CHAPTER V

SUMMARY AND CONCLUSIONS

Rubber growing soils are acidic in pH and under acidic conditions normally Zn is available for plant growth. However, the soils under rubber are highly weathered and are prone to severe leaching losses due to the intense rainfall. Low Zn content of the rubber growing soils in the traditional belt of rubber cultivation was reported by Joseph et al. (1995). Further, in an extensive study with 9682 surface soil samples covering the traditional rubber growing tract of Kerala and Tamil Nadu it was reported that 41.0 per cent of the soils in the traditional rubber growing tract is deficient in available Zn. In the traditional belt of rubber cultivation plantations are in the second or third planting cycle. Repeated cycles of cultivation might have reduced the Zn status of the soil further and Zn deficiency in young plants in the replanting fields is a common phenomenon these days. The present investigation on Dynamics of Zn in rubber growing soils was studied under four major heads viz., i) collection of profile soil samples from nine major soil series, and assessment of the status and distribution of total and different forms of Zn, ii) assessment of Zn availability in these soils using different extractants iii) modeling of Zn adsorption in the surface soils of these nine major soil series and iv) pot culture experiment to study the response of rubber plants to application of Zn.

5.1. Physicochemical properties of the soil

1. The organic carbon content of the horizon wise soil samples ranged from 0.68 per cent in the Ap horizon in Kunnathur and Thrikkannamangal series to 2.0 per cent in Panachikkad series. In general, the Kunnathur and Thrikkannamangal series
recorded the lowest organic carbon content and Lahai series recorded the highest organic carbon content.

2. The cation exchange capacity values were very low and ranged from 4.41 cmol(p+)/kg in the Bt4 (83-112 cm) horizon of Kanjirappally series to 11.25 cmol(p+)/kg in the Bt2 horizon of Panachikkad series. In the Ap horizon, the values are comparatively high in all most all the series except in Kaipuzha series where the CEC values are low in all the horizons.

3. The base saturation values were less than 35 in all the series studied except in Kunnathur series. The values ranged from 8.0 per cent in the Bt2 horizon (31.0-52.0 cm) of Kaipuzha series to 41.77 per cent in the Ap horizon (0-16 cm) of Kunnathur series. Among the nine series, the per cent base saturation values were extremely low in Kaipuzha and Lahai series.

4. Wide variation in the values of exchangeable Ca, Mg and K was recorded among the series. The exchangeable Ca values were extremely low in the Kanjirappally and Lahai series in all the horizons and comparatively high in Kunnathur series. Similarly, exchangeable Mg values were extremely low in Kanjirappally, Lahai and Kaipuzha series. Exchangeable K values were low in Vazhoor, Panachikkad and Kaipuzha series. Exchangeable Na values showed the same trend as that of K.

5. The soils were dominated by coarse sand and clay. In general, the clay content was found to increase with depth of the soil.
Status and distribution of Zinc

1. The total Zn content in the Kanjirappally series ranged from 42.40 µg/g in the lowermost layer to 66.90 µg/g in the surface horizon. The major portion of the total Zn was in the residual pool which ranged from 31.25 µg/g in the Bt5 horizon to 97.57 µg/g in the Ap horizon.

2. In the Vijayapuram series the total Zn content ranged from 60 µg/g in the Ap horizon to 93.0 µg/g in the Bt2 horizon. The water soluble and exchangeable Zn values ranged from 1.37 µg/g in the Ap horizon to 0.30 µg/g in the Bt4 horizon.

3. In the Thiruvanchoor series the total Zn values ranged from 53.40 µg/g in the Bt2 horizon to 71.40 µg/g in the Bt3 horizon. Water soluble and exchangeable Zn values ranged from 0.53 µg/g in the Ap horizon to 0.10 µg/g in the Bt4 horizon showing a gradual gradation in values down the depth.

4. The total Zn values in the Lahai series ranged from 55.20 µg/g to 63.80 µg/g. Similarly, the water soluble + exchangeable Zn fraction ranged from 0.03 µg/g in the Bt2 horizon to 0.19 µg/g in the Ap horizon. Lahai series was found to be low in total Zn content and the water soluble and exchangeable form was found to be extremely low and deficient.

5. The total Zn content for the Vazhoor series ranged from 36.0 µg/g in the Ap horizon to 86.0 µg/g in the Bt horizon. The water soluble + exchangeable Zn values ranged from 0.16 µg/g in the B horizon to 1.04 µg/g in the Ap horizon.

6. The Kunnathur series had comparatively higher values for total Zn and the values ranged from 81.70 µg/g in the Ap horizon to 103.81 µg/g in the Bt3 horizon. Though the total Zn status was found to be high, the water soluble + exchangeable Zn values were low and ranged from 0.16 to 0.55 µg/g. The major
share of the total Zn was found to be in the residual fraction and the values ranged from 70.82 µg/g in the Ap horizon to 74.59 µg/g in the Bt3 horizon.

7. The total Zn status of the Thrikkannamangal series ranged from 48.90 to 65.30 µg/g indicating comparatively low Zn status in this series. The water soluble + exchangeable Zn ranged from 0.16 µg/g in the lowermost horizon to 0.95 µg/g in the surface horizon. The residual Zn values ranged from 40.83 µg/g in the Bt1 horizon to 56.41 µg/g in the Bt4 horizon indicating that the major pool of the total Zn is in the residual fraction which is not plant available.

8. In the Kaipuzha series the total Zn values ranged from 47.90 µg/g in the Ap horizon to 92.60 µg/g in the Bt3 horizon. Water soluble + exchangeable Zn values ranged from 0.16 µg/g in the lowermost layer to 0.95 µg/g in the Ap horizon. Ap horizon alone recorded high water soluble + exchangeable Zn fraction and the lower layers recorded low values.

9. The total Zn values for the Panachikkad series ranged from 47.0 µg/g in the Ap horizon to 92.6 µg/g in the lowermost layer and the plant available fraction (water soluble + exchangeable Zn) ranged from 0.34 µg/g in the Bt3 horizon to 1.53 µg/g in the Ap horizon. The water soluble + exchangeable Zn fraction was high in the top most two layers and showed declining trend with depth.

10. The plant available fraction was only a very small fraction of the total Zn and the percent of this fraction to total Zn for the Ap horizon ranged from 1.0 to 6.0. Total Zn, water soluble + exchangeable Zn and organically bound Zn were related with organic carbon, cation exchange capacity and clay content. Water soluble Zn + exchangeable Zn showed positive and significant relation with organic carbon (0.54**) and negative relation with clay content (- 0.44**). Similarly, organically bound Zn showed highly significant positive correlation with organic carbon (0.59**) and negative relation with..
clay content (-0.34*). Total Zn recorded positive and significant relation with cation exchange capacity (0.34*) and clay (0.39*).

3. Assessment of Zinc availability

1. Zinc availability was assessed through five extractants viz., DTPA, Mehlich-1, Mehlich-2, 0.1N HCl and DTPA HCl. DTPA extracted Zn values were the lowest and the DTPA-HCl extracted the highest values. In the Ap horizon, the DTPA-Zn values ranged from 0.168 µg/g for Lahai series to 6.72 µg/g for Panachikkad series. Similarly, for mehlich-1 the values for Ap horizon ranged from 0.39 µg/g for Lahai series to 8.62 µg/g for Panachikkad series. The corresponding values for Mehlich -2 were 0.66 µg/g to 9.66 µg/g. 0.1N HCl extracted still higher values and ranged from 0.64 µg/g to 10.14 µg/g for Lahai and Panachikkad series, respectively. DTPA-HCl extracted higher values than DTPA alone and lower values than 0.1N HCl alone extraction and the corresponding values for Lahai and Panachikkad were 0.55µg/g and 9.80 µg/g, respectively.

2. The available Zn values for the Ap horizon recorded wide variation between series and Kanjirappally, Lahai and Thiruvanchoor series were found to be extremely deficient in available Zn. Even though the other six series recorded sufficiency in available Zn in the Ap horizon, low values were recorded in the lower layers. Added to that the total Zn status was found to be low. All these warrants supplementing soil through Zn application for preventing Zn deficiency and sustaining the Zn status of the soil.

3. The available Zn status of the soil for the Ap horizon ranged from 0.168 µg/g for Lahai series to 1.72 µg/g for Panachikkad series. The values ranged from extreme deficiency to sufficiency. The values were decreasing with depth and extremely low values were recorded in the lower horizons. 0.6 µg/g being the critical value
for DTPA-Zn, Kanjirappally and Lahai series were found to be extremely deficient in Zn availability. Zinc is not included in the fertilizer schedule of rubber and recently Zn deficiency in young rubber is being reported from many replanting fields. Correlations between available Zn and different fractions of Zn showed positive significant relation with water soluble + exchangeable Zn (0.80**) and organically bound Zn (0.86**) indicating that the DTPA extractable Zn is a good extractant for estimating the plant available Zn from these acid red ferruginous soil with predominance of Fe and Al oxides and hydrous oxides.

4. Correlations between available Zn and different fractions of Zn were calculated. All the extractants recorded highly significant positive correlation with water soluble plus exchangeable fraction of Zn. The correlations were 0.80**, 0.83**, 0.81**, 0.83**, and 0.81**, respectively for DTPA, Mechlich-1, Mechlich-3, 0.1N HCl and DTPA-HCL extractants. Similarly, the correlation with organically bound Zn is 0.86**, 0.83**, 0.85**, 0.81**, and 0.84**, respectively for DTPA, Mechlich-1, Mechlich-3, 0.1N HCl and DTPA-HCL extractants. The studies indicate that all the five extractants are showing good correlation with plant available Zn fraction and this has to be reconfirmed through crop response studies.

5.4. Adsorption of Zinc

The data generated from Zn adsorption studies were fitted to linear forms of Langmuir and Freundlich adsorption equations. Among the nine series, data generated for five series were fitting the linear models of these two equations. Both the equations were equally good for explaining the adsorption characteristics of the five soil series.

The derivatives from these equations viz., adsorption maxima and bonding energy from Langmuir model and rate of sorption and sorption capacity from freundlich
equation were calculated. The data generated from the adsorption studies need to be strengthened by working out its relationship with soil properties.

5.5. Response studies

Response of rubber plants to application of Zn was studied through pot culture experiments with bud grafted plants grown for six months. Zinc was supplied through two sources viz., zinc sulphate and zinc oxide. Positive response to zinc application was recorded and the significant difference in zinc concentration between the treated plants and control plants were recorded. However, no difference was noticed between different levels of Zn supply indicating that in the pot culture with low volume of soil application of Zn in the first level itself is sufficient to improve the Zn status of the soil. Available Zn status of the soil increased with the increasing levels of Zn.

Assessment of the status and distribution of Zn in the nine major soil series in the traditional belt of rubber cultivation indicated that the total Zn status of the soil is comparatively low. Similarly, the water soluble plus exchangeable fraction of the soil is very low and the values reduced down the horizons. Major share of the Zn is in the residual fraction and is not available for plant growth. Though the water soluble plus exchangeable fraction is high in some series in the Ap horizon, drastic reduction in values in the subsurface horizons were recorded indicating that Zn availability is restricted to the Ap horizon ie only to the 0-15 cm layer of the soil and down the layers the availability is low. Kanjirappally, Lahai, Thiruvanchoor and Kunnathur series were found to be extremely low in available fraction of the Zn. Added to that the total Zn status of these soils are found to be low indicating chances of depletion of Zn reserve in the long run.

DTPA extractant is found to be good for estimating the available Zn status of these acid red ferruginous soils. Positive response to Zn application was recorded on the
availability of Zn in the soil and on the leaf Zn status and dry matter yield and uptake of Zn by rubber plants. Application of Zn fertilizer to these soils especially to Kanjirappally, Lahai and Thiruvanchoor and Kunnathur soils may be beneficial for improving the plant growth and maintaining the Zn status of the soil.