STUDIES ON SOIL MICRO-ORGANISMS IN JHUM LAND ECOSYSTEM AT MEDZIPHEMA, NAGALAND

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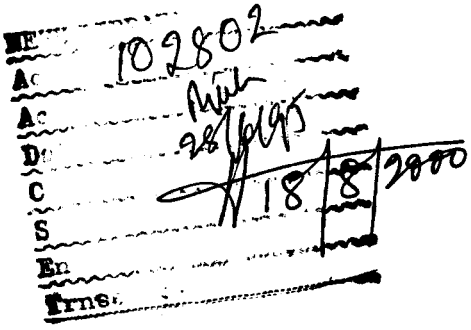

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I have the pleasure of forwarding the thesis entitled "STUDIES ON SOIL MICRO-ORGANISMS IN JHUM LAND ECOSYSTEM AT MEDZIPHEMA, NAGALAND" submitted by LOLI DAIHO for the Degree of Doctor of Philosophy in Plant Pathology of North Eastern Hill University, School of Agricultural Sciences & Rural Development, Medziphema, Nagaland. The thesis embodies the record of original investigations 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.

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L. Daiho

(LOLI DAIHO)

CHAPTER - I

INTRODUCTION

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

Ubiquitous habitat of micro-organisms influences the plants as well as animals and vice versa. Soil is regarded as the top soil layer of mother earth which support mankind in its survival and prosperity. Soil harbours various organic & inorganic substances burrowing animals, a network of plant's root system and a world of different types of micro-organisms. Thus soil ecosystem constitutes a laboratory within which are carried out various biochemical activities that enable life to continue. However, struggle for existence or survival has remained a fundamental behaviour of all living organisms. This causes competition coupled with various intricate actions and reactions among the same group or different group of organisms.

The present scenario is of spreading desertification, and rapid conversion of tropical forests to other uses because of their association with large population centres of the world. Forests have been exploited for thousands of years for many different purposes. The lowland tropical forest being often heavily in demand for agriculture or settled by immigrants. They have been cut, burnt, cultivated, regenerated and recut many times in cycles of shifting cultivation.

Shifting cultivation has been associated with the beginning of agriculture. Practices involved in shifting cultivation greatly influence the flora and fauna above as well as below the earth surface. The equilibrium of the microbial flora thus, already set up in the natural vegetation also changes and becomes dynamic.

Slash and burn agriculture (Shifting cultivation) is popularly known as 'Jhum' in North-East India. This system is believed to have originated in the Neolithic period, about 7000 B.C. (Sharma, 1976), and considered to be the first step in transition from food gathering to food production. The aged old practice is still prevalent in different parts of the world, viz., Amazon basin, South America, Manchuria, Korea, South-West China and in hill regions of India. In India, this system of agriculture is prevalent in the states of Assam, Arunachal Pradesh, Meghalaya, Nagaland, Mizoram, Manipur, Tripura, Orissa, Andhra Pradesh, Madhya Pradesh and also in some pockets of Bihar, Sikkim and Maharashtra (Borthakur et al., 1983). In Nagaland, out of net cropped area of 1,75,490 hectares during 1988-1989, 1,21,050 hectares, i.e. 68.9% of net cropped area was under jhum cultivation (Anon, 1989).

In the state of Nagaland including other states of North-East India, jhuming involves felling of forest trees partially or completely, clearing the site by burning, cultivating the land for 2-3 years and abandoning it to fallow for forest regeneration and fertility recovery. The more stable 20-30 years jhum cycle practised in the past has recently been reduced to 3-6 years rendering the land unproductive and uneconomical. This is because of heavy population pressure on the land and also reflects that these forest landscapes are under great stress of human activities. Consequently, under such conditions the maintenance of full productive potential can hardly be anticipated.

Clear-cutting of forest trees is done to prepare stand for burning and cultivation. This denudation of forest cover not only affects the above ground biomass but also the microbial population of the soil. Baath (1980) observed that clear-cutting of coniferous forest in Central Sweden had decreased the active total fungal biomass in soil. The change in root dynamics is suggested to be an important factor for the decrease of fungal hyphae in forest soil after clear felling.

Burning is an important operation of jhuming. The jhumias use fire as an important tool for clearing the site for cultivation. Removal of canopy results in various modifications in the soil such as soil moisture, temperature, light penetration, destruction of structure of soil crumb due to direct effect of rain drops and leaching in the litter of soil litter environment, while the burning alters the soil temperature which is more important.

Microbial population in an ecosystem, its dynamics and its correlation among each other and in association of higher plants have attracted the attention of Scientists from time immemorial. However, the mysteries of their social interactions and survival deepens as far as we try to investigate the details.

Jalaluddin (1969) reported that fire completely destroyed the fungal population for some time. Deka and Mishra (1983) also observed that immediately after fire no fungal flora could be isolated from

the surface layer (0-20 mm) and (20-60 mm) soil depth respectively with 20 kg and 100 kg of bamboos burning. Wright and Tarrant (1957) observed maximum effect of burning on the upper soil surface. In 1965, Ahlgren and Ahlgren reported that the reconstituted microbial population was increased than the original one probably because of the large quantity of mineral nutrients released from the ash and other changes in soil chemistry. Temporary increase in the microbial population of soil and also increased rate of mineralization of nitrogen after burning in the forest zones have also been reported (Focan et al., 1953).

The higher yield in jhum fields during the first couple of years is perhaps, due to the activity of soil micro-organisms which play a significant role in litter decomposition and recycling of nutrients. The intimate relationship of soil microflora and roots in the rhizosphere establish symbiotic relationship that results in mutual benefit, expressed as 'rhizosphere effect'. Root exudates and root excretions also serve as nutrients for microbes. The presence of Trichoderma harzianum, Rifai a competent of rhizosphere mycoflora, increased the growth responses in cucumber, pea, tomato and radish (Ahmad and Baker, 1988). In the presence of T harzianum, flowering of periwinkle has been hastened and increased the number of blooms per plant and also increased the height and weight in chrysanthemums and periwinkle (Ya-Chun Cheng et al., 1986).

Reports are available on effect of slash and burning on soil

micro-organisms (Deka and Mishra, 1983, 1984; Mishra and Sharma, 1981; Sharma *et al.*, 1982 and Sharma, 1983). However, literature shows that there is paucity of work in relation to study of microflora present, its dynamics and its association with the crop grown and the role played in jhum land ecosystem.

In the present study, an attempt has been made to investigate the soil microflora in jhum land and its influence on two major crop plants grown in jhum land ecosystem at Medziphema, Nagaland. The two crops selected under present investigation were: Paddy rice (*Oryza sativa* L.) var. Kezi, belonging to the family Poaceae, and Soybean (*Glycine max* (L.) Merrill) var. Bragg and Local belonging to the family Leguminoceae.

The present study, which has been carried out from three jhum fields at different locations of Medziphema, Nagaland elucidates the observations on environmental condition and vegetation of the study site; the effect of jhum burning on soil micro-organisms (both quantitative and qualitative changes; recolonization of micro-organisms in jhum (burnt) field soil; studies on nutrient status of the burnt jhum soil and its correlation with the microbial population; effect of burning on rhizosphere and rhizoplane mycoflora of rice and soybean in jhum field; mycorrhizal association in the roots of paddy rice and soybean in jhum land; effect of burning on some soil-borne plant pathogenic fungi; effect of root extracts of paddy rice and soybean cultivars on *Trichoderma* spp. - an early colonizer in jhum-burnt soil; *In vitro*

effect of T. harzianum on percentage seed germination and seedling growth of the above crop plants; effect of T. harzianum on growth of paddy rice and soybean plants in vivo; and antagonistic effect of T. harzianum against some common soil inhabiting pathogenic fungi.

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Davidson (1985) recognised two types of shifting agricultural practices. The traditional low intensive sustainable form which involves initial clearing of the primary forest but afterwards based on a secondary forest fallow system. Under such system, the fields or cropping plots are shifted around but not the people. The other is a more destructive form of agriculture in which people move as a wave and keep clearing new primary forests staying on only until it is worn out and the land is degraded. Then, they move on to clear more such forests. This type of jhuming agriculture was, perhaps, practised in the past in Nagaland and other parts of North-Eastern India. However, the present practice is of traditional low intensive sustainable form and also an ecologically sound form of land utilization. The second type is not sustainable and is to be condemned.

Jhuming has been a way of life in tribal tradition. It is practised not only on the normal hill slopes but also along the steep slopes of the hills. Fire is used as an important tool for clearing the cultivating site. The reduced shade allows the soil surface to dry quickly and change the nutrient pool of the top soil while burning, causes a drastic change in soil microbial population.

The earliest major study of fungi in soil was done in 1901

by Oudemans and Koning, who described fungi isolated from soil in Holland. Later, Hiltner (1904) discovered the soil zone of greatly intensified microbial activities under the direct influence of roots of plants which he named 'rhizosphere'. Roots of higher plants greatly influence the micro-organisms and vice-versa.

2.1 BURNING AND SOIL MICROORGANISMS:

Burning damages soil microbial population (Meikle John, 1955; Ahlgren and Ahlgren, 1965), and also alters soil microflora (Wicklow and Whittingham, 1978). Prescribed burning, in a Pinus sylvestris forest was found to destroy the microflora of the upper soil horizon completely (Hauke-Pace-Wiczowa, et al.,1980). Cooke (1971) reported that the species of Fusarium were killed by the fire. Katan et al.,(1976) reported that Fusarium population declined more rapidly in preheated soils.

The catastrophic disturbance like destruction by fire alters soil microflora and cover vegetation, but the species composition in due course of time becomes similar to the undisturbed site (Wicklow and Whittingham (1978). Tiwari and Rai (1976) also observed that number of fungal species and their colonisation in soil were reduced immediately after burning, but returned to their normal state after a couple of months. Deka and Mishra (1984) in their studies found that immediately after fire no fungal species could be isolated

from the surface soil (0-20 mm) depth where 60 kg of bamboo fuel was burnt. The forms could only be isolated after 15 days. Jalaluddin (1969) reported that fire completely destroyed the fungal population for some time. Wright and Tarrant (1957) observed maximum effect of burning on fungal population in the upper soil surface, while severely burned soil there was effect of fire below 40 mm. Theodorou and Bowen (1982) found that one month after burning, bacteria, actinomycetes and fungi were fewer in number in burnt than unburnt soil of 2 cm depth, which after two months followed the reverse path. Griffiths (1947) has reported the destruction of nitrifying bacteria and neglegible nitrogen supply for some time after burning.

In modern age, soil solarization is gaining importance in control of soil-borne diseases (Chauhan et al., 1988). This is usually done by covering the soil with transparent polythene sheets during hot periods. In Israel, the control of Verticillium disease (tomato, egg plant and potato), Rhizoctonia solani (potato and onion), Sclerotium rolfsii (peanuts), Pyrenochaeta lycopersici (tomato), P. terrestris (onion), Fusarium diseases (cotton, melon, tomato and onion), the free nematode Pratylenchus thornei (potato), have been achieved by soil solarization. Five days of solar heating was found sufficient to eliminate 100% of Verticillium dahliae sclerotia at a depth of 5 cm. Soil mulching for 19 days killed 100% sclerotia of S. rolfsii at 5 cm depth, and 25% at 20 cm depth (Elad, et al., 1980).

It has been reported that the fungal population was more sensitive to fire in comparison with bacteria or actinomycetes population (Deka and Mishra, 1984). This fact is probably due to the formation of heat resistant structures in hacteria (Bollen, 1969). It is also reported that species of Trichoderma were killed by fire (Bollen, 1969; Cooke, 1971; Widden and Parkinson, 1975). However, the same were frequently isolated from the burned soil surface (Deka and Mishra, 1983; Sharma, 1981).

Reports made by Widden and Parkinson (1975) indicated significant reduction in Trichoderma species due to fire in a Pine forest of Alberta. Cooke (1971) also found similar result in his studies of fungi in burned and unburned chaparral soils. However, Lucarotti et al., (1978), Deka and Mishra (1984) observed more frequent and higher number of Trichoderma occurrence in soil after burning. Wright and Tarrant (1957) observed a positive effect of light burning on the population of Fusarium species.

2.2 RE-COLONIZATION OF MICRO-ORGANISMS IN THE BURNT SOIL:

In jhum, the sterilized soil after burning is exposed to recolonization. The nature of micro-organisms appeared in the changed environment will depend upon the physico-chemical status of the new habitat. Because of soil being devoid of microbes in the beginning, zero resistance is offered for the new colonizers

In the process, a number of forms from different group of micro-organisms try to colonize the substratum available without competition.

Jalaluddin (1969) observed that Trichoderma and Penicillium were early colonizers in soil after burning. The initial colonizers of the burnt soil after 15 days were Aspergillus spp. Penicillium spp., and Fusarium spp. (Tiwari and Rai, 1976). Wright and Bollen (1961) also found that the species of Penicillium, Gliocladium, Cephalosporium, Aspergillus, Spicaria, Trichoderma and several Phycomycetes were early colonizers. Deka and Mishra (1983) also isolated the species of Trichoderma, Penicillium, Aspergillus, Phoma, Cephalosporium, and a few Mucorales quite often from the burnt soils.

The genera of Trichoderma, Fusarium, Penicillium, Mucor, and pigmented genera of fungi imperfecti were found dominant in the burnt plot in decending order (Herman and Kucera, 1979). Peterson (1970) also reported bright-coloured discomycetes commonly associated with burnt site. Sharma (1981) reported that when the soil temperature after burning dropped followed by few showers, the species of Penicillium, Cladosporium and Trichoderma were the initial recolonizers.

Trichoderma spp. were found to be one of the early colonizers in the burned soil (Jalaluddin, 1969; Wright and Bollen, 1961; Jorgensen and Hodges, Jr. 1971; Tiwari and Singh, 1977; Lucarotti et al., 1978; Herman and Kucera, 1979). Tiwari and Rai (1976)

observed that T. viride appeared in the soil after a period of two months of burning and its population increased consistently with time. This consistent increase of T. viride in burnt soil has been visualised to be of great significance because of its antagonistic character against soil inhabiting plant pathogens (Bliss, 1951).

Trichoderma spp. were among the pioneer colonizers following soil fumigation as they have fewer competitors and can reproduce rapidly (Munnecke, et al .,1981). Pullman et al., in 1981 also reported that the substracts made available by the effect of soil solarization were apparently rapidly recolonized by surviving micro-organisms beneficial to plant growth and/or antagonistic toward pathogenic organisms. Elad et al ., (1980) also observed that soil heating resulted increased population of the potential antagonist Trichoderma. Katan (1981) reported that Trichoderma species were the dominant colonizers of the heated roots.

Wicklow (1975) reported that certain ascomycetes can complete their life-cycle in burnt prairie soils and successful maturation of the Ascomycetes may be related to the intensity of burning. Seaver (1910) found some Ascomycete spores induced by heat and their fruiting bodies appeared only in burnt soil. Zak and Wicklow (1980) observed that post-fire Ascomycete community was determined by species responses to high soil temperatures, ash deposition and biotic factors associated with the sub-soil layers.

Sharma (1981) reported that the depth of soil horizon influenced the microbial rehabilitation and an insignificant difference was observed in species composition in the burnt site. He also observed that recolonization of fungal species was late in comparison to bacteria and actinomycetes.

2.3 SEASONAL VARIATION IN MICROBIAL POPULATION:

There are many factors involved in the distribution of micro-organisms in the soil profile. When the soil is dry and the temperature is high as in summer, the microbial activity is checked. However, after few showers of rain and with the availability of sufficient moisture, a conducive environment is created and decomposition of organic matter starts very rapidly involving maximised microbial activity in soil.

Mishra (1966) in his grassland fungal flora investigation in Varanasi, India, found that due to availability of sufficient moisture after the rains, the decomposition of organic matter became very fast which resulted in rapid growth and sporulation of fungi in July. The fungal population under water-logged condition in August and September dropped-off at almost all the soil depths. Similar results were obtained by Saksena, (1955). The fungal population also showed an increase when water receded and again there was fall in the fungal population till December. Mishra (1966) also

recorded lowest fungal population in January and February.

Widden and Abitbol (1980) in their studies on seasonal variation on Trichoderma species in a spruce forest soil found that T. polysporum was most abundant in autumn and winter; T. viride in spring and T. koningii and an undescribed species in summer. For T. viride, there was a significant relationship between its occurrence, soil moisture content and temperature. For the other three common species the best predictive equations incorporated to biotic variables, mainly the occurrence of other Trichoderma spp. It was suggested that seasonal variation in species of Trichoderma population was controlled to a large extent by competition with other species rather than by the direct effect of abiotic factors.

Denis et al .,(1981) also detected seasonal trend among the species level in which Paecilomyces marguandii, Fusarium solani, Aspergillus niveus and A. fumigatus were found to be dominant in Spring, than in the Fall. Isolates of Penicillium spp. and Aspergillus spp. also varied with season. Aspergillus spp. accounted for 21% of all isolates in the Spring and 9.5% in the Fall, While the Fall comprising 40% of all isolates in contrast with 15% in the Spring. Moubasher and El-Dohlob (1970) found that occurrence of Penicillium spp. was of high frequency in the Fall and suppressed during summer, whereas in case of Aspergillus spp. occurrence was of low frequency in Winter and in summer, except during conditions

of drought. The maximum fungal population was encountered between November and April, and between September and October when the temperature and moisture content of soil were relatively moderate.

Gliocladium roseum was stated to be more common in hard-wood forests than in coniferous forests (Domsch and Gams, 1970). Widden (1979) showed that soil properties influences the fungal community more strongly in comparison to distribution in respect to the type of tree cover. This was in accordance with the findings of Soderstrom (1975) and Soderstrom and Baath (1978), who showed that Trichoderma polysporum and T. viride were major Trichoderma spp. in the Norway Spruce forests in Sweden. Abdullah (1985) reported that the number of fungi in Sawda forest and Raghdan forest soils were higher in comparison to the number found in the desert and cultivated soils in Central region of Saudi Arabia.

Rao (1970) reported that Trichoderma viride was of common occurrence and characteristic of acid soil. Warcup (1951) stated that acidity and temperature of soil were of overriding importance in determining fungal species distribution. Warcup (1951), Saksena (1955) and Dwivedi (1959) have emphasized the occurrence of fungi in good number both in acidic and alkaline soils. Wong (1975) reported that pH and moisture were probably the most important soil factors determining the abundance and distribution of soil fungi. However, Menon and Williams (1957) suggested that pH of

soils, perhaps, was not a factor contributing to mycofloral changes.

Cabello (1986) observed that Fusarium oxysporum and F. solani were dominant in the fungal community of the Natraquoll and found in all seasons with relatively high frequency in the surface horizon. Michailides and Ogawa (1987) observed that temperature was more important factor than moisture in affecting survival of sporangiospores of Mucor piriformis - a California isolate (CA) from peach and a Chile isolate (CA) from nectarine.

Upadhyay (1987) observed that the population of Aspergillus nidulans in a natural field soil increased with increasing temperature and pH 15-40°C, and 5-8, respectively, while F. udum, decreased with increasing soil temperature. Adams (1987) reported that high-soil temperature and low soil moisture adversely affected survival and activity of sclerotia of Sclerotium cepivorum, Sclerotinia minor and microconidia of Sporidesmium sclerotivorum.

2.4. NUTRIENT STATUS OF BURNT JHUM SOIL AND ITS CORRELATION WITH THE MICROBIAL POPULATION:

Significant changes in soil chemical as well as biological properties were observed as a result of fire and addition of ash (Raison, 1979). Although burning lowered the nutrient contents

of the ecosystem, however, nutrient availability with the development of ash layer was generally higher in comparison to undisturbed forest floor. Cations and phosphorus readily available in the ash, cause increase in soil pH. Clayton (1976) has reported that nutrient loss of the environment in one location could add nutrient deposition to the environment in adjacent locations.

Mishra and Ramakrishnan (1983) reported that monthly sampling done throughout the monsoon period showed a gradual decline in soil nutrient concentration with passage of time after burning in jhum. This loss was more prominent under 10 year jhum cycle as compared to 5 year cycle. Volatile nitrogen loss of 855 kg/ha i.e., 39% of the pool, in an intense wild-fire of a montane coniferous forest in Washington has been reported by Grier (1975).

Tsuruta et al.,(1985) observed that samples collected from different vegetations in the same experimental site yielded variation in Aspergillus flavus population. They have concluded that the differences could be due to the amount of organic materials present in the soil, along with plant debris. Dkhar and Mishra (1986) have reported higher population of fungi, bacteria and actinomycetes in earthworm casts where organic carbon content, nitrogen and phosphorus was more as compared to the surrounding soil. Gray (1985) also observed that soils with relatively high organic matter and moisture, harbour rich microbial population.

Kjoller and Struwe (1987) found that Phomopsis scobina was more frequent in the ash litter. In the upper organic horizon, Mortierella spp. were able to utilize all the test compounds such as gelatine, starch, pectin, cellulose, chitin and gallic acid. Also a marked shift in the composition of the fungal flora was observed when the litter decomposed in June. Miller et al., (1957) reported that the genus Penicillium predominated over Aspergillus in the majority of soil samples studied.

2.5. PLANT ROOT ECOSYSTEM:

(Rhizosphere and Rhizoplane)

The term rhizosphere was introduced by Hiltner (1904) to denote the region of soil in the vicinity of root system subjected to intensified microbial activities. Rhizosphere microbiology concerns not only the growth but also the health of the plants and influence of plants is called the 'rhizosphere effect'. The rhizosphere effect concerned with the interaction among soil microbes, soil-borne pathogens and underground portions of plants. Rovira (1965) reported that the rhizosphere represents a poorly defined zone of soil with a microbiological gradient in which maximum changes in the population of microflora occur in soil adjacent to the roots and decline with distance away from it. Rhizosphere effect is calculated in terms of number of micro-organisms per gram dry weight of rhizosphere soil and away from rhizosphere soil. It is known as R/S ratio which varies with various factors viz., plant species,

age and vigour of plant, light, availability of oxygen and carbon dioxide, pH, moisture, organic content of soil and other environmental conditions (Katznelson, 1946; Lochhead and Timonin, 1940).

Brown in 1958 reported that when a virgin soil colonized by higher plants, there was a parallel development of the fungal flora. It is an interesting phenomenon and has got relevance to crop production. Papavizas and Davey (1961) observed that the rhizosphere effect extended at least upto 18 mm from the root surface. The rhizosphere effect was found to be more with the age of the plants and reached its maximum at the highest vegetative growth (Timonin, 1940; Katnelson, 1946; Rovira, 1959; Chesters and Parkinson, 1959; Rao, 1962; Gujrati, 1965 and Upadhyay, 1971). In contrary, however, Agnihothrudu (1953) reported that the number of fungi continued to decrease upto flowering stage followed by an increase afterwards. Robinson (1970) also observed that the number of fungal species isolated from roots decreased with age of both the plant cane and the ratoon cane, while in soil it remained fairly constant.

Rovira (1965) reported that the roots were colonized within 16 hours of emergence, but root tips generally remained free from micro-organisms. This colonization was maximum in the older portions of the root system indicating its better nutrient status. Roberts (1966) claimed that under certain conditions, the tips of young root hairs burst, eject their contents and get closed immediately

leaving little evidence of the rupture.

The importance of plant root excretions in influencing the rhizosphere microflora has been emphasized by many scientists. Rovira (1956, a,b,c) reported a number of amino acids and sugars; Rovira and Harris (1961) and Sulochana (1962b) the presence of vitamins; Vancura (1964) presence of certain aromatic compounds and organic acids along with sugars and amino acids; while Schonbeck (1958) found some inhibitory substances like glycosides which inhibited the growth of Byssochlamys nivea and Trichoderma koningii in the root exudates. Bhuvaneshwari and Subba Rao (1956) studied the root exudates of several crop plants and showed their importance in influencing the rhizosphere flora. Bhat (1966) and Singh (1968) showed that both root exudates and extracts stimulated the growth of fungi in culture. Rovira (1959) reported that the root exudates of plants were governed by the age of the plants, plant species, light and temperature.

Bagyaraj and Rangaswami (1966) observed higher R:S ratio in the deeper region of soil. However, Mishra in 1968 observed decreased population with increase in the soil depth. Parkinson and Pearson (1967 a,b) observed that sterile dark fungi were rapid colonizers of young roots of barley and persisted with root age.

Higher fungal population in the rhizosphere of diseased plants

have also been observed (Mukhopadhyay and Nandâ, 1974, Prakash et al., 1978 and Rai and Upadhyay, 1980). Subba Rao and Bailey (1961) also recorded higher number of rhizosphere mycoflora in the susceptible plants of tomato to Verticillium wilt.

Fungi and actinomycete population were found to be more in early stages of infection by Sclerotium rolfsii in comparison to the healthy ones (Madhava Rao, 1988). Bacteria showed decrease in population with infection. Srivastava and Mishra (1971) observed lesser population of fungi in the rhizosphere of virus infected plants as compared to healthy ones.

Timonin (1940) and Lochhead et al.,(1940) observed constant presence of Trichoderma viride in the resistant variety of some higher plants as compared to the susceptible variety. Trichoderma was reported in root-zone of only certain resistant variety of tomato and potato, (Subba Rao and Bailey, 1961; Srivastava and Saksena, 1968).

Abdul Rasheed Ansari (1986) observed exhibition of highest frequency level with Aspergillus terreus whereas Mucor globosus, Drechslera australiensis and Humicola fuscoatra exhibited the lowest frequency in case of rhizoplane of diseased Hordeum vulgare. In the healthy counterparts, the highest frequency was noticed with A. flavus and the lowest with Thielavia terricola.

As per report of Nusrath and Shaik (1988), rhizosphere and rhizoplane of susceptible variety of Pigeonpea supported higher number of fungi than those of the three resistant varieties. Rs and Rp of susceptible plants were dominated by F. oxysporum f. sp. udum, where as in resistant varieties R_1 and R_3 dominated by Penicillium citrinum in Kharif season and by A. niger and T. viride in Rabi season.

Under certain conditions, the rhizosphere has been found to be a zone of active denitrification even if the soil as a whole is aerated (Woldendrop, 1963). With nutrient supply in the soil, such as available phosphate, the rhizosphere micro-organisms also compete for the nutrients in short supply which in turn reduces the supply available to the crop plants (Barber and Loughman, 1968). However, Gerretsen (1948) observed that roots carrying rhizosphere population took up more phosphate than sterile roots from insoluble calcium phosphate. This could be probably due to excretion of 2 keto-gluconic acid by some members of micro-organisms which helps in dissolving the insoluble calcium phosphate (Louw and Webley, 1959).

Rhizoplane differs from rhizosphere in having less but stable nature of microflora. Sharma (1981) reported that short root initials covered with a thick fungal mantle were resistant to infection but an incomplete fungal sheath probably could not prevent the penetration of pathogens (Marx and Devey, 1969). Pathogenic forms

were dominant at a low degree of mycorrhizal development but at high degree of mycorrhizal association, saprophytic forms were more common, which suggested that ectomycorrhizal fungi and fungal mantle protected the plant root from the attack of pathogens (Marx, Devey, 1969) by forming a mechanical barrier. Sharma (1981) reported that the ectomycorrhizae acted as a mechanical barrier to certain pathogenic forms like Fusarium species and provided a conducive environment for the saprophytic fungi. This type of selection may help better plant growth causing lower incidence of diseases in plants having well developed ectomycorrhizal association.

Sivan and Chet (1989) reported that amendments of Trichoderma harzianum (T-35) conidia in soil significantly reduce the chlamydospore germination of F. oxysporum f. sp. melonis and F. oxysporum f. sp. vasinfectum. Number of Fusarium in the rhizosphere was inversely proportional to the number of conidia of T-35 applied to soil. Antagonists isolated from rhizosphere soil included Trichoderma viride, T. harzianum, T. polysporum, Gliocladium sp., Pseudomonas fluorescens, P. stutzcri, P. cepacia, Enterobacter sp. and Erwinia herbicola (Kim and Roh, 1987).

2.6. BURNING IN RELATION TO VESICULAR ARBUSCULAR MYCORRHIZAL ASSOCIATION:

The importance of VA mycorrhizal fungi in agricultural crops has been widely recognised. The beneficial effect was attributed to

increased phosphorus uptake by the endophyte (Gerdemann, 1975; Hayman, 1978; Khan, 1972; Mosse, 1973, 1978 and Powell, 1978). Vesicular-arbuscular mycorrhizal infection was useful to the host plant in enhancing the uptake of nutrients (Hayman, 1975) and water (Safir et al.,1972), resisting against pathogen (Marx, 1975) and in increasing the effective absorption surface of roots (Hayman and Mosse, 1971).

Klopatck et al., (1988) reported that vesicular-arbuscular mycorrhizal colonization was lower for plants grown in soils burned when dry than in those grown in soils burned when wet. Decrease in vesicular-arbuscular mycorrhizal colonization was positively correlated with soil temperature as a result of fire. Temperature effects and associated reduction in VAM were related to amount of litter burned and moisture content of soils.

Iqbal et al.,(1978) studied mycorrhizal association in paddy. Gangopadhyay and Das (1982) observed that the grain yield per plant in rice was increased by 85% in the VAM inoculated plants. Inoculation of vesicular chlamydospores supported luxuriant vegetative growth, increased phosphorus uptake and grain yield in rice. Sharma et al., (1988) found that vesicular-arbuscular mycorrhiza significantly increased the shoot and root dry weight as well as the level of phosphorus and zinc in Jaya and Ratna cultivars of rice.

Bhattarai and Mishra (1984) in their studies on mycorrhizal

association with three cultivars of potato reported that the mycorrhizal infection increased with the age of the plants, simultaneously the establishment and development of VA-mycorrhizal fungi were early and rapid in the resistant cultivars, 'SSC 1174' and 'Kufri Jyoti'.

Chaubal, Sharma and Mishra (1982) reported that vesicular-arbuscular mycorrhiza occured rarely in aquatic subtropical plant communities, but not completely absent. Besides, the root system, the shoot also helps the aquatic plants in absorbing the nutrients from water and this may be one of the reasons for the absence or less frequency of mycorrhizal association in certain plants.

2.7. SOIL MICRO-ORGANISMS AS ANTAGONISTS AND BIOCONTROL AGENTS:

Upadhyay and Mukhopadhyay (1986) observed in a glass-house experiment that Trichoderma harzianum (grown in Sorghum bran medium) applied to Sclerotium rolfsii infested in soil gave as high as 76 and 88% disease control in first and second growth cycle of sugarbeet seedlings respectively. The degree of disease control increased with increasing amount of T. harzianum applied in the soil. Weindling and Fawcett (1936) observed that T. lignorum suppressed the spores of damping off of citrus seedlings caused by Rhizoctonia solani in acidified soil pH 4.0. The antagonistic effect was transient in very acidic soils and absent in neutral and less acid soils.

Mew and Rosales (1984) readily isolated T. harzianum from

pieces of rice straw burried in the dryland soil, but not from the straw burried in irrigated fields. The ability of T. harzianum to decompose rice straw, thereby affecting the survival of Rhizoctonia solani has a potential use in disease management for dry land crops. Chet et al., (1979) reported the effective control over damping off disease of bean, peanuts and egg plants by applying T. harzianum grown in wheat bran medium to the soil infested with R. solani and S. rolfsii in green house.

Papavizas (1973) recommended integration of biological and chemical control which could control pathogens with a minimal interferances and keeping the biological equilibrium. Garrett in 1965 also observed that damping off of citrus seedlings caused by Rhizoctonia solani had been controlled by T. lignorum (either present or added) in acid soils.

Trichoderma spp. have shown to control R. solani on a variety of crops in green house (Chet and Baker, 1981; Chet et al , 1979; Hadar et al., 1979; Herman et al.,1980, 1981 and Papavizas et al.,1982). Mihuta and Rowe (1986), in their study on Trichoderma spp. as biocontrol agents of Rhizoctonia damping off of radish in organic soil, observed that in green house bioassays T. hamatum was identified to be more effective in comparison to T. harzianum. Also the isolates recovered from organic soil were generally found to be superior than that of mineral soils.

Santos and Dhingra in 1982 reported that an isolate of T. koningii when applied to soil killed 100% of the Sclerotia of Sclerotinia sclerotiorum within 60 days under field conditions. Vannacci and Harman (1987) have shown that Trichoderma harzianum strain T 12 effectively controlled Alternaria raphani and A. brassicicola. Harman et al., (1989) reported that in two field trials with sweet corn, Trichoderma harzianum strain T 12 increased plants stand, reduced seedling mortality, and increased plant growth. Nelson and Powelson (1988) observed that an isolate of T. hamatum reduced 94% rot of snap bean caused by Botrytis cinerea in comparison to untreated control.

2.8. SOIL MICRO-ORGANISMS AS PLANT-GROWTH STIMULANTS:

Pasteur in 1885 reported that microbial degradation of amendments was essential for their utilization by higher plants. Since then, micro-organisms as an incitant for plant growth besides their participation in mineralization or pathogenic activity have drawn the attention of many investigators. Lindsey (1967), Kreutzer and Baker (1975) reported that micro-organisms could induce growth of higher plants under gnotobiotic conditions. In soil infested with a fungus Trichoderma viride, but otherwise free of micro-organisms, dwarf tomatoes were significantly taller than those grown in germ-free environments (Lindsey and Baker, 1967). Promotion of radish growth in raw soil by application of T. harzianum was also observed (Baker et al.,1984). Steamed or raw soil infested with Trichoderma hastened flowering of periwinkle,

increased the number of blooms on chrysanthemums and petunias and also increased dry weights of these and other plants like tomato, pepper and cucumber (Chang et al.,1986). Pepper seed germinated 2 days earlier than untreated controls.

Cole and Zvenyike (1986) noticed significantly greater seedling emergence of tobacco where the seed beds were treated with T. harzianum. Plant dry matter was also found to be more in comparison to controls. In Colorado, in an experiment performed in commercial green house periwinkle treated by the grower with the peat-bran formulation of T. harzianum (Sivan et al.,1984), flowered earlier and was three times taller than the control.

Cuttings were also reported to root more rapidly when treated with Trichoderma spp. When chrysanthemum cuttings were treated in the progative bed with the peat-bran formulation, increased rooting with significantly greater heights and increased number of flower buds were observed (Chang et al., 1986).

The hypothesis of Salt (1979) states that growth stimulating soil microflora antagonise minor pathogens whose activities are insidious, i.e., they parasitise root-tips and cortical cells thereby inducing no obvious symptoms except to reduce growth and yield.

CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1. STUDY SITE:

Medziphema is located at lower elevation in the Kohima district of Nagaland (latitude 25°, 45' 43" N; longitude 93', 04" E and at an altitude of 305 m). Nagaland is one of the North Eastern States of India, bordering Burma on the East, Assam on the West, Arunachal Pradesh on the North and Manipur on the South (Fig.1a,b).

3.1.1. TOPOGRAPHY:

The state is geographically hilly and it comprises as a part of the Himalayan region except a narrow belt of foot hills bordering Assam and small valleys in between the lower ranges of the Western and North-Western flanks. Topographically the landscape of the state can be grouped into three divisions: (i) the foot hills with undulating to rolling topography in which the study site is also located, (ii) the lower ranges and the mid-slopes with varying degrees having sub-montaneous climate and (iii) the high hills and mountaneous region above 960 m altitude.

3.1.2. LOCALITY:

The present study was carried out in three jhum fields at different locations of Medziphema. The first field(F_1) was situated near the experimental farm of the School of Agricultural Sciences and Rural Development, Medziphema. The second field (F_2) was selected

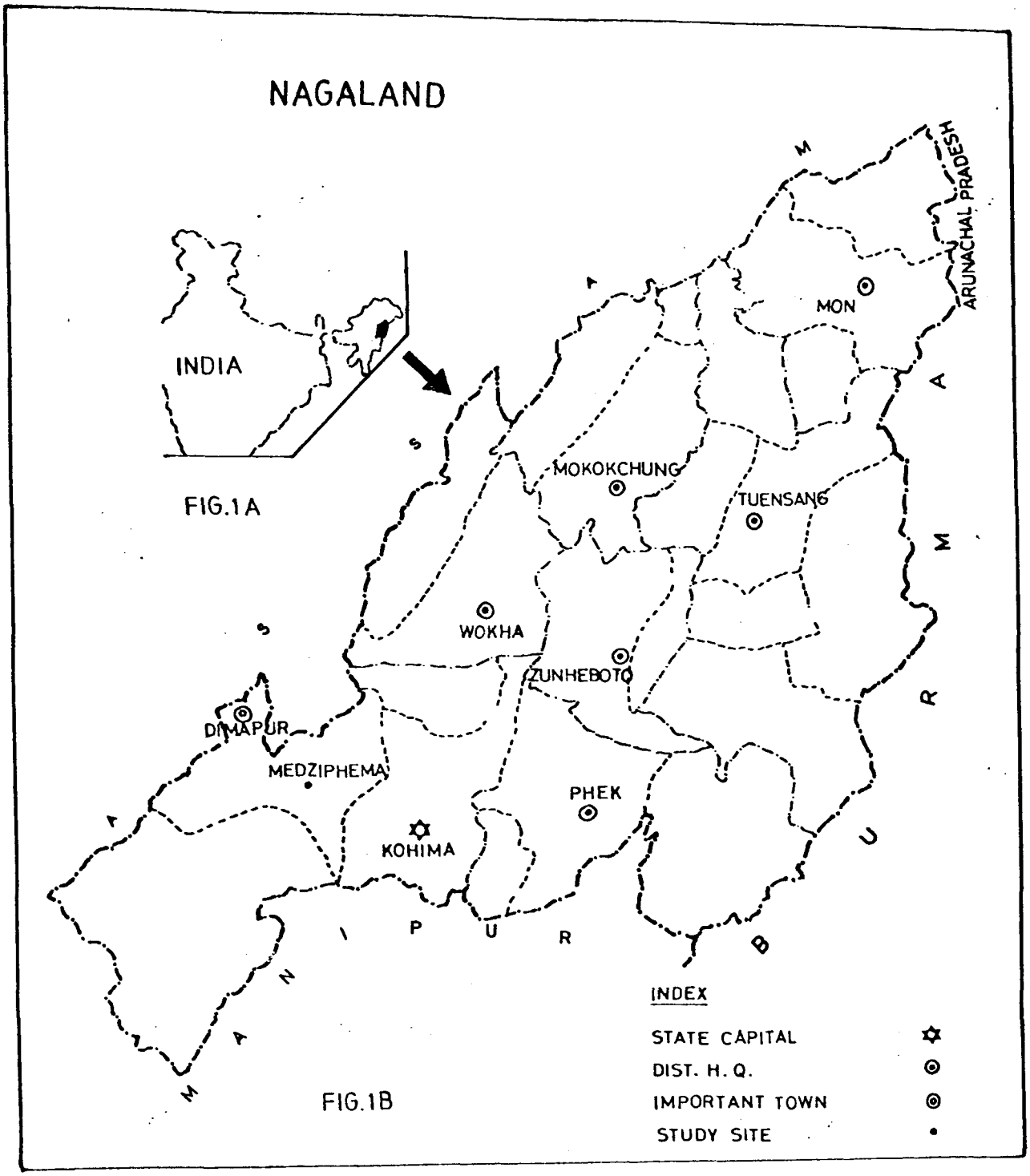


Fig. 1A. A part map of India showing Nagaland - a state in the North-Eastern Region.

Fig. 1B. Map of Nagaland showing study site - Medziphema, in Kohima district.

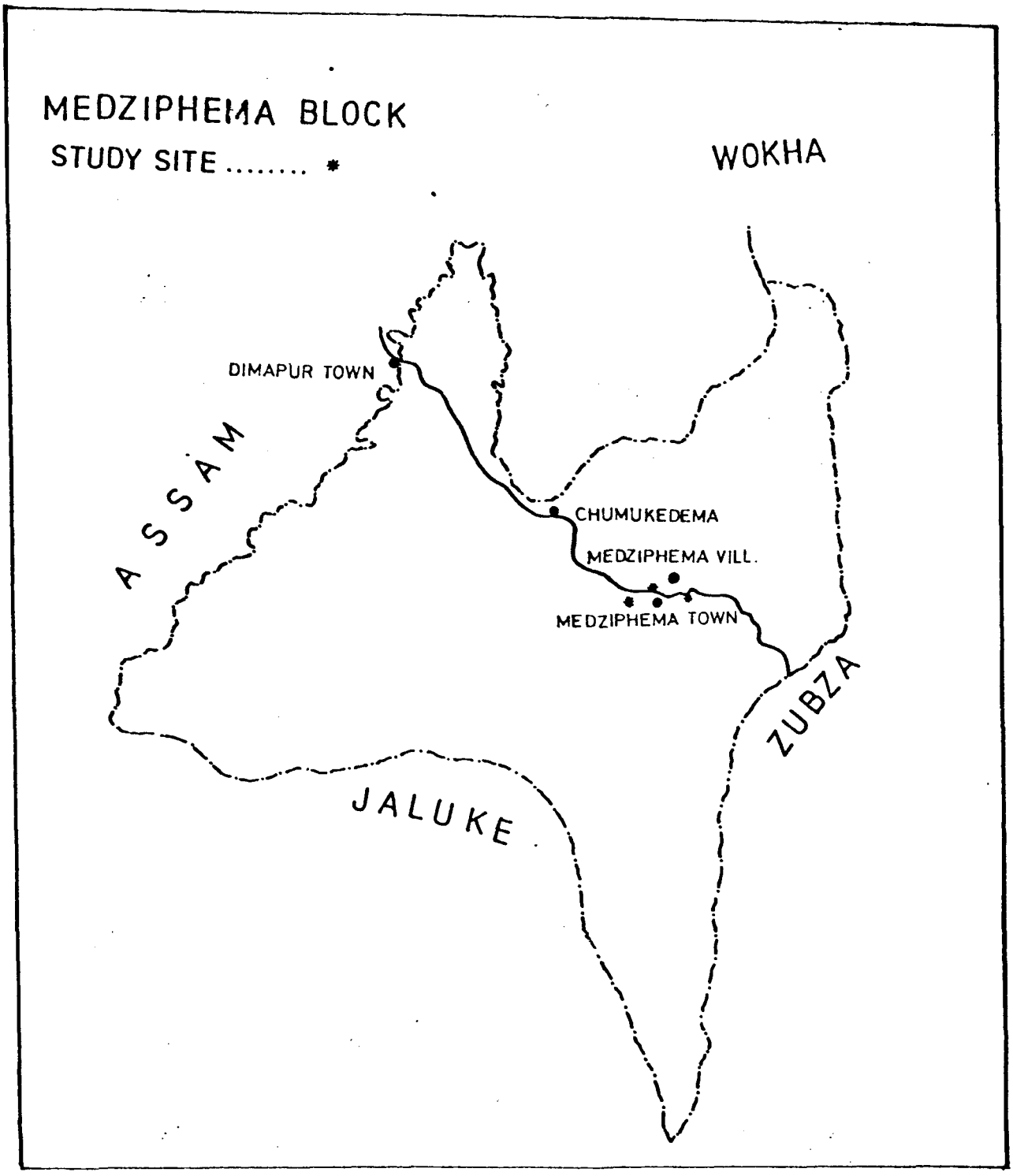


Fig. 2. Map of Medziphema block showing study sites.

behind the civil hospital, about 3 km away from the first field. The third field (F_3) selected was 3.5 km away from the second field and situated by the side of NH-39 (Fig.2). An undisturbed patch of forest land near each jhum field (C_1, C_2, C_3) served as control.

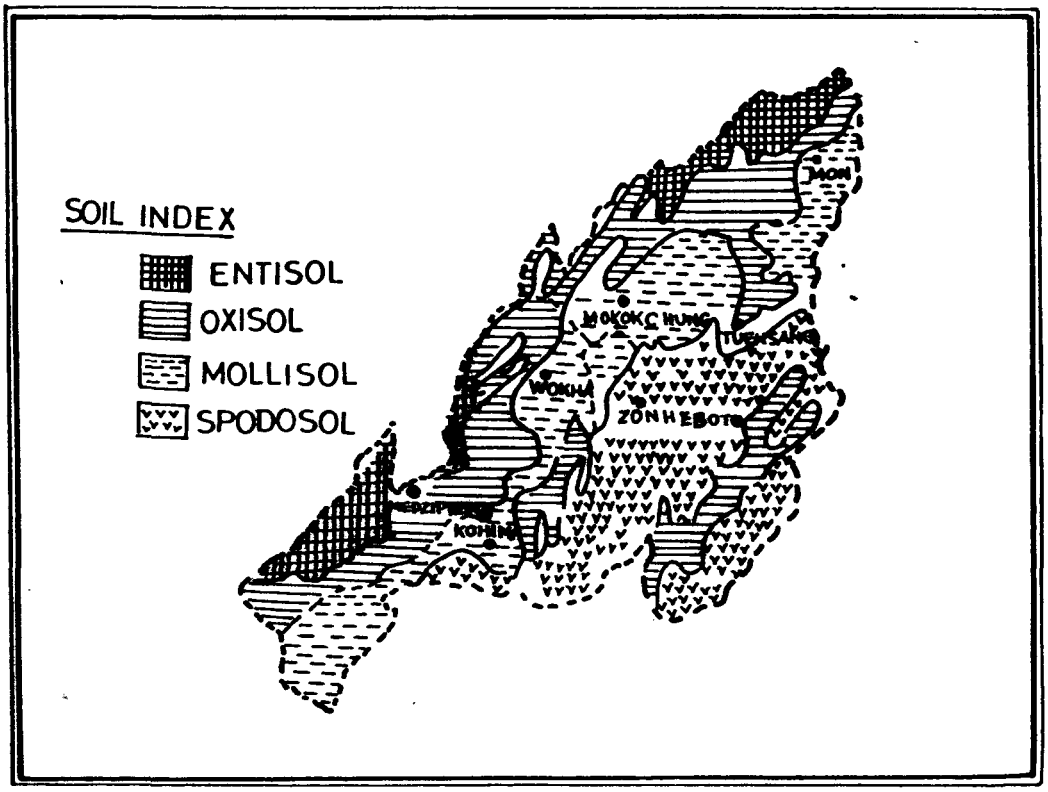
3.1.3. SOIL:

The soils of Nagaland have been tentatively grouped into four orders, such as Extinsol, Oxisol, Mollisol and Spodosol (Fig.3). The valleys and the foot hills are thus made up of alluvial and colluvial soils. The soils of the lower ranges were subjected to stronger weathering than those over the high altitudes.

The experimental site was characterised by oxisol (Fig.3), occurring over the foot hills and lower ranges in the west upto an altitude of 750 m MSL from the sea level. Such soils were strongly weathered lateritic and non-laterised latosols. The sub-surface horizon was characterised by low base exchange capacity, friable and massive structure and accumulation of iron and alluminium. These soils had a prolonged dry period (rainshadow belt) and were predominantly under degraded forest being characterised by the soils developed over sandstone and shales of Tipam series with sub-tropical rain forests. Geologically, it was composed of sandstones and carbonaceous shales belonging to the Tipam, Surma and Boraid series of miocene age. The shales were ferruginous and the sandstones were non-calcareous in nature being readily susceptible to weathering (Anon, 1975).

FIG. 3

Schematic soil map showing the different orders of soils including that of the study site in Nagaland.



3.1.3.1. SOIL-PHYSICAL:

The texture of the surface layer was usually fine loam and varies from sandy loam to fine sandy loam overlying a fine sandy loam to silt loam layer. Sub-soil is usually mixed with regolith and the texture varies from silty clay loam to clay loam. The soil upto 15 cm depth comprised of 32.75% sand, 34.75% silt, and 32.50% clay; water holding capacity 69.48%; and volume of expansion 5.41 ml/100.

The colour of the soil was usually dark brown overlying a brown to dark brown layer, and that of the sub-soil varies from reddish brown to yellowish red.

The structure of the top-soil varied from single grained to granular overlying sub-angular block and that of the sub-soil was usually massive.

The top soil was rapidly permeable overlying a moderate to moderate and slowly permeable sub-soil. The water holding capacity was moderate. However, the moisture content was low which indicated dry condition.

3.1.3.2. SOIL CHEMICAL:

The chemical characteristics of the soil of the study sites are presented in Appendix table I-VI. The soil was acidic in nature with pH varying from 4.4-5.2 which may be due to the nature of the parent materials. The organic carbon content of the soil was low

which varied from 1.2-2.9%; available potassium (K) 68.2-134 kg/ha; and Phosphorus (P) between 15.2-24.0 kg/ha.

3.1.4. CLIMATE:

The climate was sub-tropical with total rainfall 230-400 mm occurring during the monsoon period - May to September (Fig.4). The rainfall was scanty during study period from November, 1986 to March, 1987. However, it gradually increased reaching the peak during June and September, 1986 and August, 1987. The number of rainy days fluctuated with the total precipitation. There were only two rainy days in March during 1986. Rainy days gradually increased to maximum of 18 days during June, 1986. In the following year also the number of two rainy days were recorded in March and it gradually increased to maximum of 23 days in July and decreased to 15 days in September, 1987.

A seasonal fluctuation in relative humidity (Fig.4) was recorded. The maximum humidity percentage during summer ranged from 82-86 and during winter 71-79, while the minimum RH in summer and winter were 60-68% and 58-60% respectively. The maximum and minimum air temperature ranged from 30-34°C and 16-20°C respectively. Winter is cold with occassional showers extending from November to February.

3.1.5. VEGETATION:

The natural vegetation over the lower ranges of the Western flank was characterised by sub-tropical evergreen rain-forest. Dominant

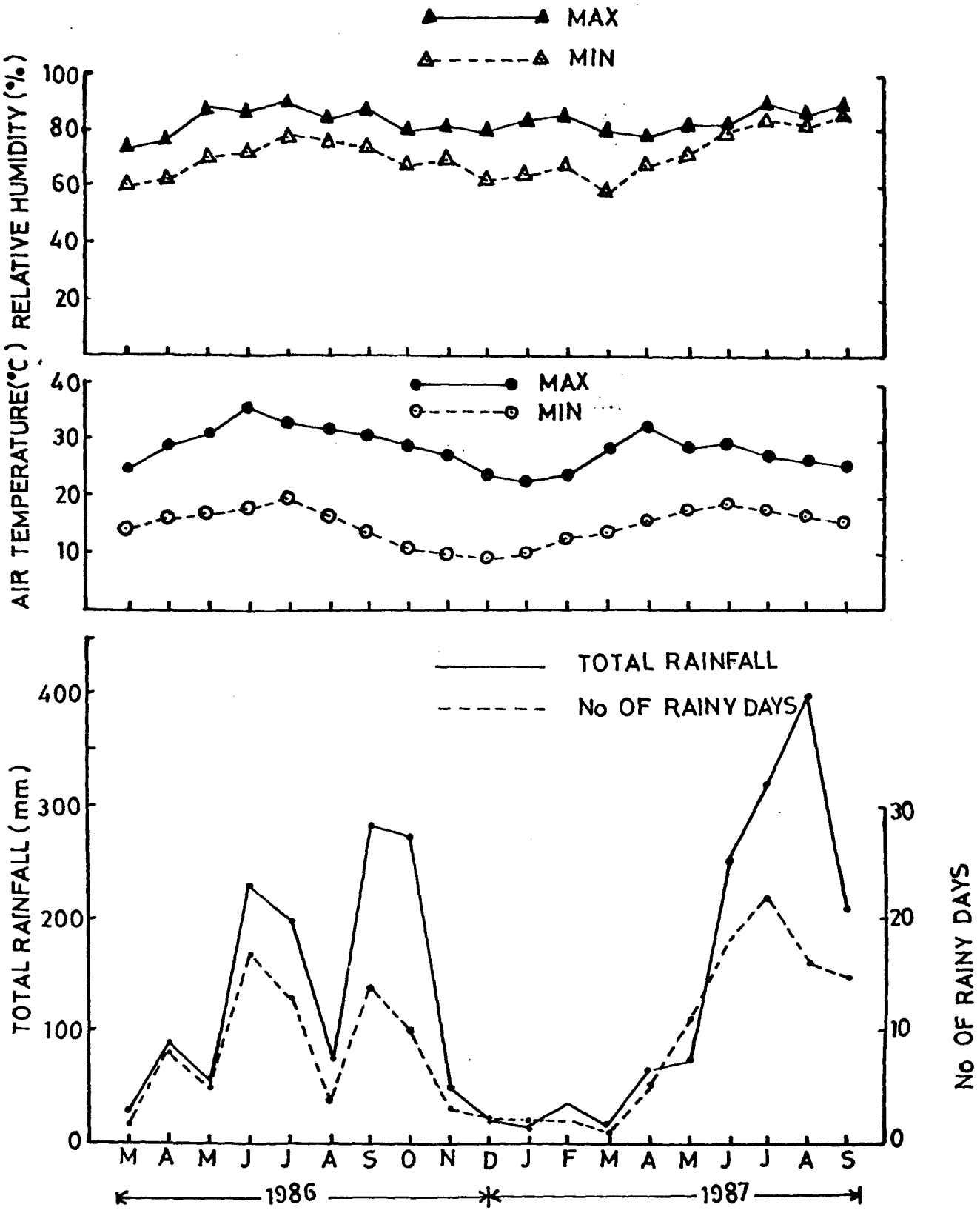


Fig. 4. Monthly variation in relative humidity, air temperature, total rainfall and number of rainy days

flora of the study site representing the deciduous woodland vegetation is presented in Table 1. Deciduous type of vegetation of one of the study sites is shown in plate I.

3.1.6. CROPS:

Paddy rice (Oryza sativa Linn. var. Kezi) and Soybean (Glycine max (L.) Merrill var. Bragg and Local), which constituted major crops of jhum cultivation were also selected for the present study. These crop plants were grown in three different fields (F_1, F_2 and F_3). However, soybean (Local) was grown only in field (F_1). Proper care was taken for protection of plants. Weeds appearing in the fields were weeded out periodically to keep the fields with pure stands of required plants.

3.2. JHUMING - SLASH, BURN AND SOWING:

Three main operations associated with jhuming are: (1) Clear cutting of standing trees and shrubs (2) burning of the dried biomass, and (3) the cultivation. The jhum system prevalent at Medziphema, Nagaland was adopted for the present study. The forests were cut in February (Plate II). The green biomass was left for drying for one month. The dried biomass was burnt on 21st March, 1986. Hard woody and incompletely burned branches were removed. First isolation was done on 28th March. Sowing of paddy rice in April and soybean was done in May by dibbling method.

3.2.1. SAMPLING:

Since the jhum paddy rice and soybean crops were harvested in September, samplings were taken from the jhum burning month (March) till harvesting month (September). As cultivation in jhum land continues for 2-3 years, the samplings were taken from March to September in the second year i.e., 1987. In the second year fields were cleared by burning the left over dried biomass of the crops along with dried weeds. ~~It is,~~ Therefore, burning intensity was very light in comparison to first year.

3.3. ISOLATION AND IDENTIFICATION OF NON-RHIZOSPHERE, RHIZOSPHERE AND RHIZOPLANE MYCOFLORA:

3.3.1. For the study of non-rhizosphere microflora in jhum burnt and control forest soil ecosystems at two different soil depth levels (0-7.5 cm and 7.5-15 cm), the soil samples were collected monthly with effect from March till September separately from three different locations. For making a sample, soil was dug out carefully with a sterilized trowel at random from three spots and mixed together. For microbial population counts, the soil dilution plate method (Martin, 1950) was employed. For this, 10 g of soil sample was taken in 250 ml conical flask containing 90 ml sterilized distilled water. Three dilutions, viz., 1:100, 1:1000 and 1: 10,000 were prepared. The first two dilutions were used for isolation of fungi and the last dilution was used for isolation of actinomycetes and bacteria.

The soil ~~solutions~~ were shaken vigorously and 1 ml was poured into each sterilized Petridishes. Four Petridishes for each dilution were taken. For isolation of fungi, each Petridish was poured with approximately 20 ml Martin's agar medium (as per composition indicated in Appendix Table X) sterilized in an autoclave at 15 lb pressure for 20 minutes, cooled and warm. Similarly, for isolation of bacteria and actinomycetes, sterilized, warm and cooled Thorton's standard medium and Jenson's medium (composition as in Appendix Table X) respectively were used.

The moisture content of soil was determined by taking 10 g of fresh soil sample in a Petridish and keeping it in an oven set at 100°C for 24 hours. The loss in weight was determined for calculating the percentage moisture content. The average number of fungi per gram of non-rhizosphere soil was calculated by multiplying the average number of colonies per plate by dilution factor and also by taking into consideration the soil moisture content.

The percentage relative abundance of individual fungal species was calculated from the total number of fungal species using the following formula:

$$\text{Relative abundance } \% = \frac{\text{Total no. of individual sp.}}{\text{Total no. of individuals of all spp.}} \times 100$$

For rhizosphere studies, plants grown in jhum land were carefully dug out with a sterilized trowel and adhering soil particles on root

system were removed by gentle tapping. The roots were cut off with a sterilized blade and collected in a sterilized 250 ml conical flask containing 100 ml sterilized distilled water. Three plants were uprooted at random from each field for sampling in seedling stage as well as mature stage. Flasks containing root pieces and sterilized distilled water were shaken well. This ~~solution,~~ thus obtained, formed 'rhizosphere soil solution'. 1 ml from this solution was pipetted and poured into each of the sterilized Petridishes followed by pouring of about 20 ml sterilized warm media of different compositions for different group of micro-organisms. Petridishes were rotated in different directions for uniform mixing of the rhizosphere soil ~~solution~~ with the medium.

Rhizosphere soil ~~solution~~ left in the flask after sampling was evaporated to dryness and weight of the moisture free rhizosphere soil was recorded. From the weight of the dry soil obtained, the weight of dry soil in 1 ml of the rhizosphere soil ~~solution~~ was calculated. The average number of fungi recorded from 4 Petridishes were taken into consideration for calculating the number of fungi per gram dry soil in the rhizosphere.

3.3.3. For rhizoplane studies, roots from the rhizosphere ~~solutions~~ were removed with a sterilized forcep into a 250 ml sterilized flask containing approximately 50 ml of sterilized distilled water and shaken well. After ten such washings, root bits were soaked in folds of sterilized blotting paper. Cut bits of approximately 2 mm size

were transferred to each Petridish containing about 20 ml of Czapek's medium (Appendix Table X).

3.3.4. Petridishes after isolation for fungi were incubated at 25± 2°C for 7 days, which was followed by observations and identification in relation to their quantitative and qualitative population. Similarly, for study of population of bacteria and actinomycetes quantitatively., Petridishes were first incubated at 30± 2°C for about 48 hours. Four replications of each set were used for the study.

3.3.5 Total number of fungal colonies of each species appearing in each Petridish was counted and identified with the help of "Manual of soil Fungi, Gilman (1975)"; A Manual of Penicillia by Raper and Thoms (1949)"; "A Manual of Aspergilli by Thom and Raper (1955)"; "Genera of Fungi by Clements and Shear, 1954"; "Illustrated Genera of Imperfect Fungi by Barnett (1970)"; "The Genus FUSARIUM" by Booth (1985); "Dematiaceous Hyphomycetes, Ellis (1971)"; and "More Dematiaceous Hyphomycetes, Ellis (1976)". Besides these, many research papers of Taxonomic values were consulted for correct identification whenever necessary. Slow growing and non-sporulating forms were transferred to different nutrient agar media for final identification. Unidentified fungal species, encountered during present investigation, were identified by International Mycological Institute, Kew Surrey, England.

3.3.6. Percentage occurrence of each fungal species in rhizosphere and non-rhizosphere was recorded. For this, each Petridish was considered as unit of study just like a quadrat in phyto-sociological study of

higher plants. Finding the moisture content of the soil samples under study in each month, the total number of fungal species from rhizosphere, non-rhizosphere and rhizoplane, average number of fungi per gram dry soil in the rhizosphere and non-rhizosphere and R/S ratio of the plants from the field in each month were also determined.

3.4. STUDIES ON VESICULAR-ARBUSCULAR MYCORRHIZA:

For the study of vesicular-arbuscular mycorrhizal fungi associated with roots, the technique of Phillips and Hayman (1970) was followed. Root segments were brought to laboratory and heated at 90°C for about 60 minutes in 10% KOH solution. The root segments were then rinsed in water and acidified with dilute HCl solution. Such acidified roots were stained by simmering for 5 minutes in 0.05% trypan blue in lactophenol. Root segments were then mounted on slides in lactophenol and observations were made under the microscope.

3.5. SOIL SAMPLING AND ANALYSIS:

Soil samples were collected monthly from different fields. Soil pH was measured in 1:5 soil water suspension using electric digital pH meter. The soil used for the analysis of organic carbon (OC), phosphorus (P) and potassium (K) was air dried and ground to pass through a 0-2 mm sieve. Soil organic carbon was determined by rapid titration method (Walkley and Black, 1934). Available P and K were determined by molybdenum blue method and flame photometer respectively (Jackson, 1967).

3.6. FUNGAL POPULATION : ITS ASSOCIATION WITH RHIZOSPHERE, RHIZOPLANE AND VESICULAR-ARBUSCULAR MYCORRHIZAL INFECTION OF PADDY RICE (Kezi) AND SOYBEAN (Local) IN JHUM (BURNT AND UNBURNT FIELD SOILS:

To study the effect of burning on rhizosphere, rhizoplane and non-rhizosphere mycoflora, soil borne plant pathogenic fungi and vesicular-arbuscular mycorrhizal infection on rice and soybean, half of the jhum field (F_1) was cleared by burning and the other half by removing the dried biomass by hand (unburnt). Soil samples were collected monthly with effect from March till September, separately from jhum burnt and unburnt field at two depth levels (0-7.5 cm and 7.5-15 cm). For study of rhizosphere, rhizoplane and VAM infection in the roots of paddy rice (Kezi) and soybean, seeds of the crops were sown in April and June respectively by dibbling method in both jhum (burnt) and unburnt field. The similar methods for sampling, isolation, incubation identification and calculation etc. as already described, were followed. The observations were taken on rhizosphere, rhizoplane and non-rhizosphere mycoflora, occurrence of soil-borne pathogenic fungi and percentage infection of VAM in the roots of above crops from both the fields were compared.

3.7. EFFECT OF TRICHODERMA HARZIANUM (IMI NO. 323745) -AN ISOLATE FROM MEDZIPHEMA SOILS ON SEED GERMINATION AND GROWTH OF SEEDLINGS OF PADDY RICE AND SOYBEAN IN VITRO:

15 days old culture of T. harzianum grown in SP-3 liquid medium (Appendix Table X) was used to find out its effect on seed germination and seedling growth of the plants under study. 100 seeds each of

paddy rice and soybean were soaked in the fungal filtrate containing the metabolites for 24 hours. The same number of seeds were soaked in liquid medium without fungal metabolite. 20 such seeds, treated and non-treated, were then transferred to each Petridish lined with filter paper moistened in sterilized water. Three replications were kept for each set. The seedling growth, plumule in case of paddy rice and radicle in case of soybean were recorded at an interval of 24 hours upto 72 hours. Total percentage of seed germination of paddy rice and soybean treated and non-treated were recorded after 72 hours.

3.8. EFFECT OF TRICHODERMA HARZIANUM ON GROWTH OF PADDY RICE AND SOYBEAN IN VIVO:

The mass culture of T. harzianum was prepared by inoculating the fungus in 500 ml conical flasks containing sand-maize medium (4:1). Thirty days old cultures of the fungus were used for soil infestation. The autoclaved pot soil was mixed with fungal inoculum in the proportion of 200:0, 200:1, 200:2 and 200:3. Three replications were kept for each treatment. The pots were kept at room temperature (24± 2°C). On the 7th day of inoculation, pots in triplicate were seeded with the seeds of paddy rice and soybean separately. The first observation was made on 15th day for paddy rice as well as soybean. However, subsequent observations in respect of paddy rice seedlings were taken at fortnight intervals, i.e., on 30th and 45th days after sowing. In respect of soybean subsequent observations on the growth (plant height) were recorded after 5 days interval upto 25th day.

3.9. EFFECT OF ROOT EXTRACTS ON THE GROWTH OF TRICHODERMA HARZIANUM AND SOME OTHER DOMINANT RHIZOSPHERE FUNGI:

50 g fresh roots of 1½ months old plants of paddy rice and soybean were thoroughly crushed separately in sterilized distilled water and filtered through fine muslin cloth. Extracts, thus obtained were mixed separately in Czapek-Dox medium so as to prepare the medium with root extract. Pure Czapek-Dox medium in Petridishes served as control. pH of the medium, in all the cases, was maintained at 6.5. For each treatment, 5 Petridishes were taken. Seven days old cultures of test fungi grown in Czapek-Dox agar medium in Petridishes were used as inoculum. Uniformity of inoculum was maintained by inoculating the Petridishes containing root extracts and the medium (sterilized) with 6 mm culture disc cut by a sterilized cork borer. Inoculated Petridishes were kept at 25± 2°C and colony diameter ~~were~~ measured at an interval of 24 hours.

3.10. ANTAGONISTIC EFFECT OF TRICHODERMA HARZIANUM AGAINST SOME COMMON SOIL-BORNE PLANT PATHOGENIC FUNGI:

The culture of T. harzianum and soil-borne plant pathogenic fungi, viz., Sclerotium rolfsii, Sclerotinia sclerotiorum, Rhizoctonia solani, Fusarium oxysporum were made on PDA medium, in separate Petridishes. Seven days old cultures were used as inoculum. Uniformity of inoculum was maintained by inoculating the Petridishes containing sterilized PDA medium with cultures of 4 mm disc size cut by a sterilized cork borer. Each Petridish was inoculated with both T. harzianum and the test fungus. The fungal inocula were placed on the medium

at opposite sides- left or right in the Petridishes. Three Petridishes were taken for each test fungus. The inhibited growth of test fungi due to the dominating and killing action were noticed upto 12 days.

3.11. STATISTICAL ANALYSIS:

All the data collected during the present study were subjected to statistical analysis by applying 't' test and analysis of variance.

C H A P T E R - IV

O B S E R V A T I O N S

O B S E R V A T I O N S

The observations of the present study have been presented in the following order-

Number	Observations	Tables
4.1.	Vegetation of study sites	1
4.2.	Percentage occurrence of fungal species isolated from jhum burnt field soils (F_1, F_2, F_3) ..	2,3,4
4.3.	Percentage occurrence of fungal species isolated from control forest soils (C_1, C_2, C_3) ..	5,6,7
4.4.1.	Percentage occurrence of fungal species in rhizosphere of paddy rice (Kezi) grown in jhum burnt and unburnt fields ..	8a
4.4.2.	Relative abundance (%) of individual fungal species in the rhizosphere of paddy rice in jhum burnt and unburnt fields ..	8b
4.5.1.	Percentage occurrence of fungal species in rhizosphere of soybean (Local) from jhum burnt and unburnt fields ..	9a
4.5.2.	Relative abundance (%) of individual fungal species in the rhizosphere of soybean (Local) in jhum burnt and unburnt fields ..	9b
4.6.	Total number of fungal species isolated from the rhizosphere, rhizoplane and non-rhizosphere of paddy rice and soybean (Local) ..	10

Table 1

Vegetation of the study sites

Habit	Plant name	Family
Trees	*Bambusa sp.	Poaceae
	*Schima wallichii Chois.	Theaceae
	Callicarpa arborea Roxb	Verbenaceae
	Dillenia indica Linn.	Dilleniaceae
	Ficus hispida Linn.	Moraceae
	Macaranga denticulata Muell.	Euphorbiaceae
Herbs	Lantana camara Linn.	Verbenaceae
	Osbeckia crinita Benth.	Melastomaceae
	Ageratum conyzoides Linn.	Asteraceae
	Borreria hispida K. Schun.	Rubiaceae
	Desmodium triquetrum (L.) DC.	Fabaceae
	Erigeron canadensis Linn.	Asteraceae
	*Eupatorium adenophorum Linn.	Asteraceae
	Eupatorium odoratum Linn.	Asteraceae
	*Mikania scandens willd.	Asteraceae
Grasses	Imperata cylindrica Beauv.	Poaceae
	Thysanolaena sp.	Poaceae
	Saccharum spontaneum Linn.	Poaceae

*Dominant species

Table 2

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES ISOLATED FROM JHUM BURNT FIELD (F_1) Soil

Name of the species	1986														1987													
	M		A		M		J		J		A		S		M		A		M		J		J		A		S	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
ABSIDIA REPENS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ALTERNARIA HUMICOLA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-
ASPERGILLUS TERREUS	-	-	9	-	-	-	1	-	-	2	8	-	6	-	8	-	5	-	-	-	4	-	5	2	6	7	12	7
A. FUMIGATUS	-	-	7	-	8	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-
A. LUCHUENSIS	-	-	-	-	3	-	1	-	1	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-
A. NIGER	8	6	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	8	6	-	-	7	
A. SYDOWI	-	-	-	-	-	-	3	9	4	2	2	-	2	-	-	-	-	-	-	-	3	-	2	8	-	-	-	-
CEPHALOSPORIUM SP.	-	-	4	1	8	3	-	-	-	2	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHOANEPHORA SP.	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
CLADOSPORIUM SP.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CURVULARIA GENICULATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FUSARIUM MONILIFORME	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	15	5	-	-	4	-	-	-	-	-	-	-
F. OXYSPORIUM	-	-	4	3	6	-	3	3	4	4	8	6	8	5	-	-	20	14	-	-	8	-	-	-	2	-	2	-
F. SOLANI	-	-	4	-	6	9	15	-	-	10	6	-	8	5	12	-	-	-	19	-	-	-	-	8	6	-	12	21
GLIOCLADIUM ROSEUM	-	-	4	3	6	3	-	-	-	-	-	-	-	-	4	-	3	-	-	-	-	5	-	-	-	5	-	-
GLIOMASTIX SP.	-	-	-	-	-	-	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HELMINTHOSPORIUM SP.	-	-	-	-	-	3	-	-	1	-	-	-	-	-	4	-	-	-	4	15	-	-	-	-	-	7	-	-
HUMICOLA SP.	-	4	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
HYALOPUS SP.	-	4	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-
GEOTRICHUM SP.	-	-	-	-	-	-	-	-	1	2	-	-	-	-	4	-	-	-	4	-	-	-	-	-	-	7	-	-
MUCOR HIEMALIS	9	12	4	11	6	14	6	16	-	8	-	-	-	-	-	-	3	7	4	15	4	-	10	15	1	19	-	-
M. RACEMOSUS	-	-	-	-	-	-	-	-	10	-	-	-	8	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-
NEUROSPORA SP.	20	16	7	1	6	9	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OIDIODENDRON SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
PENICILLIUM FREQUENTANS	6	-	-	3	-	-	-	-	1	2	-	-	-	10	-	-	-	-	7	-	-	-	-	-	-	-	10	7
P. GRANULATUM	8	-	9	7	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	2	-	-	-
P. JAVANICUM	-	-	-	-	-	-	-	-	11	6	-	-	-	-	-	8	10	-	4	-	-	-	2	-	-	-	-	-
P. FUMICULOSUM	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	8	-	7	-	-	-	-	-	-	-	-	-	-
P. LUTEUM	8	2	-	-	9	8	12	-	14	12	22	18	-	15	-	12	-	-	8	15	-	-	15	20	10	10	2	21
P. PURPUROGENUM	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-
P. RESTRICTUM	2	16	-	-	-	-	-	-	1	-	8	18	8	-	-	-	5	-	4	5	-	-	2	-	6	-	-	-
P. TURBATUM	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	5	5	5	-	-	2	-	2	-
PESTOLATIA SP.	-	-	-	5	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYTHIUM SP.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	7	-
RHIZOPUS NIGRICANS	8	4	9	13	3	3	6	8	6	8	8	4	8	10	-	-	-	5	11	10	-	-	-	-	2	-	2	-
RHIZOPUS SP.	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
SCLEROTIUM SP.	13	8	9	7	9	9	3	-	4	-	-	9	-	10	18	12	-	16	11	5	13	22	8	-	6	-	6	-
SPICARIA SP.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THIELAVIA TERRICOLA	-	-	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
THIELAVIOPSIS SP.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TORULA SP.	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	2	-
TRICHODERMA HARZIANUM	18	12	23	11	14	11	14	19	16	8	20	18	8	15	16	12	10	7	10	5	15	15	15	17	13	10	18	12
T. LIGNORUM	-	-	9	11	6	3	-	11	4	8	-	-	4	-	14	6	6	-	-	-	-	-	-	-	2	-	-	-
T. LONGIBRACHIATUM	-	8	-	-	-	-	10	-	9	-	8	9	-	5	-	-	3	7	7	7	5	5	2	-	2	10	6	-
VERTICILLIUM SP.	-	-	-	-	10	3	-	9	-	-	-	-	-	-	4	10	5	5	-	-	3	15	-	-	2	-	2	-
ZYGORHYNCHUS SP.	-	-	-	-	-	-	3	9	4	2	2	-	2	-	-	-	-	-	-	-	3	-	4	8	-	-	-	-
BLACK STERILE MYCELIA	-	4	-	11	-	-	-	-	3	2	-	9	16	-	-	9	-	-	-	-	4	17	-	-	-	-	8	-
PINK STERILE MYCELIA	-	-	-	-	-	-	-	-	1	6	8	-	6	10	-	-	-	-	-	-	-	-	2	-	10	-	-	-
WHITE STERILE MYCELIA	-	4	-	11	-	19	6	14	8	6	-	9	12	-	12	10	15	7	7	18	18	-	15	8	6	-	6	19
YELLOW STERILE MYCELIA	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	10	-	-	-	-	-	-	-	4	10	15	-	6
NUMBER OF SPECIES	10	13	14	14	14	14	21	10	31	22	11	9	15	11	11	11	12	12	13	10	15	9	17	11	21	10	17	8

I = 0-7.5 cm, II = 7.5-15.0 cm depth

Table 3

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES ISOLATED FROM JHUM BURNT FIELD (F_2)

Name of the species	1986														1987													
	M		A		M		J		J		A		S		M		A		M		J		J		A		S	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
ABSIDIA REPENS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
ALTERNARIA HUMICOLA	-	-	-	4	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASPERGILLUS FUMIGATUS	4	4	6	7	8	3	-	2	-	-	10	-	3	-	-	6	6	3	-	-	-	4	2	-	-	-	-	-
A. LUCHUENSIS	-	-	4	4	-	-	-	-	6	-	-	11	-	5	10	-	3	-	-	3	-	-	-	5	-	-	-	4
A. NIGER	8	7	4	9	5	5	5	-	-	-	-	-	-	-	-	4	-	-	3	5	-	-	2	-	-	-	-	-
A. SYDOWI	-	2	6	4	-	-	-	3	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	3	5	-	-	-
A. TERREUS	-	-	4	4	6	5	5	3	4	-	7	-	6	3	-	-	-	-	6	2	-	4	-	3	5	-	-	5
CANDIDA SP.	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	4	-	10	-	-	-	-	-	-	-	-	-	-
CEPHALOSPORIUM SP.	4	2	4	-	3	-	-	9	6	-	7	7	6	7	5	4	5	3	6	5	-	4	-	7	8	2	7	-
CLADOSPORIUM SP.	-	-	-	-	-	-	-	3	6	-	-	-	-	7	-	-	-	-	-	-	-	5	-	-	6	-	2	-
CURVULARIA GENICULATA	-	-	-	-	-	-	-	-	4	6	7	-	-	-	2	-	3	-	-	-	-	-	-	-	-	-	-	-
FUSARIUM MONILIFORME	-	-	4	-	3	9	6	-	-	5	-	-	-	-	-	-	6	-	-	-	-	-	-	-	2	-	-	-
F. OXYSPORUM	-	7	6	4	5	3	-	9	6	-	-	5	-	3	9	8	-	5	9	7	-	4	3	5	5	7	3	-
F. SOLANI	-	-	6	7	7	3	2	3	4	-	7	4	18	-	-	-	2	-	-	-	-	-	-	3	-	-	-	-
GEOTRICHUM SP.	6	-	-	-	-	-	-	3	-	-	-	-	-	-	-	4	3	-	-	-	-	-	-	-	-	-	-	-
GLIOCLADIUM ROSEUM	-	-	4	7	-	-	-	-	4	-	-	-	6	-	-	-	-	3	-	3	-	5	5	5	5	4	5	-
GLIOMASTIX SP.	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HELMINTHOSPORIUM SP.	-	-	-	4	-	-	-	-	1	-	-	-	-	-	-	-	3	-	-	3	-	4	5	-	3	-	2	-
HUMICOLA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	6	-
MUCOR HIEMALIS	8	9	6	7	-	-	6	5	6	3	3	4	5	7	7	6	-	7	3	7	27	5	7	5	-	5	5	4
M. RACEMOSUS	-	7	6	4	-	-	3	-	-	3	-	-	-	-	3	4	5	-	-	-	-	7	3	-	8	2	-	-
NEOROSPORA SP.	12	4	4	7	5	3	6	8	-	-	-	-	-	-	3	-	8	-	-	-	-	-	-	-	-	-	-	-
PENICILLIUM FREQUENTANS	-	-	-	-	-	-	-	2	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	5	6	-
P. GRANULATUM	-	7	4	4	-	3	-	6	6	6	-	7	8	-	-	6	3	7	5	-	-	5	5	3	-	5	-	4
P. JAVANICUM	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. LUTEUM	10	7	-	-	-	2	-	-	10	-	7	-	17	5	5	4	3	5	-	7	-	5	3	15	5	4	3	-
P. RESTRICTUM	-	-	-	-	3	8	-	-	4	-	-	5	-	7	-	6	6	-	6	5	-	8	5	7	-	5	8	7
P. TURBATUM	4	7	-	-	-	-	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	5	4	5	7
P. VARIABILE	-	-	-	-	-	5	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PHOMA SP.	6	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYTHIUM SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	4	-	-
RHIZOPUS NIGRICANS	12	15	-	-	3	-	-	15	-	19	12	13	-	7	10	13	16	-	11	21	23	5	15	12	3	5	11	19
RHIZOPUS SP.	-	-	6	4	-	10	6	3	7	3	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-
SCLEROTIUM SP.	4	-	-	-	13	13	8	-	16	11	18	11	11	10	16	10	6	-	8	12	19	11	3	-	5	12	6	9
THIELAVIA TERRICOLA	-	-	-	-	-	-	-	3	-	5	-	2	5	7	-	-	-	-	-	-	-	-	3	7	-	-	2	5
TRICHODERMA HARZIANUM	14	4	5	4	18	10	13	15	-	8	-	7	-	13	10	8	11	17	19	5	14	7	18	12	16	15	11	14
T. LIGNORUM	-	-	-	-	-	3	5	-	-	5	5	5	5	7	-	6	-	-	3	-	-	5	2	-	-	-	3	2
T. LONGIBRACHIATUM	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VERTICILLIUM SP.	-	4	6	6	3	5	-	2	-	-	-	-	-	-	6	2	-	7	5	2	-	-	5	-	3	5	3	5
ZYGORHYNCHUS SP.	-	4	4	-	-	-	-	-	-	-	10	-	-	7	3	-	6	-	5	-	-	-	-	-	-	-	-	-
CHOANEPHORA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
BLACK STERILE MYCELIA	4	10	-	6	3	-	4	2	-	10	-	7	10	5	4	-	-	8	6	7	12	5	5	2	6	4	5	4
PINK STERILE MYCELIA	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
WHITE STERILE MYCELIA	-	-	7	4	6	7	6	-	-	6	-	7	-	-	-	4	-	7	-	5	5	7	3	3	3	5	8	7
YELLOW STERILE MYCELIA	4	-	-	-	9	-	10	-	-	10	-	4	-	-	-	-	-	2	3	-	-	-	-	-	5	7	-	-
NUMBER OF SPECIES	14	16	20	19	16	18	17	19	18	14	12	15	12	15	15	17	18	16	16	16	6	18	20	17	19	18	19	15

I = 0-7.5, II = 7.5-15.0 cm depth

Table 4

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES ISOLATED FROM JHUM BURNT FIELD (F_3)

Name of the species	1986														1987													
	M		A		M		J		J		A		S		M		A		M		J		J		A		S	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
ABSIDIA REPENS	-	-	-	-	-	3	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
ASPERGILLUS FUMIGATUS	-	-	10	-	7	-	-	-	-	5	-	-	-	-	-	7	4	3	4	-	4	2	-	-	-	-	-	-
A. LUCHUENSIS	-	-	-	-	3	-	-	3	-	-	-	-	-	-	7	-	4	-	-	-	-	-	-	5	-	-	-	4
A. NIGER	10	6	-	-	-	7	3	-	5	-	-	-	-	-	-	5	-	-	3	5	3	-	2	-	-	-	-	-
A. SYDOWI	-	-	-	-	-	-	3	5	-	3	-	-	-	-	-	-	-	5	-	-	-	-	-	3	6	-	-	-
A. TERREUS	6	4	4	4	-	5	-	3	5	5	6	-	3	-	-	-	-	-	6	2	-	4	-	3	6	-	-	6
CANDIDA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	6	-	-	5	-	8	-	8	6	5	8
CEPHALOSPORIUM SP.	4	6	4	4	3	-	-	3	-	7	-	-	-	-	5	4	5	3	6	5	-	4	-	7	4	2	-	-
CLADOSPORIUM SP.	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	2	-	4	-	-	6	-	2	-
CURVULARIA. GENICULATA		-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	-	-	-	-	-	-	-	-	-	-	-
FUSARIUM OXYSPORUM	8	4	4	4	-	7	9	-	-	5	5	-	15	14	9	9	-	5	9	6	2	4	3	5	6	4	3	-
F. MONILIFORME	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	2	-	-	-
F. SOLANI	-	-	-	-	-	-	-	-	5	3	-	-	-	-	-	-	2	-	-	3	-	-	-	4	-	-	-	-
GEOTRICHUM SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	-	-	-	-	-	-	-	-	-	-	-
GLIOCLADIUM ROSEUM	-	-	4	4	7	3	-	3	-	-	-	-	-	-	-	-	-	3	-	3	-	4	5	4	6	4	5	-
HELMINTHOSPORIUM SP.	-	-	-	-	-	3	3	5	-	-	-	-	-	-	-	-	4	-	-	3	-	8	5	-	4	-	3	-
HUMICOLA SP.	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	5	-	-	-	-	-	-	5	-	-	7	-
MUCOR HIEMALIS	-	8	4	2	12	-	7	9	6	5	8	15	7	14	7	5	-	7	3	6	9	6	7	5	6	8	5	6
M. RACEMOSUS	6	4	-	6	-	-	7	3	13	3	12	15	17	14	4	5	5	-	-	-	-	8	3	-	2	8	-	-
NEUROSPORA SP.	18	4	9	12	7	4	3	5	-	-	-	-	-	-	4	-	9	-	-	-	-	-	-	-	-	-	-	-
PENICILLIUM LUTEUM	4	6	4	-	-	5	5	-	10	-	16	13	-	-	5	4	4	5	-	6	10	6	3	5	6	4	3	-
P. FREQUENTANS	-	-	4	4	-	2	-	6	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	6	4	-
P. GRANULATUM	-	-	4	6	4	3	0	10	5	7	-	-	-	-	-	4	4	7	3	-	-	6	5	4	-	6	-	4
P. RESTRICTUM	-	8	-	-	-	10	-	3	-	-	-	-	-	-	-	4	4	-	6	5	-	8	5	7	-	6	5	8
P. TURBATUM	-	-	-	-	-	3	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	8	4	4	4	5	8
PESTOLATIA SP.	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	5	3	-	-	-	-	-	4	4	-	-
RHIZOPUS NIGRICANS	8	8	8	4	3	2	7	3	6	7	8	13	9	-	11	9	10	-	10	19	22	-	8	12	4	10	5	4
RHIZOPUS SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	4	-
SCLOROTIUM SP.	8	6	-	7	18	9	5	-	3	-	-	-	-	-	11	19	-	7	17	15	3	8	3	-	6	4	7	4
THIELAVIOPSIS SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	7	-	3	4	-	-	-	-
TORULA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
TRICHODERMA HARZIANUM	2	11	23	12	19	10	21	12	10	20	12	16	14	13	15	4	15	7	10	5	14	8	7	12	4	4	7	14
T. LIGNORUM	-	8	4	6	7	2	-	-	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. LONGIBRACHIATUM	-	-	4	2	5	3	3	5	5	-	-	15	13	17	-	-	4	2	4	2	5	-	-	-	-	4	-	-
VERTICILLIUM SP.	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	7	-	-	3	-	-	6	2	-	-	-	3	2
ZYGORHYNCHUS SP.	-	8	6	4	-	3	-	5	11	-	15	13	-	14	4	-	4	-	4	-	8	-	7	-	-	-	15	18
CHOANEPHORA SP.	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACK STERILE MYCELIA	12	4	-	8	-	-	-	-	-	3	-	-	17	14	5	2	-	7	4	2	-	-	5	-	4	6	-	-
PINK STERILE MYCELIA	-	-	-	-	-	-	-	-	-	3	15	-	-	-	4	-	-	9	5	6	3	6	5	5	4	4	3	4
WHITE STERILE MYCELIA	-	3	4	8	-	5	7	5	3	9	-	-	5	-	-	-	2	-	-	-	-	-	3	2	-	-	-	-
YELLOW STERILE MYCELIA	10	-	-	-	5	6	17	3	-	10	-	-	-	-	-	4	-	7	-	5	5	8	3	4	4	6	8	4
NUMBER OF SPEICES	13	17	16	18	13	21	14	20	16	16	10	7	9	7	15	17	19	18	17	18	14	17	21	19	21	19	20	15

I = 0-7.5 cm, II = 7.5-15.0 cm. depth

Table 5

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES ISOLATED FROM CONTROL FOREST SOIL (C_1)

Number of species	1986														1987											
	M		A		M		J		J		A		S		M		A		M		J		J		A		S	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
ABSIDIA REPENS	11	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	-	-	-	-	-	-	-	-	-
ASPERGILLUS FUMIGATUS	-	-	-	-	2	4	-	-	4	4	-	-	-	-	3	-	-	-	2	-	2	-	2	-	2	-	2	-
ALTERNARIA HUMICOLA	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
ASPERGILLUS LUCHUENSIS	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. NIGER	-	-	4	-	-	-	1	10	4	4	2	6	-	-	-	-	3	9	2	-	-	-	9	-	6	3	7	-
A. SYDOWI	-	-	4	-	-	-	11	10	4	-	2	-	-	8	-	-	-	-	-	-	9	2	3	-	3	-	-	-
A. TERREUS	-	-	-	-	2	-	-	-	4	4	4	-	5	-	5	3	-	-	-	-	4	-	9	-	6	20	7	9
CANDIDA SP.	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	4	-	2	-	-	-	5	2
CEPHALOSPORIUM SP.	-	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAETOMIUM SP.	-	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2	-	-	-	-	-	-
CHOANEPHORA SP.	-	-	1	-	2	2	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	2	-
CLADOSPORIUM SP.	-	-	2	2	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CURVULARIA GENICULATA	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	3	3	4	-	-	-	2	-	-	-	-	-
FUSARIUM MONILIFORME	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	5	3	-	-	-	.	-	-	-	-	-	3
F. OXYSPORUM	7	8	-	5	4	4	2	5	-	4	2	4	5	-	-	-	-	-	9	-	-	17	-	-	-	-	-	2
F. SOLANI	-	-	4	2	3	-	-	-	4	-	-	4	5	-	3	-	-	-	2	-	4	8	-	17	4	15	5	6
GEOTRICHUM SP.	-	-	-	-	4	8	-	-	4	-	2	-	-	-	-	-	3	-	8	-	-	2	-	-	6	3	2	3
GLIOCLADIUM ROSEUM	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	10	10	2	3
GLIOMASTIX SP.	-	-	-	-	-	-	-	-	-	-	4	-	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HELMINTHOSPORIUM SP.	-	-	-	-	-	4	-	-	-	-	6	-	-	-	3	-	3	3	7	6	-	-	3	3	-	-	2	-
HUMICOLA SP.	-	4	2	5	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	7	-
HYALOPUS	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	4	-	-	2	-	2	-
MUCOR HIEMALIS	14	8	4	5	-	-	7	5	8	14	8	-	-	-	8	-	3	9	8	-	7	4	-	-	2	-	-	-
M. RACEMOSUS	-	-	2	2	-	-	-	-	2	-	8	-	-	-	-	3	5	-	6	9	-	-	2	-	-	-	2	-
OIDIODENDRON SP.	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
PENICILLIUM FREQUENTANS	-	-	4	-	4	8	-	10	4	-	-	4	-	13	5	3	-	7	-	-	4	4	-	-	-	-	5	-
P. GRANULATUM	11	8	-	15	-	-	-	10	-	-	-	-	3	-	-	-	5	-	-	-	-	6	-	8	3	-	-	-
P. JAVANICUM	-	-	-	-	4	18	-	10	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	8	-	-	-	-
P. FUMICOLOSUM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5	2	-	-	2	-	-	-	-	-	-	-
P. LUTEUM	15	13	4	-	10	-	20	15	8	4	8	14	-	3	14	5	-	9	6	17	-	-	14	12	3	10	5	15
P. PURPUROGENUM	-	-	2	4	-	-	-	-	-	-	-	2	-	-	-	-	3	3	-	-	-	-	2	-	-	-	-	-
P. RESTRICTUM	-	-	4	2	6	-	2	-	-	-	4	11	5	5	-	-	3	3	6	-	-	-	-	-	7	10	4	-
P. TURBATUM	-	-	-	-	2	-	-	-	-	4	2	-	2	-	-	-	3	-	-	9	7	-	2	-	2	-	8	3
PESTOLATIA SP.	-	-	-	-	4	-	2	-	-	4	-	-	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
PYTHIUM SP.	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	-	2	-	-	-	2	-	-	3	2	9
RHIZOPUS NIGRICANS	7	8	2	-	13	-	5	-	4	8	4	-	5	-	-	-	3	-	2	17	12	-	2	-	-	-	-	-
RHIZOPUS SP.	7	7	2	-	4	4	2	-	4	8	4	-	2	5	-	-	3	3	-	-	-	-	-	-	-	-	-	-
SCLEROTIUM SP.	-	7	8	5	13	12	9	5	7	-	8	-	5	11	3	21	5	-	11	15	9	-	6	6	12	7	7	-
THIELAVIA TERRICOLA	-	-	4	10	-	-	2	-	6	4	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	2	3
THIELAVIOPSIS SP.	-	-	9	-	-	-	-	-	-	-	-	-	-	-	8	8	5	3	-	-	-	-	2	-	2	-	2	-
TORULA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5	-	3	-	-	-	-	-	-	-	-	2	2
TRICHODERMA HARZIANUM	9	8	2	10	4	-	5	10	8	8	8	13	10	11	10	18	-	10	-	15	2	9	15	3	6	3	2	6
T. LIGNORUM	2	4	4	5	4	4	2	-	4	2	-	5	2	5	3	3	5	5	-	-	-	-	5	16	2	-	-	-
T. LONGIBRACHIATUM	-	9	-	5	4	6	5	-	-	4	8	11	10	2	10	-	3	9	6	5	6	6	-	-	8	3	2	3
VERTICILLIUM SP.	-	-	2	2	2	4	2	-	-	-	2	-	-	-	5	3	3	3	-	-	9	-	5	11	6	3	2	-
BLACK STERILE MYCELIA	7	4	4	5	2	2	5	-	2	8	4	11	10	5	3	-	8	-	2	-	-	-	-	3	-	-	5	16
PINK STERILE MYCELIA	-	-	4	-	-	-	7	-	-	4	-	11	2	5	-	-	5	3	-	-	-	-	2	-	2	-	-	-
WHITE STERILE MYCELIA	4	8	4	5	8	18	9	-	17	8	8	5	10	11	5	25	9	2	11	7	-	24	6	13	6	10	2	6
YELLOW STERILE MYCELIA	-	-	2	-	-	-	-	10	-	-	-	-	10	11	3	-	-	-	-	-	2	12	-	-	-	-	5	9
NUMBER OF SPECIES	13	14	28	20	22	15	19	11	19	18	22	13	18	14	19	12	26	22	19	9	18	13	22	11	22	13	27	17

I = 0-7.5 cm, II = 7.5-15.0 cm depth

Table 6

PERCENTAGE OCCURRENCE OF FUNAL SPECIES ISOLATED FROM CONTROL FOREST (C_2)

Number of species	1986														1987											
	M		A		M		J		J		A		S		M		A		M		J		J		A		S	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
ABSIDIA REPENS	5	4	10	7	-	-	-	-	-	-	6	-	4	-	-	-	4	-	-	-	-	-	-	5	5	-	-	-
ALTERNARIA HUMICOLA	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASPERGILLUS FUMIGATUS	-	-	10	5	11	7	5	-	8	4	2	2	12	2	3	8	-	5	7	-	-	-	-	-	-	-	-	4
A. LUCHUENSIS	-	-	-	2	-	-	10	-	-	11	6	7	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. NIGER	4	2	8	-	14	8	-	3	6	5	3	2	-	2	-	2	5	-	3	8	-	-	3	4	-	2	-	-
A. SYDOWI	-	-	5	-	-	5	3	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
A. TERREUS	-	4	2	5	9	4	5	3	-	5	5	-	5	6	4	5	3	-	-	7	-	-	2	5	5	2	7	-
CANDIDA SP.	7	-	-	-	-	-	-	-	-	-	-	4	5	-	5	4	-	5	7	5	-	-	-	-	-	-	-	-
CEPHALOSPORIUM SP.	-	-	4	2	5	4	3	7	10	-	8	-	-	12	-	-	6	-	-	-	-	-	-	-	-	-	-	-
CHAETOMIUM SP.	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLADOSPORIUM SP.	-	-	-	-	-	14	5	10	-	7	11	7	3	8	3	2	6	7	-	5	-	-	3	7	6	-	5	-
CURVULARIA GENICULATA	5	4	6	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
FUSAIRUM MONILIFORME	-	-	-	4	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	8	-	-	-
F. OXYSPORUM	5	2	2	7	7	4	5	3	6	5	6	5	7	-	-	-	6	-	-	8	-	-	-	-	-	-	2	4
F. SOLANI	5	4	-	-	4	4	3	-	2	-	-	-	9	8	7	4	-	8	-	-	-	-	5	4	-	-	-	-
GEOTRICHUM SP.	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7	-	-
GLIOCLADIUM ROSEUM	-	4	-	-	7	-	7	-	-	-	-	-	-	12	3	6	3	4	-	-	-	4	3	7	3	3	7	-
GLIOMASTIX SP.	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HELMINTHOSPORIUM SP.	-	-	-	2	-	4	-	5	2	-	-	-	4	-	5	4	5	4	-	4	-	-	2	4	-	-	-	-
HUMICOLA SP.	-	-	-	-	-	-	5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	5	3	5	-
MUCOR HIEMALIS	-	4	2	4	5	-	-	3	-	7	-	7	-	4	8	8	8	-	10	5	4	4	-	4	6	-	5	6
M. RACEMOSUS	4	6	-	-	-	-	3	7	8	-	8	-	7	-	-	6	-	3	-	-	7	4	5	5	-	7	-	-
PENICILLIUM FREQUENTANS	5	4	-	-	4	-	5	5	-	-	-	5	7	-	-	6	-	-	-	-	7	8	6	-	-	-	-	-
P. GRANULATUM	6	7	6	4	-	-	-	5	8	-	3	-	-	-	5	-	3	7	7	5	5	6	5	4	3	5	-	-
P. JAVANICUM	5	7	4	9	5	7	5	7	2	2	3	8	4	4	-	-	-	-	-	-	2	-	-	-	-	-	-	-
P. LUTEUM	-	-	-	-	-	4	-	-	8	7	8	10	-	6	-	8	6	3	12	5	4	6	5	-	16	7	10	-
P. RESTRICTUM	-	-	-	-	-	8	-	-	-	-	-	-	-	-	15	4	-	5	3	4	5	8	3	5	-	2	7	4
P. TURBATUM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	-	5	-	7	6	5	4	5	5	7	-
P. VARIABILE	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PYTHIUM SP.	5	7	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	5	-	-	6	-	-	-	-	5	-	4
RHIZOPUS NIGRICANS	9	7	-	-	-	-	-	17	13	14	9	7	-	6	8	7	9	7	15	9	4	6	6	5	16	10	15	4
RHIZOPUS SP.	4	-	8	11	-	-	5	-	-	5	-	14	-	-	-	4	-	-	-	-	-	6	-	-	-	-	-	-
SCLEROTIUM ROLFSII	-	-	-	-	4	-	6	-	-	-	-	-	-	-	-	-	-	-	5	-	4	2	6	2	-	-	-	-
SCLEROTIUM SP.	-	-	-	5	-	8	-	-	-	-	-	-	7	-	5	4	9	8	5	5	7	6	8	5	9	7	12	19
THIELAVIA TERRICOLA	5	7	-	-	5	-	-	-	-	-	5	-	5	-	5	-	-	5	3	-	6	-	8	4	-	3	-	4
THIELAVIOPSIS SP.	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRICHODERMA HARZIANUM	4	4	-	-	-	-	5	7	-	6	-	5	5	-	3	4	-	8	3	5	4	4	-	9	-	2	3	-
T. LIGNORUM	8	7	16	11	-	-	-	-	-	-	-	-	-	-	-	-	8	-	7	9	8	6	-	-	-	5	-	8
VERTICILLIUM SP.	-	-	8	2	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	5	-	6	-	3	3	3	6
ZYGORHYNCHUS SP.	-	-	2	-	-	-	3	-	-	7	9	5	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACK STERILE MYCELIA	5	7	8	15	9	14	15	8	13	15	6	9	11	14	5	4	13	12	2	7	15	8	5	17	-	13	-	14
PINK STERILE MYCELIA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	4	-	-	-	-	-	-
WHITE STERILE MYCELIA	5	7	-	-	-	-	-	-	-	-	-	-	5	-	5	2	-	2	3	5	-	8	5	-	5	9	9	13
YELLOW STERILE MYCELIA	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	4
NUMBER OF SPECIES	19	20	16	17	16	14	18	18	15	14	16	16	16	14	18	21	16	18	16	17	17	18	21	18	15	19	15	14

I = 0-7.5 cm, II = 7.5-15.0 cm depth

Table 7

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES ISOLATED FROM CONTROL FOREST (C_3)

Name of the species	1986														1987													
	M		A		M		J		J		A		S		M		A		M		J		J		A		S	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
ABSIDIA REPENS	6	4	6	-	3	-	4	-	5	3	-	-	-	-	-	-	5	-	-	-	-	-	-	6	5	-	-	-
ASPERGILLUS FUMIGATUS	-	-	-	-	-	3	4	-	7	-	-	-	-	-	3	7	-	6	6	4	-	-	-	-	-	-	-	4
A. NIGER	-	-	-	-	-	-	-	4	5	9	13	4	13	-	-	2	5	-	3	8	2	-	3	4	-	2	-	-
A. SYDOWI	-	-	-	-	-	-	5	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
A. TERREUS	-	-	-	5	-	-	-	5	-	5	3	-	-	-	5	4	3	-	-	7	-	4	2	4	5	2	4	-
CANDIDIA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	-	6	6	5	8	-	4	4	5	-	8	-
CEPHALOSPORIUM SP.	4	-	-	4	11	5	7	4	5	7	-	-	-	-	-	-	6	-	-	-	-	-	-	7	6	-	-	-
CLADOSPORIUM SP.	-	-	-	-	9	6	-	4	-	-	-	-	-	-	3	2	6	8	-	5	-	-	3	4	6	-	6	-
FUSARIUM MONILIFORME	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	3	-	-	-
F. OXYSPORUM	3	9	-	5	3	5	7	-	3	3	-	4	13	-	-	-	6	-	-	7	-	-	-	-	-	-	4	4
F. SOLANI	6	-	-	7	6	8	-	-	-	-	-	-	-	-	7	4	-	10	-	-	-	-	3	4	-	-	-	-
GEOTRICHUM SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7	-	-
GLIOCLADIUM ROSEUM	-	-	4	-	5	8	-	5	5	-	-	-	-	-	3	5	3	4	-	-	-	4	3	7	3	4	4	-
GLIOMASTIX SP.	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HELMINTHOSPORIUM SP.	-	2	-	-	6	3	2	4	-	3	-	-	-	-	5	4	5	4	4	4	-	-	2	4	-	-	-	-
HUMICOLA SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	3	4	6	-
MUCOR HIEMALIS	4	4	2	4	5	6	10	5	5	10	-	-	-	-	14	7	8	-	10	5	3	4	-	4	6	-	4	6
M. RACEMOSUS	-	-	2	4	5	-	4	2	7	-	-	-	-	-	-	5	-	4	-	-	7	7	4	6	6	-	-	-
OIDIODENDRON SP.	-	-	-	4	5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PENICILLIUM FREQUENTANS	6	10	5	-	9	3	-	4	-	-	-	14	-	-	-	4	-	-	-	-	7	7	6	-	-	-	-	-
P. GRANULATUM	9	4	11	9	5	3	7	7	-	-	-	-	-	-	5	-	8	8	6	5	5	5	3	4	3	6	-	-
P. LUTEUM	4	2	4	-	-	-	-	7	2	-	-	14	-	-	-	7	8	4	11	5	3	5	4	-	6	7	4	-
P. RESTRICTUM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	4	-	6	3	4	5	7	8	4	-	-	8	4
P. TURBATUM	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	-	-	4	7	5	4	4	-	6	4	-
PHOMA SP.	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RHIZOPUS NIGRICANS	9	4	6	7	-	11	4	13	2	9	12	-	-	-	5	7	19	8	15	7	3	5	6	6	6	9	4	4
RHIZOPUS SP.	6	4	7	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	5	-	-	-	-	-	-
SCLEROTIUM SP.	-	4	5	4	8	5	7	5	7	9	-	-	-	-	5	4	6	10	5	7	9	5	6	4	8	7	8	16
THIELAVIA TERRICOLA	-	-	4	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THIELAVIOPSIS SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	6	3	-	5	-	3	4	-	4	-	4
TRICHODERMA HARZIANUM	4	4	9	9	11	15	4	5	7	17	14	81	13	13	3	4	-	6	3	5	5	14	-	7	-	6	4	6
T. LIGNORUM	4	7	7	4	2	3	11	-	5	5	10	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. LONGIBRACHAIATUM	-	-	-	4	-	2	4	4	3	5	18	14	12	13	3	-	-	6	-	-	3	-	-	-	-	2	-	-
VERTICILLIUM SP.	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3	-	6	6	8	5	-	-	-	7	-	6
ZYGORHYNCHUS SP.	9	10	5	4	-	8	7	-	-	-	16	-	12	16	-	-	-	-	-	-	-	-	3	9	3	-	8	14
BLACK STERILE MYCELIA	6	-	4	4	-	-	4	7	5	9	14	14	19	14	7	-	-	-	-	-	15	-	16	-	13	14	4	16
PINK STERILE MYCELIA	-	-	4	-	-	-	-	-	3	5	-	-	-	-	5	4	3	2	6	7	5	7	4	4	-	4	-	4
WHITE STERILE MYCELIA	-	2	7	4	6	3	4	7	4	-	-	14	15	16	-	4	-	-	-	-	-	-	2	-	-	-	-	-
YELLOW STERILE MYCELIA	9	7	7	11	-	-	-	4	10	-	-	-	13	14	5	7	-	2	13	5	-	7	4	-	8	9	16	12
CHOANEEPHORA SP.	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NUMBER OF SPECIES	17	18	18	18	16	18	18	19	20	14	8	8	8	7	18	21	16	17	15	18	17	17	23	20	18	17	17	13

I = 0-7.5 cm, II = 7.5-15.0 cm depth

Table 8a

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES IN RHIZOSPHERE OF A LOCAL CULTIVAR OF PADDY RICE (KEZI) FROM JHUM BURNT AND UNBURNT FIELD

Name of species	1986										1987									
	M		J		J		A		S		M		J		J		A		S	
	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB
ASPERGILLUS TERREUS	-	15	10	11	-	12	-	-	-	-	32	7	8	6	11	7	-	7	18	9
A. FUMIGATUS	38	-	-	-	-	7	-	-	-	-	-	-	8	12	-	-	-	-	-	-
A. LUCHUENSIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
A. NIGER	-	29	14	10	10	-	11	11	8	10	7	9	-	4	10	18	12	-	18	18
CUNNINGHAMELLA ELEGANS	-	-	-	-	-	-	-	-	3	4	-	-	8	4	-	-	-	-	-	-
FUSARIUM OXYSPORUM	-	7	-	15	20	-	19	5	19	14	2	9	-	-	12	-	-	-	15	18
F. SOLANI	3	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
GLIOCLADIUM ROSEUM	-	-	-	-	-	-	-	8	4	6	-	-	-	-	10	4	18	-	-	-
MUCOR RACEMOSUS	3	-	5	16	-	-	-	13	-	-	14	33	-	-	5	-	-	-	-	-
M. HIEMALIS	-	-	9	10	8	-	6	-	6	-	7	-	-	8	-	5	-	-	-	-
PENICILLIUM FREQUENTANS	-	-	5	-	-	-	-	-	4	4	-	-	12	18	-	-	-	-	-	-
P. JAVANICUM	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	15	-	-
P. LUTEUM	-	-	-	-	-	-	-	-	6	4	-	-	-	-	10	7	-	-	-	-
PYTHIUM SP.	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	20	12	18
RHIZOPUS NIGRICANS	13	7	7	21	-	12	-	10	8	7	-	-	16	27	14	21	39	8	12	18
TRICHODERMA HARZIANUM	14	4	23	16	21	17	22	22	15	13	12	5	18	-	14	12	-	-	12	9
T. LONGIBRACHIATUM	-	-	10	-	-	-	-	-	4	6	-	-	-	-	-	-	-	-	-	-
T. LIGNORUM	-	11	-	-	-	15	4	16	6	7	-	-	-	-	-	4	-	-	-	-
VERTICILIUM SP.	6	4	-	-	2	7	7	3	4	4	2	-	6	4	5	7	-	5	-	-
ZYGORHYNCHUS sp.	-	-	-	-	9	-	-	-	-	6	-	14	-	9	-	-	-	-	-	-
BLACK STERILE MYCELIA	6	11	-	-	-	-	-	11	8	7	-	9	-	-	-	-	31	5	-	-
PINK STERILE MYCELIA	-	11	-	-	-	-	-	-	-	-	5	-	6	-	-	-	-	30	-	-
WHITE STERILE MYCELIA	18	-	17	-	-	16	9	-	5	8	10	14	12	8	10	15	-	-	12	9
YELLOW STERILE MYCELIA	-	-	-	-	30	14	11	-	-	-	9	-	-	-	-	-	-	-	-	-
NUMBER OF SPECIES	8	9	9	7	7	8	10	9	14	14	10	8	10	10	10	10	4	8	7	7

JB = Jhum Burnt, UB = Unburnt

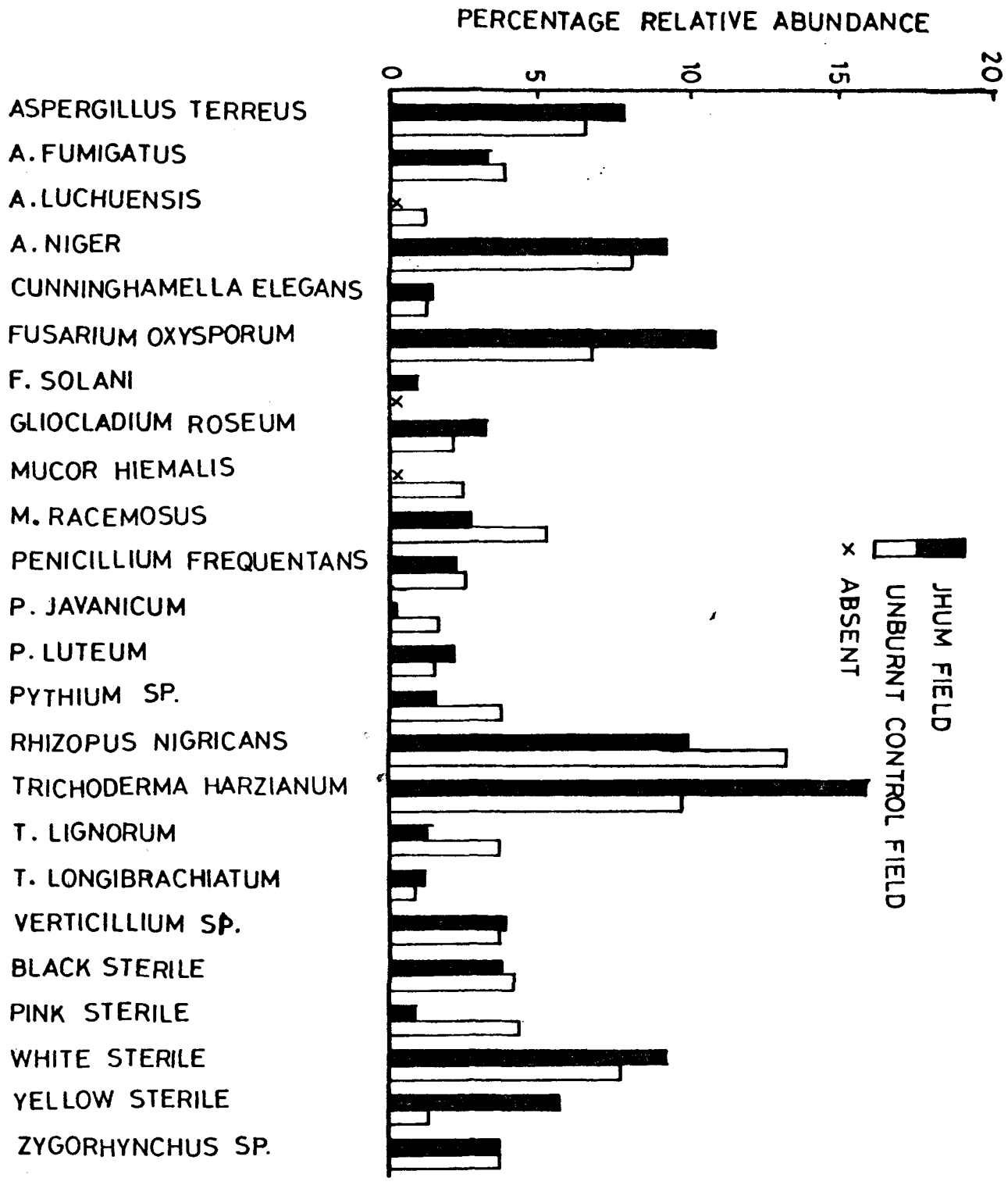


Fig. 17. Relative abundance (%) of individual fungal species in the rhizosphere of PRK in jhum burnt and unburnt control fields.

(Observation is the arithmatical mean of data recorded during 1986-1987).

Table 8b

RELATIVE ABUNDANCE (%) OF INDIVIDUAL FUNGAL SPECIES IN THE RHIZOSPHERE OF PADDY RICE (KEZI) IN JHUM BURNT AND UNBURNT FIELDS

Name of species	Jhum burnt		Mean	Unburnt		Mean
	1986	1987		1986	1987	
ASPERGILLUS FUMIGATUS	4.3	2.0	3.1	5.1	2.5	3.8
A. LUCHUENSIS	-	-	-	-	2.5	1.2
A. NIGER	9.4	9.0	9.2	7.0	9.1	8.0
A. TERREUS	1.5	14.1	7.8	6.0	7.0	6.5
CUNNINGHAMELLA ELEGANS	0.7	2.0	1.3	1.4	1.0	1.2
FUSARIUM OXYSPORUM	13.9	7.5	10.7	9.3	4.1	6.7
F. SOLANI	1.9	-	0.9	-	-	-
GLIOCLADIUM ROSEUM	1.1	5.2	3.1	3.2	1.0	2.1
MUCOR HIEMALIS	-	-	-	1.9	2.9	2.4
M. RACEMOSUS	1.1	4.2	2.6	5.1	5.4	5.2
P. FREQUENTANS	1.9	2.8	2.3	1.4	3.7	2.5
P. JAVANICUM	1.1	-	0.5	-	3.3	1.6
P. LUTEUM	1.5	2.8	2.1	1.4	1.6	1.5
PYTHIUM SP.	-	3.3	1.6	-	7.4	3.7
RHIZOPUS NIGRICANS	4.9	15.0	9.9	11.2	15.3	13.2
TRICHODERMA HARZIANUM	21.8	9.8	15.8	14.4	4.9	9.6
T. LIGNORUM	2.6	-	1.3	7.4	0.8	4.1
T. LONGIBRACHIATUM	2.6	-	1.3	1.9	-	0.9
VERTICILLIUM SP.	4.5	3.3	3.9	3.7	3.7	3.7
ZYGORHYNCHUS SP.	6.0	1.4	3.7	3.7	3.7	3.7
BLACK STERILE MYCELIA	3.0	4.7	3.8	5.6	2.9	4.2
PINK STERILE MYCELIA	-	1.9	0.9	1.4	7.5	4.4
WHITE STERILE MYCELIA	6.8	11.7	9.2	6.0	9.5	7.7
YELLOW STERILE MYCELIA	9.4	2.0	5.7	2.8	-	1.4

Table 9a

PERCENTAGE OCCURRENCE OF FUNGAL SPECIES IN RHIZOSPHERE OF SOYBEAN (LOCAL) FROM JHUM BURNT AND UNBURNT FIELDS

Name of species	1986								1987							
	J		J		A		S		J		J		A		S	
	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB	JB	UB
ASPERGILLUS FUMIGATUS	43	35	-	-	-	-	-	16	-	-	23	8	-	-	-	-
A. NIGER	-	-	-	-	9	-	-	-	14	13	-	-	-	-	14	15
A. TERREUS	-	-	-	21	-	-	18	16	-	-	-	-	-	-	-	-
CUNNINGHAMELLA ELEGANS	-	-	-	-	6	13	12	-	17	-	11	-	-	-	-	-
FUSARIUM OXYSPORUM	-	-	-	-	13	-	-	-	11	13	-	-	-	-	-	9
MUCOR RACEMOSUS	12	18	-	-	-	-	-	-	-	19	-	-	-	-	4	-
M. HIEMALIS	-	-	-	-	-	-	-	-	-	10	-	11	-	-	-	18
PENICILLIUM FREQUENTANS	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
P. JAVANICUM	-	-	-	-	-	11	18	-	-	-	24	11	10	8	-	-
P. LUTEUM	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-
RHIZOPUS NIGRICANS	14	14	55	50	34	22	-	-	22	20	12	28	72	62	73	31
TRICHODERMA HARZIANUM	-	-	-	-	9	16	16	24	8	6	-	-	-	-	-	-
T. LIGNORUM	-	12	27	12	8	11	-	24	6	-	18	17	-	-	-	-
T. LONGIBRACHIATUM	-	-	-	-	-	-	12	-	-	-	-	-	8	-	-	-
VERTICILLIUM SP.	4	3	4	4	-	3	9	9	3	-	6	3	5	8	5	7
ZYGORHYNCHUS SP.	-	-	-	-	-	-	-	-	8	6	6	11	-	8	-	13
BLACK STERILE MYCELIA	-	-	-	13	13	8	-	-	-	-	-	-	5	-	-	-
WHITE STERILE MYCELIA	27	18	-	-	8	16	15	10	11	13	-	11	-	14	4	7
NUMBER OF SPECIES	5	6	5	5	8	8	7	6	9	8	7	8	5	5	5	7

JB = Jhum burnt; UB = Unburnt field

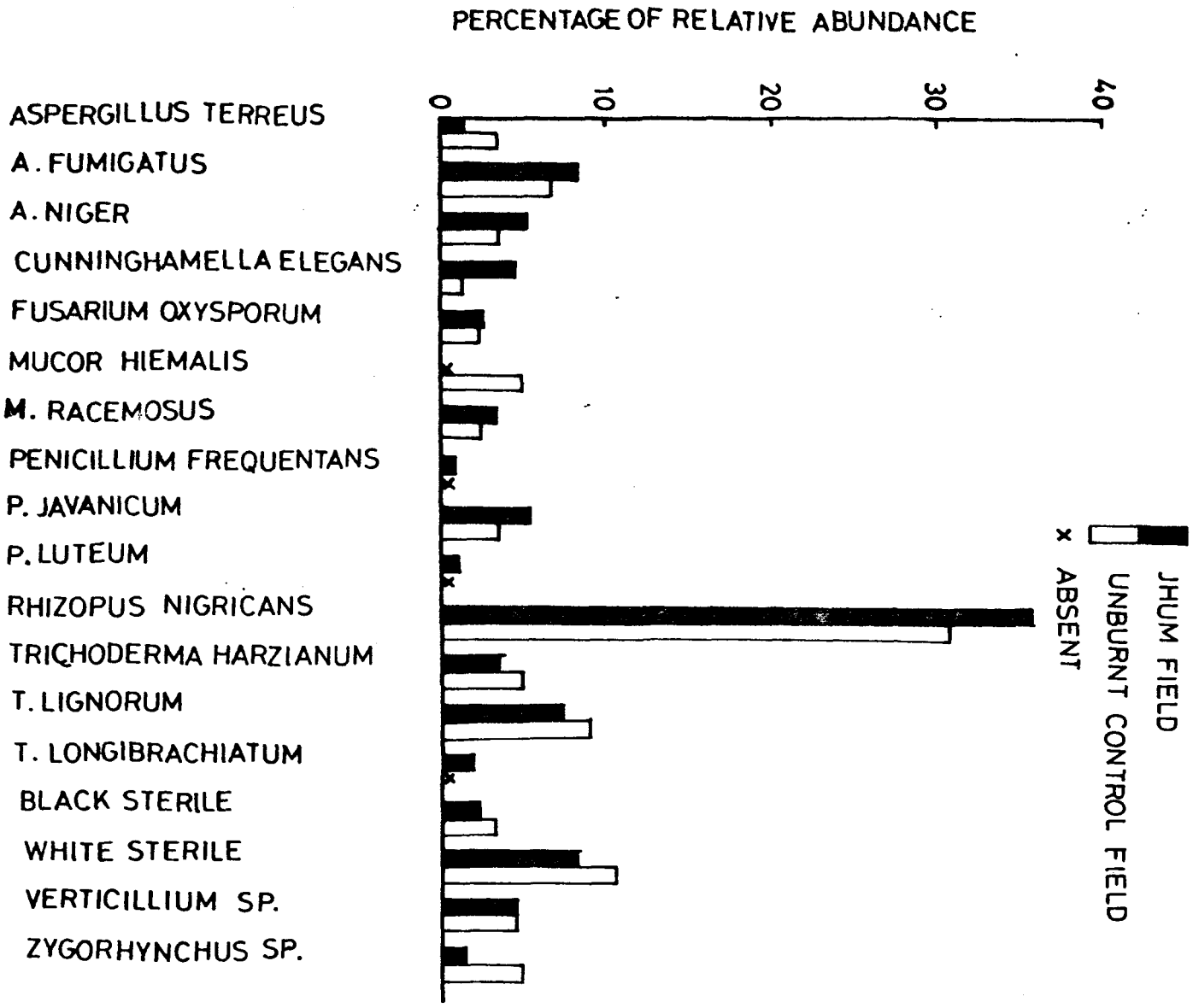


Fig. 18. Relative abundance (%) of individual fungal species in the rhizosphere of SBL in jhum burnt and unburnt fields.

(Observation is the arithematical mean of data recorded during 1986-1987).

Table 9b

RELATIVE ABUNDANCE (%) OF INDIVIDUAL FUNGAL SPECIES IN THE RHIZOSPHERE OF SOYBEAN (LOCAL) IN JHUM BURNT AND UNBURNT FIELDS

Name of species	Jhum burnt		Mean	Unburnt		Mean
	1986	1987		1986	1987	
ASPERGILLUS FUMIGATUS	12.1	4.9	8.5	11.8	2.0	6.9
A. LUCHUENSIS	-	-	-	-	-	-
A. NIGER	2.3	7.9	5.1	-	7.4	3.7
A. TERREUS	3.3	-	1.6	7.2	-	3.6
CUNNINGHAMELLA ELEGANS	3.8	6.1	4.9	3.3	-	1.6
FUSARIUM OXYSPORUM	3.3	2.4	2.8	-	5.4	2.7
MUCOR HIEMALIS	-	-	-	-	10.1	5.5
M. RACEMOSUS	3.3	3.6	3.4	3.9	1.3	2.6
PENICILLIUM FREQUENTANS	1.6	-	0.8	-	-	-
P. JAVANICUM	3.3	7.3	5.3	2.6	4.7	3.6
P. LUTEUM	2.2	-	1.1	-	-	-
P. TURBATUM	-	-	-	-	-	-
RHIZOPUS NIGRICANS	22.5	48.8	35.6	26.1	35.1	30.6
TRICHODERMA HARZIANUM	4.9	1.8	3.3	8.5	1.3	4.9
T. LIGNORUM	9.9	4.9	7.4	13.7	4.0	8.8
T. LONGIBRACHIATUM	2.2	1.8	2.0	-	-	-
VERTICILLIUM SP.	3.8	4.9	4.3	3.9	4.7	4.3
ZYGORHYNCHUS SP.	-	3.0	1.5	-	10.1	5.5
BLACK STERILE MYCELIA	3.3	1.2	2.2	6.5	-	3.2
PINK STERILE MYCELIA	-	-	-	-	-	-
WHITE STERILE MYCELIA	12.6	3.6	8.1	9.8	10.8	10.3
YELLOW STERILE MYCELIA	-	-	-	-	-	-

Table 10

TOTAL NUMBER OF FUNGAL SPECIES ISOLATED FROM THE RHIZOSPHERE, RHIZOPLANE AND NON-RHIZOSPHERE OF LOCAL CULTIVAR OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL) FROM JHUM BURNT AND UNBURNT FIELD (F_1)

Fungal species	Rhizosphere				Rhizoplane				Non-rhizosphere	
	PR(K)		SB (L)		PR (K)		SB (L)		JB	UB
	JB	UB	JB	UB	JB	UB	JB	UB		
ABSIDIA REPENS	-	-	-	-	-	-	-	-	-	+
ALTERNARIA HUMICOLA	-	-	-	-	-	-	-	-	+	+
ASPERGILLUS FUMIGATUS	+	+	+	+	-	-	-	-	+	+
A. LUCHUENSIS	-	+	-	-	+	+	+	+	+	+
A. NIGER	+	+	+	+	-	-	-	-	+	+
A. SYDOWI	-	-	-	-	-	-	-	-	+	+
A. TERREUS	+	+	+	+	-	-	-	-	+	+
CANDIDIA SP.	-	-	-	-	-	-	-	-	+	+
CEPHALOSPORIUM SP.	-	-	-	-	-	-	-	-	+	+
CHAETOMIUM SP.	-	-	-	-	-	-	-	-	-	+
CLADOSPORIUM SP.	-	-	-	-	-	-	-	-	+	+
CHOANEPHORA SP.	-	-	-	-	-	-	-	-	+	+
CUNNINGHAMELA ELEGANS	+	+	+	+	-	-	+	+	-	-
CURVULARIA GENICULATA	-	-	-	-	-	-	-	-	+	+
FUSARIUM MONILIFORME	-	-	-	-	-	-	-	-	+	+
F. OXYSPORUM	+	+	+	+	+	+	+	+	+	+
F. SOLANI	+	-	-	-	-	-	-	-	+	+
GEOTRICHUM SP.	-	-	-	-	-	-	-	-	+	+
GLIOCLADIUM ROSEUM	+	+	-	-	+	+	-	+	+	+
GLIOMISTIX SP.	-	-	-	-	-	-	-	-	+	+
HELMINTHOSPORIUM SP.	-	-	-	-	-	-	-	-	+	+
HUMICOLA SP.	-	-	-	-	-	-	-	-	+	+
HYALOPUS SP.	-	-	-	-	-	-	-	-	+	+
MUCOR HIEMALIS	+	+	-	+	-	-	-	-	+	+
M. RACEMOSUS	+	+	+	+	+	+	+	+	+	+
NEUROSPORA SP.	-	-	-	-	-	-	-	-	+	-
OIDIODENDRON SP.	-	-	-	-	-	-	-	-	+	+
PENICILLIUM FREQUENTANS	+	+	+	-	-	-	+	+	+	+
P. FUNICULOSUM	-	-	-	-	-	-	-	-	+	+
P. GRANULATUM	-	-	-	-	-	-	-	-	+	+
P. JAVANICUM	+	+	+	+	+	+	+	+	+	+
P. LUTEUM	+	+	+	-	+	-	+	+	+	+
P. PURPUROGENUM	-	-	-	-	-	-	-	-	+	+
P. RESTRICTUM	-	-	-	-	-	-	-	-	+	+
P. TURBATUM	-	-	-	-	-	-	-	-	+	+
P. VARIABILE	-	-	-	-	-	-	-	-	-	+
PESTOLATIA SP.	-	-	-	-	-	-	-	-	-	+
PHOMA SP.	-	-	-	-	-	-	-	-	+	-
PYTHIUM SP.	+	+	-	-	+	+	-	-	+	+
RHIZOPUS NIGRICANS	+	+	+	+	+	+	+	+	+	+
RHIZOPUS SP.	-	-	-	-	-	-	-	-	+	+
SCLEROTIUM SP.	-	-	-	-	-	-	-	-	+	+
SCLEROTIUM ROLFSII	-	-	-	-	-	-	-	-	-	-
SPICARIA SP.	-	-	-	-	-	-	-	-	+	+
THIELAVIA TERRICOLA	-	-	-	-	-	-	-	-	+	+
THIELAVIOPSIS SP.	-	-	-	-	-	-	-	-	+	+
TORULA SP.	-	-	-	-	-	-	-	-	+	+
TRICHODERMA HARZIANUM	+	+	+	+	+	+	+	+	+	+
T. LIGNORUM	+	+	+	+	+	+	-	-	+	+
T. LONGIBRACHIATUM	+	+	+	-	+	-	-	-	+	+
VERTICILLIUM SP.	+	+	+	+	+	+	+	+	+	+
ZYGORHYNCHUS SP.	-	+	+	+	+	+	+	+	+	+
BLACK STERILE MYCELIA	+	+	+	+	+	+	+	+	+	+
PINK STERILE MYCELIA	+	+	-	-	+	+	+	+	+	+
WHITE STERILE MYCELIA	+	+	+	+	+	+	+	+	+	+
YELLOW STERILE MYCELIA	-	+	-	-	-	-	-	-	+	+
NUMBER OF SPECIES	21	23	17	15	16	14	14	15	50	51

JB = Jhum burnt field, UB = Unburnt field, + = Present, - = Absent

Table 11a

NUMBER OF FUNGAL (THOUSAND), ACTINOMYCETES (LAKH), BACTERIA (LAKH) PER GRAM DRY SOIL AT SURFACE AND SUB-SOIL LEVELS OF JHUM BURNT AND CONTROL FOREST ECOSYSTEM

(Each figure is average mean population of three locations (fields)

Months	Type of Micro-organisms	Jhum burnt		Control forest		Jhum burnt		Control forest	
		1986	1987	1986	1987	1986	1987	1986	1987
	Fungi	4.6	5.8	6.7	6.3	5.0	5.0	5.8	5.7
Mar.	Actinomycetes	3.3.	5.0	5.4	4.8	3.1	3.5	4.2	3.9
	Bacteria	5.2	7.4	9.4	11.1	4.9	6.4	7.4	9.2
	Fungi	6.0	6.3	6.9	6.5	5.3	6.1	6.0	6.3
Apr.	Actinomycetes	3.6	6.6	5.8	6.4	3.6	5.1	5.2	5.1
	Bacteria	6.8	10.1	7.3	9.2	5.5	6.4	7.2	7.1
	Fungi	6.9	8.2	8.5	7.8	6.2	7.0	7.6	7.9
May	Actinomycetes	4.4	6.4	11.8	5.9	4.2	4.9	9.0	5.6
	Bacteria	14.3	17.6	12.9	16.3	15.0	14.5	14.4	15.8
	Fungi	7.3	6.5	7.4	6.8	6.6	6.4	6.4	6.7
Jun.	Actinomycetes	6.8	6.8	11.4	7.8	6.3	6.0	10.4	6.5
	Bacteria	10.9	9.3	11.6	12.6	10.1	11.2	13.5	12.2
	Fungi	9.2	6.6	7.5	7.2	7.3	5.8	6.9	7.2
Jul.	Actinomycetes	9.8	9.2	11.3	10.0	9.0	8.0	10.1	10.2
	Bacteria	8.6	8.9	10.6	11.5	8.5	8.1	9.5	9.7
	Fungi	7.2	6.2	7.8	7.0	6.4	5.6	7.2	7.3
Aug.	Actinomycetes	8.9	8.0	10.6	9.6	8.3	7.0	9.5	8.7
	Bacteria	9.1	16.1	11.0	15.0	9.6	13.2	9.4	14.2
	Fungi	5.9	5.6	7.5	6.6	5.7	5.2	6.8	6.2
Sep.	Actinomycetes	8.5	7.4	10.2	8.8	7.7	6.5	8.5	7.9
	Bacteria	9.3	15.5	10.9	14.3	9.6	12.3	9.0	14.2

Table 11b

NUMBER OF FUNGAL SPECIES OF SURFACE AND SUB-SOIL LEVELS OF JHUM BURNT AND CONTROL FOREST ECOSYSTEM FROM THREE DIFFERENT LOCATIONS (FIELDS)

Months	Locations (Fields)	Surface soil				Sub-Soil			
		Jhum burnt		Control forest		Jhum burnt		Control forest	
		1986	1987	1986	1987	1986	1987	1986	1987
	F_1 C_1	10	11	13	19	13	11	14	12
Mar.	F_2 C_2	14	15	19	18	16	17	20	21
	F_3 C_3	13	15	17	18	17	17	18	21
	F_1 C_1	14	12	28	26	14	12	20	22
Apr.	F_2 C_2	20	18	16	16	19	16	17	18
	F_3 C_3	16	19	18	16	18	18	18	17
	F_1 C_1	14	13	22	19	14	10	15	9
May	F_2 C_2	16	16	16	16	18	16	14	17
	F_3 C_3	13	17	16	15	21	18	18	18
	F_1 C_1	21	15	19	18	10	9	11	13
Jun.	F_2 C_2	17	6	18	17	19	18	18	18
	F_3 C_3	14	14	18	17	20	17	19	17
	F_1 C_1	31	17	19	22	22	11	18	11
Jul.	F_2 C_2	18	20	15	21	14	17	14	18
	F_3 C_3	16	21	20	23	16	19	14	20
	F_1 C_1	11	21	22	22	9	10	13	13
Aug.	F_2 C_2	12	19	16	15	15	18	16	19
	F_3 C_3	10	21	8	18	7	19	8	17
	F_1 C_1	15	17	18	27	11	8	14	17
Sep.	F_2 C_2	12	19	16	15	15	15	14	14
	F_3 C_3	9	20	8	17	7	15	7	13

Table 11c

TOTAL NUMBER OF FUNGAL SPECIES ISOLATED FROM JHUM BURNT AND CONTROL FOREST SOILS

Name of species	Jhum burnt			Control forest		
	F_1	F_2	F_3	E_1	E_2	C_3
ABSIDIA REPENS	-	+	+	+	+	+
ALTERNARIA HUMICOLA	+	+	-	+	+	-
ASPERGILLUS FUMIGATUS	+	+	+	+	+	+
A. LUCHUENSIS	+	+	+	+	+	-
A. NIGER	+	+	+	+	+	+
A. SYDOWI	+	+	+	+	+	+
A. TERREUS	+	+	+	+	+	+
CANDIDA SP.	-	+	+	+	+	+
CEPHALOSPORIUM SP.	+	+	+	+	+	+
CHAETOMIUM SP.	-	-	-	+	+	-
CHOANEPHORA SP.	+	+	+	+	-	+
CLADOSPORIUM SP.	+	+	+	+	+	+
CURVULARIA GENICULATA	+	+	+	+	+	-
FUSARIUM MONILIFORME	+	+	+	+	+	+
F. OXYSPORUM	+	+	+	+	+	+
F. SOLANI	+	+	+	+	+	+
GEOTRICHUM SP.	+	+	+	+	+	+
GLIOCLADIUM ROSEUM	+	+	+	+	+	+
GLIOMASTIX SP.	+	+	-	+	+	
HELMINTHOSPORIUM SP.	+	+	+	+	+	+
HUMICOLA SP.	+	+	+	+	+	+
HYALOPUS SP.	+	-	-	+		
MUCOR HIEMALIS	+	+	+	+	+	+
M. RACEMOSUS	+	+	+	+	+	+
NEUROSPORA SP.	+	+	+	-	-	-
OIDIODENDRON SP.	+	-	-	+	-	+
PENICILLIUM FREQUENTANS	+	+	+	+	+	+
P. GRANULATUM	+	+	+	+	+	+
P. JAVANICUM	+	+	-	+	+	
P. FUNICULOSUM	+	-	-	+	-	-
P. LUTEUM	+	+	+	+	+	+
P. PURPUROGENUM	+	-	-	+	-	-
P. RESTRICTUM	+	+	+	+	+	+
P. TURBATUM	+	+	+	+	+	+
P. VARIABILE	-	+	-	-	-	-

(Contd.)

Table 11c Contd.

Name of species	Jhum burnt			Control forest		
	F_1	F_2	F_3	C_1	C_2	C_3
PESTOLATIA SP.	+	-	+	+	-	-
PYTHIUM SP.	+	+	-	+	+	-
RHIZOPUS NIGRICANS	+	+	+	+	+	+
RHIZOPUS SP.	+	+	+	+	+	+
SCLEROTIUM ROLFSII	-	-	-	-	+	-
SCLEROTIUM SP.	+	+	+	+	+	+
SPICARIA SP.	+	-	-	-	-	-
THIELAVIA TERRICOLA	+	+	-	+	+	+
THIELAVIOPSIS SP.	+	-	+	+	+	+
TORULA SP.	+	-	+	+	-	-
TTRICHODERMA HARZIANUM	+	+	+	+	+	+
T. LIGNORUM	+	+	+	+	+	+
T. LONGIBRACHIATUM	+	+	+	+	-	+
VERTICILLIUM SP.	+	+	+	+	+	+
ZYGORHYNCHUS SP.	+	+	+	+	+	+
BLACK STERILE MYCELIA	+	+	+	+	+	+
PINK STERILE MYCELIA	+	+	+	+	+	+
WHITE STERILE MYCELIA	+	+	+	+	+	+
YELLOW STERILE MYCELIA	+	+	+	+	+	+
PHOMA SP.	-	+	-	-	-	+
NUMBER OF SPECIES	49	45	41	49	44	40

+ = Present, - = Abesent

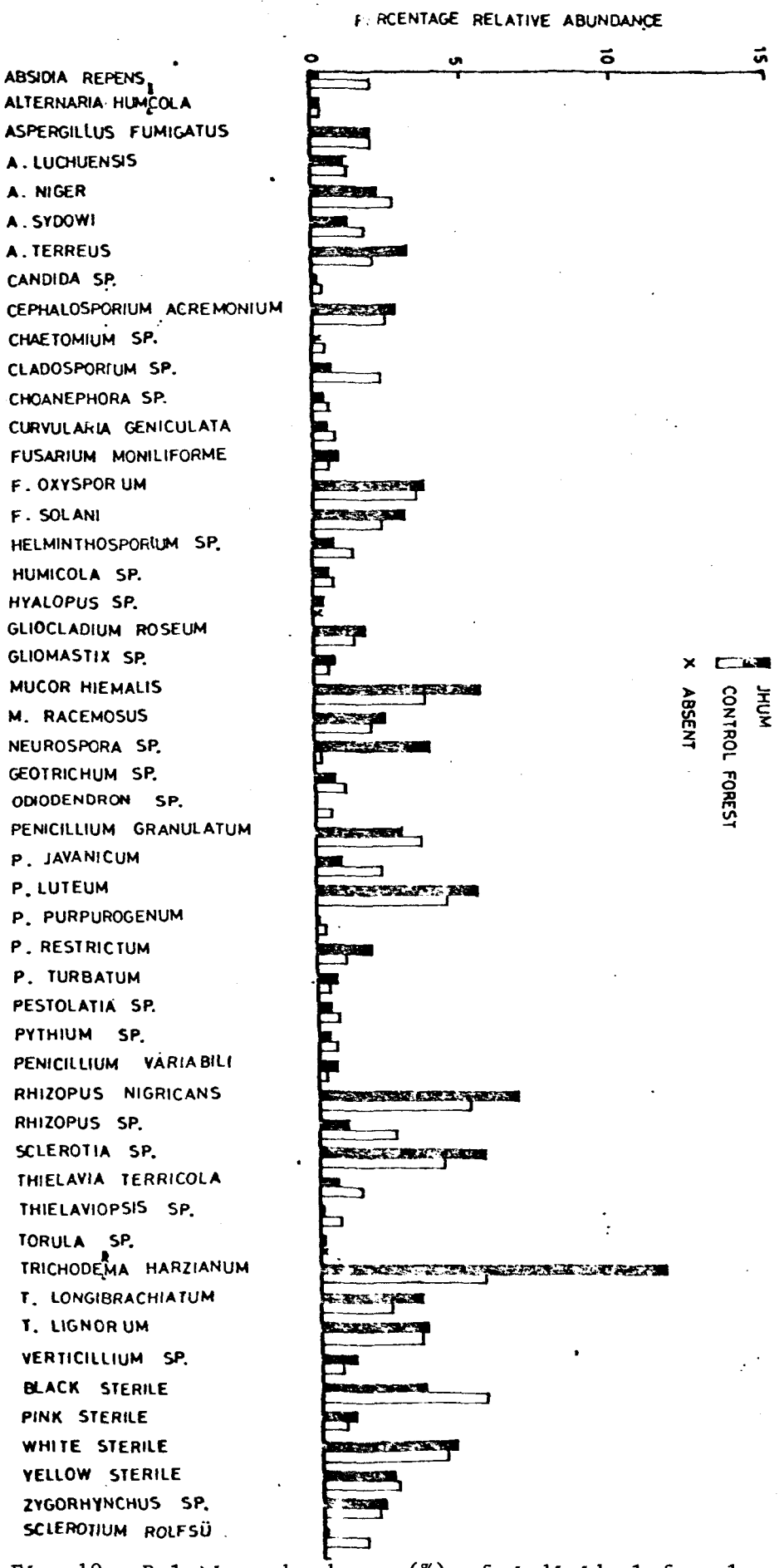


Fig. 19. Relative abundance (%) of individual fungal species in jhum burnt and control forest soil.

(Observation is the arithematical mean of data recorded during 1986-1987).

Table 11d

RELATIVE ABUNDANCE (%) OF INDIVIDUAL FUNGAL SPECIES IN JHUM BURNT AND CONTROL FOREST SOILS

Name of species	Jhum burnt			Mean	Control forest			Mean
	F_1	F_2	F_3		C_1	C_2	C_3	
ABSIDIA REPENS	0.1	-	0.7	0.2	1.4	2.5	2.2	2.3
ALTERNARIA HUMICOLA	-	0.6	-	0.2	0.3	0.3	-	0.2
ASPERGILLUS FUMIGATUS	1.0	3.0	2.0	2.0	1.1	4.0	1.0	2.0
A. LUCHUENSIS	0.6	2.1	0.5	1.6	0.2	3.2	-	1.1
A. NIGER	1.5	2.7	2.1	2.1	2.7	3.3.	1.8	2.6
A. SYDOWI	1.5	1.0	0.9	1.1	2.7	1.4	0.6	1.5
A. TERREUS	2.4	3.6	3.3.	3.1	0.9	3.8	1.4	2.0
CANDIDA SP.	0.1	0.2	0.0	0.1	0.1	q1.2	0.0	0.4
CEPHALOSPORIUM SP.	1.7	4.0	2.6	2.7	0.5	3.5	3.4	2.4
CHAETOMIUM SP.	0.0	0.0	0.0	0.0	0.5	0.3	0.0	0.2
CHOANEPHORA SP.	0.4	0.0	0.4	0.2	0.8	0.0	0.5	0.4
CURVULARIA GENICULATA	0.0	1.4	0.0	0.4	0.3	1.4	0.0	0.5
FUSARIUM MONILIFORME	0.1	2.0	0.0	0.7	0.1	1.0	0.5	0.5
F. OXYSPORUM	4.2	3.5	3.8	3.8	3.5	4.3	3.3.	3.7
F. SOLANI	4.5	3.5	1.0	3.0	1.7	2.8	2.1	2.2
GLIOCLADIUM ROSEUM	1.4	1.5	1.8	1.5	0.3	2.1	1.6	1.0
GLIOMISTIX SP.	0.7	0.5	0.0	0.4	0.8	0.1	0.6	0.5
HELMINTHOSPORIUM SP.	0.4	0.4	0.9	0.5	1.1	1.0	1.5	1.2
HUMICOLA SP.	0.4	0.0	0.5	0.3	0.6	0.5	0.0	0.4
HYALOPUS SP.	0.6	0.0	0.0	0.2	0.0	0.0	0.0	0.0
MUCOR HIEMALIS	6.3	4.7	5.2	5.4	4.5	2.6	4.1	3.7
M. RACEMOSUS	1.5	1.5	3.9	2.3	1.1.	3.0	1.6	1.9
NEUROSPORA SP.	3.6	3.0	5.0	3.9	0.0	0.0	0.0	0.0
GEOTRICHUM SP.§	0.3	1.6	0.0	0.6	1.4	1.6	0.2	1.0
OIDIODENDRON SP.	0.0	0.0	0.0	0.0	0.3	0.0	1.1	0.4
PENICILLIUM FREQUENTANS	1.5	1.0	1.1	1.2	3.3.	2.6	3.1	3.0
P. GRANULATUM	2.2	3.7	3.0	3.0	3.2	2.9	3.8	3.3
P. JAVANICUM	2.2	0.5	0.0	0.9	2.4	3.9	0.0	2.1
P. LUTEUM	9.3	3.2	3.1	5.2	8.3	3.1	1.6	4.0
P. PURPUROGENUM	0.1	0.0	0.0	0.0	0.6	0.0	0.0	0.2
P. RESTRICTUM	2.9	1.4	1.5	1.9	2.7	0.5	0.0	1.0
P. TURBATUM	0.3	1.1	0.8	0.7	0.8	0.0	0.6	0.4
P. VARIABILE	0.1	1.2	0.0	0.4	0.1	0.6	0.0	0.2

(Contd.)

Table 11d Contd.

Name of species	Jhum burnt			Mean	Control forest			Mean
	F_1	F_2	F_3		C_1	C_2	C_3	
PESTOLATIA SP.	0.7	0.0	0.3	0.3	1.3	0.0	0.0	0.4
PYTHIUM SP.	0.1	0.0	0.0	0.0	0.3	1.0	0.0	0.4
RHIZOPUS NIGRICANS	6.3	7.5	5.3	6.9	4.3	5.8	5.0	5.0
RHIZOPUS SP.	1.0	2.1	0.0	1.0	4.4	2.2.	1.2	2.9
SCLEROTIUM ROLFSII	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.4
SCLEROTIUM SP.	6.3	6.6	3.5	5.4	6.2	2.4	3.7	4.1
THIELAVIA TERRICOLA	0.3	1.6	0.0	0.6	1.9	1.7	0.7	1.4
THIELAVIOPSIS SP.	0.1	0.0	0.0	0.0	0.1	1.0	0.0	0.3
TORULA SP.	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0
TRICHODERMA HARZIANUM	13.9	6.7	13.9	11.5	7.5	2.1	6.6	5.4
T. LIGNORUM	4.9	2.9	2.3	3.3	3.2	2.0	4.7	3.3
T. LONGIBRACHIATUM	6.7	0.0	3.1	3.3	4.5	0.0	2.2	2.2
VERTICILLIUM SP.	1.1	1.6	0.4	1.0	1.1	0.4	0.4	0.6
ZYGORHYNCHUS SP.	0.0	2.1	3.6	1.9	0.0	2.6	3.3	2.6
BLACK STERILE MYCELIA	3.1	3.9	3.5	3.5	5.1	6.9	3.9	5.3
PINK STERILE MYCELIA	2.5	0.2	0.6	1.1	1.7	0.0	0.5	0.7
WHITE STERILE MYCELIA	6.7	2.8	3.5	4.0	7.1	1.3	4.3	4.3
YELLOW STERILE MYCELIA	0.7	2.6	3.3	2.2	2.1	0.3	4.5	2.3

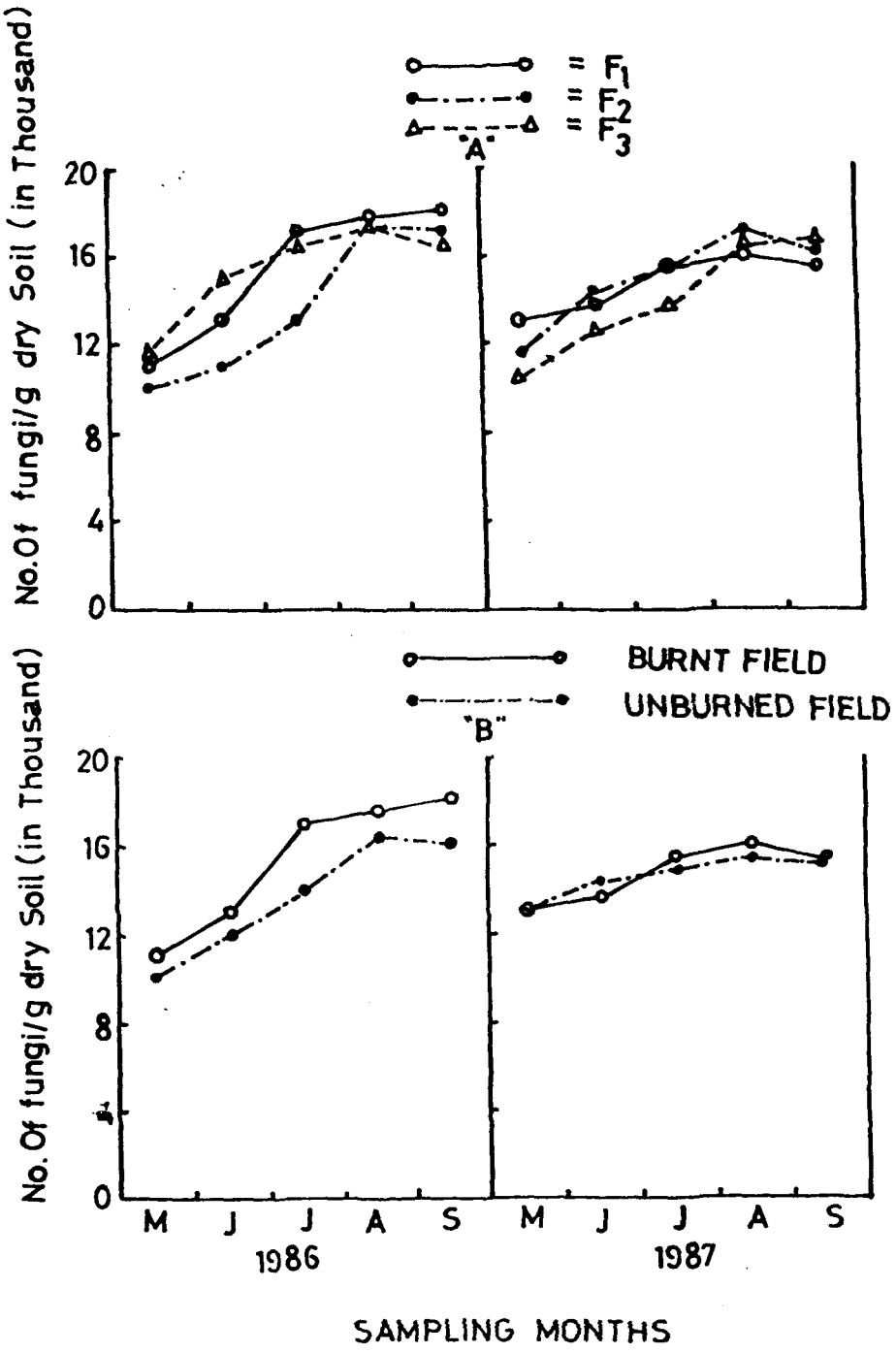


Fig. 9A Rhizosphere mycoflora of PRK from different jhum fields.

Fig. 9B Comparison of rhizosphere mycoflora of PRK in jhum burnt and unburnt fields.

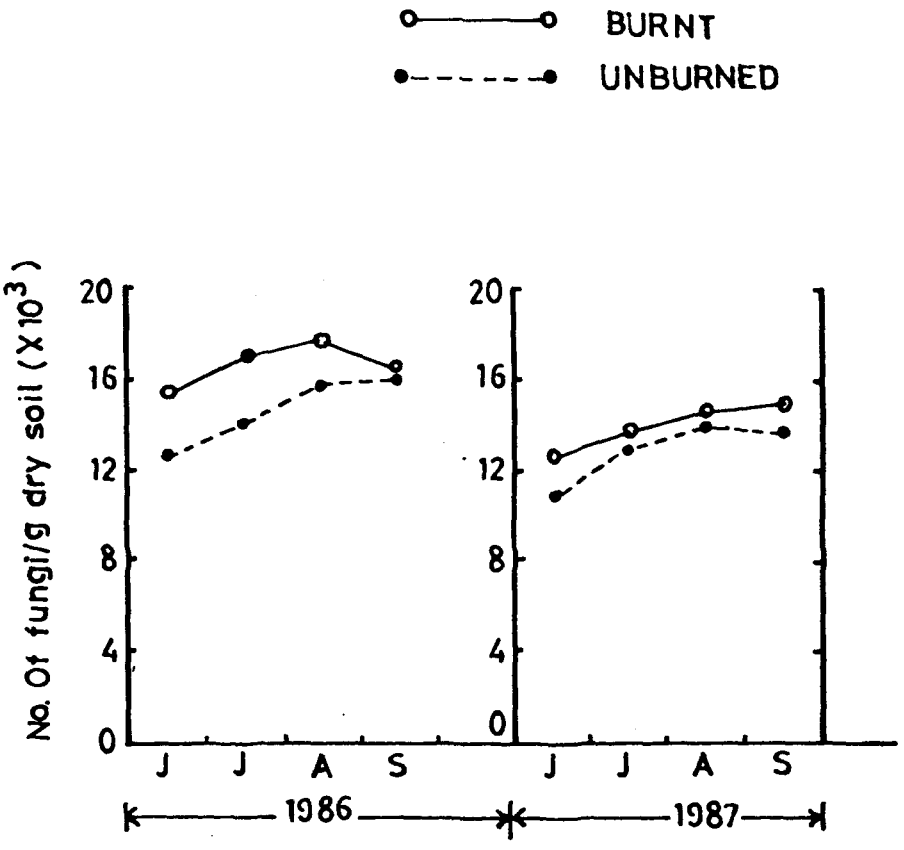


Fig. 10. Comparison of rhizosphere mycoflora of SBL in jhum burnt and unburnt field.

Table 12

AVERAGE NUMBER OF FUNGI/G DRY SOIL (THOUSAND) IN RHOZOSPHERE, NON RHIZOSPHERE, NUMBER OF SPECIES IN RHIZOSPHERE, RHIZOPLANE AND NON-RHIZOSPHERE AND R/S RATIO OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL) FROM JHUM BURNT AND UNBURNT PLOTS OF F_1

Year	Month	Plots	PADDY RICE				SOYBEAN				NON-RHIZOSPHERE	
			No./g	No. of Rh spp.	No.of Rp spp.	R/S ratio	No./g	No.of Rh spp.	No.of Rp spp.	R/S ratio	No./g	No.of spp.
1	May	JB	11.2	8	6	1.0	-	-	-	-	10.5	20
		UB	10.4	9	3	2.0	-	-	-	-	5.1	15
	Jun.	JB	12.8	9	5	1.2	15.6	5	5	1.5	10.4	25
		UB	12.4	7	4	1.3	12.6	6	6	1.3	9.5	15
9	Jul.	JB	17.1	7	5	1.2	16.9	5	5	1.2	13.6	35
8		UB	14.2	8	4	1.4	14.1	5	5	1.3	10.1	18
6	Aug.	JB	17.4	10	6	1.9	17.4	8	5	1.9	9.0	13
		UB	16.6	9	3	2.0	16.8	8	5	1.9	8.0	15
	Sep.	JB	18.3	14	7	2.1	15.8	7	7	1.8	8.6	17
		UB	16.4	14	6	2.5	16.1	6	5	2.5	6.4	16
1	May	JB	13.3	10	5	1.1	-	-	-	-	11.2	15
		UB	13.1	8	7	1.5	-	-	-	-	8.6	13
	Jun.	JB	13.6	10	6	1.3	12.7	9	7	1.2	10.2	19
		UB	14.5	10	6	1.4	10.9	8	5	1.0	10.3	12
9	Jul.	JB	15.7	10	6	1.4	13.8	7	7	1.2	11.2	20
8		UB	15.4	10	6	2.2	13.2	8	6	1.8	7.0	14
7	Aug.	JB	16.0	4	6	1.5	14.4	5	8	1.3	10.4	25
		UB	15.7	8	4	1.8	14.0	5	6	1.6	8.6	14
	Sep.	JB	15.0	7	5	1.5	15.5	5	8	1.5	10.0	22
		UB	15.2	7	5	1.5	13.9	7	5	1.4	9.8	12

JB = Jhum burnt, UB = Unburnt field

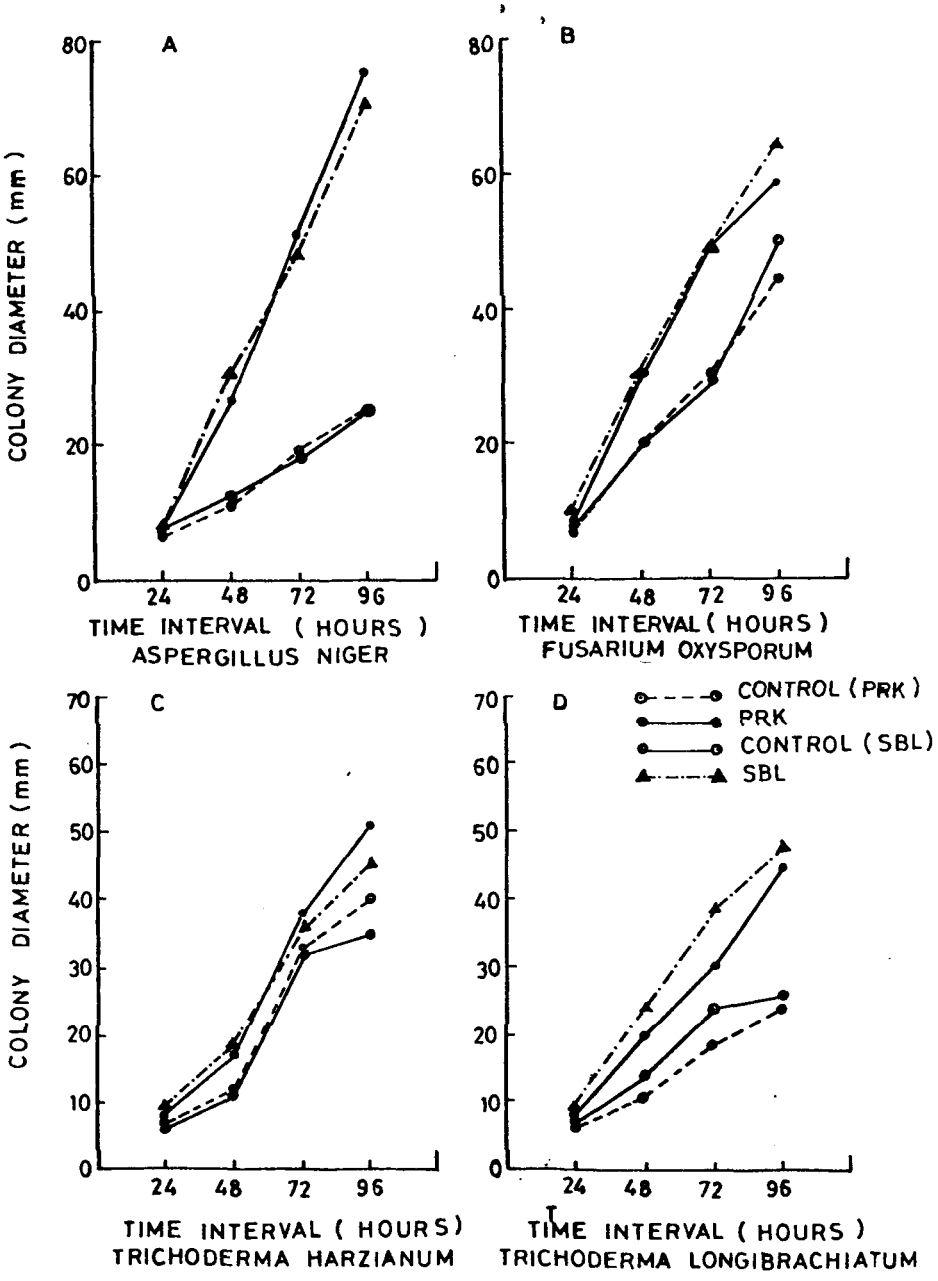


Fig. 11. Effect of root- extracts of PRK and SBL on linear growth of some dominant fungi.

Table 13

EFFECT OF ROOT-EXTRACTS OF PADDY RICE (PRK) AND SOYBEAN (SBL) ON LINEAR GROWTH OF SOME DOMINANT RHIZOSPHERE FUNGI

Fungal species	Treatments	Average colony diameter (mm) Time interval (hours)			
		24	48	72	96
ASPERGILLUS NIGER	Control	6.5	11.0	19.0	25.0
	PRK	8.0	26.5	53.0	75.0
	Control	7.0	12.0	18.0	25.0
	SBL	8.0	30.5	48.0	73.0
FUSARIUM OXYSPORUM	Control	7.0	20.0	32.0	45.0
	PRK	9.0	32.0	49.5	59.5
	Control	8.0	20.0	31.0	53.0
	SBL	10.0	31.0	49.0	65.0
TRICHODERMA HARZIANUM	Control	7.0	12.0	33.0	38.0
	PRK	8.0	17.5	38.0	53.0
	Control	6.5	11.5	32.0	35.0
	SBL	9.0	18.0	3.6	45.5
T. LONGIBRACHIATUM	Control	6.5	11.0	19.0	24.0
	PRK	8.0	20.0	30.5	45.0
	Control	7.0	14.0	24.0	26.0
	SBL	9.0	24.0	38.5	47.3

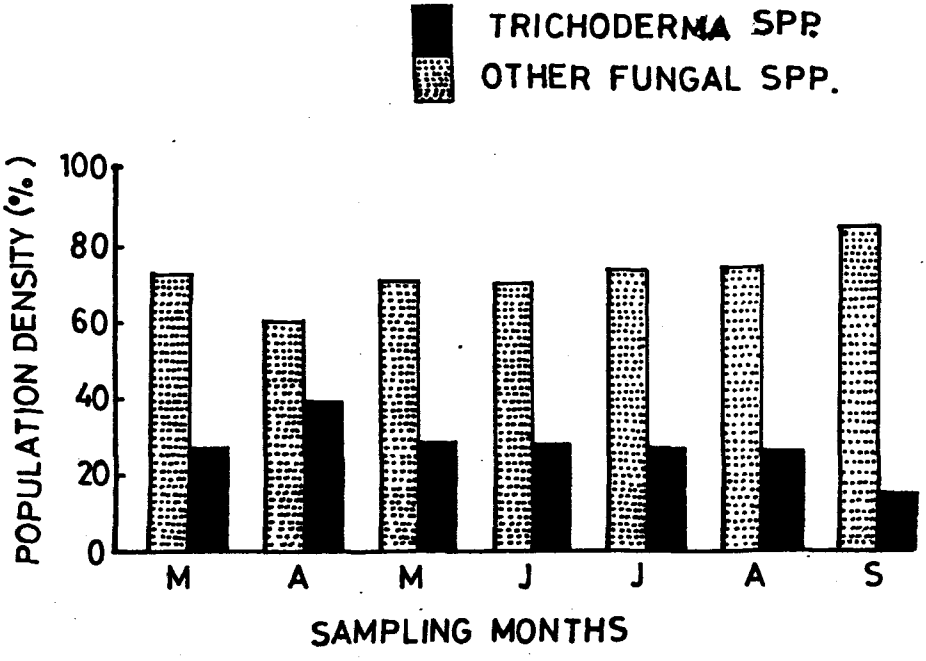


FIG.15. POPULATION DENSITY OF TRICHODERMA SPP. AND OTHER FUNGAL SPP. IN JHUM LAND.

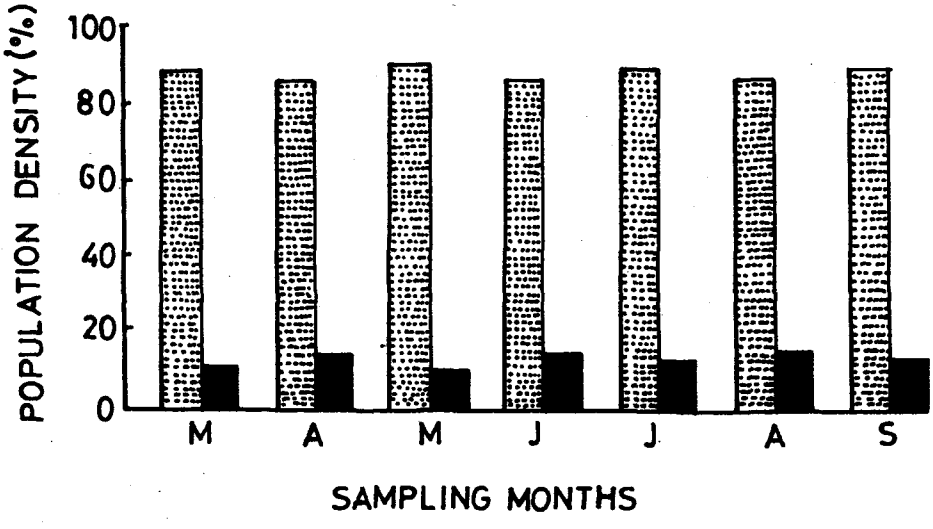


FIG.16. POPULATION DENSITY OF TRICHODERMA SPP. AND OTHER FUNGAL SPP. IN FOREST LAND.

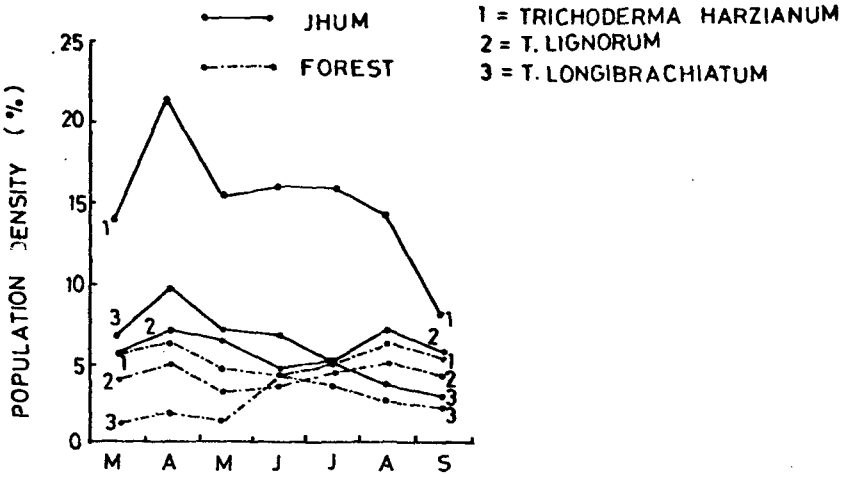


FIG.13. POPULATION OF T. HARZIANUM, T. LIGNORUM AND T. LONGIBRACHIATUM IN JHUM AND FOREST LAND.

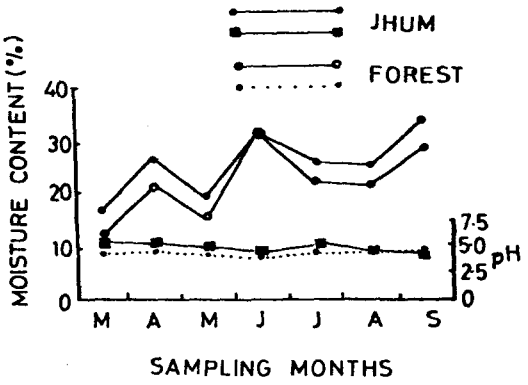


FIG.14. MOISTURE CONTENT AND pH OF SURFACE IN JHUM AND FOREST LAND.

Table 14

POPULATION DENSITY (%) OF TRICHODERMA SPP. IN JHUM BURNT SOIL

Sampling months	T. HARZIANUM	T.LIGNORUM	T.LONGIBRACHIATUM	Total	Other fungal spp.
Mar.	14.09	5.84	6.68	26.61	73.39
Apr.	21.52	7.14	10.20	38.86	61.14
May	15.21	6.61	6.89	28.71	71.29
Jun.	16.94	4.83	6.89	28.66	71.34
Jul.	16.93	5.05	4.95	26.93	73.07
Aug.	14.78	7.46	4.00	26.24	73.76
Sep.	6.52	5.48	3.44	15.44	84.56

Table 15

POPULATION DENSITY (%) OF TRICHODERMA SPP. IN CONTROL FOREST SOIL

Sampling months	T. HARZIANUM	T.LIGNORUM	T.LONGIBRACHIATUM	Total	Other fungal spp.
Mar.	5.74	3.86	1.40	11.00	89.00
Apr.	6.25	5.04	2.00	13.29	86.71
May	4.56	2.87	1.38	8.81	91.19
Jun.	4.44	4.09	4.09	12.62	87.38
Jul.	5.03	3.08	3.38	11.49	88.51
Aug.	6.49	5.08	2.87	14.44	85.56
Sep.	6.24	4.49	2.84	13.57	86.43

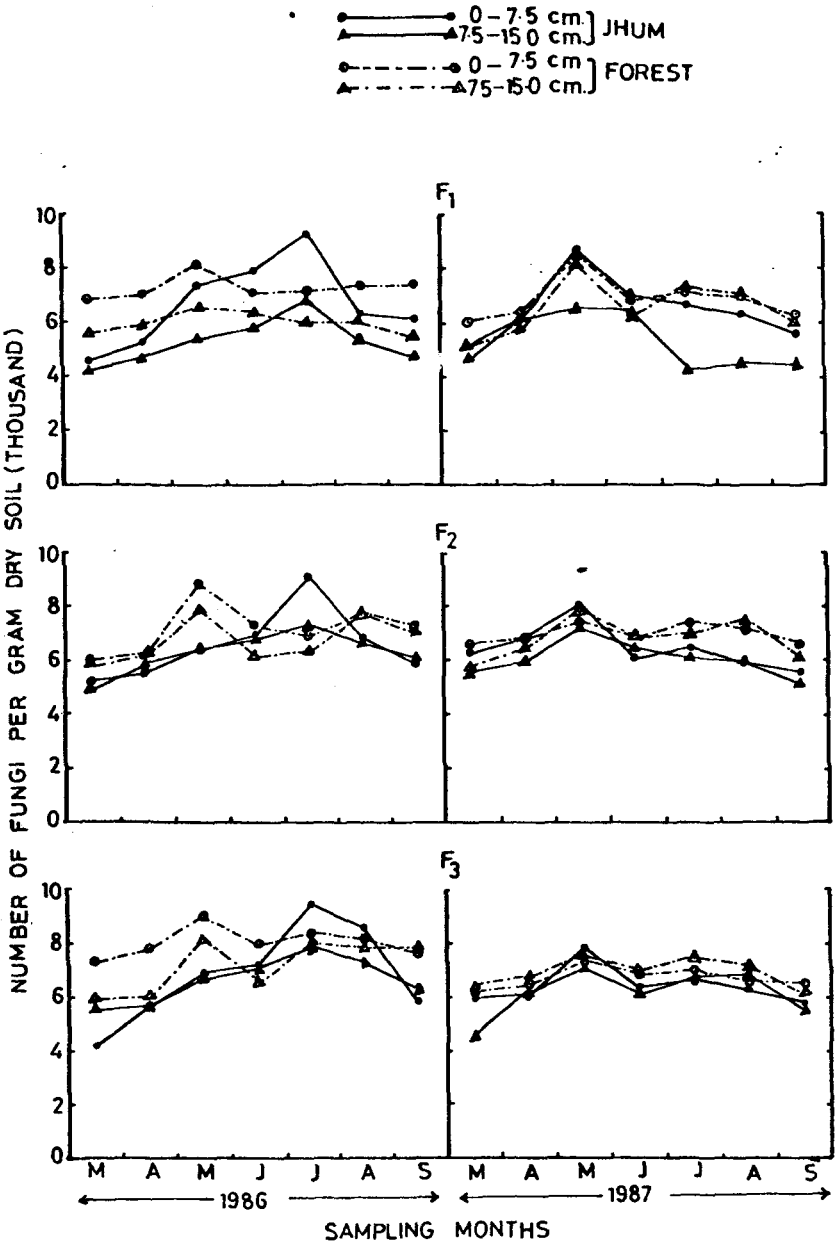


Fig. 6. Population of fungi in different jhum burnt and control forest soils.

Table 16

AVERAGE NUMBER OF FUNGI/G DRY SOIL (THOUSAND) IN JHUM BURNT SURFACE SOILS

Months	1986 Fields			Mean	1987 Fields			Mean
	F_1	F_2	F_3		F_1	F_2	F_3	
Mar.	4.5	5.2	4.1	4.6	5.2	6.3	6.0	5.8
Apr.	5.2	5.5	5.7	6.0	6.2	6.7	6.1	6.3
May	7.4	6.4	6.9	6.9	8.7	8.1	7.9	8.2
Jun.	7.8	6.9	7.2	7.3	7.0	6.1	6.4	6.5
Jul.	9.3	8.9	9.5	9.2	6.7	6.5	6.6	6.6
Aug.	6.4	6.8	8.7	7.2	6.4	5.8	6.3	6.2
Sep.	6.3	5.8	5.7	5.9	5.6	5.6	5.7	5.6
Mean	6.7	6.5	6.8		6.5	6.5	6.4	

LSD for months at 5% = 1.2
LSD for fields at 5% = 1.1

LSD for months at 5% =0.6
LSD for fields at 5% = 0.6

ANALYSIS OF VARIANCE

Source of Variance	1986 D.F.	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	0.35	0.17	0.4	2	0.06	0.03	0.21
Months	6	40.95	6.82	17.2**	6	13.03	2.17	14.57**
Error	12	4.75	0.39		12	1.78	0.14	
Total	20	46.05			20	14.87		

** Significant at 5% level

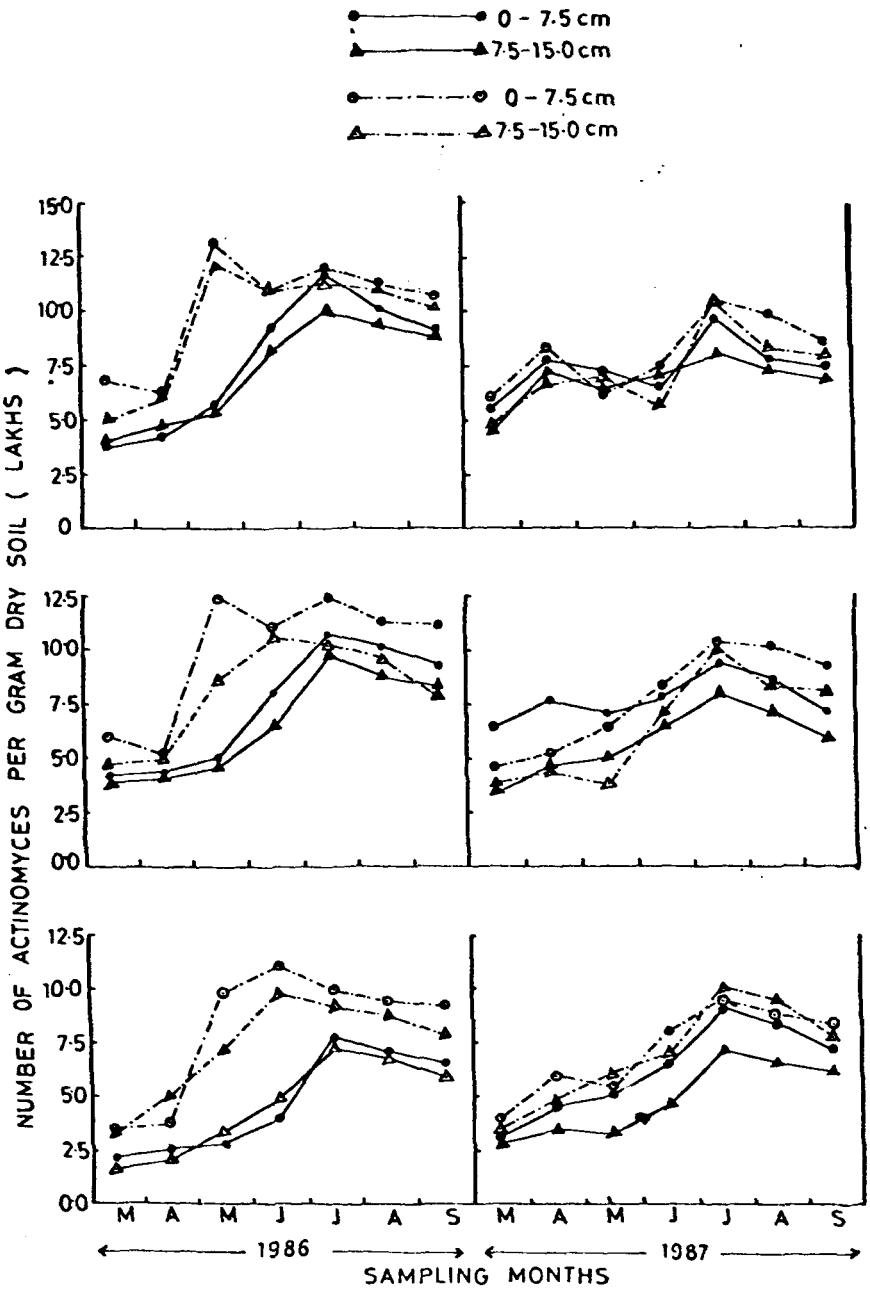


Fig. 7. Population of actinomycetes in jhum burnt and control forest soils.

Table 17

AVERAGE NUMBER OF ACTINOMYCETES/G DRY SOIL (LAKH) IN JHUM BURNT SURFACE SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	F_1	F_2	F_3		F_1	F_2	F_3	
Mar.	3.6	4.1	2.1	3.3	5.5	6.3	3.2	5.0
Apr.	4.2	4.2	2.5	3.6	7.6	7.6	4.5	6.6
May	5.6	4.9	2.6	4.4	7.4	6.8	5.0	6.4
Jun.	9.3	7.7	3.5	6.8	6.5	7.7	6.2	6.8
Jul	11.3	10.6	7.6	9.8	9.5	9.1	9.0	9.2
Aug.	9.6	10.1	7.0	8.9	7.7	8.0	8.3	8.0
Sep.	9.3	9.7	6.9	8.5	7.5	7.3	7.3	7.4
Mean	7.6	7.3	4.6		7.4	7.5	6.2	

LSD for months at 5% = 2.3
LSD for fields at 5% = 1.3

LSD for months at 5% = 1.5
LSD for fields at 5% = 1.5

ANALYSIS OF VARIANCE

Source of variance	1986 D.F	1986 S.S	1986 M.S.S	1986 F	1987 D.F	1987 S.S	1987 M.S.S	1987 F
Fields	2	37.89	18.94	32.8**	2	7.37	3.68	4.95**
Months	6	134.26	22.37	38.7**	6	31.63	5.27	7.08**
Error	12	6.92	0.57		12	8.93	0.74	
Total	20	179.07			20	47.93		

** Significance at 5% level

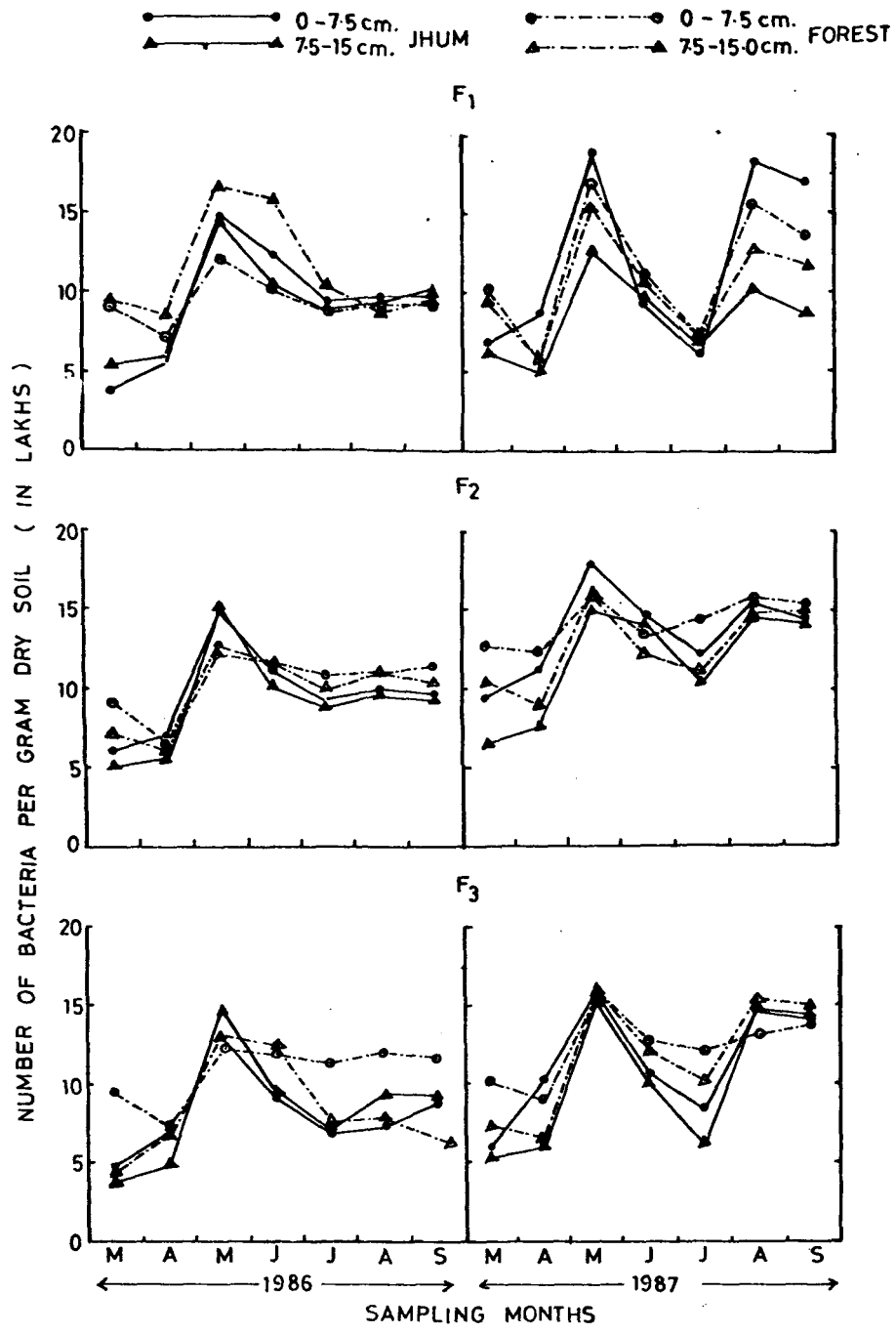


Fig. 8. Population of bacteria in jhum burnt and control forest soil.

Table 18

AVERAGE NUMBER OF BACTERIA/DRY SOIL (LAKH) IN JHUM BURNT SURFACE SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	F_1	F_2	F_3		F_1	F_2	F_3	
Mar.	4.6	6.2	4.8	5.2	6.9	9.2	6.1	7.4
Apr.	5.7	7.2	7.5	6.8	8.9	11.2	10.2	10.1
May	14.6	14.8	13.4	14.3	18.9	17.9	15.9	17.6
Jun.	12.5	11.2	9.0	10.9	2.9	14.4	10.8	9.3
Jul.	9.4	9.2	7.2	8.6	6.1	12.5	8.0	8.9
Aug.	9.7	10.0	7.7	9.1	18.0	15.3	14.9	16.1
Sep.	9.8	9.8	8.4	9.3	17.6	14.4	14.6	15.5
Mean	9.5	9.8	8.3		12.2	13.5	11.5	

LSD for months at 5% = 3.6
LSD for fields at 5% = 1.5

LSD for months at 5% = 3.7
LSD for fields at 5% = 4.9

ANALYSIS OF VARIANCE

Source of variance	1986 D.F	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	8.64	4.32	5.4**	2	21.53	10.76	1.3
Months	6	152.09	25.34	31.8**	6	304.24	50.70	6.4**
Error	12	9.53	0.79		12	93.90	7.82	
Total	20	170.26			20	419.67		

** Significant at 5% level

Table 19

AVERAGE NUMBER OF FUNGI/G DRY SOIL (THOUSAND) IN JHUM BURNT SUB-SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	F_1	F_2	F_3		F_1	F_2	F_3	
Mar.	4.3	5.0	5.6	5.0	4.7	5.6	4.6	5.0
Apr.	4.6	5.8	5.6	5.3	6.1	6.0	6.2	6.1
May	5.4	6.4	6.8	6.2	6.5	7.4	7.2	7.0
Jun.	5.7	6.8	7.2	6.6	6.4	6.4	6.3	6.4
Jul.	6.8	7.2	7.8	7.3	4.3	6.1	6.8	5.8
Aug.	5.4	6.6	7.3	6.4	4.5	6.0	6.8	5.6
Sep.	4.8	6.1	6.4	5.7	4.5	5.3	5.7	5.2
Mean	5.3	6.3	6.7		5.3	6.1	6.2	

LSD for months at 5% = 0.39 LSD for months at 5% = 1.2

LSD for fields at 5% = 0.4 LSD for fields at 5% = 1.0

ANALYSIS OF VARIANCE

Souce of variance	1986 D.F	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	7.12	3.56	71.3**	2	3.70	1.85	5.3**
Months	6	11.03	1.83	36.8**	6	8.97	1.49	4.3**
Error	12	0.59	0.04		12	4.17	0.34	
Total	20	18.74			20	16.84		

** Significant at 5% level

Table 20

AVERAGE NUMBER OF ACTINOMYCETES/G DRY SOIL (LAKH) IN JHUM BURNT SUB-SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	F_1	F_2	F_3		F_1	F_2	F_3	
Mar.	3.8	3.6	1.9	3.1	4.0	3.4	3.0	3.5
Apr.	4.9	4.0	2.1	3.6	7.1	4.8	3.5	5.1
May	5.3	4.3	3.1	4.2	6.5	5.0	3.3	4.9
Jun.	8.0	6.0	4.9	6.3	7.0	6.5	4.4	6.0
Jul.	9.9	9.8	7.3	9.0	8.1	8.5	7.2	8.0
Aug.	9.0	8.9	6.9	8.3	7.4	7.3	6.3	7.0
Sep.	8.9	8.2	6.1	7.7	6.9	6.5	6.0	6.5
Mean	7.1	6.4	4.6		6.7	6.0	4.8	

LSD for months at 5% = 0.68
LSD for fields at 5% = 0.6

LSD for months at 5% = 1.1
LSD for fields at 5% = 1.1

ANALYSIS OF VARIANCE

Source of variance	D.F.	1986 S.S.	M.S.S	F	D.F	1987 S.S.	M.S.S	F
Fields	2	23.21	11.60	76.8**	2	12.89	6.44	14.8**
Months	6	102.58	17.09	113.1**	6	39.27	6.54	15.0**
Error	12	1.81	0.15		12	5.22	0.43	
Total	20	127.60			20	57.38		

** Significant at 5% level

Table 21

AVERAGE NUMBER OF BACTERIA/G DRY SOIL (LAKH) IN JHUM BURNT SUB-SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	F_1	F_2	F_3		F_1	F_2	F_3	
Mar.	5.6	5.2	3.8	4.9	6.6	6.9	5.7	6.4
Apr.	6.0	5.6	5.0	5.5	5.0	8.0	6.3	6.4
May	14.3	15.6	14.9	15.0	13.0	14.9	15.7	14.5
Jun.	10.6	10.2	9.4	10.1	9.9	13.8	10.0	11.2
Jul.	9.0	8.8	7.8	8.5	7.2	10.6	6.5	8.1
Aug.	9.7	9.9	9.4	9.6	10.4	14.4	14.4	13.2
Sep.	10.4	9.2	9.3	9.6	8.4	14.0	14.4	12.3
Mean	9.4	9.2	8.5		8.6	11.8	10.5	

LSD for months at 5% = 0.95
LSD for fields at 5% == 0.8

LSD for months at 5% = 3.4
LSD for fields at 5% = 2.7

ANALYSIS OF VARIANCE

Source of variance	1986 D.F	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	2.91	1.45	6.2**	2	35.24	17.62	7.5**
Months	6	199.50	33.25	142.7**	6	198.79	33.13	14.1**
Error	12	2.81	0.23		12	28.08	2.34	
Total	20	205.22			20	262.11		

** Significant at 5% level

Table 22

AVERAGE NUMBER OF FUNGI/G DRY SOIL (THOUSAND) IN CONTROL FOREST SURFACE SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	C_1	C_2	C_3		C_1	C_2	C_3	
Mar.	6.8	6.0	7.3	6.7	6.0	6.6	6.3	6.3
Apr.	6.9	6.2	7.7	6.9	6.3	6.8	6.4	6.5
May	8.3	8.3	8.9	8.5	8.6	7.4	7.4	7.8
Jun.	7.1	7.2	7.9	7.4	6.8	6.8	6.8	6.8
Jul.	7.1	6.9	8.4	7.5	7.3	7.4	7.0	7.2
Aug.	7.4	7.4	8.2	7.8	7.0	7.3	6.6	7.0
Sep.	7.4	7.4	7.6	7.5	6.4	6.7	6.6	6.6
Mean	7.3	7.1	8.0		6.9	7.0	6.7	

LSD for months at 5% = 0.6
LSD for fields at 5% = 0.5

LSD for months at 5% = 0.6
LSD for fields at 5% = 0.6

ANALYSIS OF VARIANCE

Source of variance	1986 D.F.	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	3.16	1.58	16.8**	2	0.26	0.13	1.16
Months	6	6.10	1.01	10.8**	6	4.69	0.78	6.7**
Error	12	1.12	0.09		12	1.39	0.11	
Total	20	10.38			20	6.34		

** Significant at 5% level

Table 23

AVERAGE NUMBER OF ACTINOMYCETES/G DRY SOIL (LAKH) IN CONTROL FOREST SURFACE SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	C_1	C_2	C_3		C_1	C_2	C_3	
Mar.	6.8	6.0	3.5	5.4	5.8	4.5	4.1	4.88
Apr.	6.1	5.2	3.7	5.0	8.1	5.2	6.0	6.4
May	13.3	12.4	9.5	11.8	6.2	6.2	5.3	5.9
Jun.	11.5	11.1	11.5	11.4	7.5	8.2	7.8	7.8
Jul.	11.7	12.4	9.9	11.3	10.4	10.5	9.1	10.0
Aug.	11.5	11.2	9.0	10.6	9.9	10.2	8.9	9.6
Sep.	10.8	11.1	8.7	10.2	8.9	9.1	8.5	8.8
Mean	10.2	9.9	8.0		8.1	7.7	7.1	

LSD for months at 5% = 1.2
LSD for fields at 5% = 1.2

LSD for months at 5% =1.2
LSD for fields at 5% = 1.2

ANALYSIS OF VARIANCE

Source of Variance	1986 D.F	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	21.09	10.54	20.3**	2	3.64	1.82	3.9**
Months	6	150.42	25.07	48.2**	6	71.06	11.84	25.6**
Error	12	6.23	0.51		12	5.54	0.46	
Total	20	177.74			20	80.24		

** Significant at 5% level

Table 24

AVERAGE NUMBER OF BACTERIA/G DRY SOIL (LAKH) IN CONTROL FOREST SURFACE SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	C_1	C_2	C_3		C_1	C_2	C_3	
Mar.	8.9	9.3	9.6	9.4	10.2	13.1	10.1	11.1
Apr.	7.4	6.8	7.8	7.3	5.9	12.9	8.8	9.2
May	12.5	13.4	12.8	12.9	17.2	15.8	15.9	16.3
Jun.	10.4	12.2	12.2	11.6	11.5	13.0	13.4	12.6
Jul.	8.9	11.3	11.7	10.6	7.7	14.3	12.7	11.5
Aug.	9.2	11.4	12.3	11.0	15.8	15.6	13.6	15.0
Sep.	9.2	11.8	12.0	10.9	13.2	15.5	14.0	14.3
Mean	9.5	10.9	11.2		11.6	14.3	12.6	

LSD for months at 5% = 1.1 LSD for months at 5% = 3.7

LSD for fields at 5% = 1.2 LSD for fields at 5% = 4.5

ANALYSIS OF VARIANCE

Source of variance	1986 D F	S.S	M.S.S	F	1987 D F	S.S	M.S.S	F
Fields	2	12.50	6.25	13.9**	2	25.50	12.75	4.06**
Months	6	67.51	11.25	25.0**	6	109.20	18.20	5.7**
Error	12	5.38	0.44		12	37.66	3.13	
Total	20	85.39			20	172.36		

** Significant at 5% level

Table 25

AVERAGE NUMBER OF FUNGI/G DRY SOIL (THOUSAND) IN CONTROL FOREST SUB-SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	C_1	C_2	C_3		C_1	C_2	C_3	
Mar.	5.6	5.9	5.9	5.8	5.1	5.6	6.3	5.7
Apr.	5.8	6.2	6.0	6.0	5.9	6.4	6.6	6.3
May	6.6	7.8	8.2	7.6	8.3	7.9	7.6	7.9
Jun.	6.4	6.2	6.6	6.4	6.4	6.8	7.0	6.7
Jul.	6.1	6.4	8.2	6.9	7.4	6.8	7.5	7.2
Aug.	6.2	7.7	7.8	7.2	7.1	7.5	7.2	7.3
Sep.	5.5	7.2	7.7	6.8	6.1	6.2	6.3	6.2
Mean	6.0	6.8	7.2		6.6	6.7	6.9	

LSD for months at 5% = 1.0 LSD for months at 5% = 0.6

LSD for fields at 5% = 0.9 LSD for fields at 5% = 0.6

ANALYSIS OF VARIANCE

Source of variance	1986 D.F	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	4.91	2.45	8.3**	2	0.34	0.17	1.4
Months	6	7.23	1.20	4.0**	6	10.73	1.78	14.6**
Error	12	3.53	0.29		12	1.46	0.12	
Total	20	15.67			20	12.53		

** Significant at 5% level

Table 26

AVERAGE NUMBER OF ACTINOMYCETES/G DRY SOIL (LAKH) IN CONTROL FOREST SUB-SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	C_1	C_2	C_3		C_1	C_2	C_3	
Mar.	5.0	4.5	3.2	4.2	4.5	3.7	3.5	3.9
Apr.	5.9	4.7	5.0	5.2	6.5	3.9	4.8	5.1
May	12.0	8.0	7.0	9.0	7.0	3.6	6.1	5.6
Jun.	11.1	10.5	9.7	10.4	5.6	7.0	7.0	6.5
Jul.	11.2	10.1	8.9	10.1	10.6	10.0	10.0	10.2
Aug.	11.0	9.5	8.1	9.5	8.5	8.2	9.4	8.7
Sep.	10.2	7.8	7.7	8.5	8.0	8.0	7.7	7.9
Mean	9.5	7.9	7.1		7.2	6.3	6.9	

LSD for months at 5% = 1.3
LSD for fields at 5% = 1.4

LSD for months at 5% = 1.6
LSD for months at 5% = 1.6

ANALYSIS OF VARIANCE

Source of variance	1986 D.F	S.S.	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	20.96	10.48	17.0**	2	2.92	1.46	1.8
Months	6	107.21	17.86	29.0**	6	88.12	14.68	18.1**
Error	12	7.38	0.61		12	9.71	0.80	
Total	20	135.55			20	100.75		

** Significant at 5% level

Table 27

AVERAGE NUMBER OF BACTERIA/G DRY SOIL (LAKH) IN CONTROL FOREST SUB-SOIL

Months	1986 Fields			Mean	1987 Fields			Mean
	C_1	C_2	C_3		C_1	C_2	C_3	
Mar.	9.4	7.9	4.8	7.4	9.1	10.5	7.9	9.2
Apr.	8.4	6.1	7.3	7.2	6.0	8.6	6.7	7.1
May	17.0	12.7	13.5	14.4	15.4	16.0	16.0	15.8
Jun.	16.1	12.0	12.5	13.5	11.0	12.8	12.8	12.2
Jul.	10.7	10.0	7.7	9.5	7.6	11.4	10.1	9.7
Aug.	8.8	11.1	8.5	9.4	12.2	15.2	15.2	14.2
Sep.	9.8	10.6	6.4	9.0	12.2	15.2	15.2	14.2
Mean	11.5	10.0	8.7		10.6	12.8	12.1	

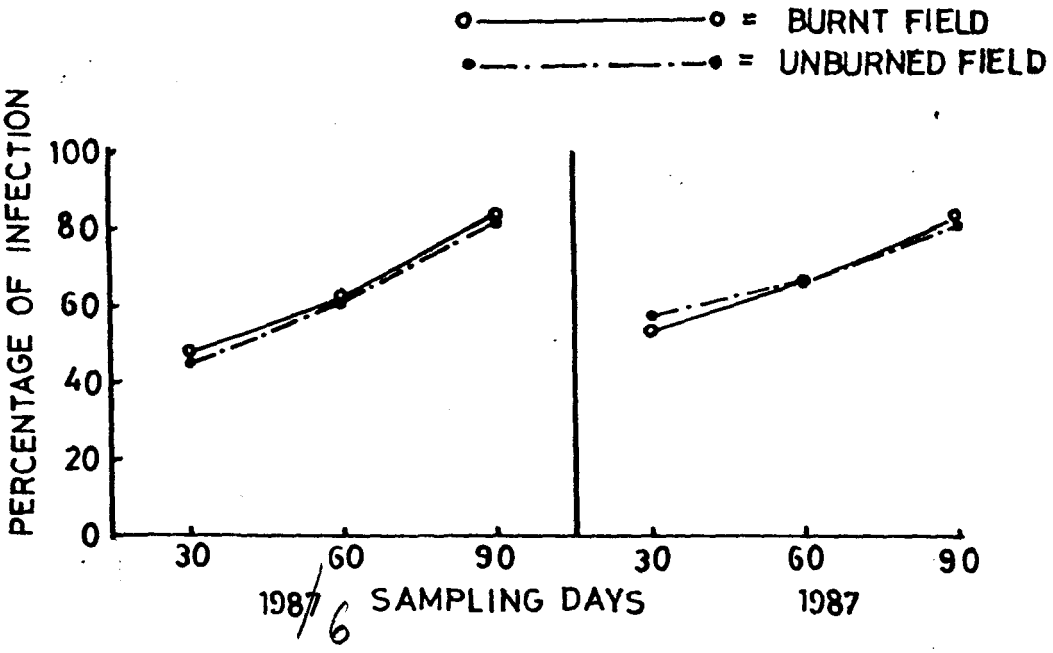
LSD for months at 5% = 2.2
LSD for fields at 5% = 2.6

LSD for months at 5% = 1.6
LSD for fields at 5% = 1.6

ANALYSIS OF VARIANCE

Source of variance	1986 D.F	S.S	M.S.S	F	1987 D.F	S.S	M.S.S	F
Fields	2	27.16	13.58	6.2**	2	16.00	8.00	9.7**
Months	6	143.78	23.96	11.1**	6	189.57	31.59	38.6**
Error	12	25.87	2.15		12	9.80	0.81	
Total	20	195.81			20	215.37		

** Significant at 5% level



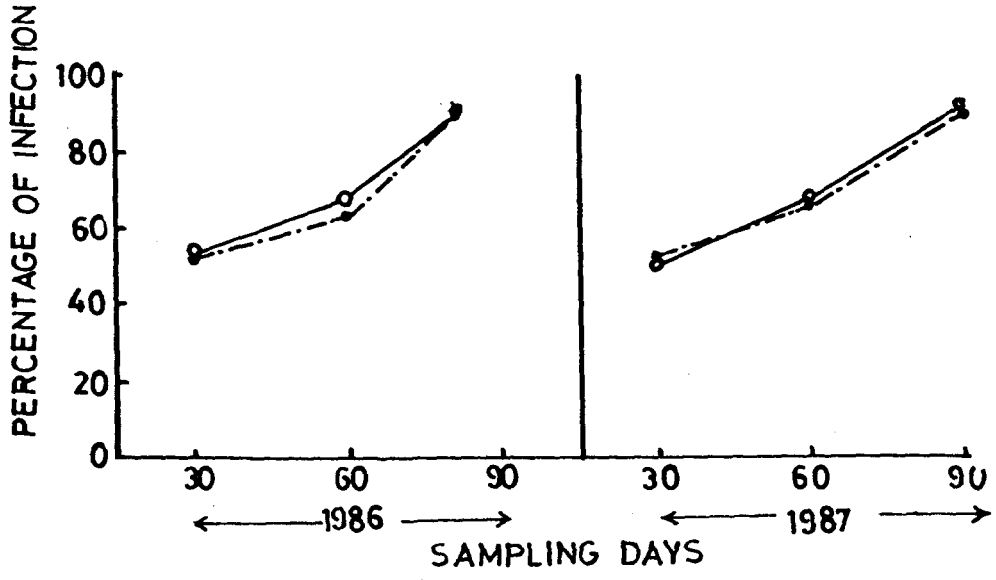


Fig. 12A. Percentage infection of vesicular-arbuscular mycorrhiza in the roots of PRK.

Fig. 12B. Percentage infection of vesicular-arbuscular mycorrhiza in the roots of SBL.

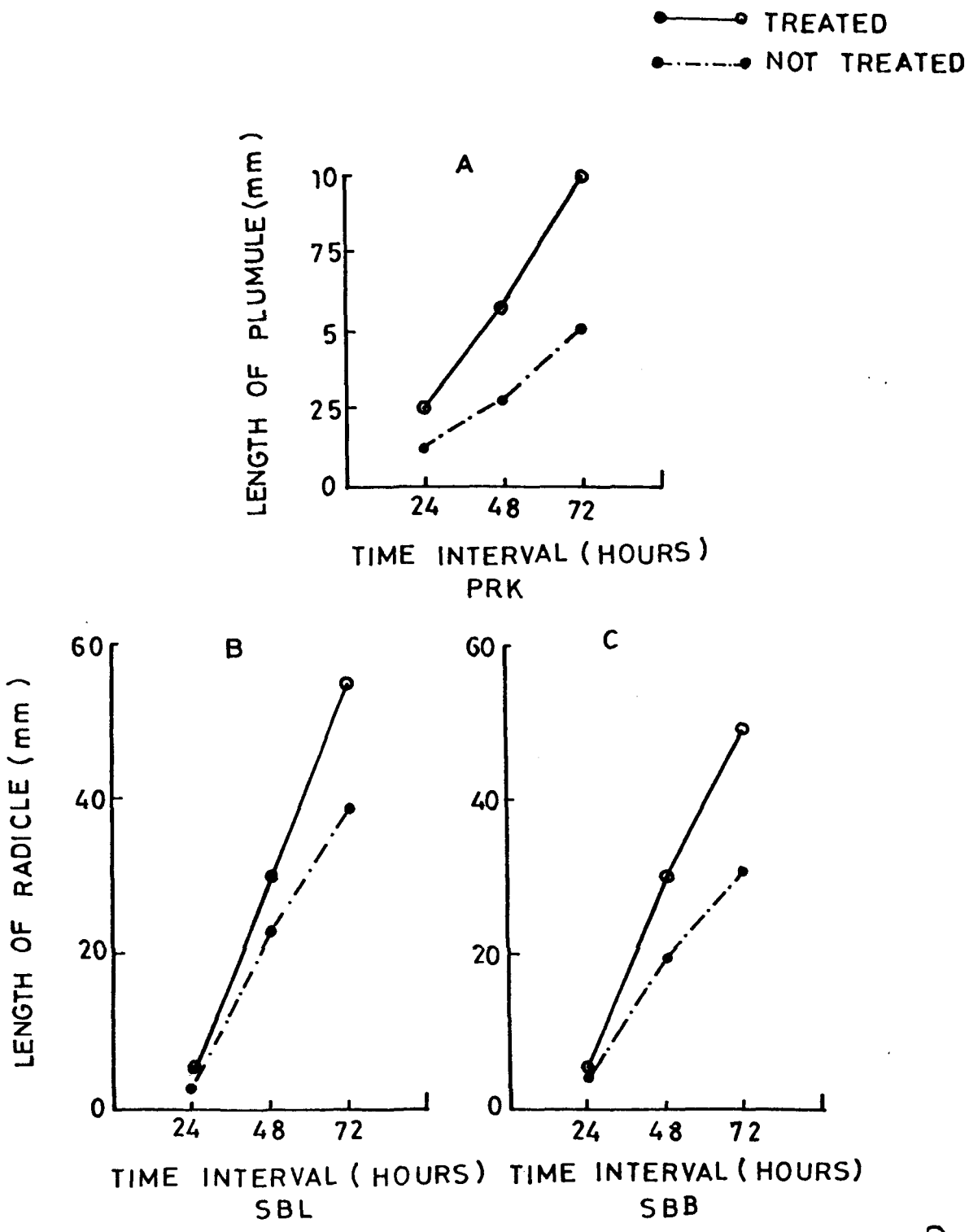


Fig. 20. Effect of Trichoderma harzianum on growth of plumule of PRK and radicle of SBL in vitro.

Table 28

PERCENTAGE INFECTION OF VESICULAR-ARBUSCULAR MYCORRHIZA IN THE ROOTS OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL)

Age of plants (Days)	1986				1987			
	Paddy rice		Soybean		Paddy rice		Soybean	
	JB	UB	JB	UB	JB	UB	JB	UB
30	48.2	44.5	53.2	50.4	52.0	56.0	50.0	52.2
60	62.0	59.9	66.9	62.5	65.2	65.0	68.1	65.0
90	83.3	80.3	90.1	90.0	83.1	80.0	92.0	89.9

JB = Jhum burnt field, UB = Unburnt field

Table 29

EFFECT OF TRICHODERMA HARZIANUM ON PERCENTAGE SEED GERMINATION AND GROWTH (AVERAGE LENTH IN mm) OF PLUMULE OF PADDY RICE (PRK) AND RADICLE OF SOYBEAN (SBL AND SBB) IN VITRO

Plants	Radicle/ plumule	Observation (hours)						Percentage seed germination	
		Treated			Not treated				
		24	48	72	24	48	72	Treated	Not treated
PRK	Plumule	2.0	5.6	10.0	1.3	2.6	5.0	100.0	100.0
SBL	Radicle	5.6	30.0	54.6	2.3	23.0	38.3	100.0	73.3
SBB	Radicle	5.3	25.0	49.0	4.0	19.6	31.3	100.0	88.8

Table 30

EFFECT OF TRICHODERMA HARZIANUM ON THE GROWTH (AVERAGE HEIGHT OF PLANTS IN cm) OF PADDY RICE (KEZI) IN VIVO

Age of plants (Days)	TREATMENTS			
	200:0	200:1	200:2	200:3
15	2.6	2.5	2.3	2.6
30	7.6	8.0	10.0	9.7
45	9.9	10.4	12.3	11.7

LSD for age at 5% = 0.50

LSD for treatments at 5% = 0.58

LSD FOR AGE & TREATMENTS AT 5% = 1.01

ANALYSIS OF VARIANCE

Source of variance	D.F.	S.S	M.S.S	F
Age	2	474.60	237.33	656.41*
Treatments	3	15.81	5.27	14.57*
Age & treatments	6	9.45	1.57	4.35*
Error	24	8.67	0.36	
Total	35	508.59		

* Significant at 1% level

Table 31

EFFECT OF TRICHODERMA HARZIANUM ON THE GROWTH (AVERAGE HEIGHT IN cm) OF SOYBEAN (LOCAL) IN VIVO

Age of plants (Days)	TREATMENTS			
	200:0	200:1	200:2	200:3
15	9.1	10.5	13.0	13.6
20	19.0	21.3	22.8	23.6
25	27.0	31.0	33.5	33.6

LSD for age at 5% = 0.94
LSD for treatments at 5% = 1.08
LSD for age & treatments at 5% = 1.88

ANALYSIS OF VARIANCE

Source of variance	D.F	S.S	M.S.S	F
Age	2	2331.09	1165.54	932.43*
Treatments	3	155.47	51.82	41.45*
Age & treatments	6	9.40	1.56	1.25
Error	24	29.99	1.24	
Total	35	2525.95		

* Significant at 1% level

CHAPTER - V

RESULTS AND DISCUSSION

R E S U L T S A N D D I S C U S S I O N

The results and interpretation of experimental findings of the present study have been represented as follows:

5.1 Jhum burning and its effect on soil micro-organisms.

5.2 Recolonization of micro-organisms in the jhum field soil.

5.3 Seasonal variation in microbial population of jhum land and control forest ecosystems.

5.4 Nutrient status of jhum burnt soil and its correlation with the microbial population.

5.5 Plant root ecosystem - rhizosphere and rhizoplane mycoflora of paddy rice and soybean (Local) in jhum field.

5.6 Effect of root-extracts of paddy rice and soybean on some dominant rhizosphere fungi.

5.7 Jhum burning in relation to vesicular-arbuscular mycorrhizal association of paddy rice and soybean.

5.8 Jhum burning and its effect on soil-borne plant pathogenic fungi.

5.9 Antagonistic effect of Trichoderma harzianum - a local isolate from jhum field on some dominant soil borne plant pathogenic fungi.

5.10 Effect of T. harzianum on seed germination and seedling growth of paddy rice and soybean in vitro.

5.11 Effect of T. harzianum on growth of paddy rice and soybean in vivo.

5.12 Effect of jhum burning on population of Trichoderma spp. - an early colonizer in jhum burnt soil.

5.1 JHUM BURNING AND ITS EFFECT ON SOIL MICRO-ORGANISMS:

5.1.1 GENERAL:

The removal of forest canopy in the process of jhuming resulted in various ecological modifications such as exposure of surface soil to direct sunlight, soil moisture and temperature, destruction of the structure of soil crumb due to the direct effect of rain drops and leaching in the litter of the soil litter environment. Burning is the most significant operation in jhuming (Plate III-V). The soil micro-organisms, in direct contact with the soil, are subjected to considerable change due to changes in moisture, temperature and supply of nutrients. This ecological perturbation because of jhum practice caused quantitative as well as qualitative changes in the composition of soil microflora.

There are various reports available on effect of fire or burning on microflora which have indicated that fire destroyed microflora of upper soil horizon (Jalaluddin, 1969; Hauke Pacewiczeowa and Trazcinska, 1980). Maximum effect of burning was found in the upper soil surface (Wright and Tarrant, 1957), and no effect of burning on microbial population in mineral soil horizon (Jorgensen and Hodges, 1971). Deka and Mishra (1984) could not isolate any fungus from the surface layer soil (0-20 mm and 20-60 mm) immediately after burning where 20 kg and 100 kg of bamboo fuel was burnt.

5.1.2 DYNAMICS OF MICROBIAL POPULATION:

During the present study, a significant difference in fungal, actinomycetes, and bacterial population of jhum burnt surface soil and control forest surface soil was observed. First isolation was done after 7 days of burning in March 1986. The population of micro-organisms from surface soil of jhum burnt fields was drastically reduced as compared to control forest soils. The population data (mean value from 3 fields) showed that average number per gram dry soil reduced to 4.6 thousand, 3.3 lakh and 5.2 lakh as compared to 6.7 thousand, 5.4 lakh, and 9.4 lakh respectively, in case of fungi, actinomycetes and bacteria (Tables 16-18, and 22-24; Figs. 6-8).

Qualitatively, the number of fungal species was also reduced in jhum burnt surface soil in comparison to species recorded from the control forest surface soil during March 1986. The number of fungal species isolated from three different fields were 10, 14 and 13 as compared to 13, 19 and 17 from control forest soil (Table 11b). This quantative as well as qualitative reduction in the microbial population of jhum burnt surface soil was attributed to jhum burning.

As regard to the effect of jhum burning at sub-soil level, the data showed no significant difference either quantatively or qualitatively on microbial population. As already mentioned by Debano (1974), it may be due to the fact that soil is a poor conductor of heat

and only a small portion of heat produced is transferred downward to the soil.

El-Abyad and Webster (1968) observed that temperature was not the significant determining factor of perpetuation for pyrophilic or non-pyrophilic fungi and the overall effect of heat on spore germination was negligible. Berry (1970), studying the Louisiana plots which were burnt annually for about 50 years, observed only minor increase in soil pH, moisture and temperature and no changes in soil micro-organisms. Considering all other factors which may affect microbial population directly or indirectly, it may be recalled that the time between burning and sampling (Wright and Tarrant, 1957), intensity of heat produced and soil depth (Deka and Mishra, 1984) undoubtedly, bear significant effect on the degree of change in the microflora.

An initial reduction in microbial population followed by a gradual and continuous recovery to preburn level have also been observed (MeikleJohn, 1955; Wright and Bollen, 1961; Berry, 1970). The following findings of the present study partially support the above findings. The reduced population of fungi and actinomycetes 4.6 thousand and 3.3 lakh respectively per gram dry soil as observed in March after burning gradually increased in the following months reachings its maximum in July, 9.2 thousand and 9.8 lakh per gram dry soil and again attaining the population almost identical to preburn level of 5.9 lakh in September. However, the populations were reduced to 5.9 thousand and 8.5 lakh in September. In case of bacterial population, an initial count of 5.2

lakh after burning in March reached maximum to the total count of 14.3 lakh in May and touched its preburn level, 9.3 lakh in September.

The gradual increase in the population of micro-organisms during couple of months after burning in the present study could not be correlated with any other factor except the rich nutrient status of jhum burnt soil which may certainly attribute to the enhanced microbial activities relating to multiplication and colonization of new forms. The peak counts in case of bacteria recorded in May and fungi and actinomycetes recorded in July from jhum burnt surface soil clearly indicated that bacteria could utilize the nutrients at faster rate and its population increased earlier than that of fungi and actinomycetes (Table 11a, Figs. 6-8).

Lesser number of bacteria, actinomycetes and fungi recorded in burnt soil as compared to unburnt soil of 2 cm depth which followed the reverse path after two months by (Theodorou and Bowen, 1982) are concomitant to the results obtained during the present investigation. The data on population of various micro-organisms in the present study elucidated that control forest soil generally harboured more number in all the months in comparison to jhum burnt soil, except in few cases where fungal population was more in jhum soil in July 1986 in all the fields and in F_1 in 1987. Bacterial population was more in May, 1986 in F_2 and F_3 and in F_1 in 1987. However, population of actinomycetes was always found to be more in control forest soil in comparison to

jhum burnt soil from all the fields during study period (Tables16-27, Figs. 6-8).

In the sub-soil (7.5-15 cm), no significant change in the fungal and actinomycetes population was observed due to jhum burning. However, bacterial population could show significant difference initially in the jhum burnt sub-soil, (4.9 lakh) as compared to control forest sub-soil, where the total count was 7.4 lakh (Table 11a). There was no significant difference in fungal species composition between the sub-soil of jhum burnt and control forest soils which indicated insignificant effect of jhum burning on mycoflora in sub-soil region.

Qualitatively, MeikleJohn (1955), Deka and Mishra (1984), found no significant difference in the fungal species composition of burnt and unburnt soil, whereas Jorgensen and Hodges (1971) observed minor differences in the total number of genera or species as a result of burning. The present data also showed minor difference in the number of species in jhum burnt and control forest surface and sub-soils. The number of speices were found to be generally more in control forest surface as well as sub-soils (Tables 11a and 11b). Neurospora sp. was frequently isolated from burnt soil during March-April. However, the same was not isolated from the control forest soil during the present study period.

Thus, it is concluded that jhum burning directly affects soil microbial population. In the soil surface layer the effect was more

pronounced on quantity and less so on quality. However, in the sub-soil, burning effect on soil micro-organisms was insignificant which is in line with the findings of MeikleJohn (1955), Deka and Mishra (1984).

5.1.3 DISTRIBUTION AND COMPARISON OF MYCOFLORA IN JHUM BURNT AND CONTROL FOREST SOIL ECOSYSTEMS:

The number of fungal species isolated from jhum field soils F_1 F_2 and F_3 were 49, 46 and 41 respectively (Tables 2-4). The total number of fungal species isolated from all the 3 jhum fields was 53 (Table 11c). 35 species were common to all the fields while some of them were restricted to certain fields only. Fungi specific to field F_1 were Hyalopus sp., Penicillium funiculosum, P.purpurogenum, and Spicaria sp. Penicillium variabile and Sclerotium rolfsii were confined to F_2 only.

The number of fungal species isolated from control forest soils C_1, C_2 and C_3 were 49, 44 and 40 respectively (Tables 5-7). The total number of fungal species isolated from all the 3 control forest soils was 54 (Table 11c). A perusal of table 11c showed that 35 fungi were common to all the fields while some of them were restricted to particular field only. Fungi specific to C_1 were Hyalopus sp., Penicillium funiculosum, P. purpurogenum and Torula sp. Again, Penicillium variabile and Sclerotium rolfsii were restricted to field C_2 while the fungus confined to field C_3 was Phoma sp.

The total number of fungi isolated from both jhum burnt and control forest soils ecosystems was 55. The fungi isolated only from the jhum burnt soils were Neurospora sp. and Spicaria sp. whereas, fungal species confined to control forest soils were Sclerotium rolfsii and Chaetomium sp. (Table 11c)

Above fungal specificity between the two ecosystems clearly indicates that two different ecosystems have some effect on diversity of fungal population. Jhum burnt soils harboured less number of fungal species than the control forest soils. The difference was found to be more in surface soil than that of the sub-soil. The numbers of fungi which were identified to be dominant in both the ecosystems were Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus, Trichoderma and black sterile mycelia.

Invariably, a marked quantitative as well as qualitative difference in between jhum burnt and control forest soils mycoflora was noted. In comparison to jhum burnt soils, a higher number of fungi quantitatively and qualitatively were found in control forest soils. As both, the jhum burnt and control forest fields were side by side such difference is inferred to be caused by modifications of habitat due to jhum burning operation. Jhum burning affected reduction in fungal population. This reduced but stabilised mycoflora largely depended on nutrients released from ash in the soil. Mycostatic activities of common and abundantly colonizing soil fungi might not allow other rare and non-precolonized forms to compete for survival. With contrast to this changed habitat, control forest soils possessed sufficient moisture, litter, less light and other suitable condition which could enable multiplication and

colonization of fungal forms resulting higher number of fungi quantitatively as well as qualitatively.

5.1.4 RELATIVE ABUNDANCE OF INDIVIDUAL FUNGAL SPECIES IN JHUM BURNT AND CONTROL FOREST SOIL ECOSYSTEM:

The abundance of individual fungal population in soil is the ultimate result of the sum of all inherent abilities of a fungus to increase. This may also be denoted as biotic potential. Environmental resistance and ecological perturbation are the factors acting on biotic potential and in opposition to species obtaining maximum population. Jhum burnt soil obviously becomes an attractive substract contributing towards mineral nutrients and competition for mycofloral complex.

The data on relative abundance percentage of individual fungal species from the mycofloral complex of jhum burnt and control forest soil indicated that fungi like Zygorhynchus sp., Verticillium sp., Aspergillus terreus, Fusarium spp., Mucor spp., Penicillium luteum, P. restrictum, P. turbatum, P. variabile, Cephalosporium acremonium, Gliocladium spp., Neurospora sp., Sclerotium sp., Rhizopus nigricans, Trichoderma spp., Pink and white sterile mycelia were dominant in jhum burnt soil (Table 11d, Fig. 19). The species of Penicillium, Trichoderma, Mucor, Rhizopus and Fusarium were reported to have been killed by fire (Bollen, 1969, Cooke, 1971; Widden and Parkinson, 1975). However, these species were isolated frequently and Trichoderma in particular was found to be more common in burnt soil. Deka and Mishra (1983) also reported

to have isolated the above fungal genera frequently from the burnt site. Although, these genera were found to be killed by fire, the air-borne spores and conidia from adjoining areas might reach upto the soil surface and recolonize.

Response of individual fungi in jhum burnt and control forest soil ecosystems may be classified into five categories. Those which showed (a) increased population in jhum burnt soil; Examples were - Aspergillus terreus, Cephalosporium acremonium, Fusarium oxysporum, F. solani, F. moniliforme, Gliocladium roseum, Glimistix sp., Mucor hiemalis, M. racemosus, Neurospora sp., Penicillium luteum, P. restrictum, P. turbatum, P. variabile, Rhizopus nigricans, Sclerotium sp., Pink sterile mycelia Trichoderma harzianum, T. lignorum, T. longibrachiatum, Verticillium sp., Zygorhynchus sp., and white sterile mycelia (b) increased population in control forest soil - Examples were Absidia repens, Aspergillus luchuensis, A. niger, A. sydowi, Candida sp., Cladosporium sp., Choanephora sp., Curvularia geniculata, Helminthosporium sp., Humicola sp., Geotrichum sp., Penicillium granulatum, P. javanicum, P. purpurogenum, Pestolatia sp., Pythium sp., Rhizopus spp., Thielavia terricola, Thielaviopsis sp., black sterile mycelia, yellow sterile mycelia, and Sclerotium rolfsii. (c) Balanced or equal population in both jhum burnt and control forest soils, examples were Alternaria humicola, Aspergillus fumigatus, (d) present in jhum burnt soil only, examples were Hyalopus sp., Torula sp., Neurospora sp. and (e) present only in control forest soils, examples were Chaetomium sp., Sclerotium rolfsii,

and Oidiodendron sp. (Table 11d, Fig. 19). Of course, this sub-division may not be very sharp and therefore intermediate susceptibility are bound to occur.

5.2 RECOLONIZATION OF MICRO-ORGANISMS IN JHUM BURNT FIELD SOIL:

The results obtained by many workers on effect of burning on micro-organisms are variable. Some have reported damaging effect on microbial population of soil (MeikleJohn, 1955; Ahlgren and Ahlgren, 1965); whereas, some have stated that burning could alter soil microflora which in due course of time became similar to undisturbed site (Wicklow and Whittingham, 1978). A few workers have observed that prescribed burning completely destroyed the microflora of the upper soil horizon (Hauke-Pace-wiczwa, et al., 1980). Berry (1970) studying the Louisiana plots which were burnt annually for 50 years observed no change in soil micro-organisms. However, during the present study reduction in microbial population was recorded initially after burning. Changed habitat with reduced microbial population having almost zero resistance could possibly offer scope for recolonization of microbes on its sterilized and exposed soil surface.

The data on the present studies showed that the fungal species such as Aspergillus fumigatus, A. niger, A. terreus, Mucor hiemalis, Neurospora sp., Penicillium frequentans, P. luteum, Rhizopus nigricans, Trichoderma harzianum, Fusarium oxysporum, Sclerotium sp., Black sterile mycelia, Cephalosporium sp., Choanephora sp. were early colonizers in

jhum after burning (Tables 2-4). Many of the above mentioned fungal species were highly sporulating in nature and it could be because of lesser biotic competition in the burnt soil that they colonized quickly and occupied dominant position in the burnt soil. Wright and Bollen (1961), Jalaluddin (1969), Tiwari and Rai (1976), Sharma (1981) and Deka and Mishra (1983) also listed most of the above mentioned fungal species in the list of early colonizers after soil burning.

It has been reported by Cooke (1971) that fungi like Fusarium spp. were killed by the fire. Similar killing effect of fire or burning on Trichoderma spp. has also been reported by Bollen (1969), Cooke (1971), and Widden and Parkinson (1952). However, in the present investigation, both the fungal species were found to be of more frequent occurrence and to higher numbers, and the genera of Trichoderma, Fusarium, Penicillium, Rhizopus and Mucor constituted the dominant group of mycoflora recolonizing the jhum burnt soils.

5.3 SEASONAL VARIATION IN MICROBIAL POPULATION OF JHUM LAND AND CONTROL FOREST ECOSYSTEMS:

Many factors are involved in distribution of micro-organisms in a soil profile. Microbial activities are checked when soil is dry and temperature is high. Sufficient soil moisture is attained after rains which creates favourable environment for maximised microbial activities involving deposition of organic matter. Mishra (1966) while studying the grassland fungal flora, found that due to availability of sufficient moisture after the rains, the decomposition of organic matter became

very fast which resulted rapid growth and sporulation of fungi in July.

In the present investigation, quantitatively increased population of fungi, actinomycetes and bacteria were invariably recorded during April to September when the rainfall and soil moisture content (%) were found to be in the range of 55-285 mm and 27-34 per cent respectively (Appendix Table XI and Fig.4). Minimum population in case of fungi, actinomycetes and bacteria recorded in the month of March, which happened to be the driest month with minimum rainfall and soil moisture, from jhum burnt as well as control forest soils. The maximum population of fungi and actinomycetes was recorded in July, while maximum population of bacteria was recorded in the month of May (Table 11a). Populations of different group of micro-organisms recorded in March were significantly different to the population records of May-July. These findings are in accordance with the findings of Mishra in 1966.

Moubasher and El-Dohlob (1970) reported that Penicillium spp. occurred with high frequency in the fall, suppressed during summer, whereas Aspergillus spp. occurred with low frequency in winter and with high frequency in summer. Gliocladium roseum was more common in hard-wood forests than in coniferous forests (Domsch and Gams, 1970). Trichoderma polysporum was most abundantly recorded in autumn and winter, T. viride in the spring and T. koningii in summer (Widden and Abitbol, 1980). In a grassland study in Varanasi, India, Mishra (1966) found that Thielavia terricola, Chaetomium globosum, Aspergillus niger,

A. terreus and Paecilomyces fusiporus were dominant throughout the year.

The present data showed that Absidia repens was more abundant in spring. Curvularia geniculata, Fusarium solani, Penicillium purpurogenum, Thielavia terricola Choanephora sp.,Aspergillus sydowi, Gliocladium roseum, Zygorhynchus sp. were of frequent occurrence in spring and summer (Tables 5-7).

The dominant fungi found throughout the study period were: Aspergillus fumigatus, A. niger, A. terreus, Fusarium oxysporum, Mucor hiemalis, Rhizopus nigricans and Trichoderma harzianum. This indicated that these fungal species have the greater ecological tolerance to withstand extremes.

Sclerotium rolfsii - a soil borne pathogenic fungus causing great damage to vegetable crops, pulses and ornamentals at Medziphema was isolated frequently during May-June. Trichoderma lignorum was more common in spring while black sterile mycelia was more common during August-September. However, white sterile mycelia was not specific to any season.

deleted

Whatsoever may be, No regular pattern of increase or decrease in the mycoflora in relation to number of species according to seasonal changes could be detected.

5.4 NUTRIENT STATUS OF JHUM BURNT SOIL AND ITS CORRELATION WITH THE MICROBIAL POPULATION:

The surface layer soil is the richest in organic matter content. This layer of soil also harbours maximum number of micro-organisms. Thus, the soil organic matter content has a high correlation with the fungal population as well. The earthworm casts in the soil also provides a good substrate for the growth of micro-organisms as it is richer in nitrogen, phosphorus and organic carbon content as compared to the surrounding soil (Dkhar and Mishra, 1986).

Burning frees the minerals contained in litter and humus for reuse by plants, but much of the carbon and nitrogen are lost (Spur, 1964). Nutrient losses to the atmosphere in one location may result in added atmospheric deposition in adjacent locations (Clayton, 1976). Heyward and Barnette (1934) reported that wood-ash added to the soil after a fire was known to increase both the content of exchangeable cations and pH of soils. Burning also chemically altered a portion of the plant nutrient supply from an organic form to a mineral form in ash which was often readily soluble (Webyle and Packer, 1974). Increase of phosphate and exchangeable cations content of the top soil after burning has also been observed (Nye and Greenland, 1960).

The present data (Appendix Tables 1-6) showed that the values of pH, phosphorus and potassium increased in the jhum burnt soil. With the onset of the monsoon the microbial population responded to the

increased soil nutrients released in the form of wood-ash by picking up steady increase in their number reaching the peak in May (bacteria) and July (fungi and actinomycetes), (Tables 16-18; Figs. 6-8).

The important fungal genera that responded positively to the changed environment due to burning were Aspergillus terreus, Fusarium spp., Cephalosporium acremonium, Sclerotium sp., Verticillium sp., Gliocladium spp., Mucor spp., Pink and white sterile mycelia, Zygorhynchus sp., Neurospora sp., Penicillium luteum, P. restrictum, P. turbatum, P. variabile, Rhizopus nigricans and Trichoderma spp. (Table 11d; Fig. 19). In a physiological study of Fusarium and Aspergillus, it was observed that phosphates and light phosphorus contents influenced the mycelial growth of the fungi (Brown, 1925; Rannerfelt, 1934). Light burning was found to have a positive effect on the occurrence of Fusarium spp. (Wright and Tarrant 1957). The above mentioned observations were similar to what has been observed in the present investigations.

Thus, the dominancy of the above mentioned fungal species as encountered in the jhum burnt soil may be attributed to the increased soil pH, phosphorus and potassium. This also showed their ability to utilize different ash nutrients present in the jhum burnt soil. In addition, high sporulating nature of certain fungi and lesser biotic factors of the changed habitat may also offer a suitable environment for early colonization and dominance in the jhum burnt soils.

5.5 PLANT ROOT ECOSYSTEM: RHIZOSPHERE AND RHIZOPLANE MYCOFLORA OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL) IN JHUM FIELD:

Rhizosphere microflora of a plant depend largely upon plant species, the age, root habit, soil conditions, pH, moisture, organic content, availability of oxygen, carbon dioxide, physiological set up of the plant and other environmental conditions (Timonin, 1940; Lochhead et al., 1954; Rovira, 1956, 1965; Buxton, 1957 and Katznelson, 1965). The rhizosphere effect which is also denoted as R/S ratio can be calculated in terms of number of micro-organisms per gram dry weight of rhizosphere soil and number in the soil away from rhizosphere. This effect also varies with the various factors mentioned above.

Since, paddy rice and soybean are among the major crops of jhum cultivation, an attempt was made to study the nature and population of fungi present in the rhizosphere. Jhum, which consists of slash and burn operation and cultivation (Plates II-VII), changes the soil ecosystem and it is, therefore, such effect of changed habitat on rhizosphere mycoflora was considered to be an interesting aspect of investigation. For comparison, adjoining unburnt plot was taken where dried slashed biomass was removed and burning was not done.

5.5.1 RHIZOSPHERE MYCOFLORA OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL):

Observation made in the present investigation during 1986-1987 on rhizosphere mycoflora of paddy rice (kezi) and soybean (Local) (Table 12a and Fig. 9b) revealed that average number of fungi per gram dry

rhizosphere soil from rhizosphere of paddy rice in jhum burnt condition was always more from May (11.2 thousand) to September (18.3 thousand) in comparison to unburnt in May 10.4 and September 16.4 thousand per gram dry rhizosphere soil during 1986. However, during 1987 (the second year of jhuming when the burning was very light consisting of dried biomass of crop remains plus weeds), no distinct variation in the population of rhizosphere fungi was found out from jhum burnt (May 13.3 to September 15.0 thousand) and from unburnt (May 13.3 to September 15.2 thousand). Similar results were obtained in the rhizosphere of soybean, where average number of fungi/g dry rhizopshere soil in jhum burnt field were recorded as 15.6 in June, 17.4 thousand in August and 15.8 thousand in September in 1986. During 1987, it was recorded as 12.7 in June and 15.5 thousand in September. In case of unburnt field it was found to be 12.6 in June and 16.1 thousand in September during 1986, whereas, during 1987, it was 10.9 it was 10.9 in June and 13.9 thousand per gram dry rhizopshere soil in September.

Rhizosphere effect R/S ratio in case of both the plants grown in jhum burnt as well as unburnt field were always more than one. It ranged from 1.0 to 2.5 in case of paddy rice, whereas 1.3 to 2.5 in soybean.

Again, such variation in jhum burnt field may be considered to be caused by available ash, where nutrient supply in contrast to organic form is readily available to the root region.

Contradictory reports are available on effect of rhizopshere with

the age of the plants. Timonin (1940), Katznelson (1946), Chester and Parkinson (1959), Gujrati (1965), Upadhyay (1971) have found that rhizosphere effect was more with the age of the plants and reached its maximum at the highest vegetative growth, whereas Agnihotrudu (1953) reported that the number of fungi continued to decrease upto flowering stage followed by a increase afterwards.

In the present investigation, continuous increase in the rhizosphere fungal population was found which reached its maximum upto fruiting stage. These results are concomitant with the results of former workers in which rhizosphere effect was found to be more with the age of the plants.

Qualitatively, no regular pattern of increase or decrease in number of fungal species from the rhizosphere of plants grown either in jhum burnt or unburnt field were observed with the age of both the plants - paddy rice (May to September) and soybean (June to September). However, in comparison to unburnt field, the total population count was found to be always higher in the rhizopshere of plants grown in jhum burnt field (Figs. 9b and 10).

Altogether 18 fungal species were isolated from the rhizosphere of soybean - 17 were isolated from jhum burnt field and 15 from unburnt field. *Penicillium frequentans*, *P. luteum*, and *T. longibrachiatum* were found to be restricted to rhizosphere of soybean from jhum burnt while *Mucor hiemalis* was confined to rhizosphere

of soybean from unburnt field. Almost common fungal species prevailed in both the field condition (Fig. 18).

Out of 24 number of fungal species isolated from rhizosphere of paddy rice, 21 species were isolated from jhum burnt field and 23 species from unburnt field. Fusarium solani was found to be restricted to rhizosphere of paddy rice from jhum burnt and Aspergillus luchuensis, Zygorhynchus sp. and yellow sterile mycelia were restricted to rhizosphere of paddy rice from unburnt field.

Percentage relative abundance of individual fungal species such as Aspergillus terreus, A. niger, Cunninghamella elegans, Fusarium oxysporum, Gliocladium roseum, Penicillium luteum, Trichoderma harzianum, Verticillium sp., white sterile mycelia, yellow sterile mycelia form showed higher percentage occurrence of these members in the rhizosphere of plants from the burnt field (Fig. 17). In the rhizosphere of plants of unburnt field soil Aspergillus fumigatus, Mucor racemosus, Penicillium frequentans, P. javanicum, Pythium sp., Rhizopus nigricans, Trichoderma lignorum, and black sterile mycelia showed higher percentage occurrence (Fig. 17).

However, in comparison to unburnt field, the total population count was found to be always higher in the rhizosphere of plants grown in jhum burnt field (Fig. 9b; 10). It was also observed

that when R. nigricans population shooted up, the population of potent antagonist like T. harzianum and T. lignorum decreased and vice-versa (Fig. 17 & 18).

5.5.2 RHIZOPLANE MYCOFLORA OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL):

Total fungal species isolated from the rhizoplane of paddy rice in jhum burnt field was 16, while in the unburnt field it was 14 (Table 10). Penicillium luteum and Trichoderma longibrachiatum were restricted to the rhizoplane in the burnt field. The rest 14 other species were common to both the fields.

From the rhizoplane of soybean total 15 number of fungal species were isolated. A total of 14 species were isolated from the jhum burnt field and 15 species from the unburnt field. Gliocladium roseum was isolated from the rhizoplane of the burnt field only.

Fungi like Cunninghamella elegans, Penicillium frequentans, were restricted to rhizoplane of soybean and the fungi like Penicillium luteum, Pythium sp., Trichoderma lignorum and T. longibrachiatum were found to be restricted to rhizoplane of paddy rice.

5.5.3 NON-RHIZOSPHERE MYCOFLORA:

Total number of fungal species isolated from non-rhizosphere of jhum burnt and unburnt fields were 50 and 51 respectively. Fusarium solani, Neurospora sp. and Phoma sp. were restricted to jhum burnt

field, whereas Absidia repens, Chaetomium sp., Penicillium variabile and Pestolatia sp. were isolated from unburnt field only. The rest were common to both (Table 10).

5.5.4 DISTRIBUTION AND COMPARISON OF RHIZOSPHERE, RHIZOPLANE AND NON-RHIZOSPHERE MYCOFLORA OF PADDY RICE (KEZI) AND SOYBEAN (LOCAL):

Table 10 elucidated that the total number of fungal species isolated from the rhizosphere, rhizoplane and non-rhizosphere of paddy rice and soybean from jhum burnt and unburnt field were found to be 56 in number. Out of these non-rhizosphere, rhizosphere and rhizoplane mycoflora constituted 55, 24 and 17 number of species respectively. Maximum number (55) of fungal species were in non-rhizosphere, whereas, minimum of 17 from rhizoplane and a moderate number of 24 in the rhizosphere. Above results are in confirmity with the tacit assumption that rhizosphere develops with a certain basic recognizable features which differentiate them from those of the soil, a short distance away from the root system. Naturally, this offers scope for only less number of species with competitive ability. Rhizoplane harbours still lower number of species than the rhizosphere.

In the present study, fungi viz., Aspergillus luchuensis, Fusarium oxysporum, Gliocladium roseum, Pythium sp., Pink sterile mycelia and yellow sterile mycelia were isolated from the rhizosphere

of paddy rice only. However, the fungi which were isolated from rhizosphere of soybean were all common to paddy rice. The dominant fungal species in the rhizosphere of paddy rice were Aspergillus terreus, A. niger, Fusarium oxysporum, Rhizopus nigricans, Trichoderma harzianum, and Mucor racemosus whereas, A. fumigatus, Cunninghamella elegans, Pencillium javanicum, Rhizopus nigricans, Trichoderma lignorum and Mucor hiemalis were found to be dominant in the rhizosphere of soybean(Local). The present findings, thus, support the findings of Rangaswamy and Balsubramanian (1963), Horny and Ullstrup (1967) who mentioned that particular plant species stimulated the growth of specific micro-organisms in their rhizosphere.

Paddy rice and soybean belonged to the families of Poaceae and Leguminoceae respectively. Their habit, time of flowering, in general, were different. Hence, the difference in the fungal species composition in their rhizospheric soils is inferred to be caused by the difference in the quality of amino acids and sugars present in addition to their distantly related factors.

The higher number of fungi in the rhizosphere of both the plants from jhum burnt field was inferred to be caused due to the difference in nutrient content of the soils. The richer contents of potassium, phosphorus and higher value of soil pH in the burnt jhum field could accelerate fungal activities as well as enrich the soil fertility for better growth of crop plants. Plants in return may release higher amount of root-exudates which may also help in

enhancing the fungal population. The fungus Cunninghamella elegans was isolated from the rhizospheric soil only. This may be an indication of the broader spectrum of nutrient content in the rhizospheric soil as compared to the adjoining non-rhizospheric soil.

Qualitatively, there was no significant difference in total number of fungal species composition in rhizosphere of both the crop plants. The fungal species encountered were common in both the plants except that Aspergillus terreus, A. niger, Fusarium oxysporum, Rhizopus nigricans, Trichoderma harzianum, and Mucor racemosus were dominant in rhizosphere of paddy rice, whereas A. fumigatus, Cunninghamella elegans, Penicillium javanicum, Rhizopus nigricans, Trichoderma lignorum and Mucor hiemalis were dominant in the rhizosphere of soybean.

5.6 EFFECT OF ROOT EXTRACTS OF PADDY RICE AND SOYBEAN ON SOME DOMINANT RHIZOSPHERE FUNGI:

The experiment was designed with the aim to study the effect of freshly prepared root extracts of the plants on some dominant fungi encountered under the present investigation.

Varied effect of root extracts on different fungi have been shown by many workers which may be due to the presence of various amino acids, sugars and other chemicals. Bhat (1966), Leelavathy (1966), Singh (1968) and Upadhyay (1971) have reported that root extracts and exudates of plants stimulated the growth of fungi. For this study, four fungal species namely Aspergillus niger, Fusarium oxysporum, Trichoderma harzianum and T. longibrachiatum were selected.

As shown in Table 13, Fig. 11, the test fungi responded significantly to the root extracts of paddy rice and soybean. Maximum effect of root extracts was observed with linear colony growth on Aspergillus niger and Fusarium oxysporum. The average colony diameter of A. niger after 96 hours in root extracts of paddy rice and soybean were 75 mm and 73 mm respectively as compared to 25 mm in control. After 96 hours, F. oxysporum showed maximum growth (65 mm and 59.5 mm respectively) in the root extracts of soybean and paddy rice.

However, Trichoderma harzianum showed better growth (53 mm) in the root extracts of paddy rice as against 45.5 mm in the root extracts of soybean. The response of T. longibrachiatum to the root extracts of the test plants were almost similar where the colony diameters in the root extracts of paddy rice and soybean were 45.0 mm and 47.3 mm respectively.

5.7 JHUM BURNING IN RELATION TO VESICULAR-ARBUSCULAR MYCORRHIZAL ASSOCIATION OF PADDY RICE AND SOYBEAN:

Most of the mycorrhizal fungi live saprophytically, and it is therefore, the removal and burning of plant residues by forest fire may cause harm to the mycorrhizal association with tree seedlings (Dey and Duffy, 1963). Burning caused damage to soil microflora and mycorrhiza (Mikola, et al., 1964; Wright and Tarrant, 1957, and Wright, 1971). Fire and jhuming also reduce mycorrhizal population (Mikola, 1970, and Nicolson, 1967).

In regard to the above considerations, an attempt was made to study the effect of jhum burning on mycorrhizal association of paddy rice and soybean. The experimental data showed higher percentage of vesicular-arbuscular mycorrhizal association in the roots of plants under study in the jhum burnt field as compared to unburnt control field. The percentage infection in 30, 60 and 90 days old seedlings of paddy rice in jhum burnt field were 48.2, 62.0 and 83.3 respectively as against 44.5, 59.9 and 80.3 per cent respectively in unburnt field (Table 28, Fig. 12A).

Similarly, in case of soybean roots 53.2, 66.9 and 90.1 per cent infection of VAM were recorded with 30, 60 and 90 days old plants of jhum burnt field against 50.4, 62.5 and 90.0 per cent respectively in case of unburnt field.

The present finding is supported by the fact that the herbs such as Eupatorium adenophorum and E. odoratum are heavily infected by vesicular-arbuscular mycorrhiza and although these plants were burnt in jhum field, the roots having mycorrhizal fungus remained unaffected by the fire. Therefore, when the above mentioned crop plants were grown they became the test plants and percentage infection of VAM on these plants increased through the roots of the herbs which carried the mycorrhizal fungus, coupled with lesser biotic factors due to burning.

However, in the unburnt field, there was more competition for food and space and therefore vesicular-arbuscular mycorrhizal

fungus could not develop and multiply successfully as it could multiply in the jhum burnt field. This factor resulted in having lesser infection on the test plants - paddy rice and soybean (Plate XIX).

In the following year of cultivation during 1987, the roots of both paddy rice and soybean showed lesser percentage infection in 30 days old plants in jhum burnt field as compared to the percentage infection recorded in unburnt field (Fig. 12B). However, the reverse path was followed after 60 days. Such variation could be explained because of the fact that the mycorrhizal fungus in the jhum burnt field might take some time for its proper development which followed its steady increase due to lesser biotic factors. Another factor which may be accounted in this regard, may be because of the individual species of mycorrhizal fungi responding differently to some specific soil factors, and the relationship is based on the dominance of specific type of mycorrhizal fungi as explained by Indera D. Bhattarai and Mishra (1983).

The soil pH is also reported to have effect on frequency of mycorrhizal infection and it is known to control the availability of nutrients from the soil to the plants, thereby regulating the status of mycorrhiza (Baylis, 1967). The soil pH range in the present study was found to be from 4.9-5.7 in the jhum burnt field, whereas, it was from 4.4-4.9 in the unburnt field (Appendix Table I-VI). Thus, it is evident that the higher value of soil pH may be one of the factors which contribute to the higher percentage infection of

VAM in the roots of the crop plants grown in the jhum burnt fields.

5.8 JHUM BURNING AND ITS EFFECT ON SOIL-BORNE PATHOGENIC FUNGI:

The damage to soil microflora including mycorrhizal fungi due to burning was found to enhance the pathogenic activity and increase the susceptibility of seedlings to root rot diseases (Viro, 1969).

In the present investigation, significant impact of burning on soil-borne plant pathogens of surface soil was observed. The impact was more significant on weak pathogen (Pythium sp.) whose non-reoccurrence in the jhum burnt soil could be due to the presence of highly antagonistic fungus - Trichoderma spp. having increased population after jhum burning (Table 2-4 and 14; Figs. 13 and 19).

Sclerotium rolfsii was infrequently isolated from the control forest soil (Table 6). However, the same was not isolated from the jhum burnt soil. Diminishing impact was observed on Fusarium oxysporum F. moniliforme, F. solani, Verticillium sp., Helminthosporium sp. and Pestolatia sp. immediately after the burning. but it was noticed that after span of time their population increased and attained ever higher number in the jhum burnt soils. This may be ascribed to the adaptable ability of these pathogenic fungi to the changed soil environment coupled with their recolonization ability due to fast sporulating nature. Ahlgren and Ahlgren (1965) also explained that the reconstituted population increased and turned more active than the original one perhaps because of the large quantity of mineral

nutrients released from the ash and other changes in soil.

The results of the present investigation, undoubtedly suggested that jhum burning has direct and indirect effect on controlling soil-borne pathogenic fungi. Burning directly destroyed the pathogens with sufficient heat produced, and indirectly by stimulating the growth of antagonists like Trichoderma spp. Thus, the direct and indirect effects of burning may be accounted for the lesser disease occurrence on crop plants under jhum cultivation at Medziphema, Nagaland. Control of Verticillium and Fusarium diseases in vegetable crops in Israel and control of V. dahliae in Pistachio orchards in California, USA by soil solarization have also been reported (Katan, 1981, 1984). Cartia in 1989 also reported a good control of Pyrenochaeta lycopersici, Verticillium dahliae, Phoma lycopersici, Phytophthora capsici and Sclerotinia by soil solarization in green house and field experiments in Sicily. However, the same may not be practicable in high rainfall areas with humid climatic conditions throughout the year.

5.9 ANTAGONISTIC EFFECT OF TRICHODERMA HARZIANUM ON SOME DOMINANT SOIL BORNE PLANT PATHOGENIC FUNGI:

Antagonistic effect of Trichoderma spp. on plant pathogenic fungi have been reported by many mycologists on Sclerotium rolfsii by Chet et al., (1983); Cook and Baker (1989); Upadhyay and Mukhopadhyay (1986); Waraitch (1987); Harman et al., (1989); and

Singh et al. (1987), Rhizoctonia solani (Chet and Baker, 1980, Elad et al., 1983; Herman et al., (1989), Sclerotinia sclerotiorum (Santos et al., 1982, Cook and Baker, 1983; Whipps, 1987, Singh, 1987), Fusarium and Phytophthora (Cook and Baker, 1983); and Pythium (Mukhopadhyay and Chandra, 1986, and Harman et al., 1989).

Trichoderma lignorum present naturally or added in acid soils, found to be effective in controlling damping-off of citrus seedlings caused by Rhizoctonia solani (Garrett, 1965). T. lignorum also prevented reinfestation of fumigated soil by Sclerotium rolfsii and Rhizoctonia solani under controlled and field conditions (Chet and Henis, 1983). Further, amendment of mass culture of T. harzianum in wheat bran to soil infested with S. rolfsii or R. solani in the glass house, effectively controlled damping-off of bean, groundnut and egg-plants (Chet and Elad, 1982).

Effective control of various plant pathogenic diseases by T. harzianum have been emphasized by many mycologists: Sugar beet rot caused by Sclerotium rolfsii (Mukhopadhyay and Upadhyay, 1983, 1986); Wilt of chick pea complex caused by Fusarium (Mukhopadhyay and Kaur, 1990); Tobacco and sugarbeet disease caused by Pythium aphanidermatum (Mukhopadhyay et al., 1986, Mukhopadhyay and Chandra, 1986); damping-off of radish (Chet and Baker, 1980), and Sclerotinia wilt and rot of knol-khol and collar rot of pigeon-pea by Sclerotium rolfsii (Singh et al., 1988).

In the present study, the T.harzianum Rifai (CMI No. 323745) an isolate found to be dominant in jhum soil of Medziphema was selected for its antagonistic effect on Sclerotium rolfsii, Sclerotinia sclerotiorum, Fusarium oxysporum and Rhizoctonia solani and was found effective in controlling the growth of test pathogens in vitro (Plates XIV-XVII). The above mentioned culture of T. harzianum showed its capability of growing rapidly over the colony, decaying the sclerotia and coiling the hyphae of R. solani (Plate XVIII).

5.10 EFFECT OF TRICHODERMA HARZIANUM ON SEED GERMINATION AND SEEDLING GROWTH OF PADDY RICE AND SOYBEAN IN-VITRO;

Micro-organisms induce growth regulating effects on higher plants under gnotobiotic conditions (Lindsey, 1967, and Kreutzer et al., 1975). Baker, (1988) reported that rate of seed germination in maize, tobacco and tomato was increased by 1 or 2 days compared with controls where Trichoderma spp. were not present. Chang et al., (1986) also reported 2 days earlier germination of pepper seeds than untreated control. Further, increased rooting in carnation and chrysanthemum cuttings by treatment with peat bran culture of Trichoderma species have also been observed by Baker in 1986, and Chang et al., 1986. Bedding plants like marigold, pepper, periwinkle and petunia treated with T. harzianum (culture in peat bran) showed increase in growth and hastened flowering (Baker et al., 1986).

In consideration with the above findings, experiments were designed in present study to see the effect of T. harzianum isolate

on seed germination and growth of paddy rice and soybean. Soybean (var. Bragg and Local) seeds treated with metabolite of T. harzianum showed 100% germination while in case of non-treated control, the germination percentage was found to be 73.3% in var. Local and 88.8% in var. Bragg. The seeds of paddy rice showed 100% seed germination in both treated and untreated control (Table 29, Plate VIII).

However, significant difference in plumule growth of paddy rice seedlings were recorded in treated and nontreated seeds. The average length of plumule of treated seeds measured 10.0 mm after 72 hours, whereas, it was only 5.0 mm in the case of non-treated control. The average length of radicle of treated and non-treated local soybean seeds were 54.6 mm and 38.3 mm respectively; whereas, average length of radicle of soybean var. Bragg recorded in treated and non-treated were found to be 49.0 mm and 31.3 mm respectively (Table 29, Fig. 20, Plates X & XI).

The stimulatory effects on seed germination and seedling growth of paddy rice and soybean as observed in the present investigation with T. harzianum treatments are in confirmity with the stimulatory effects of Trichoderma species on rate of seed germination in maize, tomato and tobacco (Baker, 1988).

5.11 EFFECT OF TRICHODERMA HARZIANUM ON GROWTH OF PADDY RICE AND SOYBEAN IN-VIVO:

Growth stimulatory effects of micro-organisms on higher plants

under gnotobiotic condition have been reported by Lindsey in 1967, and Kreutzer et al., in 1975. Steamed or raw soil infested with Trichoderma species was found to hasten flowering of periwinkle, increase the number of blooms of chrysanthemum and petunia flowers and also increase the dry weight of these and other plants like tomato, pepper, and cucumber (Chang et al., 1986). Dwarf tomatoes were found to be significantly taller in soil infested with Trichoderma viride than those grown in germ free environments (Lindsey et al.,1967). Baker et al. in 1984 observed promotion of radish growth in raw soil by application of T. harzianum.

As above experiments were confined to the ornamental and vegetable plants, in the present investigation, paddy rice and soybean which constitute the major crops in jhum cultivation were selected. Moreover, in my earlier experiments, it was observed that T. harzianum increased the growth of radicle and plumule in both paddy rice and soybean and also percentage seed germination in soybean varieties in laboratory conditions. The present investigation was carried out to find out the effect of T. harzianum on growth of paddy rice (Kezi) and soybean (Local) in field conditions.

The results indicated significant increase in average height coupled with earlier flowering in both the plants treated with T. harzianum in autoclaved pot soil. In pot experiment, 45 days old paddy rice plants treated with sand maize culture of T. harzianum (200:2) were found to be tallest in height (12.3 cm) as against

untreated control (200:0) attaining only 9.9 cm height. The treated plants also flowered 6 days earlier than the untreated plants (Table 30 and Plate IX).

Similar experiment with the plant - soybean indicated maximum height of plants (33.6 cm) with 200:3 treatment against minimum of 27.0 cm with 200:0 (untreated control) which was found to be highly significant. However, the growth of plants in height between the treatments with 200:2 and 200:3 were non-significant. Flowering of treated plants was also found to be enhanced by 6 days. Further, better root development was also observed in case of treated soybean plants (Plate XIII).

Thus, the present findings, which have depicted stimulatory effects on paddy rice and soybean with the treatments of T. harzianum, corroborate the results obtained by Lindsey (1967), Kreutzer and Baker (1975), Baker et al., (1984, 1986) and Chang et al., (1986).

5.12 EFFECT OF JHUM BURNING ON POPULATION OF TRICHODERMA SPECIES - AN EARLY COLONIZER IN JHUM BURNT SOIL:

Species of the fungus Trichoderma have been recognized as early colonizer of soil after fumigation, sterilization, fire or burning. Trichoderma species were among the pioneer colonizers following soil fumigation (Munnecke et al., 1981). Trichoderma viride population increased consistently with time after fire (Tiwari and Rai, 1976).

It was observed in the present investigation that jhum burning created a favourable condition for rapid colonization of Trichoderma species in the jhum burnt soils. As compared to control forest soil, the population density of different species of Trichoderma (Table 14, Fig. 13) showed a sudden rise in the population density after burning during April in jhum burnt field. The maximum population density of 21.52 per cent was observed with T. harzianum in jhum burnt soil in comparison to the maximum of 6.49 per cent recorded with the same species in control forest soil. Among the three species of Trichoderma maximum population (density percentage) was recorded with T. harzianum and minimum with T. lignorum in jhum burnt soil. However, population was found to be reduced ultimately after span of time in August and September (Fig. 13).

In comparison to colonizatioon of other fungal species in jhum burnt field, the maximum colonization of Trichoderma species in respect of population density was recorded in April when the population of other species were least. However, with maximum population (density recorded) of other fungal species in August and September the total Trichoderma population density was found to be minimum (Table 14, Fig. 15). Whatsoever may be no significant variation was found in the population density of Trichoderma species and other fungal species in control forest land (Table 15, Fig. 16).

Plate I. A patch of forest canopy before slashing for burning

Plate II. A patch of slashed forest before burning for jhuming.

PLATE I

PLATE II

Plate III. Burning of the dried biomass in jhuming

Plate IV. After burning - The jhum field

PLATE III

PLATE IV

Plate V. Jhum field after burning fire-wood collection by jhumia for domestic use before burning.

Plate VI. The crop pf paddy rice in jhum field. Picture also show tree stumps.

PLATE V

PLATE VI

Plate VII. The crop of paddy rice before harvesting in one of the jhum fields at Medziphema.

PLATE VII

Plate VIII. Effect of *Trichoderma harzianum* metabolite on percentage seed germination and plumule elongation of paddy rice (Kezi). Top row untreated; Botton row - treated.

Plate IX. Effect of soil amendment with *Trichoderma harzianum* on the growth of paddy rice (Kezi).

PLATE VIII

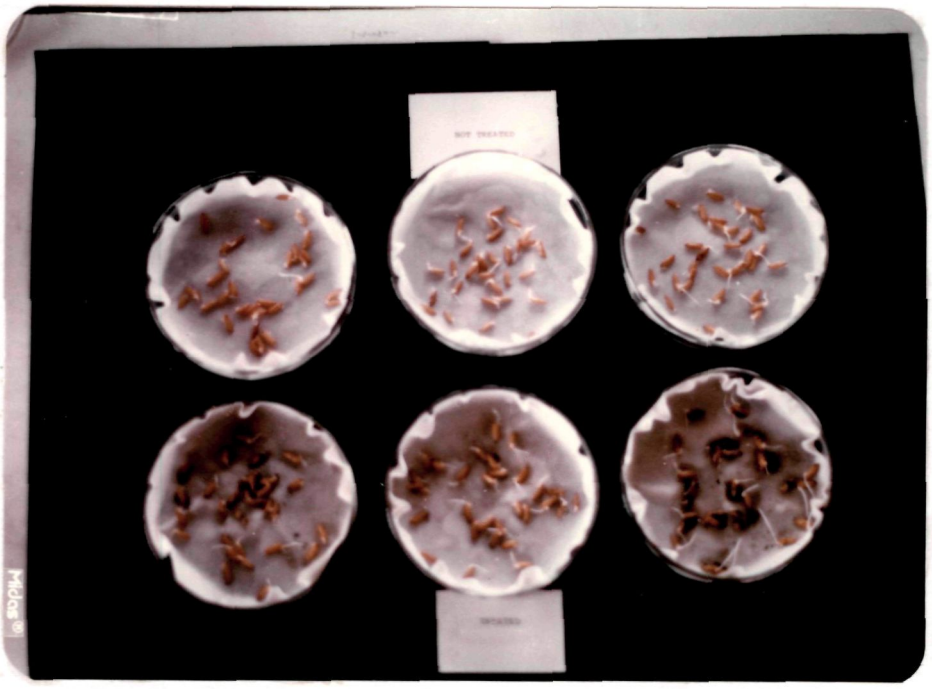


PLATE IX

Plate X. Effect of T. harzianum metabolite on the radicle elongation of soybean (Local). Upper row - not treated; Lower row - treated.

Plate XI. Effect of T. harzianum metabolite on the development of radicle (Soybean) and plumule (Kezi). Upper row - treated; Below - not treated.
Left - Soybean (Local); Middle - Soybean (Bragg); Right - paddy rice.

PLATE X

PLATE XI

Plate XII. Effect of soil amendment with *T. harzianum* on the growth of soybean (var. Bragg). Right to left : Ratios - 200:0, 200:1, 200:2 and 200:3 of sterilized soil and sand-maize culture of *T. harzianum*.

Plate XIII. Effect of *T. harzianum* on the root development of soybean var. Bragg. Left - treated; Right - not treated.

PLATE XII

PLATE XIII

Plate XIV. Pure culture of *T. harzianum* (Left) and *Sclerotium rolfsii* (Right) on PDA medium.

Plate XV. Antagonistic effect of *T. harzianum* on *S. rolfsii in vitro* (Left) as compared to pure culture of *S. rolfsii* (Right).

PLATE XIV

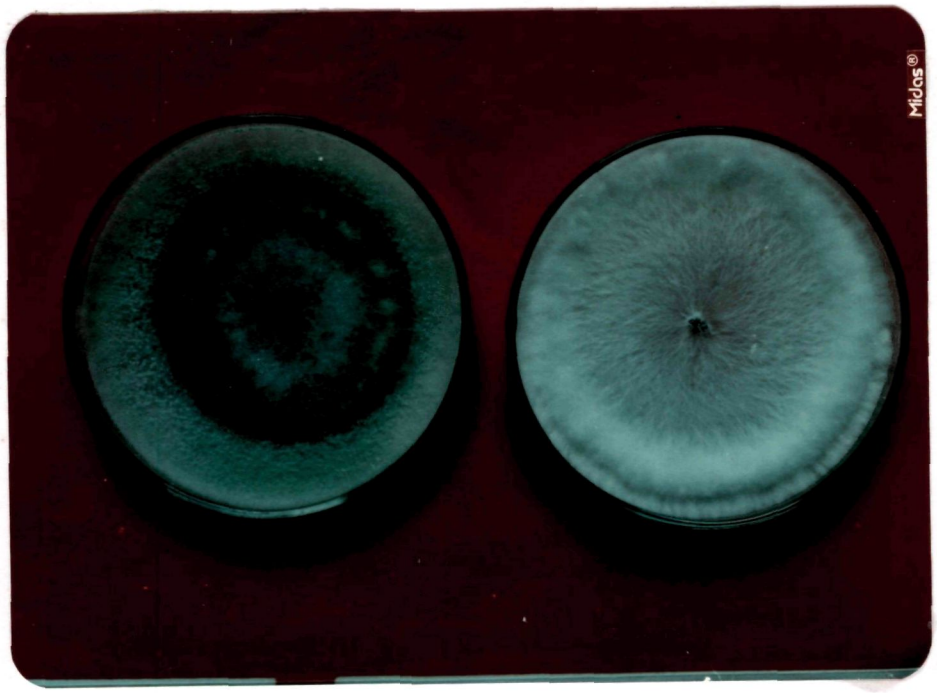


PLATE XV

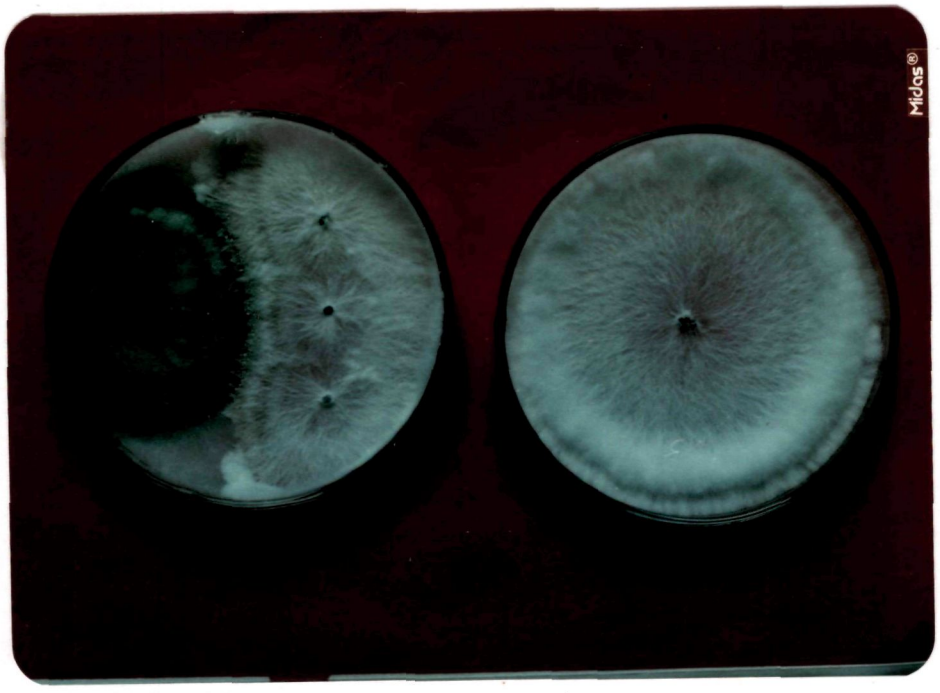


Plate XVI. Antagonistic effect of *T. harzianum* against *Rhizoctonia solani* *in vitro* (Left). Pure culture of *R. solani* (Right top). Pure culture of *T. harzianum* (Right bottom).

Plate XVII. Antagonistic effect of *T. harzianum* against *Sclerotinia sclerotiorum* (Left). Pure culture of *S. sclerotiorum* (Right).

PLATE XVI

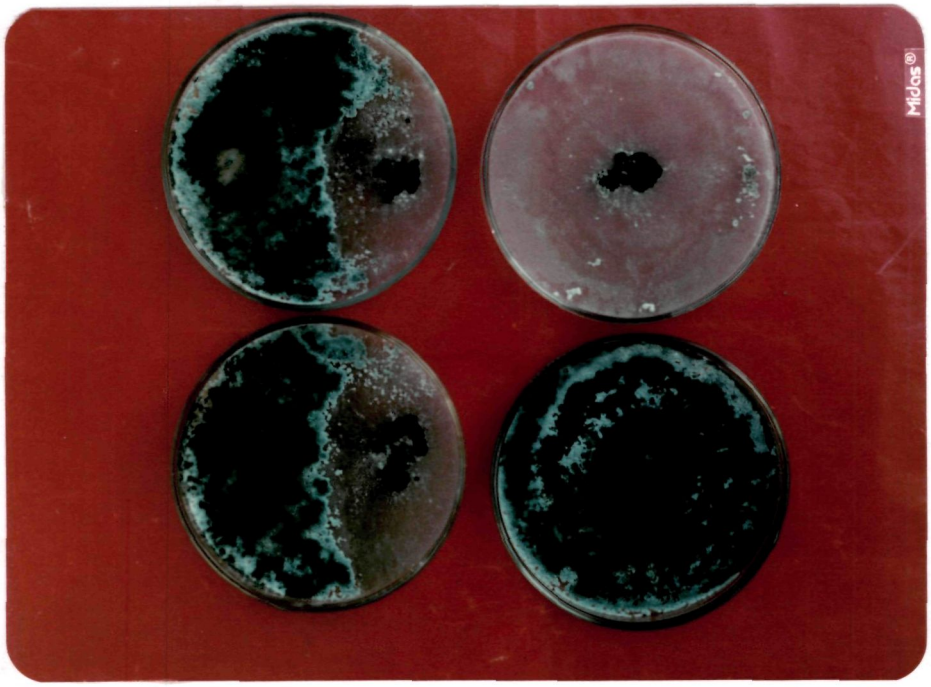


PLATE XVII

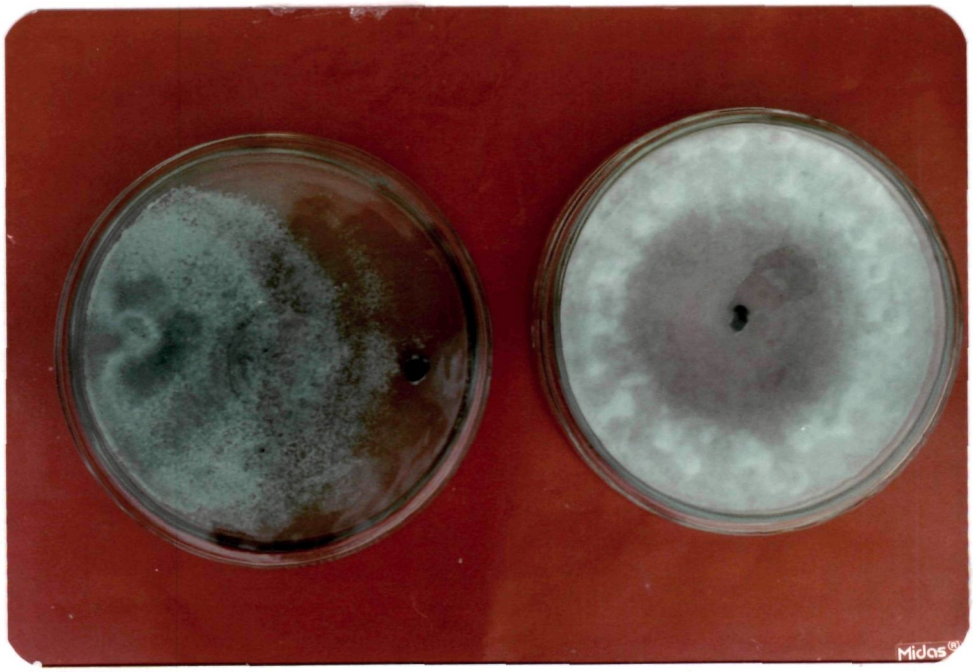


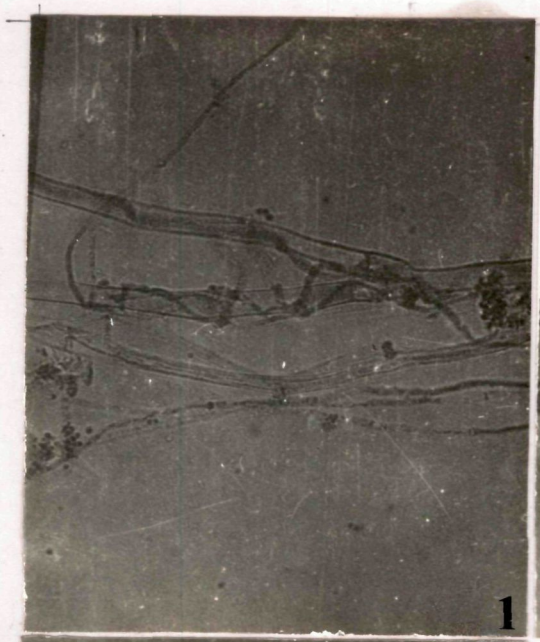
Plate XVIII. 1. Coiling of Trichoderma harzianum around hypha of Rhizoctonia solani.

2. Enlarged view of coiling of T. harzianum.

3. Penetration of Trichoderma harzianum into hypha of R. solani.

4. Formation of loop by Trichoderma harzianum.

PLATE XVIII


1


2


3

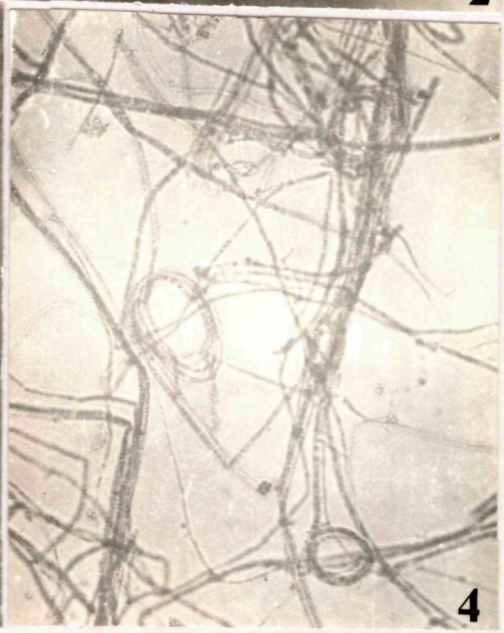
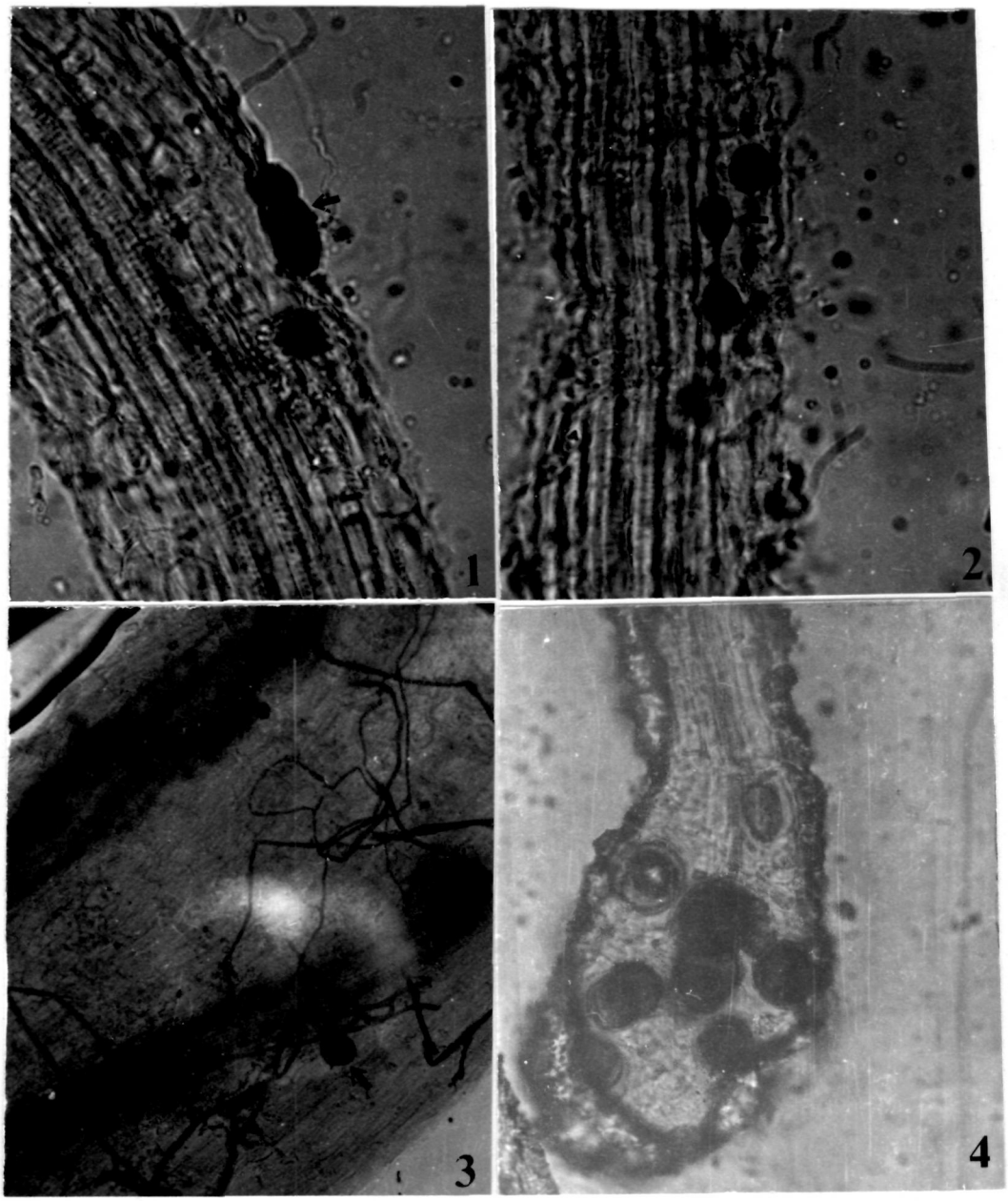

4

Plate XIX. 1 and 2 . Vesicle formation in the roots of PRK.

3. Vesicle formation in the roots of SBL.

4. Spores in the roots of PRK.

PLATE XIX



C H A P T E R - V I

S U M M A R Y

S U M M A R Y

Jhuming has remained as sustainable form of agriculture among tribal people in hill areas of North-Eastern region of India. The system involves in cutting of regenerated forest biomass and burning followed by sowing the seeds. Studies on soil micro-organisms were carried out for two successive years from three jhum fields and adjacent control forests at different locations of Medziphema, Nagaland. Since, paddy rice (kezi) and soybean were considered to be major crops of jhum cultivation, it was, therefore, studies on rhizosphere and rhizoplane mycoflora of these crops were also undertaken.

A drastic reduction in fungal, actinomycetes and bacterial population of jhum burnt surface soil was noticed as compared to control forest surface soil. However, microbial population which was reduced initially after burning showed a gradual and continuous recovery upto preburn level. In the sub-soil (7.5-15 cm), no significant change in fungal and actinomycetes population was observed because of jhum burning, except in bacterial population, which showed significant difference initially.

The dominant genera of fungi recorded from the jhum burnt soil were: Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus and Trichoderma. A marked quantitative as well as qualitative difference in between jhum burnt and control forest soil mycoflora was observed. A higher

number of fungi quantitatively and qualitatively were found in control forest soil as compared to jhum burnt soils.

The fungal species viz., Aspergillus fumigatus, A. niger, A. terreus, Mucor hiemalis, Neurospora sp., Penicillium frequentans, P. luteum, Rhizopus nigricans, Trichoderma harzianum, Fusarium oxysporum, Sclerotium sp., Cephalosporium sp., Choanephora sp. and black sterile mycelia were found to be early colonizers in jhum after burning.

During April to September, when the rainfall and soil moisture content were found to be in the range of 55-285 mm and 27-34 per cent respectively, quantitative increase in fungal, actinomycetes and bacterial population was noticed. Minimum population of fungi, actinomycetes and bacteria were recorded in the month of March which happened to be the driest month. However, maximum population of fungi and actinomycetes was recorded in July, while maximum population of bacteria could be recorded in the month of May. Regular pattern of increase or decrease in mycoflora could not be observed as per seasonal change.

An increase in potassium, phosphorus and pH of soil was detected in jhum burnt field, however, organic carbon content was found to be decreased.

Effect of jhum burning on rhizosphere mycoflora of paddy rice (Kezi) and soybean indicated increased number of fungi per gram dry soil in the rhizosphere of both the plants in the first year as compared

to unburnt control field. The rhizosphere effect was found to be more with the age of both the plants. Maximum fungal population was recorded from fruiting stage. The rhizosphere effect (R/S ratio) of both the plants grown in jhum burnt as well as unburnt field was found to be always more than one. No regular pattern of increase or decrease in number of fungal species with the age of plants could be recorded from the rhizosphere of plants grown in jhum burnt or unburnt fields. However, in comparison to unburnt field, the total population count was found to be always higher in rhizosphere of the plants grown in jhum burnt field.

The number of fungal species recorded were found to be maximum in non-rhizosphere, moderate in rhizosphere and minimum in rhizoplane of both the plants. In comparison to soybean, higher number of fungi per gram dry soil as well as higher number of fungal species were recorded in the rhizosphere of paddy rice grown in jhum burnt field.

It was revealed from studies on effect of root extracts of paddy rice and soybean on some dominant rhizosphere fungi that all the test fungi responded significantly to the root extracts. Maximum effect of root extracts on radial growth was observed with Aspergillus niger and Fusarium oxysporum. In comparison to soybean better growth of Trichoderma harzianum was recorded with root extract of paddy rice.

Percentage of vesicular-arbuscular mycorrhiza was found to be higher in the roots of plants grown in jhum burnt field as compared

to unburnt control field. Between the two plants, percentage infection was found to be more in soybean.

Effect of jhum burning was found to be significant on soil borne plant pathogens of surface soils. The impact was more significant on weak pathogen like Pythium sp. However, diminishing impact could be noticed on Fusarium oxysporum, F. moniliforme, F. solani, Verticillium sp., Helminthosporium sp., and Pestolatia sp.. immediately after burning which regained its original number and attained even higher number in jhum burnt soils after a span of time.

Trichoderma harzianum Rifai, isolated from jhum soil showed antagonistic effect on Sclerotium rolfsii, Sclerotinia sclerotiorum, Fusarium oxysporum and Rhizoctonia solani. It was also found to be effective in controlling the growth of the test fungi in-vitro.

Stimulatory effect on percentage seed germination of paddy rice and soybean was observed with the treatment of fungal metabolite of T. harzianum. The treatment also promoted the growth of seedlings, plumule in case of paddy rice and radicle elongation in case of soybean in the laboratory condition.

In field condition, an increase in height coupled with enhancement in flowering of paddy rice and soybean plants were observed with soil amendment of sand maize coulture of T. harzianum.

Population density of Trichoderma spp., which showed sudden rise after jhum burning, reduced after some time. Among the species of Trichoderma, maximum percentage of population was recorded with T. harzianum. No significant variation in population density was observed between Trichoderma spp. and other fungal species in control forest ecosystem.

C O N C L U S I O N

In total, the present investigation has elucidated about the invaluable impact of jhum burning on agro-ecosystem. The change in habitat due to jhum burning was found to be influenced and regulated by abiotic as well as biotic factors. Ecological disturbances, thus created gave birth to setting up of a new equilibrium in the new environment which was also dynamic and varied with the factors like microbial population, plant species, age and vigour of plant, soil level, pH, moisture and organic content of the soil and other environmental factors. Rhizosphere effect was found to be positive. The shift in microbial population caused disappearance of some plant pathogenic fungi and colonization of newer and beneficial forms. The results obtained out of various experiments revealed that - (1) jhum burning created condition for colonization of higher percentage of VAM association with the root of crop plants which not only helps in nutrient uptake but also help in combating the attack of pathogenic or other harmful micro-organisms (2) Some fungal species like Trichoderma

in soil also acted as two in one system in promoting the growth of the plants in one hand and being antagonistic to soil borne plant pathogenic fungi on the other. This fact has supported as to how less disease infestation and higher crop production in jhuming is accomplished.

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B I B L I O G R A P H Y

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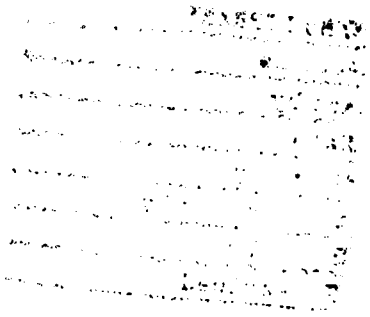

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A P P E N D I C E S

Table I

PHYSICO-CHEMICAL CHARACTERS OF SURFACE SOILS FROM JHUM BURNT AND CONTROL FOREST FIELD F_1

Year	Sampling months	pH		M.C.(%)		O.C.(%)		K (kg/ha)		P (kg/ha)	
		I	II	I	II	I	II	I	II	I	II
1986	Mar.	5.7	4.8	12.0	19.9	1.7	1.8	213	76	27.0	18.0
	Apr.	5.4	4.9	21.0	26.0	1.6	1.9	204	85	24.6	16.5
	May	5.4	4.8	16.5	20.0	1.5	2.1	160	102	23.3	17.0
	Jun.	4.9	4.7	31.0	31.0	1.6	2.3	143	101	18.6	18.0
	Jul.	5.0	4.8	22.3	25.3	1.6	1.8	133	110	18.0	17.5
	Aug.	4.9	4.8	21.0	23.2	1.4	1.7	120	73	17.5	15.8
	Sep.	4.8	4.8	29.0	36.1	1.3	1.7	118	68	17.5	15.0
1987	Mar.	5.4	4.9	16.6	14.8	1.6	1.2	100	92	21.8	20.0
	Apr.	4.6	4.7	18.0	19.0	1.3	1.8	119	85	22.5	18.5
	May	4.4	4.7	16.3	21.0	1.7	1.7	82	91	21.8	18.5
	Jun.	4.7	4.6	17.0	23.3	1.8	1.9	70	102	18.5	16.6
	Jul.	4.8	4.7	21.3	36.1	1.4	1.8	65	96	19.0	17.0
	Aug.	4.6	4.8	20.0	30.0	1.4	1.8	65	90	16.7	18.0
	Sep.	4.5	4.7	16.0	20.2	1.3	1.6	52	72	15.9	17.4

I = Jhum burnt, II = Control forest, M.C. = Moisture content, O.C. = Organic Carbon, K = Potassium

P = Phosphorous

Table II

PHYSICO-CHEMICAL CHARACTERS OF SURFACE SOIL FROM JHUM BURNT AND CONTROL FOREST FIELD F_2

Year	Sampling months	pH		M.C.(5)		O.C.(%)		K (kg/ha)		P (kg/ha)	
		I	II	I	II	I	II	I	II	I	II
	Mar.,	5.9	4.7	14.0	19.1	1.8	1.8	209	86	38.0	21.4
	Apr.	5.9	4.9	24.0	28.6	1.7	1.8	163	92	35.6	22.8
	May	5.8	4.9	18.5	20.4	1.8	2.0	144	116	35.0	20.0
1986	Jun.	4.9	4.8	27.0	32.0	1.9	2.1	125	122	34.5	23.2
	Jul.	5.0	4.8	22.0	26.4	1.7	1.7	120	121	33.0	23.8
	Aug.	4.9	4.4	16.0	22.3	1.7	1.6	118	114	20.5	21.0
	Sep.	4.8	4.8	28.7	33.0	1.5	1.7	116	110	28.3	18.4
	Mar.	5.0	4.9	14.0	17.4	1.6	1.7	115	122	28.6	18.2
	Apr.	4.8	4.7	21.0	20.2	1.8	1.8	118	114	28.5	20.4
	May	4.5	4.8	18.0	19.0	1.7	1.9	79	108	24.6	20.1
1987	Jun.	4.6	4.7	19.8	29.4	1.9	2.2	72	120	22.0	24.0
	Jul.	4.9	4.7	24.0	30.5	1.8	1.8	66	84	19.0	23.3
	Aug.	4.7	4.9	28.2	32.5	1.6	1.7	65	81	18.0	19.4
	Sep.	4.6	4.8	18.0	20.0	1.4	1.6	53	86	17.8	19.2

I = Jhum burnt, II= Control forest, MC= Moisture conmtent, O.C= Organic carbon, K = Potassium, P = Phosphorus

Table III

PHYSICO-CHEMICAL CHARACTERS OF SURFACE SOIL FROM JHUM BURNT AND CONTROL FOREST FIELD F_3

Year	Sampling months	pH		M.C.(%)		O.C.(%)		K (kg/ha)		P (kg/ha)	
		I	II	I	II	I	II	I	II	I	II
1986	Mar.	5.0	4.5	14.8	18.3	1.3	1.7	174	114	36.6	18.4
	Apr.	4.9	4.6	24.0	30.0	1.1	1.9	162	122	33.0	18.2
	May	4.8	4.5	18.0	22.0	1.4	1.8	160	126	31.0	20.2
	Jun.	4.8	4.4	29.8	34.0	1.6	1.8	171	134	28.0	19.6
	Jul.	4.9	4.5	25.0	29.0	1.2	1.6	165	110	27.3	19.0
	Aug.	4.8	4.8	17.2	31.0	1.1	1.5	158	115	26.4	17.2
	Sep.	4.6	4.4	29.0	36.0	1.1	1.6	156	113	24.0	15.0
1987	Mar.	4.9	4.6	16.0	18.0	1.5	1.6	149	121	25.6	19.4
	Apr.	4.9	4.8	23.0	21.0	1.6	1.9	144	116	23.0	20.2
	May	4.8	4.5	17.0	20.0	1.4	1.8	146	122	22.2	18.6
	Jun.	4.9	4.7	20.1	26.2	1.7	1.8	154	130	21.6	17.4
	Jul.	4.8	5.2	24.2	36.3	1.6	1.5	135	116	22.4	20.0
	Aug.	4.6	4.6	27.0	32.0	1.5	1.6	131	109	19.8	18.7
	Sep.	4.8	4.6	21.0	23.0	1.3	1.6	124	94	17.8	18.0

I = Jhum burnt, II= Control forest, M.C.= Moisture content, O.C.+ Organic Carbon, K = Potassium, P = Phosphorus

Table IV

PHYSICO-CHEMICAL CHARACTERS OF SUB-SOIL FROM JHUM BURNT AND CONTROL FOREST FIELD F_1

Year	Sampling months	pH		M.C.(%)		O.C.(%)		K (Kg/ha)		P (kg/ha)	
		I	II	I	II	I	II	I	II	I	II
	Mar.	5.0	4.7	16.3	18.0	1.6	1.3	72.8	68.2	18.1	17.0
	Apr.	4.9	4.8	19.8	25.2	1.4	1.6	135	73.4	18.2	15.7
	May	4.8	4.8	22.2	21.0	1.4	1.1	124	68.6	18.2	15.6
1986	Jun.	4.8	4.7	28.3	26.3	1.8	2.2	118	78.7	19.0	16.1
	Jul.	4.8	4.5	24.0	24.7	1.4	1.8	120	78.8	22.4	15.7
	Aug.	4.7	4.5	19.5	19.8	1.2	1.6	106	71.0	17.9	15.7
	Sep.	4.6	4.6	24.0	23.2	1.1	0.9	118	68.6	16.6	15.7
	Mar.	4.9	4.9	17.0	19.3	1.4	1.7	92.2	69.4	18.0	17.9
	Apr.	4.7	4.7	18.1	20.4	1.5	1.6	78.4	72.4	17.8	16.6
	May	4.9	4.7	19.2	18.9	1.5	1.9	73.6	76.0	17.4	16.9
1987	Jun.	4.8	4.6	21.0	21.2	2.2	2.1	77.2	79.0	17.1	16.5
	Jul.	4.8	4.7	23.0	25.0	1.8	1.6	91.0	69.4	17.2	16.9
	Aug.	4.4	4.8	24.0	28.0	1.6	1.3	98.0	73.6	16.6	15.9
	Sep.	4.5	4.7	19.0	18.0	0.9	1.3	72.0	71.8	16.6	16.0

I = Jhum burnt, II = Control forest, M.C.= Moisture content, O.C.= Organic carbon , K = Potassium, P = Phosphorus

Table V

PHYSICO-CHEMICAL CHARACTERS OF SUB-SOIL FROM JHUM BURNT AND CONTROL FOREST FIELD F_2

Year	Sampling months	pH		M.C. (%)		O.C. (%)		K (Kg/ha)		P (Kg/ha)	
		I	II	I	II	I	II	I	II	I	II
1986	Mar.	4.9	4.8	16.0	20.6	1.2	1.7	110	110	26.0	18.5
	Apr.	5.2	5.0	21.0	26.4	1.3	2.0	122	106	28.0	19.0
	May	4.9	4.7	19.8	20.3	1.1	1.8	117	108	25.0	16.2
	Jun.	4.7	4.8	29.7	31.0	1.1	2.0	125	102	26.2	18.0
	Jul.	4.8	4.7	23.7	24.3	1.1	1.6	124	113	24.5	17.0
	Aug.	4.6	4.4	18.1	20.3	1.1	1.4	121	121	25.0	16.5
	Sep.	5.0	4.6	23.0	24.0	1.0	1.1	108	120	24.8	16.8
1987	Mar.	4.9	4.8	18.9	18.0	1.8	1.3	120	110	26.0	17.5
	Apr.	4.6	4.8	21.7	18.8	1.3	1.5	116	108	21.8	17.0
	May	4.8	4.9	20.7	17.3	1.2	1.0	109	110	20.4	18.0
	Jun.	4.8	4.9	22.0	23.2	1.2	1.6	122	111	18.5	17.2
	Jul.	4.8	4.6	22.8	27.5	1.3	1.9	115	116	19.6	16.5
	Aug.	4.4	4.8	24.0	26.0	1.2	1.3	110	118	19.0	16.0
	Sep.	4.5	4.7	18.0	20.4	1.1	1.4	99	109	17.5	19.5

I = Jhum burnt, II = Control forest, M.C. = Moisture content, O.C. = Organic carbon, K = Potassium

P = Phosphorus

Tables VI

PHYSICO-CHEMICAL CHARACTERS OF SUB-SOIL FROM JHUM BURNT AND CONTROL FOREST FIELD F_3

Year	Sampling months	pH		M.C.(%)		O.C.(%)		K (kg/ha)		P (kg/ha)	
		I	II	I	II	I	II	I	II	I	II
	Mar.	4.8	4.4	16.0	17.0	1.0	1.2	106	112	23.0	18.0
	Apr.	4.7	4.8	18.8	18.0	1.6	1.9	115	119	24.0	18.5
	May	4.5	4.4	17.0	19.4	1.3	2.1	121	104	22.5	16.4
1986	Jun.	4.6	4.4	28.2	31.0	1.6	2.0	124	110	24.0	15.2
	Jul.	4.4	4.5	23.0	28.0	1.5	.17	125	108	23.2	16.0
	Aug.	4.4	4.6	19.6	24.0	1.2	.13	115	107	22.0	15.8
	Sep.	4.8	4.4	34.2	34.0	1.3	1.5	104	102	20.4	15.2
	Mar.	4.6	4.4	17.0	17.0	1.1	1.2	120	110	22.0	17.6
	Apr.	4.4	4.6	20.0	21.8	1.6	1.8	125	115	20.8	16.4
	May	4.6	4.4	19.2	21.7	1.3	1.6	127	114	21.4	15.3
1987	Jun.	4.6	4.6	22.0	24.0	1.8	1.3	132	110	20.2	15.0
	Jul.	4.7	4.9	23.0	27.0	1.0	1.6	118	108	21.4	16.3
	Aug.	4.9	4.4	24.8	28.0	1.2	1.6	124	116	20.3	16.3
	Sep.	5.0	4.5	19.0	20.0	1.4	1.8	98	107	19.0	15.4

I = Jhum burnt, II = Control forest, M.C. = Moisture content, O.C. = Organic Carbon content, K = Potassium P = Phosphorus

Table VII

NUMBER OF FUNGI/G DRY SOIL IN JHUM BURNT AND CONTROL FOREST SOIL. MEAN VALUES (THOUSANDS)

ANALYSIS OF VARIANCE

Months	SURFACE SOIL				SUB-SOIL			
	Jhum burnt		Control forest		Jhum burnt		Control forest	
	1986	1987	1986	1987	1986	1987	1986	1987
Mar.	4.6	5.8	6.7	6.3	5.0	5.0	5.8	5.7
Apr.	6.0	6.3	6.9	6.5	5.3	6.1	6.0	6.3
May	6.9	8.2	8.5	7.8	6.2	7.0	7.6	7.9
Jun.	7.3	6.5	7.4	6.8	6.6	6.4	6.4	6.7
Jul.	9.2	6.6	7.5	7.2	7.3	5.8	6.9	7.2
Aug.	7.2	6.2	7.8	7.0	6.4	5.6	7.2	7.3
Sep.	5.9	5.7	7.5	6.6	5.7	5.2	6.8	6.2
F	17.23**	14.57**	10.84**	6.74**	36.85**	4.30**	4.09**	14.66**
LSD (5%) (For months)	1.2	0.63	0.62	0.67	0.39	1.2	1.0	0.68
FIELD REPLICATIONS								
F_1	6.7	6.5	7.3	6.9	5.3	5.3	6.0	6.6
F_2	6.5	6.5	7.1	7.0	6.3	6.1	6.8	6.7
F_3	6.8	6.4	8.0	6.7	6.7	6.2	7.2	6.9
F	0.44	0.21	16.84**	1.16	71.32**	%.#@**	8.34**	1.43
LSD (5%) (For fields)	1.1	0.6	0.5	0.6	0.4	1.0	0.9	0.6

** Significant at 5% level

Table VIII

NUMBER OF ACTINOMYCETES/G DRY SOIL IN JHUM BURNT AND CONTROL FOREST SOILS. MEAN VALUES (LAKHS)

ANALYSIS OF VARIANCE

Months	SURFACE SOIL				SUB-SOIL			
	KJhum burnt		Control forest		Jhum burnt		Control forest	
	1986	1987	1986	1987	1986	1987	1986	1987
Mar.	3.3	5.0	5.4	4.8	3.1	3.5	4.2	3.9
Apr.	3.6	6.6	5.0	6.4	3.6	5.1	5.2	5.1
May	4.4	6.4	11.8	5.9	4.2	4.9	9.0	5.6
Jun.	6.8	6.8	11.4	7.8	6.3	6.0	10.4	6.5
Jul.	9.8	9.2	11.3	10.0	9.0	8.0	10.1	10.2
Aug.	8.9	8.0	10.6	9.6	8.3	7.0	9.5	8.7
Sep.	8.5	7.4	10.2	8.8	7.7	6.5	8.5	7.9
F	38.79**	7.08**	48.24**	25.62**	113.16**	15.03**	29.00**	18.13**
LSD (5%) (For months)	2.3	1.5	1.2	1.2	0.68	1.1	1.3	1.6
FIELD REPLICATIONS								
F_1	7.6	7.4	10.2	8.1	7.1	6.7	9.5	7.2
F_2	7.3	7.5	9.9	7.7	6.4	6.0	7.9	6.3
F_3	4.6	6.2	8.0	7.1	4.6	4.8	7.1	6.9
F	32.85**	4.95**	20.30**	3.93**	76.85**	14.80**	17.01**	1.80
LSD (5%) (For fields)	1.3	1.5	1.2	1.2	0.6	1.1	1.4	1.6

** Values significant at 5% level

Table IX

NUMBER OF BACTERIA/G DRY SOIL IN JHUM BURNT AND CONTROL FOREST SOILS
MEAN VALUES (LAKHS)

ANALYSIS OF VARIANCE

Months	SURFACE SOIL				SUB-SOIL			
	Jhum burnt		Control forest		Jhum burnt		Control forest	
	1986	1987	1986	1987	1986	1987	1986	1987
Mar.	5.2	7.4	9.4	11.1	4.9	6.4	7.4	9.2
Apr.	6.8	10.1	7.3	9.2	5.5	6.4	7.2	7.1
May	14.3	17.6	12.9	16.3	15.0	14.5	14.4	15.8
Jun.	10.9	9.3	11.6	12.6	10.1	11.2	13.5	12.2
Jul.	8.6	8.9	10.6	11.5	8.5	8.1	9.5	9.7
Aug.	9.1	16.1	11.0	15.0	9.6	13.2	9.4	14.6
Sep.	9.3	15.5	10.9	14.3	9.6	12.3	9.0	14.2
F	32.88**	6.48**	25.09**	5.79**	142.75**	14.15**	11.11**	38.68*8
LSD (5%) (For months)	3.6	3.7	1.1	3.7	0.95	3.4	2.2	1.6
FIELD REPLICATIONS								
F_1	9.5	12.2	9.5	11.6	9.4	8.6	11.5	10.6
F_2	9.8	13.5	10.9	14.3	9.2	11.8	10.0	12.8
F_3	8.3	11.5	11.2	12.6	8.5	10.5	8.7	12.1
F	5.43**	1.37	13.94**	4.06**	6.22**	7.53**	6.29**	9.79**
LSD (5%) (For fields)	1.5	3.2	1.2	2.0	0.8	2.7	2.6	1.6

** Significant at 5 % level

Table X

NUTRIENT MEDIA WITH COMPOSITION USED IN THE PRESENT STUDY

Martins Agar Medium

KH_2PO_4	:	1.0 g
$Mgso_4$ $7H_2o$	:	0.5 g
Peptone	:	5.0 g
Rose bengal	:	1:15000
Dextrose	:	20.0 g
Agar-agar	:	15.0 g
Distilled water	:	1000 ml

Thorton's Standard Medium

K_2HPO_4	:	1.0 g
$MgSo_4$	:	0.2 g
$Cacl_2$	:	0.1 g
Macl	:	0.1 g
$Fecl_3$	:	0.002 g
KNo_3	:	0.5 g
Asparagine	:	0.5 g
Manitol	:	1.0 g
Agar-agar	:	15.0 g
Distilled water	:	1000 ml
pH 7.0	:	7.5

Czapek's medium

Na No_3	:	2.0 g
K_2HPo_4	:	1.0 g
Mg so_4. $7H_2o$	:	0.5 g
Kcl	:	0.5 g
Sucrose	:	30.0 g
Agar-agar	:	15 g
Distilled water	:	1000 ml

Jenson' Medium

K_2HPo_4	:	0.5 g
Mg So_4	:	0.2 g
Dextrose	:	2.0 g
Casein	:	0.2 g
Agar	:	15 g
Distilled water	:	1000 ml
pH	:	6.2-6.4

P D A Medium

Peeled potato	:	250 g
Dextrose	:	20 g
Agar agar	:	15 g
Distilled water	:	1000 ml

SP. 3 Liquid Medium

Glucose	:	50 g
Yeast Extract	:	1 g
Peptone	:	1 g
KH_2Po_4	:	1.5 g
$(NH_4)_2$ So_4	:	1.5 g
$Mgso_4$	:	1.10 g
Distilled water	:	1000 ml

Table XI

METEOROLOGICAL OBSERVATIONS DURING MARCH 1986 TO SEPTEMBER 1987 UNDER MEDZIPHEMA CONDITION

Month	Relative Humidity (%)		Air temperature(°C)		Total rainfall (mm)	No.of rainy days
	Max.	Min.	Max.	Min.		
1986	72	60	25.2	14.1	30.4	2
Mar.	72	60	25.2	14.1	30.4	2
Apr.	76	62	28.6	15.6	89.2	8
May	88	70	30.9	16.7	55.0	5
Jun.	86	72	35.2	18.2	232.0	17
Jul.	90	78	33.4	20.0	200.0	13
Aug.	84	76	32.5	17.3	75.0	4
Sep.	88	74	31.4	13.7	285.0	14
Oct.	80	68	29.3	11.4	271.0	10
Nov.	82	70	27.8	9.8	49.0	3
Dec.	80	63	24.2	9.7	20.0	2
1987						
Jan.	84	64	22.8	10.4	16.0	1
Feb.	86	68	24.7	12.6	36.9	3
Mar.	80	58	29.4	13.7	15.0	2
Apr.	78	68	32.9	16.4	65.2	5
May	82	72	29.3	18.6	74.4	11
Jun.	83	79	30.6	19.0	255.1±	18
Jul.	90	84	28.7	18.5	320.8	22
Aug.	86	82	27.6	17.6	402.8	16
Sep.	89	86	26.2	16.4	211.6	15

Table XII

FUNGAL SPECIES IDENTIFIED FROM INTERNATIONAL MYCOLOGICAL INSTITUTE, FERRY LANE, KEW, SURREY, ENGLAND

Specimen Number	Herb. IMI Number	Identification
T-4	323748	*Trichoderma lignorum*
C-4	323766	*Fusarium oxysporum* Schlecht
UB-2	323757B	*Fusarium solani* (Mart.) Sacc.
C-3	323765	*Fusarium moniliforme* var. *intermedium*
B-5	323761	*Neurospora* sp.
T-1	323745	*Trichoderma harzianum* Refai
T-3	323747	*Gliocladium roseum* Bainier
UB-1	323756	*Trichoderma longibrachiatum* Refai
C-1	323749	*Penicillium variabile* Sopp.
B-3	323752	*Aspergillus fumigatus* Fres.

SHORT FORMS USED IN THE TEXT

JB = Jhum burnt field

UB = Unburnt field

PRK = Paddy rice (var. Kezi)

SBL = Soybean (var. Local)

SBB = Soybean (var. Bragg)

F_1 = Jhum field - 1

F_2 = Jhum field - 2

F_3 = Jhum field - 3

C_1 = Control forest near field - 1

C_2 = Control forest near field - 2

C_3 = Control forest near field - 3

SMC = Sand-maize culture

RH = Relative humidity

VAM = Vesicular arbuscular mycorrhiza

Rs = Rhizosphere

Rp = Rhizoplane

NRs = Non-rhizosphere

M = March

A = April

M = May

J = June

J = July

A = August

S = September