.582	43.75	26.76	26.59	18.89	24.616	23.59	57	32.27	9.13	48.29	7.531	33.41	14.22

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