ECOLOGICAL STUDIES ON MYCORRHIZAE OF PINE (PINUS KESIYA ROYLE EX. GORDON)

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I certify that the thesis entitled "ECOLOGICAL STUDIES ON MYCORRHIZAE OF PINE (Pinus kesiya Royle Ex. Gordon) submitted by Shri Gauri Dutt Sharma, M.Sc. for the degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong embodies the record of original investigation carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D degree. This work has not been submitted for any degree of any other University.

R.R. Mishra

Dated : January 28, 1981
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Signature of the
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CONTENTS

I N T R O D U C T I O N

The term mycorrhiza was first coined by Frank (1885) to denote the association between fungus and root (mykes; fungus; rhiza: root). Mycorrhiza based on its morphological characters has been delineated in two major groups i.e. ectomycorhiza(where fungus does not enter inside the cortical cells and lies intercellularly and may form mantle and Hartig net) and .endomycorrhiza (where fungus enters inside the cortical cells and grows both within and between the cortical cells, but does not form any fungal sheath or Hartig net). A third group: ectendomycorrhiza is also recognised (where fungus forms Hartig net and penetrates inside the cortical cells). Many beneficial fungi form association with roots of higher plants. It has now been well established that such association is more or less a rule and not the exception. In certain cases, however, like Centrospermae (Cactaceae exception), Plumbaginales, Cruciferae, Helobiae, Farinosae, Cyperales, Droseraceae, Denotheraceae and Helorrhagaceae, mycorrhizae generally are not reported. Certain nonmycorrhizal plants on the other hand when transferred from marshy to dry habitat develop mycorrhizae.

Most of the tree species particularly the members of the families : Pinaceae, Fagaceae, Batulaceae, Silicaceae and Tiliaceae possess ectomycorrhizal association. Ectomycorrhizae are generally formed by higher basidio-

mycetes but the members of the ascomycetes, deuteromycates and some zygosporic species of phycomycetes have also been reported to form this type of association (Gerdemann,1974; Trappe, 1962, 1977).

Endomycorrhiza is mainly formed by two types of fungi i.e. those with septate and nonseptate hyphae. Fungi of the former group are generally associated with the roots of orchids and the members of Ericales group. Among endomycorrhiza, vesicular arbuscular mycorrhiza (VAM) is widely distributed and is formed by phycomycetous fungi belonging to the family Endogonaceae. Vesicles function as a storage or reproductive organs while the arbuscules serve primarily as an organ for nutrient exchange between plant root and the fungus. Arbuscules have very short life and may collapse within few hours after discharging the nutrients. The hypha may re-enter in the same cell and may again form the arbuscules. Vesicular-arbuscular mycorrhiza does not induce morphological changes in the roots of host plant and they play very little role in protection of roots from pathogans.

Ectomycorrhiza helps in the establishment and survival of forest tree species through absorption of inorganic nutrients, production and supply of growth regulators, deterrent to root pathogens, decreasing soil toxicity

and increasing resistance to extreme soil temperatures. In absence of mycorrhiza, tree species become stunted and yellow or they may even die. Mycorrhizal fungi generally are not host specific and may have wide range of host spectrum. A tree species may harbor more than one fungal symbiont at a given time. The mycorrhizal fungi depend on host plant for supply of simple carbohydrates, a photosynthate of green plants and cannot compete with saprophytic microorganisms in utilizing energy from litter decomposition. Ectomycorrhize modify the morphology of roots and this change is correlated with the production of cytokinins and other growth regulators which increase the physiological process of the roots.

Mycorrhizal association develops when either a spore or mycelium of mycorrhizal fungi encounters the roots of planted seedlings. The spore germinates and mycelium surrounds the roots and enters inside it. If the process is delayed the seedlings either die or even if survive becomes stunted. To overcome this practical problem in forestry, inoculation of the seedlings with suitable mycorrhizal fungi before or at the time of planting is recommended. Supply of fertilizer and water does not help the recovery of the stunted seedlings until the suitable mycorrhizal fungi are inoculated. This phenomenon becomes more clear when an exotic tree species fails to flourish if planted in absence of the mycorrhizal fungi.

Though studies on ectomycorrhizae have received enough attention during the past few years, yet the nature of mycorrhizal formation is not properly understood. The factors affecting the host and the fungus and their interaction in relation to environmental and edaphic factors need careful investigation.

It has been found that pine seedlings grow better in presence of Boletus felleus and Hebeloma mesophaeum (Rosendohl, 1943). However, their efficiency at species level for nutrient uptake and plant growth may vary in different environmental conditions. Some of them may tolerate a wide range of environmental conditions while few others may not.

A large quantum of information is available on phosphorus uptake by mycorrhizal fungi but the knowledge on uptake of other nutrients is fragmentary. Some indications, however, exist about the uptake of sulphur (Rhodes and Gerdemann, 1978a,b), nitrogen, (Melin, 1952; Richard, 1964), Calcium, magnesium, iron and other elements.

After the introduction of term rhizosphere by Hiltner (1904) it is now well established that maximum biological activity lies in root region than in soil away from root. Mycorrhizal and rhizospheric microbes play an

indispensable role in nutrient cycling, converting nutrients from unavailable to available form, releasing some enzymes and chemicals which regulate nutrient absorption by root and maintaining a balance between pathogenic and nonpathogenic population of soil ecosystem. Some of the rhizospheric microbes may be selective in their effect on the growth of mycorrhizal fungi and their metabolic products regulate the association of a particular fungus with host plant(Nye,1968). In mycorrhizal roots the nature of the exudates which regulate the root microflora may be different. Root exudates generally have the selective effects on the root microflora and this nature of selectivity of ectomycorrhiza is not understood properly. The studies on the interaction of rhizospheric microflora and mycorrhizal fungi may provide better information regarding the understanding of synergism, satelism and antagonism processes in a forested ecosystem. The study will provide clues regarding the nature of diversity and ecotypic variation on effectiveness of certain ectomycorrhizal fungi and will offer the immense opportunities for management of forests(Marks and Kozlowski, 1973).

It is obvious that rhizosphere region exerts a preferential effect on symbiotic or parasitic associations. A detailed investigation of the microbiology of the root region in this light is therefore, warranted.

Soil temperature, pH and nutrient status have great impact on the proper functioning of the mycorrhiza. Laboratory studies on the effect of these factors are available. Not much is, however, known about the field conditions where numerous other factors also operate simultaneously.

The present work was undertaken to understand the ecology of mycorrhizal association of pine (Pinus kesiya Royle) and also its effect on rhizosphere population and nutrient cycling in a subtropical pine forest ecosystem. Mycorrhizal fungi and rhizosphere microbial complexes were studied at regular monthly interval for three years. Pure cultures of fungal symbionts were obtained by using different techniques. To confirm their symbiotic relationship with pine, axenic mycorrhizal synthesis in agar was also conducted. Their role in nutrient uptake was assessed in pot culture studies.