CHAPTER 1

INTRODUCTION
Chapter 1
Introduction

Rice (*Oryza sativa* L.) is the principal crop and staple food of the people of Assam and grown extensively ranging from low lying traditional paddy fields to the slope of the hills. Some rice varieties can well be grown on dry land subjected to several periodic moisture stresses while some other varieties can be raised in flooded ecosystem. Rice can also be grown on any type of soil subject to adequate supply of soil moisture during its growth phases and exhibits reasonable yield performance. Assam presents a wide diversity of climate, ecology, altitude, temperature, rainfall, physiography and water availability, enabling the farmers to grow a large number of traditional varieties. The state is second to Arunachal Pradesh in terms of land mass among entire North-eastern states. The state is located between 90° and 96° E longitude and 21° and 28° N latitude and covers an area of 78,438 sq. km. with an estimated population of 312 lakhs as on 2011 (Economic Survey, Assam, 2011a). At present rice cultivation occupies about 25.30 lakh hectares in Assam, which is 66% of gross cropped area. Although rice is the major staple food in Assam, its present productivity is only 1.76 tonne per hectare against the national average of 2.13 tonne per hectare (Economic Survey, Assam, 2011b).

Assam being situated in sub-tropical monsoon zone of the country is experiencing hot and wet (rainy) summer and dry cool winter, with high relative humidity across the seasons of the year. The four distinct seasons that the state experiences can be categorized as (i) Pre-monsoon (March to May), (ii) Monsoon (June to September), (iii) Post-monsoon (September to November) and (iv) Winter (December to February). The monsoon season is the main rice season (*Kharif*) characterized by high rainfall, nearly cloudy weather, high relative humidity and high temperature. The monsoon season receives more than 70% of the total rainfall of the year.
In Assam, three cultural types of rice can be grown in three different seasons of the year (Bhagabati et al., 2001) viz.

i. **Ahu** rice (March/April to June/July), is also known as Pre-*Kharif* rice.

ii. **Sali** rice (June/July to November/December), is also known as *Kharif* or monsoon rice including deepwater rice (*Bao* rice)

iii. **Boro** rice (November/December to April/May), is also known as Rabi rice.

*Sali* is the main type of rice cultivated during the rainy summer period, occupying about 70% area and contributing 75% to the production. The rice field of Assam remains more or less water-logged during the rainy period. This period is mostly suitable for wet cultivation. In this system, the land is thoroughly ploughed with the help of a country plough. The field is ploughed repeatedly 3 or 4 times within interval of few days. This system of soil preparation is called puddling. The weeds get decomposed due to puddling operation and this decomposition brings about many biochemical changes in the rice field soil. *Sali* rice seedlings are generally transplanted in the month of June-July sometime extending up to August and harvested in the month of November-December sometime extending up to January. At the time of harvest, the soil becomes completely dry. After harvest, the lower parts of rice crops including the straw and roots remain in the field. The decomposition of these also influences the biochemical and microbiological status of soil.

Soil is the most important ecological factors which provide nutrients, water supply and anchorage to the crop. The soil of the state are generally classified under Entisols, Inseptisols and Ultisols, mostly derived from the perennial weathering deposits of the parent materials transported from the Assam Sub-Himalayan ranges. Rice soils represent both alluvium and new alluvium soils distributed on old flood plain and new flood plain respectively. The soils are acidic in reaction, rich in organic deposits with normal to medium ratings for nitrogen and phosphorous and low rating of potash content. Based on the toposequence, there exists a gradient in soil fertility status, which increases down the slope. The soils developed on low lying old flood plain is the dominant type of rice soil in
the state and which show heavier soil textures with good water holding capacity, ensuring adequate soil moisture status for cultivation of the rice crop. The physical, chemical, environmental and agronomical characteristics of the rice soils not only determines the type of the soil but also determines the agronomic potential and the management strategies of the rice soils for obtaining high yield of rice varieties grown. As far as soil requirement is concerned, rice grows in almost any place. It grows in a variety of soils provided water is available and temperature is warm. It thrives on sands to clay, from acidic to alkaline and from open to poorly drained soils. However, it does best on medium textured soils with a dry substratum.

The soils of the experimental site is of old alluvial type with very deep, brownish to yellowish brown with texture of fine loams to coarse loams, showing deficiency of phosphate and moderate potash content. Organic matters in the soils forms a variable but very important proportion of the soil particles and may be of more or less unrelated fragments of animals or crops or may have been decomposed, eventually becoming humus. All these nutrients are required for growth of microorganisms, therefore microorganisms also constitute an essential moiety of soil which are present everywhere. Generally, microbes live on particle surface or in the interconnecting spaces between the soil crumbs. Growth of rice crop can bring about complex changes in the physical, chemical and biological status of agricultural soils.

The soil represents a favourable habitat for microorganisms and is inhabited by a wide range of microorganisms. Soil microorganisms are essential components of biotic community responsible for breakdown of organic materials, mobilization of nutrients, maintenance of soil-plant quality and ecosystem biogeochemistry (Hackel et al., 2004). Soil with its various horizons forms a complex mosaic of habitat, within which different individual factors control the distribution of microorganism. This may be due to variation in deposition of organic and inorganic matters in each horizon that directly or indirectly influence the growth of the microorganisms. Organic matter in soils forms a variable but very important proportion of the soil particles. The degradation of these organic matters in flooded rice field soils is accomplished by several groups of microorganisms that
operate the anaerobic microbial food chain (Hori et al., 2010). The diversity of microorganisms present in a particular soil type may be judged on the basis of morphological properties, nutritional characteristics or synthetic abilities of the microorganisms. The microbial equilibrium of the soil is subjected to change through the influence of several factors like the age of the crops, soil type, soil treatment, seasons, temperature and moisture condition. The type of crop can also bring about complex changes in the physical, chemical and biological status of agricultural soil. Besides these, ploughing tillage, application of fertilizers and biocides can affect the microorganisms in agricultural soils.

Each soil type has a specific role upon the growth and development of microorganisms due to its chemical components. Soil microorganisms occupy a key position in the maintenance of soil health and function in both natural and managed agricultural ecosystems. This is because microbes are involved in soil structure formation, decomposition of organic matter, removal of toxins and cycling of nutrients like carbon, nitrogen, phosphorus and sulphur. However, the availability of nutrients is often limiting for microbial growth in soil and most soil microorganisms may not be physiologically active in the soil at a given time. The various experiments on ecological research for understanding the principles governing the occurrence and activities of microorganisms inhabiting in soil are real pathways of soil microbiology. The activities of microorganisms in soil are very complex to determine specifically because of the complexity and occurrence of innumerable competitions among them. In such soil the various groups of microorganisms form an interlocked system among themselves, which is more or less in equilibrium with the environment and which, fluctuates with the changes in the environmental factors. The contribution to microbial activity was measured by evaluation of the microbial community functions in soil (Berg and Steinberger, 2010). One of the functional aspects of the microbial community that can be measured is the rate of CO$_2$ evolution.

The conditions prevailing in the waterlogged soil are quite different. The anaerobic condition prevailing in waterlogged soil plays an important role on the
microorganisms. The effects of decreased oxygen level and increased concentration of carbon dioxide under anaerobic condition on the distribution of microorganisms have still remained confused. Generally the microorganisms become more active in soil having adequate moisture and suitable carbon source. In such conditions the microorganisms consume more oxygen and release carbon dioxide. Characteristics of soils remarkably vary at specific loci, which constitute the micro sites colonized by the microorganisms. This may be due to difference in the availability of nutrients, oxygen and carbon dioxide concentration, hydrogen ion concentration, osmotic pressure and oxidation-reduction potential. So, the type and the dimension of the microbial population may vary at the different microhabitat. Similarly, the microbial populations also vary at various places within a given area based on the moisture content of the soil, organic matter and types of cultivated crops. In a soil having uniform texture and composition the number of microorganisms markedly falls off in the lower layers and continues to decrease with depth. A change in the environmental conditions and in the physiological status of the crops also leads to changes in their microflora.

The rhizosphere represents one of the most complex ecosystems on Earth with almost every root on the planet expected to have a chemically, physically and biologically unique rhizosphere (Jones and Hinsinger, 2008). Rhizosphere contains lots of organic substrates which harbor a high count of microorganisms, especially fungi. Species richness is usually high in the rhizosphere than root-free soil. It has been estimated that one gram of surface soil contains 50,000 to a million fungi (Wahid et al., 1997). The loss of organic materials from roots provides the energy for the development of active fungal population in the rhizosphere around the root. Fungal species and their population in the soil vary depending on many factors such as type of soil, vegetation, temperature, organic matter, and moisture content. Root system excretes chemical compounds into the surrounding soils and thus the rhizosphere has an important effect on the diverse microbial population of the soils. It is a unique habitat with distinctive microbial complex, which differs from that of root free soil and are in the state of dynamic equilibrium, which may vary with the age, health and vigour of the crop and with the
variable environmental conditions. The spatial extension of the rhizosphere is highly variable and can range from several mm to less than 1mm. Chemically and physically the rhizosphere is perhaps the most complex and changeable of all environments. This is because of the release of carbonaceous material by plant roots that vary both in chemical characteristics and quantity. Together, these materials are termed as rhizodeposits and are responsible for the so-called rhizosphere effect. In studying the fungal flora of the rhizosphere of crop plants many investigators have taken an interest in the interrelation of higher plants and these microorganisms. The rhizosphere fungi as a consequence of their activity exude a number of active substances which directly affect the soil microflora and higher plants.

The interaction of soil microorganisms with rice crop is based on interdependent relationship, in which rhizosphere microflora are affected by the crops in a number of ways. The crop roots stimulate microbial development and the microflora in turn can have an important influence on crop growth. Even after the death of the crop the residue considerably changes the soil population. Decomposition of dead organic matter is the key process providing for the return of biogenic elements to the soil and determining the productivity and stability of terrestrial ecosystems (Vorobeichik, 2007). The microbial mediated decomposition of plant residue is a key process with wide ranging effects on ecosystem functioning and stability (Wakelin et al., 2010). Several groups of microorganisms live in a soil in varying proportions; some are more efficient than the others in obtaining their nutrients. Some are highly specific in their food requirements, while others are less particular. Among them some mutualistic, symbiotic, synergistic, antagonistic relationships exist. This activity in soil is influenced by the availability of nutrients, both in inorganic and organic forms and is conditioned by soil factors such as aeration, moisture and reaction. These soil factors are influenced by external factors such as water and temperature on one hand and manuring, fertilizer, tillage etc. on the other. Tillage alters soil structure exposing more organic matter to microbial attack while no-tillage practices stimulate the formation and stabilization of macro aggregates, which represent an important mechanism for protection and maintenance of soil organic matter.
(Beare et al., 1994) besides other effects as more stable temperature and changes in the distribution of organic matter and nutrients in the soil (Dick, 1984). High organic carbon content of soil may influence micro population up to ten fold than the soil with less carbon content. Organic matter entering soil ecosystems has direct impacts on soil microbial community structure and soil fauna (Wardle et al., 2006). Soil microorganisms undergo constant changes in their quantity and quality, but by and large, these changes are only temporary and soon equilibrium is reached.

Soil microbial biomass is the living component of soil organic matter and it generally comprises 1-5% of total organic matter content. Because of its high turnover rate, microbial biomass could respond more rapidly to changes of soil environment than soil organic matter. As organic matters are the preferred energy source for the microorganisms, ecosystems with high organic substances tend to have higher microbial biomass contents as well as its activities (Hassink, 1994). Most of the enzymatic transformations in soil are accomplished by microbial biomass due to which a part of the organic materials are stabilized as humus and the remaining carbon and other nutrients are utilized by microorganisms for their own growth (Anderson and Domsch, 1980). Measurement of the size of soil microbial biomass alone couldn’t indicate microbial activity; microbial activities also include activities of general enzymes such as phosphatase and dehydrogenase. Moreover, microbial biomass and enzyme activities have been shown to be more sensitive than total carbon concentration to soil management practices. Therefore, soil microbial biomass and soil enzymatic activity can be utilized as indicator for changes in soil quality produced by agricultural practices. Results of previous studies based on a long-term field experiment indicate that among various microbial parameters, measured activities of dehydrogenase and phosphatases, as well as microbial biomass carbon and nitrogen are more significantly correlated with chemical characteristics of soils and with crop yields (Gajda and Martyniuk, 2005).

Soil enzymes play key biochemical functions in the overall process of organic matter decomposition in the soil system. They are important in catalyzing several important reactions necessary for the life processes of microorganisms in soils and
stabilization of soil structure. These enzymes are constantly being synthesized, accumulated, inactivated and/or decomposed in the soil, hence playing an important role in agriculture. The activities of these enzymes in soils undergo complex biochemical processes consisting of integrated and ecologically connected synthetic processes and in immobilization and enzyme stability. In this regard, all soils contain a group of enzymes that determine soil metabolic processes which, in turn, depend on its physical, chemical, microbiological and biochemical properties. Enzymes in soil differ in their origin, function and turnover times (Burns, 1982). This heterogeneity arises because soils contain a diversity of mineral and organic compounds that interact with soil enzymes (Sinsabaugh, 1994). Soil enzymes may include amylase, glucosidase, chitinase, dehydrogenase, phosphatase, protease and urease released from plants, animals, organic compounds and microorganisms (Dick and Tabatabai, 1984). Enzymes may originate from biotic (viable cells) or abiotic (extracellular) components and their very specific reactions may only allow a small fraction of the total population being detected in the test. Therefore, soil enzyme activities may not always show a strong correlation with other soil biological parameters (Dick, 1994).

The overall enzyme activity of soil is derived from the activity of accumulated enzymes and from that of proliferating microorganisms. The activity of any particular enzyme in soil is a composite of activities associated with various biotic and abiotic components, like proliferating cells, latent cells, cell debris, clay minerals, humic colloids and the soil aqueous phase (Burns, 1982). Enzyme activities are associated with active microorganisms because the microbial biomass is considered the primary source of enzymes of soils. The measurement of soil enzymes can be used as indicative of the biological activity or biochemical process. Soil enzyme activities are greatly influenced by both natural and anthropogenic disturbances (Dick, 1997). Soil enzyme activities have potential to provide a unique integrative biological assessment of soils because of their relationship to soil biology, easy of measurement and rapid response to changes in soil management. Documentation of the levels of activity of various enzymes in soils is now quite extensive. The mineralization of organic compounds in soil is largely a result of
Enzymatic reactions. Extracellular enzymes may be bound to the outside of cell membranes or released by microorganisms and plants to increase nutrient availability. Extracellular enzymes enable soil microbes to degrade complex substrates into low molecular weight compounds that can be assimilated for growth (Schimel and Bennett, 2004). Therefore, constraints on enzyme production and activity may regulate carbon degradation and the release of nutrients from complex compounds (Allison, 2006b). Many organisms release enzymes into the soil as a part of physiological activity. Although most of the enzymes released into the soil may be quickly metabolized by other living organisms, some may simply exist in the soil solution or become highly stabilized by bonding with soil colloids or humic substances, associations that can allow enzymes to remain active for many years in some soils.

Amylases, the starch-hydrolyzing enzymes, hydrolyze α1-4D glucosidic linkage of amylose and amylopectin. Amylases are now classified into three main groups viz., exo and endo-acting enzymes and debranching enzymes (Mishra et al., 2003). Amylolytic enzymes are widely distributed among bacteria, actinomycetes and fungi. Amylases are usually extracellular and are produced at relatively low amount in some organisms. They can also be induced by different sugars like maltose, glucose, maltooligosaccharides, dextrin and starch in bacteria, yeast and fungi. Soil amylases may be influenced by different factors ranging from cultural practices, type of vegetation, environment and soil types. For example, plants may influence the amylase enzyme activities of soil by directly supplying enzymes from their residues or excreted compounds, or indirectly providing substrates for the synthetic activities of microorganisms. Greater understanding about the roles and other chemical, biological, physical and agronomic factors influencing functioning of amylase enzymes in the soil will further define the significance of these enzymes in the soil, and enable proper management techniques to be devised to maximize the benefits that may be derived from such enzymes.

Dehydrogenase is involved in the electron transport system to remove the oxidative substrate, and has been found to correlate with the oxygen uptake and organic substrate removal rates. The biological activity in soil is commonly determined by the
dehydrogenase activity. The significant role play by the dehydrogenase enzymes is the biological oxidation of soil organic matter by transferring protons and electrons from substrates to acceptors. These processes are a part of respiration pathways of soil microorganisms and are closely related to soil air-water conditions. However, in the case of complex systems like soils the relationship between an individual biochemical property and the total microbial activity is not always obvious because the microorganisms and processes involved in the degradation of the organic compounds are highly diverse (Quilchano et al., 2002).

Phosphatase, a microbial extracellular enzyme, cleaves the phosphate groups from substrates such as nucleic acid and is involved in the phosphorus cycle in soil. Acid phosphatase provides a potential index of mineralization of soil organic phosphorus. In soil ecosystems, phosphatase enzymes are correlated to phosphorus stress and plant growth. Apart from being good indicators of soil fertility, phosphatase enzymes play key roles in the soil system. Phosphatases are involved in transformation of organic and inorganic phosphorus compounds in soil. Land plants have evolved many morphological and enzymatic adaptations to tolerate low phosphatase availability. This includes transcription activity of acid phosphatases, which tend to increase with phosphorus stress. It was further reported that enzyme phosphatase secreted by some soil microorganisms and plant catalyze the microbial transformation and phosphate solubilization activities in soil. This phenomenon has triggered greater microbial proliferation as influenced by physiological stages of plants and nutrients sources.

Soil is the largest carbon pool in terrestrial ecosystems, containing more than two-thirds of total carbon in the terrestrial ecosystems. Soil respiration (belowground respiration) is the major pathway of carbon transfer from soil to atmosphere, and a tiny amount of change in soil respiration rate may have profound impact on the atmospheric CO₂ budget, thus understanding soil respiration is crucial for the carbon balance of terrestrial ecosystems and for the global carbon balance. The intensity of the CO₂ emission from the soil is due to root respiration, the living activity of microorganisms (bacteria, fungi, algae, and protozoa), and physicochemical soil processes (Kuzyakov,
Soil respiration normally refers to the total soil CO₂ efflux at the soil surface. It is the combination of biotic, chemical and physical processes. Various factors are identified to affect soil respiration rate: soil temperature, soil moisture, root nitrogen concentrations, soil texture, and substrate quantity and quality, among which soil temperature and moisture dominate. Soil temperature and moisture often interact to control the rate of soil respiration, and it's often hard to separate the effects of the two. Studies show that soil respiration usually responds to the most limiting factor, temperature or moisture. Soil respiration is not sensitive to temperature under lower moisture (below 75%), but is more responsive at higher moisture content (100-250%). Similarly, soil respiration is not sensitive to moisture under lower temperatures (below 5°C) but more responsive at higher temperatures (10-20°C). The regulation of soil temperature and moisture to soil respiration is so strong that the two effects can be coupled to make predictions of soil respiration.

Interactions of rice crop with fungi at seed level have attracted the attentions of a number of research workers. Seed mycoflora are of considerable importance due to their influence on the overall health, germination and final crop stand in the field. Generally speaking, the seed borne fungi cannot be said to belong to any particular class or group, although instances can be cited where there is a close and often specialized affinity between members of an alliance and the crops thereon they live. Many fungi get established internally and externally with seeds during pre-harvest period. Many of them get associated with seeds during storage. These pre and post-harvest mycoflora not only cause seed deterioration but also make seed unfit for human consumption (Miller, 1995). The quality of seeds and the rate of their germination depend upon the period of storage because of the difference in the longevity of associated fungal species. These fungi may adversely affect seed germination and seedling vigour, cause seed discolouration and may reduce seed weight also. Healthy and pathogen free seed is the basic requirement for disease free crop. Infected seeds serve as the source for spread of the pathogen in disease free areas. Numerous examples exist in agricultural literature for the international spread of plant diseases as a result of the importation of seeds that were infected or contaminated.
with pathogenic fungi. Occurrence of fungi on seed produced in a definite region may fluctuate considerably from year to year reflecting yearly variation of weather conditions. Seed moisture has been considered to be prime factor in the colonization of seed by fungi. Rovira (1956), is of the opinion that seed mycoflora could establish themselves on the root surface. There is a growing interest in seed pathology in many countries both in terms of testing seeds for quality and in terms of seed research in the field of seed borne fungi. The fungi may attack the seeds which result in the form of seed abortion, shrunken seeds, reduced seed size, seed rot, seed necrosis, seed discoloration, reduction or complete loss of germinability and physiological changes. A large number of seed borne fungi are known to produce toxic metabolites when cultivated on synthetic media. These metabolites are the substances discharged by fungi in their metabolic processes.

Sown seeds encounter the environment of the interacting factors of the soil ecosystem supporting the intricate course of germination. Along with the setting in of the process of germination of the seeds, the viable fungal spores, born on the seed surface, also germinate, under the given moisture and temperature condition of the soil, and interact with the microorganisms already present, from beforehand, in the soil, in the sphere of the sown seeds, in response to their mutualistic and antagonistic relationships. Some of the fungi growing in close association of the germinating seeds positively respond, later, to the root exudates of the seedlings and behave as rhizosphere mycoflora (Bhowmik and Das, 1985). The soil mycoflora, which establish as rhizosphere fungi while growing in the close vicinity of the sown seeds of the respective crops find their natural way inside the germinating seeds along with the inhibition of water or by diffusion. The early secondary metabolites of the rhizosphere fungi may also produce effect on the germinability of the seeds by either stimulating or inhibiting the process of germination.

The production and supply of high quality grain remains of prime importance. Rice seeds must thus be protected in the field and in storage after harvest against fungal attack. Attack by fungi not only reduces the quality of the grain but some species of fungi can produce highly toxic chemicals or metabolites known as mycotoxins. Some species of
Alternaria, Aspergillus, Cladosporium, Penicillium and Rhizopus are known to produce one or more mycotoxins or antibiotics. These metabolites can affect rice crop by inhibition of seed germination and viability, root and shoot development, and by interference with chlorophyll synthesis.

Plant naturally releases carbon compounds across the root cell plasma membrane and any efflux is termed as exudation. A vast array of compounds in the rhizosphere is one of the most remarkable metabolic features of plant roots. These compounds include organic acids, amino acids and specific sugars. Carbohydrates and organic acids are the dominant component of root exudates and generally have a wide C/N ratio (Naher et al., 2008). Root exudates are readily available carbon source for microorganisms in the rhizosphere which participate in the early colonizing process. About 64 to 86% of carbon released into the rhizosphere is used by microorganisms (Hutsch et al., 2002). The amount and composition of root exudates entering the soil is variable. It depends on plant species and age of plants. Soil environment and microbial community of the rhizosphere also influence the net root exudation. Root derived organic matter inputs to soil are diverse and range in complexity. Labile exudates (such as sugars, amino acids and organic acids) are readily available to microbes and have a half life in soil of only a few hours (Paterson et al., 2008a). Roots also lose complex material (due to root turnover) and material of intermediate complexity, such as polysaccharides and proteins. These different forms of inputs constitute rhizodeposition, which provides a diverse source of substrate to soil microbial communities and is responsible for the well recognised stimulation of microbial biomass, size and activity around roots (Berg and Smalla, 2009).

Rhizodeposition, the release of carbon compounds from living roots, provides a source of nutrients and signals that represent the driving force to attract and stimulate growth and metabolic activities of a complex microbial community at the root-soil interface. Estimates of rhizodeposition vary considerably, and may range from less than 10% of the organic compounds produced through photosynthesis to more than 40% (Grayston et al., 1997). Variation in rhizodeposition is considered to be an important driver of microbial community development, as it has been demonstrated that there is specificity amongst
populations in use of different rhizodeposits (Paterson et al., 2007). While stimulating the growth of some microbes, rhizodeposits could also potentially have a negative effect on others, due to antimicrobial properties or by simply being the wrong carbon source to support particular microbes. This has led to the concept of co-evolutionary relationships in the rhizosphere, where plant root exudates ‘shape’ soil microbial communities (Badri and Vivanco, 2009), implying a tight coupling between individual plant species and the diversity of their rhizosphere microbes.

Crop debris, a principal amendment applied to the soil system, play an important role in maintaining soil fertility and other physical properties of soil. Farming practice on rice-based cropping system, which involves heavy application of chemical fertilizers, may cause depletion of certain nutrients in soil and certain others would generally accumulate in excess resulting in nutrient imbalance, which affects soil productivity and environmental pollution (Tran et al., 2008). Crop residue decomposition is essential for maintaining health of the soil, increasing water holding capacity and improving soil-water-air conditions.

Decomposition of rice straw depends on those microbes that can easily colonize and degrade cellulose and lignin. The process of decomposition is a complex phenomenon and completed by multitude of organisms, where fungi play an important role, because they grow well under semi-solid fermentation conditions by virtue of their ability to ramify through solid substrate. It is known fact that microorganisms, fungi in particular secrete enzymes which biodeteriorate the substrate and utilize the so produced simpler forms for their nutrition (Singh and Saxena, 2004). Earlier studies carried out by different workers have established that different fungi occur in active state in soil and for obtaining their nutrition these fungal forms must be producing enzyme to biodeteriorate cellulosic and other plant materials. Cultivation of the soil and incorporation of residues are major factors in the activity of fungi in rice-field soil. Rice stubbles constitute of a part of the root system and just above the ground portions, which is highly rich in cellulose and lignin (Vibha and Sinha, 2007). It plays an important role in meeting the nutrients demand of rice and succeeding crops, if incorporated into the soil and allowed to
decompose. Crop residue decomposition is essential for maintaining health of the soil, increase water holding capacity and improving soil-water-air continuum. Many fungi are found to occur during the period of decomposition of residues (Warcup, 1957). Decomposition of rice straw depends on those microbes that can colonize and degrade its various constituents, especially cellulose, holocellulose and lignin (Abdel-Hafez et al., 1978; Coronel et al., 1991). Soluble components such as simple sugars and storage materials are utilized first and relatively quickly, followed by structural polymers like cellulose and hemicelluloses and then lignin and lignocelluloses (Susan, 1998). As microorganisms decomposed crop materials the constituent of substrate changes rapidly which offer new avenues to different groups of microorganisms. Many heterotrophic fungi and bacteria are responsible for the decay process releasing locked up nutrients. Fungi are generally active in decomposing major constituents of crop tissues namely cellulose, lignin, pectin and hemicelluloses. It has been established by now that the rates and mechanisms of plant tissues decomposition are determined by their biochemical composition, the hydrothermal environmental conditions, the presence of available nitrogen, and the nature of the microbial populations (Kovaleva and Kovalev, 2009). The population of bacteria, actinomycetes and fungi in the soil vary on the basis of their efficiencies to utilize constituents of crop residue during the time of degradation. Many wood rotting Basidiomycetes are known to be very efficient in utilizing cellulose. It is well known that breaking down of litter is followed by the release of CO$_2$ under aerobic conditions and rate of CO$_2$ evolution is generally taken as a measure of metabolic activity in soil.

The pattern of distribution of microorganisms and their activity in rice field soil so far discussed is not universal pattern as microbes in the soil are greatly sensitive to the slightest changes in the soil environment. So, to know the microbial composition with respect to their activities under variable climatic condition is of utmost importance. Assam represents an area with unique climatic conditions characterize by high rainfall with annual flood accompanied by humid climate. Therefore, it is of great interest to know the distribution pattern of various microbial population and their activities under
such varying environmental conditions. The present work focuses on the distribution of microorganisms and their activities in the rice field soils of Jalukbari area of Guwahati.

The scope of the proposed study is confined to the following aspects:

- Analysis of physico-chemical characteristics of soils of the experimental field
- Quantitative determination of soil microflora at different depth of rice crop field
- Quantitative and qualitative analysis of rhizosphere and non-rhizosphere microflora of rice crop at different stages of growth and their activities
- Analyses of seed mycoflora of rice and their relationship with rhizosphere mycoflora
- Effect of root exudates of rice on germination of some predominant fungal spores
- Effect of cultural filtrate of seed borne fungi on rice seed germination
- Studies on the degradation of rice stubbles by soil fungi