THE EFFECTS OF SOIL AMENDMENTS ON SELECTED PROPERTIES OF TEA SOILS AND TEA PLANTS (*Camellia sinensis* L.) IN AUSTRALIA AND SRI LANKA

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AFFECTIONATELY DEDICATED

TO

MY PARENTS, TEACHERS AND MY FAMILY

ABSTRACT

Organic matter transformations and nutrient cycling in soils depend on the activity of soil organisms. Deterioration of soil fertility lowers the biological activity and results in lower productivity. In the absence of adequate organic matter, the processes of conversion of nutrients to plant-available forms and their retention are very low. To enhance the activity of soil organisms especially that of beneficial microbial populations, the addition of high quality organic amendments is very important. Even though there are plenty of organic materials available in tea lands, there is inadequate information on their suitability and influence on the biological properties of soils.

The present research has attempted to determine the extent to which the microbial activity and productivity of tea soils in Australia and Sri Lanka can be manipulated by use of readily available soil amendments. Trials were conducted using grass and leguminous mulching materials with different C/N ratios, in combination with two pH amendments (dolomite and 'Minplus™' – a finely ground volcanic rock dust - both applied at rates of 2500 kg ha^{-1} only for the pot trials and 1000 kg ha^{-1} for the other trials) and an inoculum of biologically active rain forest soil. The nursery stage of tea (*Camellia sinensis*) propagation was studied in a shadehouse at James Cook University, Townsville, Australia, and young tea (unpruned, 1 year after planting) and mature tea (pruned bushes, 5 years since planting) were studied in a field in Sri Lanka.

In the nursery trial, mulching materials consisting of finely chopped *Brachiaria decumbens* (a grass), *Calliandra calothyrsus* (a legume), and tea prunings were applied at a rate of 35 tonnes fresh weight ha^{-1} $year^{-1}$ to pots with or without tea seedlings.

The grass mulch with Minplus improved soil organic carbon, CEC, soil pH, microbial biomass carbon, plant available phosphorus, and total nitrogen contents of the soil and enhanced the growth of plants when compared to the effects of *Calliandra* legume and tea mulch. All the combinations of mulches with dolomite reduced plant growth even though they enhanced some soil properties. Application of grass and legume mulches increased the beneficial population of gram positive bacteria, fungi, and mycorrhiza. Grass mulch also improved the growth of tea as measured by shoot weight and total biomass. The addition of a rainforest inoculum to the soils of the nursery tea plants increased the soil microbial biomass carbon and growth of tea plants even in the absence of any mulch.

The field trials in Sri Lanka demonstrated the extent of the changes induced by mulches and soil pH modifiers in soil microbial properties, including the abundances of functional groups of microbes (bacteria, fungi, mycorrhizae), soil microbial biomass carbon, and microbial respiration. In addition organic carbon, soil pH, nitrogen and mulch decomposition rate were measured. The mulching materials tested were: refuse tea (25 tonnes ha^{-1} $year^{-1}$), Mana grass (*Cymbopogon confertiflora*), and branches of Dadap (*Erythrina lithosperma*), a leguminous tree (35 tonnes fresh weight ha^{-1} $year^{-1}$). In addition to these treatments, lemon grass (*Cymbopogan nardus*) 20,000 plants ha^{-1} as live mulch in young tea and a *Trichoderma* fungal culture in the mature tea were used. For young tea and mature tea, Mana and Dadap were applied four times and Refuse tea three times per study period and the lemon grass was planted at the start of the trial on a 15 x 15 cm spacing in the young tea; *Trichoderma* was applied once to the mature tea trial at a rate of 500 g of spore culture / plant.

The results indicated that Dadap and Refuse tea raised the yield of tea significantly by 16% and 19% respectively in young tea, and by 14% in mature tea for both mulches. The mulches enhanced soil pH, microbial biomass carbon, soil respiration and also suppressed the most detrimental gram negative bacterial populations one year after the application of treatments in young tea and increased soil nitrogen by refuse tea in mature tea trial. The quality of tea increased in tea grown under the control and lemon grass mulch treatment in young tea and in *Trichoderma* fungus-treated plots in mature tea.

Minplus rock dust and the rainforest soil inoculum enhanced the growth of the nursery plants. The most suitable mulching materials to accelerate the biological activity were found to be those with C/N ratios below 20, and low in lignin and unoxidisable polyphenol. Therefore, the suitable materials for use as mulches on tea lands are *Brachiaria grass*, refuse tea, and Dadap legume. They also suppressed the development of pathogenic bacterial populations particularly gram negative bacteria. These materials also improved the biological properties of soil and thereby enhanced the growth and yield of tea.

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CHAPTER 3

THE YOUNG TEA TRIAL , ST. COOMBS ESTATE, SRI LANKA

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Glossary of terms

AP	Available phosphorus
CEC	Cation Exchange Capacity determined as the sum of the basic cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) and the acidic cations (H^+, Al^{3+})
Dadap	The small leguminous tree *Erythrina lithosperma*
Dolomite	Calcium and magnesium carbonate: $CaMg(CO_3)_2$
FAME	Fatty Acid Methyl Ester
Guatemala grass	*Tripsacum laxum*
Immature tea	Young tea (1-2 yrs old)
JCU	James Cook University
Lemon grass	*Cymbopogon nardus*
Made tea	Black tea after processing
Mana grass	*Cymbopogon confertiflorus*
Mature tea	More than 20 years old tea
MBC	Microbial biomass carbon
MBN	Microbial biomass nitrogen
Minplus	Finely ground volcanic rock dust produced by Pacific Mineral Developments Pty Ltd, Innisfail.
N	Nitrogen
NH_4^+	Ammonium cation
Nursery tea	1-9 months old tea
OC	Organic carbon
P	Phosphorus
Plucking Table	Top part of the canopy where flush is harvested

PO_4^{3-}	Phosphate anion
Refuse tea	Waste product of the tea manufacturing process and is the partly ground, brown stalk and fibrous particles remaining after separating the commercial components of the manufactured tea
S	Sulphur
SO_4^{2-}	Sulphate anion
TRI	Tea Research Institute of Sri Lanka
Young tea	1-2 years old tea