REVIEW OF LITERATURE

The serieigenous insect *Antheraea proylei* **Jolly.** is crossed between *Antheraea pernyi* from China and its male counterpart *Antheraea roylei* of India in 1969 and the fertile hybrid *A.proylei* was established in 1973-74 in India as a commercial rearing which help the upliftment of rural areas in North-Eastern and North-Western in Himalayan states where the Oak plantation grow abundantly in Natural forest. *Antheraea proylei* **J.** temperate tasar silkworm feed on *Quercus serrata, Quercus acutissima, Quercus griffithii, Lithocarpus dealbata* in North-Eastern Himalayans and *Quercus leucotrichophera, Quercus floribunda, Quercus semecarpifolia* in North-Western Himalayans. Leaf of *Quercus serrata* is used for Oak tasar silkworm rearing and is considered to be the primary host plant of Oak tasar silkworm producing in North-Eastern Indian States *i.e.* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland. The *Quercus serrata* plant is an erect, deciduous tree and attains a height of about 25-30 meters and above when full grown with a trunk up to1.5 meters diameter. The Oak plants regulated water cycle; conserve soil moisture and environmental/ecological stability of the fragile mountain ecosystem. In *Quercus serrata* foliar variations (Srivastava *et al.*,2004) like lanceolinear, lanceolate, elliptic, oblong, obovate, oblanceolate, spathulate, cuneate. Texture deep or light green, both sides glabrous or glabrous above, pubescent beneath, thick medium or thin (papery). Leaf margin, awn tipped and undulate/serrata/dentate. Leaf apex acute/obtuse/acuminate/mucronate and 10-20 pairs lateral veins. Sprouting and Flowering in February-March and fruiting in May-June, ripening in October-November, and seeds collection in the month of December. Four foliar fungal diseases caused by Rust (*Cronartium quercum*), Powdery mildew (*Phyllactinia corylea*), Sooty mould (*Chaetophorma quercifolia*), Leaf blister (*Taphrina carulescence*) (Das and Pandey, 1991, Ghose *et al.,* 1992), and four foliar fungal diseases and Leaf curl disease caused by virus (Srivastava *et al.*, 2004). The inter-specific hybridization in *Quercus* sp is very common due to open pollination. It has been realized that replacement of Oak forest with Pine in the Himalayas affects the nitrogen cycle (Singh *et al.*, 1984) and causes heavy landslides leading to heavy and damage. Pine has got less soil holding capacity and no coppicing capacity. Oak tree hold soil more strongly than pine and have more coppicing power which should be publicized in order to encourage plantation of

more Oak trees by Non Government Organization and Govt. Department like (Forest and Sericulture) *Antheraea proylei* **J.** (Temperate tasar silkworm) is biovoltine in nature Spring crop during (March-April) and Autumn crop during (September-October). Spring crop is commercial crop as well as seed crop and Autumn crop is seed crop only. Seasonal factors greatly influence the growth and development of temperate tasar silkworm. The silkworms require nutritious leaf for healthy and uniform growth of silkworm and its effect production of quality cocoons.

According to Singh and Tikko, (1989) Pandey, Rath and Goel (1989) *Q. serrata* plants were pruned in December/January for Spring crop rearing and light pruning/clipping in August for Autumn crop rearing one month before rearing. According to Das and Pandey (1991) pruning schedule to support rearing one of the important steps in the growth of Oak tasar industry, *Q.serrata* light pruning followed by fertilizer application during winter (December-January) helps to rejuvenate the plant for maximum flush of new leaves during spring season. When pruning was conducted during October-November the newly sprouted buds gave rise to thin, small and yellowish foliage, which showed signs of stunted growth, may be due to unfavorable season for the plant to grow. Therefore, pruning during October and November is not recommended. The effect of pruning on the nutritive value of the leaves of *Quercus serrata* in a significant increase in the level of soluble protein, total sugar, total free amino acids etc which gave better performance of rearing as compared to rearing of *A.proylei* on un pruned plants (Ghosh and Srivastava, 1996).

Leaf yield of *Q.serrata* per hectare in economical plantation of 1.2 X 1.2 m spacing (8000Kg without any input *i.e.* Farmyard manure and Nitrogen, Phosphous, Potash, which is increasing to 13000Kg) when applied 7000Kg FYM and N_{150Kg} P_{50Kg} K_{38Kg} per hectare.

Source**:** Regional Tasar Research Station**,** Imphal**,** Manipur (1998).

Sinha and Jolly(1971) analysed the foliage constituent of *Quercus serrata and Q.incana.* Quality of leaves may adversely affect the physiology of individual insect (Sinha *et al.,* 1986), Fenny (1970) has reported the trends in the spring leaves of *Q.robusta.* Chinese tasar silkworm, *Antheraea pernyni* on Oak during the spring season presence of lesser amount of tannins content, which is increasing in the

following seasons as a result leaves unsuitable for silk worm (Fenny,1969). The studies on foliar constituents of Oak tasar silk worm host plants were also reported Banerjee *et al.*, (1993) Ghosh *et al.*, (1995, 1996). In spring season higher crude protein% and less crude fibre % and also resulting higher % Effective Rate of Rearing Oak tasar silkworm (*Antheraea proylei* **J.**). The quality of leaves has got direct influence on the healthy growth and survival of silkworm Sinha *et al.*, (1986). Better quality of leaves greater possibilities of obtaining good cocoon harvest. Therefore, the selection of the food plants processing superior nutritive value could be utilized for the healthy development of silkworm for obtaining good crop. According to Pandey and Goel (1991) crude protein contents of young leaves were higher than old leaves in 3 Oak species were *Q.serrata* showed maximum 28.92%, *Q. semecarpifolia* 20.77% and *Q. incana* 16.47% but old leaves contained less protein contents than young leaves. Pandey(1995) observed seasonal changes in the leaf composition of *Q.serrata,* where leaf protein were 6.81% in March and 7.89% in April which were decreasing 4.74% in October and ash 2.23% in April 1.95%, as result the leaf quality of March and April month was found most suitable for rearing of *A.proylei.* A strong positive correlation was found between leaf content and larval body weight. The higher survival of Oak tasar silkworm during Spring season may be due to higher protein content of leaves during April. Leaf quality for many lepidopteron larvae is determined on protein content basis (Mattson, 1980). The Autumn crop of Oak tasar not fully success may be due to decline in protein content and excess of relative humidity. Ponnuvel *et al.,* (1996) leaf moisture percentage of *Quercus serrata* leaves decreasing from February to November (71.9% to 56.78%) and crude protein decreasing from March(10.17%) maximum and minimum in September (5.39%) and October (5.07%).In Spring crude fibre less (0.09%) in February and 5.28% in March), but in Autumn season crude fibre 6.85% in September and 7.66% in October. Carbohydrates contents of leaves observed low in Spring season and increasing in Autumn season. Rana *et al.,* (1987) studies food consumption, utilization and rate of growth of *A.proylei* feeding with *Quercus serrata* leaf. In a period of about 36 days of its larval life, the average cumulative consumption was 72.88 gm. The quality of food consumption increased with increase in age of the worm and reached its peak in the fifth instars. The assimilation and tissue growth were positively correlated to the amount of food consumed.

Sericulture and silk weaving is the part and parcel of cultural heritage of the people of NE India (Unni *et al.,* 2009). Tasar silk production is one of the major agro-based industries playing an important role in the rural economy of NE states. The Oak tasar (*Antheraea proylei* **J**.) silkworm, the larvae of which feed on leaves of Oak tree *Quercus* sp, is an important source of tasar silk, a rough, coarse and nubby silk usually with natural shade of beige (Singh and Singh 1998). The hard and compact Oak tasar cocoons can't be satisfactorily softened by boiling in plain water unlike the mulberry (*Bombyx mori* **L.**) silk cocoons (Jolly, Sonwalker and Prasad, 1979) due to presence of relatively low amounts of sericin and high amount of protein tannin complexes in the form of pro-anthocyanidins and are thus difficult to reel (Pandey, 1990) The proteolytic activity of the pineapple extract helps in partial solubilisation of the proteinaceous silk gum(sericin). Binding the silk (fibroin) stands together in silkworm cocoon. *Quercus serrata* fed Oak tasar cocoons which contain relatively more sericin, are easily cooked with alkaline method in the North-East India. The reelability of *A.proylei* cocoons was found 53.43% and tannin in the cocoon shell, less reelability (Pandey,1990).

Soaking in boiling water has been found to significantly reduce tannin content. The reduction is due to leaching out of tannins. Cooking and treatment with alkalis (NaOH, KOH, Na_2CO_3, $NaHCO_3$). Oak tasar cocoon cooking with 1% sodium carbonate solution gives good results in respect of reelability, yield per 1,000 cocoons and other technological properties. Reelability, production/8 hrs/reeler and yield of raw silk per 1000 cocoons stand at,204gm and 347 gm respectively which are at almost at par with that of Biopril-50 (Tikoo and Goel,1987). Temperate tasar cocoon were cooked using 0.5% Sodium Carbonate an 0.5% Sodium Silicate at 90ºC for 30 minutes (Rajkhowa,1998).Cocoon cooking by the standardized enzymatic procedure developed *i.e.* pressure cooking of Oak tasar cocoons for 30 minutes and soaking in pineapple extract for 12 hours at room temperature gives a very high reeling performance as compared to traditional method (Devi,*et al.,* 2012).

The fungi presence on the leaf surfaces was recognized by De Bary in 1886 and described that *Dematium pullulans* as a fungus commonly occurring under such situation. It was known that population of pathogenic microorganisms as well as non-pathogenic microorganisms may also grow on the surface of living leaves and

other aerial parts of plants. The term "Phyllosphere" was proposed by Last (1995 a) and Ruinen (1956) to describe the milieu of leaf surfaces. Dickinson (1965), Last and Deighton (1965) restricted this term to the zone near leaves and used "Phylloplane" to actual leaf surfaces. The populations of microorganisms colonizing on leaf surface form an ecology niche which can be studied either as the phylloplane or the phyllosphere (Davenport,1976). The aerial habitat colonized by microbes is term phyllosphere and the inhabitants are called epiphytes (Lindow and Brandle, 2003). Several earlier workers viz. Ruinen (1961); Last and Deighton (1965); Leben (1965); Sinha (1965); and Sharma and Mukerji (1974) had done extensive investigation on the epiphytic micro flora of living leaves. In mid 1950's the study of microorganisms of leaf surface has become a recognized field of investigation, and in 1970 it was felt to hold an international symposium on the subject and the proceedings were published in 1971 (Preece and Dickinson,1971). The increasing research being carried out in the field was reflected in a second symposium after five years (Dickinson and Preece, 1976). In July 2005, the Centre of Ecology and Hydrology, Oxford hosts the 8th International Symposium on the Microbiology of Aerial Plant surfaces at St Catherine's College (Bailey *et al.,* 2006). and its reflects the extensive progress made in the field of this study, and to mention a few of the workersof this field are, Diem (1974); Fokkema (1981); Mishra and Dickinson (1981); Sharma *et al.*,(1984); Cabral(1985); Fokkema and Van Den Heuvel (1986); Legault *et al.*,(1989); Adhikari (1990); Kinkel (1997); Andrews and Harris (2000); Yang *et al.*,(2002); De Jager *et al.*,(2001); Andrew *et al.*,(2002); Osono(2002); Lindow and Brandle (2003); Osono *et al.*, (2004).

Phylloplane mycoflora.

Last (1995a) studied seasonal incidence of sporobolomyces on leaves of different three crop viz. spring and winter sown wheat and spring sown barley. Ruinen (1961) observed that maximum population of microbes' senescent foliage. She had also observed that olingonithrophilic and nitrogen fixing bacteria as first colonizers on the leaf surface. Kerling (1964) studied the leaf surface fungi on rye and strawberry and observed that the population of *Botrytis cinera* increased rapidly as the leaves of strawberry approached to senescence. Hudson (1962) termed the active microorganisms present on the leaf as colonizers, were classified into two categories: (i) Common primary saprophytes which are also present in the air, so

referred them as field fungi viz. *Aspergillus* sp, *Penicillum* sp, (ii) Restricted primary saprophytes which are specific to the host plant. Last and Deighton (1965) reported that bacteria and yeast like organisms were more abundant on the leaves than the hyphomycetes, and members of Sporobolomycetaceae dominated on the surface of diseased leaves infested by fungi, nematodes and mites etc.

According to Dickinson (1965) distinguished three different groups of leaf fungi viz, the transient fungi present on the leaf surface including yeasts and other propagules which are capable of sporulating on leaf surface but are not isolated from washed discs. The second groups of fungi dominated by *Cladosporium herbarum* were recorded from both leaf surface washings and washed discs, and third group consisted of forms growing vegetativly on leaf surface but pycnidia were formed only on moribund leaves. Leben (1965) distinguished the epiphytic leaf microorganisms as 'casuals' and 'residents', the first one remaining inactive or developing only on organic debris fallen on the leaf from elsewhere, the later growing actively on the leaf surface and using nutrients excreted by the leaf. There were an intermediate may also exist in addition to 'casuals' and 'residents' microorganisms. Hogg and Hudson (1966) recognized three distinct patterns of fungal distribution on Birch leaves. According to them *Cladosporium herbarum* is a primary colonizer. Holoman (1967) investigated leaf surface microflora of three potato varieties where *Aureobasidium pullulans* and *Cladosporium herbarum* were the usual inhabitants. According to Dickinson (1967) forms like *Cladosporium*, *Stemphylium* and *Alternaria* were very frequently observed on the leaves of *Pisum sativum* and point out that not all the fungi recorded by moist chamber technique were phylloplane saprophytes but several species viz, *Penicillum* sp, and *Aspergillus fumigatus* constitute casual inhabitants of the phylloplane and their presence may be reflect the relative abundance of their spores in the atmosphere which was very important during the investigation.

Lamb and Brown (1970), they were also confirmed that the microflora present on leaf surface may be divided into two groups (i) the residents group which are actively growing in saprophytic form (ii) the transient species which are deposited on the surfaces of leaves as a wind borne propagules. The residents are the nature of epiphytic organisms which grow and reproduce as saprophytes on the leaf surface whereas transient organisms are present merely by chance on the surface and

active growth and reproduction do not occur in such forms. According to Mishra and Srivastava (1971 b) however, differentiated the phyllosphere and phylloplane and retained both the terms to denote in the two different regions of leaf surface as rhizosphere and rhizoplane regions of root. The recent years workers use either of the term, and they consider them more or less synonym (Dickinson, 1976). Diem (1973) reported *Cladosporium* sp to be the only important colonizer of Barley phyllosphere. Tiwari and Sahu (1987) isolated 26 fungal species belonging to sixteen genera at various stages from the leaf surface of *Brassica campestris* **L**.

The colonization of leaf surfaces by fungi presents a very interesting study with regard to substrate relationship (Pugh and Buckley, 1971). Occurance of the microbial pattern of the phyllosphere is characteristic of a particular plant species (Pillai and Sen, 1966; Garg *et al.*, 1978), the host species themselves play an important role in microbial colonization by providing different niches to the microorganisms (Dickinson, 1981; Hirano and Upper, 2000; Mercier and Lindow, 2000; Lindow and Brandl, 2003; Chmiel, 2004). The nature and size of the phyllosphere microbial community which is a reflection of the host plant leaf characteristics together with environmental fluctuations of particular area (Dickinson, 1986). The microbial communities of leaves are diverse and variations in population sizes are caused in great part by the large fluctuations in the physical and nutritional conditions characteristic of the phyllosphere (Lindow and Brandl, 2003).

The numbers of microorganism increasing with advancing age of leaf which were observed by (Ruinen, 1956; Pugh, 1958; Hudson, 1962; Kerling, 1964; Sinha, 1971; Kumar and Singh, 1981; Narula and Mehrotra, 1981; Cabral, 1985). De Jager *et al.*, 2001 reported that gradual increase of filamentous fungal and yeast densities from foliole stage, through flash and juvenile to mature leaf stage in Mango (*Magnifera indica*) phylloplane and the most common fungal genera isolated were *Cladosporium* sp and *Alternaria* sp. They also observed higher densities and diversities of bacteria and the filamentous fungi over the abaxial leaf surface.

Hirano and Upper (1991) Thompson *et al.*, (1993) observed that the epiphytic communities are dynamic, but non-uniformly distributed in time and space of leaf. The physical surface of the leaf is highly dynamic (McGrath and Andrews,

2006). The cuticle erodes progressively which can change the topography, the wettability of the surface, exudation of nutrients and retention of microbes (Mechaber *et al.*,1996; Schonerr and Baur, 1996; Schreiber *et al.*,2001; Andrew *et al.*, 2002). The non-pathogenic fungi which inhabit the phyllosphere depend upon nutrients extruded from the leaf or those deposited from the atmosphere (Belanger and Avis 2002; Inacio *et al.*, 2002). According to Lindow and Brandle (2003) availability of carbon containing nutrients on leaves is a major determinant factor of epiphytic colonization. Several studies have revealed that small amounts of nutrients can be washed from the leaves. The simple form of sugars such as glucose, fructose, and sucrose are the dominant carbon sources on the plants that have been examined and are thought to simply leach from the interior of the plant (Tukey, 1971; Mercier and Lindow, 2003). In addition to nutrient levels, for the growth and abundance of phylloplane fungi is also influenced by environmental conditions such as availability of water (moisture), ultraviolet radiation and temperature (Breeze and Dix, 1981;Newsham *et al.*,1997; Zak,2002).The microbial community dynamics are most influenced by the external factors such as micro-climate (Andrews *et al.*,1980; Jacques *et al.*,1995), anatomical features (Andrew and Kennerly, 1980; Jacques *et al.*,1995), the physical variations (Ishimaru *et al.*,1991), the environmental changes (Dickinson, 1965; Collins and Hayes, 1976; Irvine *et al.*,1978 Breeze and Dix, 1981; Thompson *et al.*,1993; Lindow and Anderson, 1996) and the use of agrochemicals (Gibbs, 1972; Andrews and Kennerly, 1978; Blakeman, 1985).

The factors like moisture, pH, temperature, and wax deposition on leaf and height affect on microbial colonization on the phylloplane (Holloway, 1971; Hallam and Juniper, 1971; Forester, 1977; Barlocher *et al.*, 1978; Dwivedi and Kumar, 1981; Merall, 1981). A few investigators have also correlated climatic factors such as atmospheric temperature, humidity, wind velocity, light and rain (Gregory, 1961; Hirst and Stedman; (1963) Kumar and Singh, 1981; Sharma *et al.*, 1984; Adhikari, 1990). The qualitative composition of the epiphytic microorganisms depends on many environmental factors especially at the beginning of spring season, as in this stage new leaves sprouting (Burlaga and Garbolensha, 2006). Pandey *et al.*, (1989); Sahu and Tiwari (1985, 1988); Tiwari and Sahu 1987, 1989, 1991); Sahu *et al.*, (1986, 1988); Thompson *et al.*, (1993). The environmental factors are the most important physical factors, which affect the total microbial population present on the

leaf surface. The microbial species composition also changes over time, and some inhabitant may impact on the other inhabitants by producing inhibitory compounds (McCormack *et al.*,1994; Andrews and Harris, 2000 Koitabashi., 2002).

Air mycoflora:

According to (Mishra and Tiwari, 1976 a) there is very close co-relation between the air spora of one locality and the leaf surface fungi of plants growing in the area. The fungal colonizers on the leaf surface which come from air or from soil. The investigation in the aerobiology in India, was started by Cunningham (1873) who reported the changes in atmospheric spore content of Calcutta prison . The atmosphere consists of the different gaseous component as well as living organisms and non-living agents which is either fly or which depended on the wind for their dispersal. Among the latter are the microscopic forms which form the air spora (Gregory, 1973). Grainer (1954) reported higher concentration of *Helminthosporium avenae* in air at lower level of infected Oat crop. According to Last (1955 b) in his study of air spora within and above mildew infected cereal crops found higher population near the ground. Gregory (1957, 1961) also observed that a direct correlation between air-spora and the micro-flora of leaf surface. Pady *et al.,* (1967) reported that many of the air borne fungal hyphae are conidiophores which are probably released by the wind current from dead leaves of crops. Pady (1971) also pointed out that the leaf is thus a most suitable site for the both saprophytic and parasitic fungi and under favorable conditions spores are produced in large numbers and released into the air. The spores of various obligate pathogens such as rusts, smuts are usually present in the large numbers in the air and they exhibit a characteristic release pattern (Gregory, 1961; 1971). And he also suggested three main ways for the arrival of spores *i.e.* (i) dry wind borne route, (ii) in rain drops and (iii) in rain splash droplets. The studies on air spora in India have been done by several workers in time to time they were Konger and Baruah (1958); Rajan *et al.*, (1952); Sreeramalu (1967, 1970); Baruah and Bora (1965); Sreeramalu and Ramalingam (1965); Subbareddy (1970); Tilak (1974); Singh and Baruah (1979):Ramalingam (1971); Rajkumar and Gupta (1976).

The many fungi present on the aerial surface may be directly related to inoculation from the atmosphere which in turn is related to the production of

deciduous propagules elsewhere (Dickinson, 1976). Studies on myco-organic component of air over crop fields are important in understanding the mode of dissemination of airborne plant pathogens and in establishing the forecasting systems for the disease control (Kamal and Singh, 1974). It is a clear understanding of the nature, periodicity and density of the fungal propagules in the air is helpful in making a forecasting regarding the presence of fungal diseases and the quantum of viable pathogenic propagules likely to cause infection (Mishra and Tiwari, 1976 a). The leaf surface releases a fungal spore which is largely contributed to the air spora of the locality. Mishra and Srivastava (1971 a), a kind of cyclic phenomenon exists between fungal spores of air, soil and plant surface and some forms, maintain their specificity in the special environment. Many researchers {Lamb and Brown (1970); Mishra and Srivastava (1971a, 1972); Sinha (1971); Burrage (1976); Mishra and Tiwari (1976a); Kumar and Gupta (1980); Dixit and Gupta (1980); Sahu and Tiwari (1988);} have contributed to the comparative studies between phylloplane and air spora of the different fields to get a clear picture in this tropic.

In the atmosphere presents a tremendous diversity of the airborne spores with a high concentration, frequently occurring from spring to fall in temperate areas of the world (Gregory, 1973; Levetin, 1995). Numbers of spores in the air usually differ depending upon the pattern of rainfall of that area, and number of conidia decrease dramatically just after rain, side by side at that time ascospores increase (Alexopoulos *et al.*,1996). The air spora constitutes both the source of fungi that colonize on the leaf surface and the sink of spores released from the leaf surface by various dispersal mechanisms (Pedgley, 1991; Kinkel, 1997; Aylor, 2002). The airborne spores impact on the leaf surfaces and may adhere due to structural or chemical features of the epidermis and the spore (Andrews and Buck, 2002). The release of spore from many fungi inhabiting the phylloplane is passive through the action of wind or rain splash; however, other spores are actively propelled into the atmosphere by the various mechanisms (Kinkel, 1997; Aylor, 2002; Levetin, 2002). Singh *et al.,* (1990) reported that predominance of *Cladosporium* during winter, *Alternaria* during summer and *Penicillum* species during autumn season. Fang *et al.,* (2005) reported that a high frequency of air borne fungi in regions with high vegetation coverage in summer season in Beijing and also mentioned that most of the airborne fungal spores came from vegetation rather than from soil. According to

Huang *et al.,* (2002) airborne fungi were higher in winter season than other seasons at municipal landfill sites in Southern Taiwan and ascribed it to the geographic characteristics of the sampling area. The microorganisms which are found on the surface of plants either as pathogens or as saprophytes also get suspended in air. The species of microorganisms which were found in air vary according to the different geographical location. The microbial flora of air of a particular area always depends on the environmental conditions of that region (Basumatary *et al.,* 2002).

Levetin and Dorsey (2006) during their study of airborne spores on the roof of a building on the University of Tulsa campus with leaf surface fungi collected from *Ulmus americana* and *Quercus palustris* trees from the same campus reported that 19% of the fungal population isolated from leaves are found in air and suggested that some leaf surface fungi are major contributors to the air spora. The most abundant taxa in air samples recorded by them are *Cladosporium* followed by *Alternaria*. Air pollution is one of the most serious problems to human health. The Fungi are among the most important natural pollutants which can be pathogenic under specific circumstance (Nourian *et al.,* 2007) . The Geographical location, climate, and short-term meteorological conditions are mainly responsible for outdoor types and levels of fungal spores (Codina *et al.,* 2008). This air-borne fungal flora, is so called opportunistic fungi, they change the spectrum of fungal diseases (Singh, 2001).

Rhizosphere and non-rhizosphere (soil) mycoflora:

The microbial association and their activity amply evidence are soil, rhizosphere, rhizoplane and phylloplane are the specialized ecological niches (Manoharachary and Mukerji, 2006). The plant roots support the growth and activities of a wide variety of microorganisms that may have a profound effect on the growth and or health of plants (Ladygina, 2005). The term “rhizosphere” was first used in 1904 by Lorenz Hiltner, a soil bacteriologist and professor of agronomy at the Technical college of Munich, (Campbell and Greaves, 1990) to describe the interaction between bacteria and legume roots. At present rhizosphere is recognized as a biologically active zone of the soil around plant roots that contains different living organisms such as soil-borne microbes including actinomycetes, bacteria, fungi, microalgae, protozoa, invertebrates (collembolans, nematodes, earthworms) in

their abiotic environment (Kennedy 1998).According to Pinton *et al.*, (2001), the term rhizosphere includes both the volume of soil influenced by the root and the root tissues colonized by micro-organisms. The Rhizosphere is a soil ecological region where soil is subjected to specific influence by plant roots due to exudates from root cells and sloughing of root tissues (Giddens and Todd, 1984; Curl and Truelove, 1986). Rhizosphere represents a poorly defined zone of soil, with a microbiological gradient, in which maximum changes in the population of microflora in soil, which is evident adjacent to root and decline with distance away from it (Newman, 1978; Bowen, 1991; Mukerji, 2002).

The Rhizoplane is more closely or narrowly defined and describes the surface of the plant root itself along with tightly adhering soil particles (Curl and Trueloved, 1986; Boltton *et al.*, 1992). The term "rhizoplane" was first proposed by Clark (1949) and cited by Sharma and Singha (1974). The root surface or the rhizoplane who support a relatively high biological activity and it reflects more sensitivity than the rhizosphere (Bruehl, 1987). The rhizosphere can be divided into several distinct zones (Lynch, 1987).These also include the endo-rhizosphere (root tissue including the endodermis and cortical layers), the rhizoplane (the root surface with the epidermis and mucilaginous polysaccharide layer), and the ecto-rhizosphere (the soil immediately adjacent to the root).

The physical, chemical, and biological properties differing of the root associated soil, compared with those of the root-free bulk soil, which are responsible for changes in microbial diversity and for increased numbers and activity of microorganisms in the rhizosphere micro-environment (Kennedy,1998). The great array of root-microbe interactions results in the development of a dynamic environment known as the rhizosphere where microbial communities also interact (Barea *et al.*,2005).

The most of earlier workers like Katzneelson, 1946; Agnihothrudu, 1955; Parkinson, 1957; Sadasivan1965; Sorenson, 1997; have reported the phenomenon of accumulation of microorganisms around the root zone. Parkinson *et al.*, (1963) investigated that colonization of roots of barley, cabbage and dwarf bean by fungi and opined that initial root colonization may be by awide range of soil fungi, but that this mixed population rapidly gave way to a stable and typical root surface mycoflora dominated by such fungi as *Fusarium* sp, *Cylindrocarpon radicicola*, *Gliocaldium* sp and *Penicillum* sp. Parkinson ad Pearson (1967) reported that a

marked decrease of total fungal population in increasing depth of soil. They however observed that the sterile dark forms of fungi increased in frequency of occurrence with increasing depth. Parkinson and Thomas (1969) reported that there is close similarity between the rhizosphere and non rhizosphere mycofloras and really marked qualitative changes in the rhizosphere mycoflora accompanying increasing the plant age.

The rhizosphere micro-floras of crop plants increase during the maturity stage have been observed by several workers (Katznelson, 1965). Mehrota and Claudius (1974) reported that a general increase in the microbial population of rhizosphere soil as compared to non rhizosphere soil. They also reported that microflora of the rhizoplane was stimulated to a lesser degree than the corresponding rhizosphere. Mall (1975) who studied the root region mycoflora of coriander and reported that the fungal species which appeared in rhizosphere of four day old plants changed with the age of the plant and in sampling after maturation of seeds, the pattern was completely different. In the rhizoplane the fungal population increased with increase in age of the plants and it was maximum during flower initiation and during flowering with decreased at seed stage but again showed manifold increase after seed maturation.

According to Subrahmanyan and Rao (1977) the peaks in rhizosphere populations of *Arachis hypogeal* **L**. when the plants were at flowering stage and again at maturity and *Penicillum* sp followed by *Aspergillus* sp has been reported as dominant groups from the rhizosphere in Kharif season, while in Rabi season, *Aspergillus flavus* and *Aspergillus* sp. were most dominant. El-Amin and Saadabi, (2007) reported that significant variation in total number of fungal colonies and percent abundance of fungal species in the rhizosphere soil of Sugarcane obtained from the various study sites and increased fungal activities with plant age. The highest number of fungi reported in the rhizosphere of *Hibiscus esculentus* each week followed by rhizoplane and lastly by the non-rhizosphere soil (Oyeviola, 2009). He also reported that *Aspergillus niger* and *Aspergillus clavatus* were predominant in both rhizosphere soil and the rhizoplane, while *Penicillum oxalicum* and *Alternaria herbarum* were predominant in rhizosphere soil only.

It is now well established that the quantitative and qualitative differences between soil and rhizosphere populations depend on the mineral nutrition of the plants and the oxygen content of the root environment (Troldenier, 1979).

According to (Grayston *et al.*, 1996), it is the loss of carbon compounds from the roots which drives the development of enhanced microbial populations in the rhizosphere when compared with the bulk soil. After germination of seeds the roots grow through the soil and the loss of organic material provides the driving force for the development of active microbial populations around the root and it is, known as the rhizosphere effect (Whipps, 1990; Morgan and Whipps, 2001). Pandey and Palni (2007) investigated on the rhizosphere effect in the trees of the Indian Central Himalayans and reported that (i) the microbial population and the corresponding R: S ratio in long duration plants (*e.g*. perennial trees) are considerably lower in comparison to short duration annual crops. (ii) The microbial population and the rhizosphere effect would appear to decrease when increasing the altitude and (iii) under cold and harsh climatic conditions of sub-alpines, the tree root exudates tend to become more acidic, and exert a negative influence on the microbial population.

The microbial communities that colonize the roots due to many factors may affect the structure and species compositions (Yang and Crowley, 2000). The fungal flora associated with plant roots is subject, either directly or indirectly, to the influence of a number of factors such as soil type, and pH and the fungal flora of the root zone changes as the plant grows with certain fungi assuming predominance (Peterson, 1961). The factors such as soil type, soil moisture, pH, temperature, plant age, relative humidity and several other factors are known to influence rhizosphere effect (Manoharachary and Mukherji, 2006; Gangopadhyay and Banerjee, 1987). Parkinson *et al.*,(1963)reported that the incidence of any fungus in a soil is dependent on the structure and past biotic history of that soil, but how the influence of soil type operates in relation to root colonization which is not clear.

The interactions between the plants and the rhizosphere organisms are governed by the properties of that habitat, such as the presence of the growing plant, soil structure, partial pressure of oxygen, water content, temperature and plant nutrients (Trolldenier, 1979). The soil factors particularly moisture, physical structure and nutrient level, which influence the amount of exudation and hence colonization of roots (Whipps and Lynch, 1986). The variety of abiotic and biotic factors shapes soil and plant associated habitats and modifies the compositions and activities of their microbial communities, which in turn bear upon the quality of their environment, the growth of plants, and the production of root exudates (Bever *et al.*,

1997). The microbial activity in the rhizosphere affects the rooting pattern and the supply of available nutrients to plants, thereby modifying the quality and quantity of root exudates (Bowen and Rovira, 1999; Barea, 2000). The plant root exudates contain simple carbon substrates, including the primary metabolites, such as sugars, amino acids, and organic acids, in addition to a diverse array of secondary metabolites that are released into the rhizosphere and surrounding soil (Jones *et al.*, 2004). The microorganisms that colonize the rhizosphere help plants to acquire Phosphate(P) and Potash (K), and some enhance Nitrogen(N) uptake from the soil by their effect on root morphology and physiology (Coking, 2003).

The root exudates influence the growth of bacteria and fungi that colonize the rhizosphere by altering the soil chemistry in the vicinity of the plant roots and by serving as selective growth substrates for soil microorganisms. The microorganisms in turn influence of the composition and quantity of various root exudates components through their effects on root cell leakage, cell metabolism, and plant nutrition (Yang and Crowley, 2000). The rhizosphere microbial communities differ between plant species (Batten *et al.*,2006; Inns *et al.,* 2004; Westover *et al.,* 1997) and between different developmental stages of a given plant (Mougel *et al.,* 2006). Rahman *et al.,* (2003) screened microbial population of *Machilus bombycina* and *Litsea polyantha* from Goalpara district, Assam, during summer and winter season. They also reported highest occurrence of *Fusarium* sp from both rhizosphere and non rhizosphere soil of *Machilus bombycina* during summer season and *Aspergillus* sp winter season. The highest occurrence of *Penicillum* sp was found by them in rhizosphere of *Litsea polyantha* while in non rhizosphere *Aspergillus* sp was the highest. According to Pandey and Palni, (2007), conifers of subtropical and temperate locations, namely *Cedrus*, *Pinus* and *Taxus* support relatively higher microbial population in the rhizosphere in comparison to non-coniferous species.

According to Jones and Darrah, (1996) plants can directly control levels of carbon within the rhizosphere and thereby control the size of the microbial population. Free living microorganisms can also enhance plant growth through the suppression of soil borne plant pathogenic microbes and deleterious soil microbes (Kloepper, 1992). The region of soil surrounding and including the plant root is of crucial importance for the plant health and nutrition (Marschner, 1995). The microbes living in the complex region of rhizosphere influence crop health and also

yield. The area of this zone depends on the soil type and the host under study and soil environmental conditions (Manoharachary and Mukerji, 2006) First of all the Rhizosphere is a unique hot spot in the soil at the viewpoint of microbial ecology as soil microorganisms are considerably stimulated in the vicinity of the roots, as a consequence of release by roots of a range of Carbon (C) compounds (Jones *et al.*, 2004). The Rhizosphere is relatively nutrient rich because 40% of the photosynthesis moving into the roots are lost to the soil in the form of soluble exudates, mucilage, and shed. It is a habitat for a vast interactive community of rhizotrophic microorganisms whose activities largely determine the physico-chemical properties of the rhizosphere soil. The microbial composition in the rhizosphere very often differs greatly from that of the surrounding soil and from one plant species to another, as a result of diverse plant microbe interactions are observed (Egambrediyeva, 2006).

The soil is a rich habitat for the growth of diverse and interacting population of the microbes, and fungi are one of the most important functional groups of soil microbes and which are critical to nutrient cycling, Transport of nutrients to plants, plant growth, and disease suppression (Christensen, 1989; Thorn, 1997). In the beginning of the study of soil fungi was made as early as 1886 when Adamtz in Germany isolated several fungi species and in course of his biochemical studies on soils (Saksena and Sarbhoy, 1964). A very wide range of soils under many different types of vegetation and from many different geographical areas have been examined for the presence of fungi by many of investigators (Saksena, 1955; Mishra, 1966; Gams and Domsch, 1969; Rama Rao, 1970; Manoharachary, 1977; Bisset and Parkinson, 1979; Behera and Mukerji, 1985; Hawksworth, 1991; Zou *et. al*, 2000; Azaz and Pekel, 2002; Manoharachary *et al.*, 2005; Rane and Gandhe, 2006; Sagar *et al.*, 2007, Shukla and Tripathi, 2007).

According to Saksena and Sarbroy (1964) observed periodicity of fungi throughout the year, maximum number of micro fungi being present during the winter and the rainy seasons during their investigation of fungi in different soils of Allahabad. They isolated 19 species of *Aspergillus* which were reported to be encountered in every season. Sundaram, (1977) while studying by three different methods, fungal flora of rice field soils, found most of the belonging to well known genera of *Aspergillus*, *Penicillum*, *Fusarium*, *Curvularia*, *Dreschlera*, *Chaetomium*. Hashem, (1993) reported twenty four species of nine different genera of fungi from

four different places and the predominant genus reported as *Aspergillus* from all soils during the investigation.

According to Zou *et al.,* (2000) for the same kind of soil, the number and species of the microorganisms in the surface layer were the, and it declined with the increase of the depth. They also observed that the number of microorganisms increases with the increase of atmospheric temperature. The seasonal variations in forest soil mycoflora was observed by Mishra,(1966),Rama Rao,(1970),Persiani *et. al*,(1998) and many workers Christensen (1981) compared 33 micro-fungal communities from several different environments and found a clear correspondence between fungal species composition and vegetation type and concluded that soil micro-fungi are remarkable indicators of environmental similarity. The differences in micro-fungal assemblages between coniferous and deciduous forest in southern Qubec was observed by Widden (1986). Rane and Gandhe (2006) isolated maximum number of fungi during winter season a minimum number during rainy season. According to Waldrop and Firestone (2006), change in microbial community composition seasonally is due in large part to soil temperature. The population and activity of microbes in soils are influenced by a variety of factors such as climate, soil fertility stats and vegetation (Ross 1987; Sarathchanda *et al.,*1988; Okano *et al.,* 1991).According to Tiwarii, Jagrati and Verma (2011) *Aspergillus niger* and *Trichoderma viride* having potential as bio-control agents of wood decay fungi. Trans,N.Ha (2010) Using *Trichoderma* species for bio-control of plant pathogens in Vietnam.

The seasonal patterns in microbial community compositon and it is not clear whether there are predictable seasonal patterns in microbial community composition. The microbial community composition from season to season are largely random and unpredictable (Bardgett, *et al.,*1999) or seasonal community dynamics are so small as to be unimportant (Waldrop and Firestone 2006). Shukla and Tripathi (2007), studied distribution of micro fungal communities in forest soil and observed that the density of fungal propagules had a close inverse relationship with the pH of the soil. The actual community composition was highly related to environmental conditions, which seems to be more important for the presence or absence of microbial species than incubation time or tree species.