Chapter 6

Summary and Conclusion

The Western ghats are the Peninsular hill ranges extending over 1400 km starting from the north near Tapti river ending near Kanyakumari. It is an area of rich biodiversity especially the southern part of Agasthyamalai ranges. These ranges covering an area of about 2000 sq. km and the projecting Peak (Agasihyarkudom) form the most diverse and unknown ecosystem in peninsular India. This region consists of a compact block of 12 reserve forests supporting various types of ecosystems, providing the diversity and complexity in its unique nature. Present study was taken up to understand the existence and survival of wild yams and aroids in the ecosystem and the study was limited to these plants with a view to domesticate the dominant and useful ones among them.

Since the interdependency between micro and macro flora is quite well established, it is highly essential and a prerequisite to study microflora profile in the root zone and their interaction with respect to the growth and establishment of these plants. These crops are distributed throughout these ranges. Detailed survey revealed that nine species of yams (*Dioscorea*) and five species of aroids are scattered in the ecosystem.

Rhizosphere studies revealed that seasonal influence on microbial profile of yam’s and aroids was distinct. Evaluation done at two successive years showed that in both the years, the incidence of micro flora was stable. However seasonal effect was quite evident and profound on their profile. In addition, mycorrhizal association was also assessed. In the initial phase a survey on quantitative distribution of rhizosphere microflora of wild yams was conducted. Thirty sampling sites in the study area were considered for above purpose. Seasonal analysis were carried out for the monitoring the
changes in microbial profile at each season. Evaluation of seasonal influence on microflora at various seasons revealed that, bacterial population was more at pre and post monsoon seasons. Lowest population was recorded during monsoon. The same trend was followed in actinomycetes and fungi also. But an increasing tendency was evident in post monsoon season Non rhizosphere microbial population was much lower when compared to rhizosphere microbial population. The qualitative and quantitative distribution of fungal flora varied with locations. Thirty-seven fungal species were identified and documented. Frequency of occurrence of fungal species in each sample site was evaluated in every season. Frequency of occurrence of bacterial flora varied with locations and season. One hundred and thirty eight bacterial isolates were recorded and grouped on the basis of gram’s reaction. Distribution of actinomycete flora in the location exhibited the same trend as in the case of bacterial flora.

Fungal flora associated with the rhizosphere was screened for P solubilising capacity and most efficient ones were isolated for future studies. Their ability to digest to rock phosphate was assessed. Quantitative distribution of P solubilising bacteria was also assessed. Screening of N₂ fixing bacteria was carried out and the quantitative assessment of N₂ fixing ability was also evaluated.

Wild edible aroids used by the habitat people were surveyed in detail. They were found in cosmopolitan distribution at the marshy spots of reserve forests. The rhizosphere microbial profile of aroids was enumerated in all the twelve reserve forests. But when compared with profile of wild yams, the population is low. Twenty fungal flora were identified and most of them are having phosphate solubilising ability. Bacterial population was enumerated and gram negative count was more.
Since arbuscular mycorrhizal fungi are known to play an important role in phosphorus nutrition and other nutrients like N, K, Cu, Zn their association with these crops merits importance. Spore population in soils varied with locations and seasons. Even though seasonwise difference was noticed in the spore load, forests sandy loam harboured maximum spore count. Mycorrhizal colonization varied with different species at different places. Twenty isolates were finally short-listed according to their identical characters. Frequency of occurrence of AMF isolates showed that high percentage of colonization was limited to the isolate *Glomus mosseae* in all the 12 reserve forests. It is interesting to note that more than one isolate was found to harbour a single host plant (Wild Yam). Even though there is no host specificity of AMF, a strong association with the host plant was evident.

To assess the influence of *Glomus mosseae* on the growth parameters and nutrient uptake with host plant, pot culture experiments were carried out. Interaction studies also carried out to assess the phosphate solubilising capacity of the soil fungi and nitrogen fixing ability of the bacteria along with the AMF – *Glomus mosseae* on the growth of hosts. Under different levels of fertilizer and phosphorus application mycorrhizal plants showed increased growth parameters like under ground and aerial tuber production as well as total biomass. Assimilation and rate of absorption of nutrients like N, P, K, Cu and Zn were also studied.

**Salient findings and suggestions**

1. The survey showed that yams and aroids are distributed throughout the study area in varying intensities.

2. Among Yams, *Dioscorea pentaphylla* was the dominant one in all the R.Fs followed by *D. wallichii* and *D. oppositifolia*. Aerial tubers were more compared to under ground tuber.
3. While enumerating the microbial profile of the wild yams highest bacterial count was noticed from Papanasan RF and lowest from Veerapuli RF, whereas highest actinomycetes population was recorded from Kottur extension and lowest from Kuluthupuzha RF. In the case of fungi, highest population was observed from Peppara RF and the lowest from Lower Kodayar.

4. In each reserve forests seasonal influence was observed in dominant fungal species. But in the case bacteria, grouping by gram staining reaction was done. In rhizosphere of wild yam, gram positive bacteria was the dominant.

5. Incidence of actinomycetes flora viz. *Waksmania* sp., *Micromonospora* sp., *Nocardia* sp. were common in all the RF’s irrespective of locations.

6. Among the fungal isolates *Achlya* sp., *Aspergillus niger*, *Mucor* sp., *Aspergillus fumigatus*, *Rhizopus oryzae*, *Mennoniella* sp., *Cunninghamella* sp. showed phosphate solubilising capacity. On quantitative assessment *Mucor* sp. exhibited maximum rate P solubilisation (15.3%)

7. Both gram positive and gram negative bacterial flora exhibited P solubilizing capacity.

8. From the bacterial isolates gram negative isolates showed nitrogen-fixing capacity. Isolates from lower Kodayar showed maximum rate of nitrogen fixation (0.00353mg/25ml of medium).

9. In the wild aroids, among the rhizosphere microflora, highest bacterial population was recorded from Kottur RF and lowest from Kuluthupuzha RF. In the case of actinomycetes highest count noticed from Mangamalai and lowest from Aryankavu and Veerapulli RF. Again Veerapulli RF harboured maximum count of fungal isolates. High population of all the three components of the soil microflora was noticed in pre monsoon season.
10. High incidence of AMF spores and mycorrhizal symbiosis in yams were observed. Spore population in soil varied with location and seasons.

11. *Dioscorea pentaphylla* showed high rate of colonisation among the other wild yams. All of the 20 AMF cultures identified, belongs to five genera viz *Acaulospora* sp., *Gigaspora* sp., *Glomus* sp., *Sclerocystis* sp., *Scutellospora* sp. The distribution is varied with location and seasons. High percentage of frequency occurrence was noticed of Kottur RF(29.1%).

12. It is interesting to note that *Glomus mosseae*, *Gigaspora margarita*, *Glomus aggregatum*, *Acaulospora* sp., *Gigaspora* sp., *Acaulospora laevis* and *Glomus* sp. were uniformly associated with wild yams.

13. Detailed studies regarding the myco/micro flora with in the 12 RFs indicated that Veerapuli RF had rich microbial diversity in Agastyaimalai ranges.

14. The pot culture studies showed growth parameters like percentage of colonization, spore production, biomass of fresh and dry root, shoot, aerial and underground tubers, total biomass along with harvest and leaf area indices and chlorophyll content were assessed and correlated.

15. Influence of AM fungi on the uptake of NPK content of leaf, vine, tuber and micro nutrients Cu and Zn were evaluated and found significant.

16. It was observed that *Glomus mosseae* showed a colonization of 54% in *D. pentaphylla*. No significant variation in colonization was noticed between two years.

17. Spore production of *Glomus mosseae* was found to increase when the fertilizer application increased up to F1 level from F0 and no additional benefit was observed when fertilizer level was extended to F2 level.
18. Incremental addition of fertilizers at different levels did not show any improvement in biomass production.

19. At different phosphatic levels with nitrogen fixing organism, dry shoot biomass was significantly increased in mycorrhizal yams.

20. Influence of mycorrhizal colonization was manifested as an increase in shoot biomass production when nitrogen fixing organism was coinoculated under different fertilizer level. This was evident up to P1 level.

21. Mycorrhizal plant produced more aerial tubers. When the dose of fertilizer increased, production of aerial tuber also enhanced. But influence of phosphatic fertilizer on the aerial tuber production was significant only at P1 and P2 level. In a tripartite inoculation system of mycorrhiza, p solubilising fungi and nitrogen fixing organism; enhancement of aerial tuber production was evident. At different levels of phosphatic fertilizer application, tuber biomass production was significant up to P1 level.

22. At half dose of fertilizer increase in underground tuber biomass production (fresh) was visible with the dual inoculation of P solubilising fungi and mycorrhiza. A significant increase in dry tuber biomass was observed in the combined inoculation of p solubilising fungi and mycorrhiza at F1 level.

23. Enhanced fresh root biomass responds to fertilizer level was found up to F1 level with mycorrhizal yam. But highest root biomass was obtained in combined inoculation of nitrogen fixing organism and mycorrhizal fungi. Dry root biomass production was increased at F1 level when they are inoculated with P solubilising fungi and nitrogen fixing organism.

24. Total biomass production was high in mycorrhizal plant and an increase was noticed at F1 level. But at P2 level phosphatic fertilizer application positive significance was observed.
25. Mycorrhizal yams yielded more harvest index (HI) in individual inoculations with P solubilising fungi and nitrogen-fixing bacteria. Incremental addition of phosphatic fertilizer enhanced HI in mycorrhizal plants.

26. Leaf area index (LAI) was more in mycorrhizal yams. Sole inoculation of P solubilising fungi or nitrogen fixing bacteria showed an increase in F1 level or P1 level of application.

27. Mycorrhizal plant had higher chlorophyll content. But no definite trend or effect could be drawn by the inoculation of P solubilising fungi or nitrogen-fixing organism at different levels of fertilizer application.

28. Influence of AM fungi in the uptake of NPK revealed that different tissue of the plant behaved independently. However, leaf nitrogen content is higher in mycorrhizal plants. At different fertilizer levels nitrogen content improved only up to F1 level. P solubilising fungi and nitrogen fixing organism favoured accumulation of nitrogen content in leaf tops only. Same trend was visible at different levels of P application.

29. In mycorrhizal plants Vine nitrogen showed a significant increase when P solubilizer and nitrogen fixing organisms coinoculated.

30. A positive gradual increase in tuber nitrogen was noticed in F0 to F2 levels by the dual inoculation of nitrogen fixer and P solubilising fungi.

31. Interaction of mycorrhizal plants with P solubilising fungi and nitrogen fixing organism increased P content in leaf tops. Increased fertilizer application retarded the absorption and accumulation of P. Same trend was observed at different levels of phosphatic fertilizer application.

32. There was no positive correlation between mycorrhiza and Vine phosphorus. High content of vine P was noticed at F1 level...
33. Dual inoculation of mycorrhiza and P solubilizer did not show any definite trend in uptake of P in tuber tissue. Similar trend was repeated in case of nitrogen fixing organisms.

34. Mycorrhizal plant invariably enhanced K uptake and maximum content was recorded in F1 level of fertilizer application at leaf top. Interaction of P solubilizer and nitrogen fixer support the absorption of more K in mycorrhizal yams. Significant enhancement of vine K content was noticed in mycorrhizal plant at F1 levels. Same trend was visible in tripartite inoculation system of mycorrhiza, P solubilizer and nitrogen fixer organisms. Tuber potassium level was increase gradually in mycorrhizal plants from F0 to F2 levels. But individual inoculations of mycorrhizal plants with P solubilising fungi and nitrogen fixing organism showed an increase up to F1 level.

35. Micro nutrients like Cu Zn are very little in leaf tops of mycorrhizal yams. The tripartite inoculation showed that mycorrhizal plants influenced the accumulation of copper on leaf tops. There was no significant influence on the absorption of Cu and accumulation in vine tissue of yams neither by mycorrhiza nor by Nitrogen fixers and P solubilizers. At different phosphatic fertilizer application in P1 level, a gradual increase of Vine Cu was visible. Mycorrhizal plants enhanced copper levels in tubers. At F2 levels maximum accumulation was recorded. Zinc content was more in mycorrhizal plants. Its absorption was higher in leaf tops at dual inoculation with P solubiliser or nitrogen fixer. But vine Zn accumulation was observed by the sole inoculation of P solubilizer or nitrogen fixer at F2 level.

36. Residual analysis showed that soil phosphorus was more in the mycorrhizal rhizosphere. Gradual increase in concentration was
visible from F0 to F2 levels. Combined inoculation reduced the P content in the soil.

37. Residual analysis of soil copper indicated a positive trend in accumulation of copper in the rhizosphere soils of mycorrhizal plants and the same was exhibited at different fertilizer levels also. Moreover, the same trend was showed for soil Zn.

**Scope for future studies**

The data resolved out of this study extending from the survey of yams and aroids from different reserve forests of Agasthyamalai ranges through the isolation of beneficial organisms associated with these crops and assessing their efficiency to promote plant growth was an indicator of equilibrium at which the vast biodiversity exists in the area. The main aim of the investigation was to understand the nature of biodiversity and their interaction. The present research work, though it concluded at pot culture experiments to evaluate the interaction of macro and micro flora in domesticated /controlled condition, its merits importance as a food crop to be popularised, leaving other benefits it can offer to human community. In depth studies in areas like its application in medicine, specific microflora associated with its root system, beneficial organisms like N₂ fixers, P Solubilizers, cellulose digesting flora, lignoclastic fungi are few areas to mention, are very much essential, for future research.