CHAPTER – X

Summary and Conclusion

- Qualitative and quantitative estimation of soil microbial population, antagonistic actinomycetes and phosphate solubilising bacteria (PSB) and physico-chemical properties of tea soil of three tea zones of Brahmaputra valley was made in the present study using standard methodology, during summer and winter.
- The soil of the three tea growing zones showed wide textural variations ranging from sandy to clay through sandy-loamy.
- The soil pH varied from pH 4.1-5.5, representing the acidic nature of tea growing soil.
- The status of soil organic carbon was of medium to high.
- Soil of UAZ and SBZ showed medium to high status of available nitrogen, phosphorus and potash.
- Little variation in soil physico-chemical properties of different zones cannot be ignored due to variation of garden practices in different gardens with respect to application of chemical fertilizers.
- Bacteria were found to be the most dominant in the tea soil of all soil conditions, among which nitrogen fixers like Azotobacter, Azospirillum and phosphate solubilizers were of common occurrence.
- Population of bacteria, fungi, actinomycetes, Azospirillum and phosphate solubilizers excelled in rehabilitated soil which may be due to the improved soil fertility, higher organic matter content and higher nutrient status of the top-soil.
Microbial population was found to be maximum during summer while fungi population was in higher number during winter.

Phosphate solubilizers were found to be almost absent during winter in both UAZ and NBZ due to the slowing down activity of phosphate solubilizer in soil which supports the fact that absorption of phosphorus ceases in winter.

Significant (p<0.05) interactive effect of season, abiotic stress (waterlogged and droughty) and microbes was noted in the tea soil of most of the areas except in Lankasi T.E.

The microbial population of soil under drought was recorded to be significantly higher (P<0.05) during winter in both NBZ and SBZ.

Overall study of the microbial population under biotic stress during both the season exhibits that microbes were found to be higher in disease infested area in comparison to non-infested area.

Among the three zones, microbial population was found to be highest in UAZ. The study has indicated the variation of microbial load in different conditions like rehabilitation and non-rehabilitation soil. No specific trend of microbial diversity can be depicted for all the T.E may be due to the differences in garden practices adopted by different T.E of the study area.

Twelve PSB have been isolated from the tea soil of 19 different tea estates of three different zones of Brahmaputra valley in the present study, on the basis of their characteristic phosphate solubilising zone. A wide range of phosphate solubilising efficiency of the strains (32.25-136.5%) was observed.

The acidic soil of the present study area may be ideal for actinomycetes growth.
The present study revealed that 17 actinomycetes strains with typical morphological and cultural characteristics were isolated from tea soils of selected tea gardens of the study area. The range of actinomycetes population density was from 1.3-9.0×10⁴ cfu/g.

Most of the PSB and actinomycetes of the present study were isolated from rehabilitated area, of which much of them were isolated from the UAZ while more numbers of actinomycetes were isolated from SBZ.

PSB and actinomycetes are potential sources of antagonistic agent that can be profitably utilized in development of bio-inoculants. Use of bio-inoculants against soil-borne pathogens of tea plants becomes a promising area of research leading to eradication of soil-borne tea diseases thereby enhancing the growth and yield of the crop. The stain isolated from the tea soil of the present study area provides scope for further investigation in the area of bio-inoculants in tea plantation.

The test pathogens (*U. zonata* and *F. lamaeensis*) were isolated from collar and root region of tea plants showing the symptoms of charcoal stump rot and brown root rot disease. Culture growth of *U. zonata* was found to be slower than *F. lamaeensis*.

Special attention is to be paid in isolation of *U. zonata* and *F. lamaeensis* in finding out suitable temperature as they favour low temperature at their initial growth.

Seven PSB and 11 actinomycetes were screened for their ability to inhibit the growth of two test pathogens *U. zonata* and *F. lamaeensis* in PDA medium.

Out of the 7 isolates of antagonistic PSB, isolate MM/PH/BST showed maximum percent inhibition (PI) against both the test pathogens, followed by the isolate MM/PH/KMP.
Out of 11 actinomycetes isolates with antagonistic potentialities, isolate MM/PH/AC-09 showed maximum inhibition against *U. zonata* followed by the isolate MM/PH/AC-02.

Isolate MM/PH/AC-02 exhibited highest PI against *F.lamaoensis* followed by the isolate MM/PH/AC-09.

In the *in-vitro* antagonistic test with the selected PSB and actinomycetes isolates, PSB isolate MM/PH/BST and actinomycetes isolate MM/PH/AC-09 were found to be more effective antagonistic to *U.zonata* and *F.lamaoensis* than other isolates tested for.

All the four antagonistic strains of PSB (MM/PH/BST and MM/PH/KMP) and actinomycetes (MM/PH/AC-02 and MM/PH/AC-09) were found to possess potentiality, to control both the test pathogens (*U.zonata* and *F.lamaoensis*), as well as to promote the growth of tea under nursery trial.

Among the four antagonistic isolates MM/PH/BST and MM/PH/AC-09 were found highly effective in increasing the growth parameters of the tea plants as well as in decreasing disease occurrence, which justify the fact that antagonism is one of the important traits of plant growth promoting microbes.

Both the isolates of antagonist PSB (MM/PH/BST and MM/PH/KMP) showed their maximum growth in the medium with pH between 5.0 and 6.0 and considered to have a positive character of antagonist PSB to survive in acidic tea soil of the study area.

In case of both the antagonist actinomycetes (MM/PH/AC-02 and MM/PH/AC-09) optimum growth of the strains was recorded between pH 4.5 and 5.5, and this is the pH level generally maintained in the tea soil.
• Both glucose and sucrose were found to be the good source of carbon for the vegetative growth of the tested PSB isolates (MM/PH/BST and MM/PH/KMP) perhaps due to their important role in solubilisation of phosphate.

• In case of actinomycetes, dextrose was found to be the best carbon source for the growth of both the isolates.

• When tested for nitrogen source, optimum growth of PSB isolate MM/PH/KMP was noted in glutamic acid, while the growth of the PSB isolate MM/PH/BST was effectively enhanced in ammonium nitrate as nitrogen source.

• Satisfactory growth of actinomycetes was noted in all the nitrogen sources ammonium nitrate, potassium nitrate, glutamic acid, ferrous nitrate and sodium nitrate tested and glutamic acid was found to be more effective in this aspect.

• Finally it can be said that microbial diversity in the tea soil of Brahmaputra valley was noted to a greater extent but no definite pattern of microbial diversity can be depicted. The information gathered from this study can be utilized in future for incorporating beneficial microbes as bioinoculants in the degraded tea soil for rejuvenation so as to minimize duration of tea soil rehabilitation. Occurrence of a good number of microbes was detected in the study area having potentiality of phosphate solubilization and antagonism. Four highly effective PSB and actinomycetes strains from the study area can be used as biocontrol agent against two soil borne pathogenic fungi causing two primary root diseases of tea is one of the important findings of the present study. The
PSB and actinomycetes strains can profitably be utilized for better growth and production of tea in the tea growing areas. Therefore these strains have the future prospect of application in the charcoal stump rot and brown root rot infested area for the purpose of plant growth enhancement and disease control, of tea.