THE INFLUENCE OF PHOSPHORUS FERTILISER FORMS AND RHIZOSPHERE PROCESSES ON THE PHOSPHORUS NUTRITION OF TEA (*Camellia sinensis* L.)

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To the Memory of

My late Parents

For their

Enormous love, care and guidance

ABSTRACT

The understanding of the phosphorus (P) nutrition of tea, has mainly derived from trials evaluating yield response to applied P fertilisers. The literature indicates that the fertiliser P requirement of tea is generally low (below 15 kg ha^{-1} yr^{-1}), inspite of the generally high P fixing capacity of the Ultisols used for growing tea. Very little published information is available on the reactions of P fertilisers in tea soils and on the chemistry of P in the tea rhizosphere to explain this low P requirement of tea.

Because the tea soils are highly acidic (4.5 - 5.5) a locally mined, low cost, sparingly soluble phosphate rock (Eppawala phosphate rock, EPR) has been recommended as a P fertiliser for tea in Sri Lanka. But there is no experimental information available on its suitability for tea when compared to soluble P fertilisers.

The main objective of this thesis is to study the mechanisms involved in P utilisation from the tea rhizosphere, when both soluble (triple superphosphate) and sparingly soluble EPR fertilisers are used. An existing technique used to study rhizosphere processes of annual crops was modified to study the chemical processes involved in P utilisation from the rhizosphere of camellia plants, which are of the same family as tea. The depletion of soil and fertiliser P in slices of soil away from the rhizoplane were measured using a sequential chemical P fractionation procedure. The technique allowed isolation of soil slices at increasing distances from the rhizoplane and characterisation of the depletion pattern of soil P forms in the camellia rhizosphere. Subsequently this technique was used to study the rhizosphere processes in tea and other crops normally grown in association with tea.

A glasshouse study conducted to compare the mechanisms of P utilisation of tea (clone TRI 2025) with calliandra, Guinea grass and beans showed that all species depleted resin-P and NaOH-P_i in their rhizospheres. In contrast to other species, tea accumulated NaOH-P_o (organic-P) in the rhizosphere. All plant species acidified their rhizospheres and the magnitude of acidification is in the order of Guinea grass > bean and tea > calliandra. The higher acidification in the rhizosphere compared to the bulk soil caused more EPR dissolution near the roots.

Another glasshouse trial which examined the P utilisation efficiencies of tea clones showed that TRI 2023 and TRI 2025 had a higher external P efficiency than S 106 due to greater root surface area and P uptake per unit root surface area. But the internal efficiencies were not significantly different between the clones. All tea clones acidified the rhizosphere and the magnitude of acidification is of the order : TRI 2023 > TRI 2025 > S 106. The dissolution of EPR in the rhizosphere also followed the same order. All three clones accumulated NaOH-P_o in the rhizosphere.

Rhizosphere pH of tea (clone TRI 2025) decreased compared to the bulk soil, when N was supplied as the NH_4^+ [$(NH_4)_2SO_4$] or the NH_4^+ + NO_3^- [NH_4NO_3] form and it increased when N was supplied as the NO_3^- [$Ca(NO_3)_2$] form. The $(NH_4)_2SO_4$ treatment caused the highest dissolution of EPR in the rhizosphere, whereas the $Ca(NO_3)_2$ treatment showed the lowest in accordance with the magnitude of pH decline. Cation-anion balance in the plants showed that whatever form of N was applied, plants utilised more NO_3^- than NH_4^+. High nitrification rates in the rhizosphere were probably responsible for this inspite of the addition of a nitrification inhibitor.

A glasshouse trial with young tea plants (TRI 3072) showed that the agronomic effectiveness of the sparingly soluble EPR was equal to or better than the readily soluble TSP (triple superphosphate) fertiliser. This was due to the high rate of EPR dissolution in the acid soil. About 75% of the applied EPR was dissolved in the soil during the 10 month period of the study. The results also showed that the borax soil P test used to predict the P requirement of tea, as currently used in Sri Lanka, was the best of the six soil P tests investigated. This test has the advantage of requiring only one calibration curve relating yield and soil P values in estates fertilised with both soluble and sparingly soluble PR fertilisers.

This thesis contributed new knowledge regarding P uptake processes in the rhizosphere of tea plants.

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