MYCOFLORA ASSOCIATED WITH LEAF LITTER DECOMPOSITION IN HOMESTEADS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Mycoflora associated with leaf litter decomposition in homesteads"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled, **"Mycoflora associated with leaf litter decomposition in homesteads"** is a record of research work done independently by Jannet Daniel under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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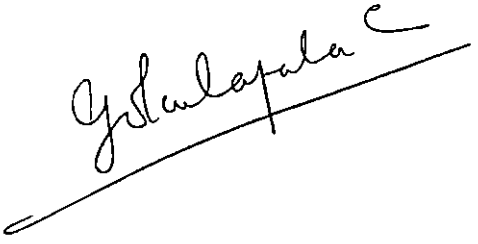

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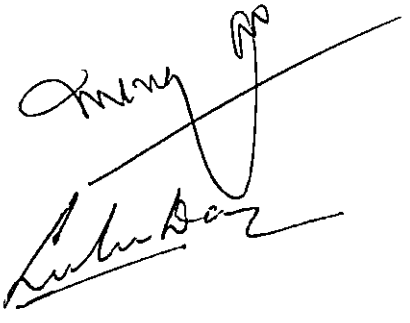

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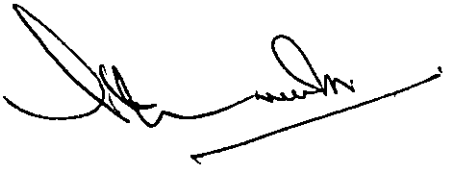

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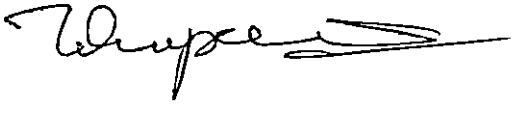

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INTRODUCTION

INTRODUCTION

Litterfall is the primary mechanism for transfer of plant detritus from above ground parts of trees to the soil surface. Decomposition of the detritus provides the main source of energy and nutrients for soil and litter organisms and is a major natural pathway for the recycling of nutrients to the plant community. As the major renewable source of diverse types of organic matter, the amount and nature of litterfall has an important bearing on soil formation and maintenance of soil fertility.

According to Swift et al. (1979) the rates and pathways of litter decomposition are determined by the qualitative and quantitative composition of the decomposer commmunity, the physical environment and the quality of the resources that the animals and microorganisms are utilizing. The substrate quality includes not only the concentration and availability of nutrients but also modifiers such as tannins which affect the activity of the heterotrophs.

In ecology the word litter is used with two meanings, ie., the layer of dead plant materials present on the soil surface; and dead plant materials which are not attached to a living plant. The litter layer may be clearly distinguishable from an underlying mineral layer or there may be no sharp

boundary between a layer containing recognizable plant structures and a layer containing only the amorphous organic material.

Plant organs neither die instantly nor fall instantly when dead. Abscission of a leaf follows a more or less prolonged senescence, when much of the mineral content is withdrawn to the stem and the phylloplane fungi are already decomposing the available carbohydrates.

Biodegradation of litter is the break down of complex substances into simpler substances by the agency of or through the use of any living organism. The speed at which dead plant material decomposes depends largely upon its physical properties. In leaves, the ratio between surface and volume is very important as are the chemical properties of the material. Thus the leaves of different kinds of tree and shrub species decompose at quite different speeds. The time intervals required for decomposition of the individual species of leaf litter are of course not absolute, but dependent on various factors and one of the most important of these is the influence of site. Differences in time taken for decomposition become magnified in pure stands which are permanently under the influence of one kind of cover.

In natural forests and man made protected plantations cycling of nutrients is an important aspect as considerable amounts of nutrients are released to soil through leaf fall and made available for reabsorption. Charley and Richards (1983)

reported that leaf fall accounted for 60-70 per cent of total litterfall and they also accounted for most of the inputs of nutrients like Ca, Mg, S, N, P, K that reached the floor in organic debris.

Mathew (1993) estimated the litter addition to the homestead in Kerala by jack (Artocarpus heterophyllus Hanek) trees is 137.11 kg of litter, which was annually added by litterfall by the two 14 year old jack trees with canopy coverage of $122m^2$. The maximum litterfall was noticed during the month of November and the minimum during May. He has also mentioned the major nutrients present. According to him, the maximum litter addition by mango trees (Mangifera indica L.) was during the month of June (9.43 kg) which accounted for 10.68 per cent of the total input by litterfall. The minimum amount of litter was recorded during the month of August, with a litterfall of 6.57 kg. The total annual litter addition was estimated to be 88.26 kg.

It is well documented that the biodegradation of litter plays a very important role in the release of nutrients. The nutrients taken up by the roots get translocated to different parts of plant and a major portion of these nutrients gets locked up in leaves. By biodegradation they are released to the soil and thus play an inevitable role in nutrient cycling. Under the typical tropical condition prevailing in Kerala, no work has been carried out to study the role of fungi in the biodegradation of

leaf litters. Under these circumstances an investigation was undertaken with the following objectives:

(1) Isolation of leaf litter degrading fungi during different stages of decomposition.

(2) Identification of the litter degrading fungi isolated.

(3) Fungal succession during litter degradation.

(4) Study of detailed morphological structures of isolated fungi by preparing slide cultures.

(5) Effect of varying temperature regimes (25°C, 35°C, 45°C) on litter degradation.

(6) Assessment of extent of dry weight loss during decomposition and the influence of environmental factors on litter decomposition.

(7) Biochemical changes during litter decay (Ash, carbohydrates, cellulose and total nitrogen).

(8) Working out the decay potential of isolated fungi.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In soil plant systems, plant nutrients are in a constant dynamic state of flux. The nutrients taken up from the soil are used for the metabolic processes and later when plant parts senesce and decompose, the nutrients bound up in the plant parts get released to the soil. Thus in a broad sense, nutrient cycling refers to this continuous transfer of nutrients from soil to plant and back to the soil following a cyclic pattern.

Plant leaf litter is high in nutrients especially nitrogen and is decomposed rapidly whereas other lignified materials like woody residues and cereal straw are more resistant to decomposition containing lesser nutrients (Swift et al., 1979).

Fungi play a key role in leaf litter decomposition along with other biotic agents, after penetrating deep into large pieces of litter and attacking it with the powerful enzyme systems (Hudson, 1966). The sequence of fungal successions on a natural substrate is based on a comprehensive nutritional relationship between the different fungi and the substrate (Macauley and Thrower 1966).

The present study is centered around the mycoflora involved in litter decomposition in jack (Artocarpus heterophyllus Hanek) and mango (Mangifera indica L.) and the

changes brought about thenceforth. The available literature regarding the area of study has been reviewed and presented in this chapter.

Mycoflora associated with leaf litter

A wide array of fungi belonging to different taxonomic groups have been recorded from leaf litter of diverse plant species both in the temperate as well as in the tropical regions and such studies have been very well documented (Hering 1967; Eicker 1973; Jensen 1974; Visser and Parkinson 1975; Mary and Sankaran, 1991).

Mycoflora associated with leaf litter in temperate regions:

Aureobasidium pullulans Arnaud and Cladosporium spp have been recorded as common occupants of ash, birch, hazel and oak litter (Hering, 1965).

Hogg and Hudson (1966) observed that Aureobasidium pullulans and Cladosporium spp were isolated from leaf litter of the European Beech (Fagus sylvatica L.) well after leaf fall. Cladosporium cladosporioides (Fres.) de Vries was isolated in abundance during leaf fall and reached a peak relative density during the Spring (March-May).

Cladosporium and Alternaria were isolated from the leaves of wheat and barley and Aureobasidium was common on barley leaves (Dickinson et al., 1976).

Collybia peronata a basidiomycete fungus was found to cause decay of leaves of birch (Betula pendula Roth.) oak (Grevillea robusta A. Cunn.) and beech (Fagus sylvatica) leaves. This was found growing in association with the naturally occurring leaf microflora (Dix and Simpson, 1984).

Widden and Hsu (1986) reported the occurrence of Trichoderma sp on decaying maple and pine litter. Many fungi were isolated during summer season from sugar maple (Acer saccharum Marsh.) in southern Wisconsin. They were mainly species of Verticillium, Mortierella, Paecilomyces, Penicillium, Trichoderma and Penicillium, the last two were the abundant group in the late summer months. Litter harvested in late summer or early fall in Southern Quebec, characteristically contained significant number of species of the genera, Acremonium , Gliocladium, Metarrhizium, Monocillium, Mucor, Mortierella, Paecilomyces and Verticillium (Kuter, 1986).

Seventy six fungal colonies were isolated from decomposing sugar maple leaf and it was observed that members of Hyphomycetes dominated (72%), Coelomycetes (17%) and Mucorales comprised four per cent as the abundant groups (Kuter, 1986).

The mixed leaf litter of a deciduous forest in Kingston, Rhode Island was studied by Carreiro and Koske (1992). They found that the predominant mycoflora included Geomyces sp., Mortierella sp and Mucor sp.

The saprophytic fungi isolated from wheat straw buried in litter bags included Trichoderma harzianum Rifai, Cladosporium sphaerospermum Penz., C. herbarum (Pers) Link ex. Ray, Alternaria alternata, Ulocladium botrytis Preuss, Paecilomyces marquandii Massee, Mucor hiemalis Wehmer, Fusarium sp., Phoma sp., Chaetomium globosum Kunze ex Steud, Geotrichum sp. and Gliocladium sp. (Robinson et al., 1993).

Mycoflora associated with leaf litter in the tropics

Studies conducted on unsterilized mixed leaf litter of non deciduous forest trees in Varanasi revealed that the decomposition of leaf litter was aided by the fungal species consisting of Trichoderma harzianum Rifai, Mortierella subtilissima Oudemans, Aspergillus niger Van Tieghem, Curvularia lunata Boedijn. Mucor advena, Penicillium rubrum Stoll, C. cladosporioides and Robillarda phragmitis (Cunnell) Morelet. Among these Mucor advena, Penicillium rubrum, Aspergillus niger and Trichoderma harzianum were found to be fast growing and exhibited higher degree of colonisation (Rai and Srivastava, 1982).

The decay rate of leaf litter of tree species of Eucalyptus tereticornis Sm., Albizia falcataria (L.) Fosberg. and Tectona grandis L. were studied by Mary and Sankaran (1991) in Kerala and an attempt was made to quantify and isolate the

microflora. The number of fungi/gram of litter varied between 1.4 to 88.2 x 10^5 in Albizia, 0.6 to 27.1 x 10^5 in Eucalyptus and 1.7 to 116.3 x 10^5 in teak. The fungal population was highest during July 1985 and lowest during June 1986 in Albizia and teak. In Eucalyptus the highest counts were recorded during August 1985 and lowest during December 1985. There was a significant reduction in the fungi during June 1985. The fungi isolated from Albizia belonged to 26 genera. Of these, the Fungi Imperfecti were represented by 20 genera (77%) Zygomycetes by five (19%) and Ascomycetes by one genus.

Thirty four genera of fungi were isolated from Eucalyptus leaf litter. Among these 27 (79%) genera belonged to Fungi imperfecti, four (12%) to Zygomycetes and one genus to Ascomycetes. Marasmius sp was the only Basidiomycete observed.

The fungi isolated from teak litter belonged to 32 genera, of which Fungi imperfecti were represented by 28 genera (87.5%), Zygomycetes by three (9.4%) and Ascomycetes by one genus. Marasmius was found colonizing the litter during October 1985 (Mary and Sankaran, 1991).

The leaf litter decomposition of Calycopteris floribunda Lam., a bushy twiner of tropical forests was studied by Reddy in 1982 and he found that more than 80 fungal species were present during different stages of decomposition. The fungal species isolated were Aspergillus niger, A. flavus Link.

A. nidulans (Eidem), A. terreus (Thom), Colletotrichum gloeosporioides Penz, Cunninghamella echinata Leadner, Chaetorichum sp., Alternaria alternata, Penicillium citrinum Thom. Pestalotia spp, Fusarium spp, Rhizoctonia sp, and Rhizopus sp.

During the study of the leaf litter fungi from South Western part of Maharashtra, a few interesting hyphomycetes have been collected. These include Codinaea falcatispora Maire, Codinaea fruticola Maire, Codinaea ixorae Maire and C. falcatispora isolated from dead fallen leaves of Pithechlobium dulce Benth. and also from leaflets of Albizia sp. C. fruticola was isolated from fallen pods of Butea monosperma, and C. ixorae was isolated from dead leaves of Ixora sp. (Patil et al., 1991).

Decomposition of leaf litter of Albizia amara Bovine was studied using the mesh bag technique for a period of one year from March 1992 to February 1993 under the field and in vitro. The fungi involved in decomposition were isolated. The number of fungi/g of litter ranged between 1.2 to 68.2 x 10^5 in field condition and 1.5 to 73.2 x 10^5 in vitro. The fungal population was highest during August, 1992 and lowest during June, 1992. The fungi isolated from A. amara belonged to 18 genera. The dominant primary colonisers of the litter were Penicillium sp, Aspergillus sp and Doliomyces mysorensis. The population of

Penicillia decreased during the course of decomposition. (Vijaya and Naidu, 1995).

Fungal succession on decomposing leaf litter

The concept of fungal succession on plants and other substrates has now become well established (Hudson, 1968; Hayes, 1979). The sequence of this succession upon a natural substratum reflects a complex interaction of nutritional relationships between each fungus and the substratum together with competition between individual fungi (Macauley and Thrower, 1966).

The process of colonization which culminates in the decomposition normally begins much before plants senesce or shed parts or organs. Visser and Parkinson (1975) carried out the investigations on aspen from the bud stage of the leaves to humus level, grading the material into different levels of degradation. They have recorded limited changes in mycoflora after leaf fall and carrying over of phylloplane mycoflora to the litter.

The actual mechanisms responsible for the parent species replacement are poorly understood, Garrett (1963) has suggested that fungal succession are autogenic processes in which the sequential appearance of taxa are determined by the depletion of available carbon sources. Fungal successions are seasonal

ie., changes in climatic conditions are the primary factors determining the successive appearance and disappearance of taxa.

Saito (1956) reported the fungal species involved in the decomposition of the litter of Fagus crenata. Three species of Penicillium sp. were most abundant in terms of fungi isolated. These were P. lapidosum (Rap. & Fenn.), P. raistrickii G. Smith and P. chrysogenum Thom and along with Cladosporium herbarum Link and Aureobasidium pullulans which were also isolated. Other fungi isolated included Absidia glauca Hagen Mortierella ramanniana Linnum and Trichoderma spp.

Pugh (1958) conducted studies on colonization of the temperate monocotyledon, Carex paniculata. Metasphaeria cumana Sacc. was the most frequently recorded ascomycete on the outer leaves. Aureobasidium pullulans was restricted to the outer leaves. Cladosporium herbarum, Stysanus stemonitis, (Person) Corda were found on the very dry outer leaves.

Witkamp (1960) estimated fungal populations present on fresh litter of alder (Alnus glutinosa) poplar (Populus alba) birch (Betula pendula) and oak (Quercus sp.) for seven weeks after shedding. An initial dominant flora of Sphaeropsidales was replaced by Cladosporium herbarum, Aureobasidium pullulans, Mortierella sp. and Trichoderma sp were found to increase in two year's litter.

Meredith (1962) studied the pattern of fungal colonization on leaves of Banana (Musa sapientum L) on the midrib and petiole and found that Verticillium theobromae and Deightoniella torulosa Hughes were the dominant species. These were followed by Nigrospora sp, Gloeosporium musarum Cooke and Massee, Pyricularia musae Sacc; and Zygophiala jamaicensis Mason which spread over the whole leaf before extensive drying occurred. After the drying up of litter, the mycoflora were replaced by the fungi including species of Cladosporium, Aspergillus, Fusarium and Curvularia.

A generalized scheme of fungal successsion on plant remains was put forth by Hudson (1962) and Garrett (1963). The succession of mycoflora are designated as weak parasites with restricted abilities to degrade structural polymers, followed by primary saprophytic sugar fungi replaced by cellulolytic fungi and the lignolytic fungi. The lignolytic fungi are usually members of Basidiomycotina and Deuteromycotina and towards the end of the decomposition process, members of Mastigomycotina and Zygomycotina and the slime moulds take the upper hand.

Dickinson (1965) reported the fungal population on green and moribund leaves of the perennial evergreen shrub, Halmione portulacoides. The leaf surface was dominated by Cladosporium. On senescent leaves, Cephalosporium sp, Fusarium culmorum Sacc and Stemphylium botryosum Wallroth were the predominant fungal species.

The leaf litter of Eucalyptus regnans has been studied by Macauley and Thrower (1965). The initial litter fungi were species which had invaded the leaves while still on the tree. These included Protostegia eucalyptia Cooke, Readeriella mirabilis, Sydow., Cyloplea sp., Cladosporium herbarum and Alternaria tenuis, while others established themselves as saprophytes after the leaves had fallen which included Piggotia substellata Berk and Broome, Hormiscium pinophilum Kunz, Ceuthospora innumera Fr. Sclerotiopsis austratasica Speg and Trichoderma viride Pers. ex. Gray.

Hering (1965) examined leaves of oak, hazel and ash in the litter layer of Lake District wood. The predominant species of fungi over the period 0-6 months after leaf fall, were Aureobasidium pullulans, Cladosporium herbarum, Epicoccum nigrum, Coleophoma rhododendri Syd. and Polyscytalum fecundissimum Reiss. After this, from 6 to 24 months, Penicillium sp., Mucor sp. and Trichoderma viride were the predominant species.

Dickinson (1967) followed the fungal colonization of pea leaves (Pisum sativum) L. during the entire growing season of the plants and into the first stages of decomposition. Cladosporium herbarum and Aureobasidium pullulans became dominant on yellow leaves and later during senescence Alternaria tenuis and Stemphylium botryosum Wallr. increased in frequency and Cladosporium herbarum dominated the microflora of newly

fallen leaves. Fusarium avenaceum Link and Epicoccum nigrum were the only other saprophytes common on the washed fallen leaves.

Hogg and Hudson (1966) described the succession of microfungi on living and dead leaves of the European beech Fagus sylvatica. The first colonizer of the leaves was Gnomonia errabunda Ces. & de Not, found parasitizing leaves as early as July, within three months of unfolding. Cladosporium herbarum which was also a primary colonizer occurred earlier, but only on damaged necrotic area and by October it was present on all leaves. Another fungus which appeared with lower frequency was Botrytis cinerea Pers.

Tubaki and Yokoyama (1971) studied the mycoflora on sterilized leaves placed in the natural litter and recognized four groups of epiphytic fungi. This consisted of members of Mucorales, as the first group. Cladosporium sp. and Trichoderma sp were present during entire period of leaf decay and were classified as the second group while the third group included Ceratocystis sp. Subulispora sp. and Sympodiella sp. which were associated with early stages of decomposition and were the first invaders of newly fallen dead leaves. Toxotrichum sp., Thysanophora sp. Verticillium sp. were rare in the early periods of decay but was common during the latter half of the decay period and these were accomodated in the fourth group.

According to Pugh (1974), the succession of fungi on leaves and litter frequently omits the sugar fungi. The primary colonizers can produce a wide range of enzymes including cellulase, cutinase, pectinase and protease as well as enzymes for sugars and other carbohydrates. The final stage in the litter decompositon of Typha latifolia a semi-aquatic plant, was represented by nematophagous fungi such as Dactylaria, Dactyella and Arthrobotrys.

Fungi were isolated by dilution plating from green and senescent sugar maple leaves and from decomposing leaf litter sampled at periodic intervals for three consecutive years. Populations from the green and senescent foliage were dominated by a few ubiquitous taxa including Aureobasidium pullulans, Cladosporium cladosporioides and Phoma exigua Desm. that remained abundant for upto eight months after leaf fall. P. frequentans P. multicolor, P. brevicompactum Dierckx and P. implicatum Biouge were typically the first to appear after abscission and increased in relative abundance as decay progressed. Many of the fungi which were first isolated from sugar maple leaves in the summer after abscisson have been reported as typically associated with advanced stages of litter decay including species of genera Mortierella, Mucor and Trichoderma that appeared in populations from maple litter at the end of the first year of decay (Kuter, 1986).

Fungal succession in the Tropics

Sharma and Mukerji (1974) identified four types of fungal colonizers on Gossypium hirsutum and sesamum (Sesamum indicum L). Fungi which had a negligible role in decomposition such as Aspergillus sp.and Penicillium sp. formed one group. Fungi which played an active role in decomposition only after leaf senescence such as Helminthosporium sp. and Colletotrichum sp. formed another group. A third group consisted of true decomposers viz., Cladosporium and Alternaria which grew actively both when leaves were green and healthy and also when they were senesced. Species of myxomycetes belonged to the fourth category. These fungi sporulated in vitro under favourable conditions of moisture and substrate during advanced stages of decomposition.

The fungal species involved in the decomposition of the tree species of Albizia, Eucalyptus and teak has been studied by Mary and Sankaran (1991). The dominant primary colonizers of the Albizia litter were Penicillium sp., Aspergillus sp., Robillarda sessilis, and Doliomyces mysorensis. The relative abundance of A. niger was highest during south west monsoon Penicillium sp. was the predominant fungus on freshly fallen litter. The population of Penicillium decreased during the course of decomposition. A flavus, Curvularia lunata, Doliomyces mysorensis, Fusarium sp., Robillarda sp. and Trichoderma viride

were the most frequent and dominant secondary colonizers. The members of the Zygomycetes mostly appeared at the advanced stages of decomposition. The dominant primary colonizers of Eucalyptus leaf litter were Penicillium, Aspergillus, Chaetomella and Curvularia. The secondary colonizers recorded were A. flavus, A. niger, Chaetomella circinoseta, Curvularia lunata, Fusarium sp, Phoma sp., Robillarda sp. Trichoderma viride and Mucor sp which were frequent and dominant. The members of Zygomycetes were prevalent during the advanced stages of decomposition (Mary and Sankaran, 1991).

The primary colonizers of teak litter were Aspergillus sp., Penicillium sp., Tritirachium sp., Coniella granate, Myrothecium verrucaria and Chaetomella circinoseta. Among the saprophytic fungi A. flavus , A. niger, Curvularia lunata and species of Fusarium, Alternaria and Myrothecium, showed comparatively higher frequency of occurrence and dominance than any other fungi. Mucor and Rhizopus were isolated during the advanced stages of decomposition. The relative abundance of Penicillium decreased during the course of decomposition while Trichoderma viride was frequent at the later stages of decay (Mary and Sankaran, 1991).

The succession of fungal community on decomposing pine apple leaf and root litter was studied during different seasons in India by Tiwari et al. (1994). Fifteen and eighteen fungal species were isolated from leaf and root litter respectively.

Fungal communities of both were dominated by members of the sub division Deuteromycotina. Early colonizers were identified as members of Aspergillus and Mucorales.

Factors affecting leaf litter decomposition

The rate of litter decomposition is influenced by a number of factors including moisture content, temperature, nature of micro organism and soil fauna active in the decomposition process (Tenney and Waksman, 1929).

The microbial counts from various leaf species, stands and altitudes differed significantly and were positively correlated with difference in litter breakdown rates. The chief factors controlling the rate of litter breakdown and the microbial populations were the stage of decomposition, moisture content, presence of possible soluble inhibitors and pH (Witkamp, 1959).

Webster and Dix (1960) have discussed the role of abiotic edaphic factors such as soil structure, soil water, soil atmosphere and soil physical and chemical properties on the activity of soil organisms.

The lower moisture contents of the litter caused by less precipitation and higher temperatures at lower elevations reduced microbial activity. (Mitchell et al., 1941; Warcup, 1957; Witkamp, 1960).

Dessication strongly inhibits microbial breakdown of litter as reported by Witkamp and Van der Drift 1962. Badurowa and Badura (1968) isolated 162 fungal species from Kamienslaski reserve with data on temperature, soil moisture, organic content and pH. It is inferred that the composition of the litter is decisive for the occurrence of particular fungal groups.

According to Griffin (1972) temperature affects the competitive interactions among fungi and seasonal changes in temperature can potentially alter the temporal partitioning of resources among fungal species with similar substrate utilization potentials.

Among climatic variables, rainfall and temperature have been found to be of major importance in litter degradation (Witkamp, 1966; Singh and Gupta, 1977). According to Meentemeyer (1978) the two most important factors controlling litter decomposition, are probably the prevailing climatic environment and substrate quality.

Soderstorm (1979) reported higher soil microbial biomass when soil moisture was at ten to twenty per cent and soil temperature was at one to five degree celsius.

Fluctuations in mycoflora are related to the seasonal changes in temperature and moisture as reported by Sinha (1983). Singh and Joshi (1982) revealed that the temperature and

moisture are critical environmental facors for high rates of decomposition and the litter decomposition was found maximum during rainy season. The high rate of decomposition may be attributed to optimum temperature and moisture and better aeration of soil as the decomposition depends on the microbial populations of leaf litter.

Entry et al. (1987) reported high cellulose degradation rates in forest soils when microbial biomass was higher. Both cellulose and lignin degradation correlated more strongly with microbial biomass when soil moisture was 40 to 60% than when the soil moisture was 20 per cent.

Margaret and Koske (1992) conducted study at the University of Rhode Island, Kingston on the effect of temperature on decomposition and development of microfungi communities in leaf litter microcosms at zero, ten and twenty degree celcius. Temperature caused major differences in the species composition and structure of the microfungal communities isolated. As temperature decreased, Zygomycete species increased whereas Deuteromycetes species decreased. At zero and ten degree celsius, communities were dominated by the Deuteromycetes Geomyces pannorus and Geomyces asperculatus respectively and by several species belonging to Zygomycetes. At 20c the community consisted almost entirely of Deuteromycetes with the genera Trichoderma, Humicola and Sporothrix being most abundant.

Vijaya and Naidu (1995), conducted study on decomposition of leaf litter of Albizia amara Bovine was studied using the mesh bag technique for a period of one year from March, 1992 to February, 1993 under the field and laboratory conditions. The decomposition rate in the field was significantly higher than that in the laboratory. This difference was mainly attributed to the difference in soil and atmospheric conditions. The litter moisture content, atmospheric temperature, soil temperature and relative humidity were always higher outdoors.

Nitrogen content of plant material is important in controlling the rate of decomposition (Findlay, 1934; Millar et al., 1936, Merrill and Cowling, 1966).

Lignin content of the litter exerts more control over the rate of decomposition than nitrogen. (Bollen, 1953, Fogel and Cromack, 1977). Lignin is an interfering factor in the enzymatic degradation of cellulose and other carbohydrates as well as proteins. High level of lignin may thus slow decomposition rates as reported by Alexander in 1977. Herman et al. (1977) and Berg et al. (1982) reported that the decomposition rates of lignin in nitrogen rich litter were significantly lower than that of low nitrogen litter.

Upadhyay (1994) studied the seasonal decomposition rates and the influence of initial chemical constitutents on decomposition rates of litter of ten species in different forest

ecosystems of central Himalayas. The species with higher lignin and C/N ratio decomposed slowly. Those species with larger water soluble compounds, base contents and acid soluble cell wall components decomposed faster. Soil fauna also play a definite role in decomposition. The increase in surface area by fragmentation caused by micro arthropods lead to increased decomposition rates (Kevan, 1962).

Soil fauna are equally important as fungi in the litter decomposition. They contribute to the breakdown of litter in many ways (Edwards et al., 1970). The role of soil fauna in litter decomposition has been evaluated by many workers (Edwards et al., 1970; Madge, 1965; Curry, 1969; Anderson, 1973; Wood, 1974; Reddy, 1984).

Singh et al., (1994) conducted studies on leaf litter production and decomposition in Dalbergia sissoo and Bombax ceiba plantations in Uttar Pradesh. They have reported that the slow rate of decomposition in Dalbergia sissoo as compared to that of Bombax ceiba is mainly attributed to its leaf toughness, besides the quality of litter on which the microbial activity depends.

Dry weight loss during decomposition

Lousier and Parkinson (1975) conducted studies on the litter decomposition in cool temperate deciduous forest. The dry weight loss of decomposing aspen leaves was measured at 1, 5, 8, 12, 18 and 24 and 30, month intervals by using 3 mm mesh litter

bags and at 12, 24, 36, 48 and 60 month intervals by using 10 mm mesh bags. The dry weight loss for aspen leaf litter was 26.2 ± 2.0% after 12 months, 40.0 ± 1.6% after 30 months.

Dry weight loss of leaf litter due to decomposition after a period of 18 months (May 1985 to October 1986) under field and laboratory conditions were estimated by Mary and Sankaran (1991) in a study conducted in and around the Forest Research Institute, Peechi, Kerala.

The study was carried out on Albizia, Eucalyptus and Teak leaf litter. The weight loss of Albizia litter under field condition was 93.9 per cent after 18 months. In the laboratory 74 per cent of Albizia litter decomposed during the same period. Eucalyptus leaf litter lost 63.7 per cent of its initial weight in the field and 59.7 per cent in the laboratory. Tectona grandis lost 95.7 per cent of its weight in the outdoors and lost 91.9 per cent of its initial weight in the laboratory.

The decomposition parameter (K) values worked out for Albizia, Eucalyptus and Teak litters were 1.67, 0.74 and 2.0 respectively.

O'Connell (1986) conducted a study on the effect of legume understorey on decomposition and nutrient content of Eucalypt forest litter. E. marginata leaf litter confined in mesh bags lost 37 per cent of its initial dry weight in the

first months on the forest floor and 44 per cent of its initial dry weight after 20 months.

Gallardo and Merino (1993) observed that leaf toughness significantly explained the mass loss in two Mediterranean ecosystems.

Singh et al. (1993) reported the annual dry weight loss (percent of original) of the following leaf litter and followed the order : Sal (87) > Teak (72) > Poplar (65) > Eucalyptus (50). The weight loss in Sal was rapid during first three to six months. The same trend was observed in teak but the process of decomposition was comparatively slower than Sal. There was a slow rate of decomposition of Eucalyptus leaf litter as compared to other species. The poplar litter showed a steady rate during first six months and by the end of the year about 65% of the original litter decomposed. The decomposition parameter (K) for Sal, Teak, Poplar and Eucalyptus as 2.01, 1.26, 1.05 and 0.69 respectively, the high decomposition rates of leaf litter in Sal and Teak being attributed to the physical and chemical properties of the leaf.

An in vitro experiment was carried out with the litter of seven Mediterranean species of plants to compare their mass losses during the initial leaching phase of decomposition (Ibrahima et al., 1994). Samples were taken at 1, 6, 24, 72, 168 and 240 h. Depending on the species the litter lost between

7-15 per cent of initial dry mass and water content values were between 130-360 per cent of dry mass.

Singh et al. (1994) estimated the K value for Bombax ceiba as 1.67, higher than that of Dalbergia sissoo (1.32). As compared to the latter, the former took less time (1.8 years) for 95 per cent decay also.

Vijaya and Naidu (1995) studied the decomposition of leaf litter of Albizia amara Bovine for a period of one year from March 1992 to February, 1993 under the field and laboratory conditions. In the field the dry weight loss of litter after 12 months was 80.0 per cent and in laboratory it was 61.3 per cent.

Biochemical changes

The degradation of leaf litter brings about structural and biochemical changes which have been studied in many litter degradation systems.

Rodin and Bazilevich (1967) found that N clearly dominated the mineral content of the litterfall in tundra and deciduous forests of the temperate zone, on the other hand Ca was predominant in broad leaved forests of temperate zone and in sub-tropical rain forest communities. They further reported that mineral return in annual litterfall may exceed 200 kg/ha in tropical rain forests and 100-200 kg/ha in temperate deciduous forest.

Lousier and Parkinson (1975) conducted studies on litter decomposition in a cool temperate deciduous litter and found that the nutrients were returned to soil through tree leaf litter fall. The importance by weight of some of the nutrients returned was in the order Ca > N > K > Mg > P > Zn > Fe > Mn > Na > Cu. The total weight of these nutrients released to the soil was 116 kg/ha with N, Ca, K comprising 39 per cent, Mg and P comprising 9.8 per cent of the total.

Leaves accounted for 50.7 per cent of total litterfall and they also accounted for most of the inputs of Ca, Mg, S, N, and K in organic debris (Charley and Richard, 1983).

Reddy et al. (1990) conducted a biochemical analysis of Calycopteris floribunda litter during different stages upto 180 days of decomposition. The ash content increased with the progress of leaf composition, whereas cellulose and lignin content decreased. Change in lignin content was insignificant in the later stages of decomposition. Total and protein nitrogen content gradually decreased with the progress of decomposition.

MATERIALS AND METHODS

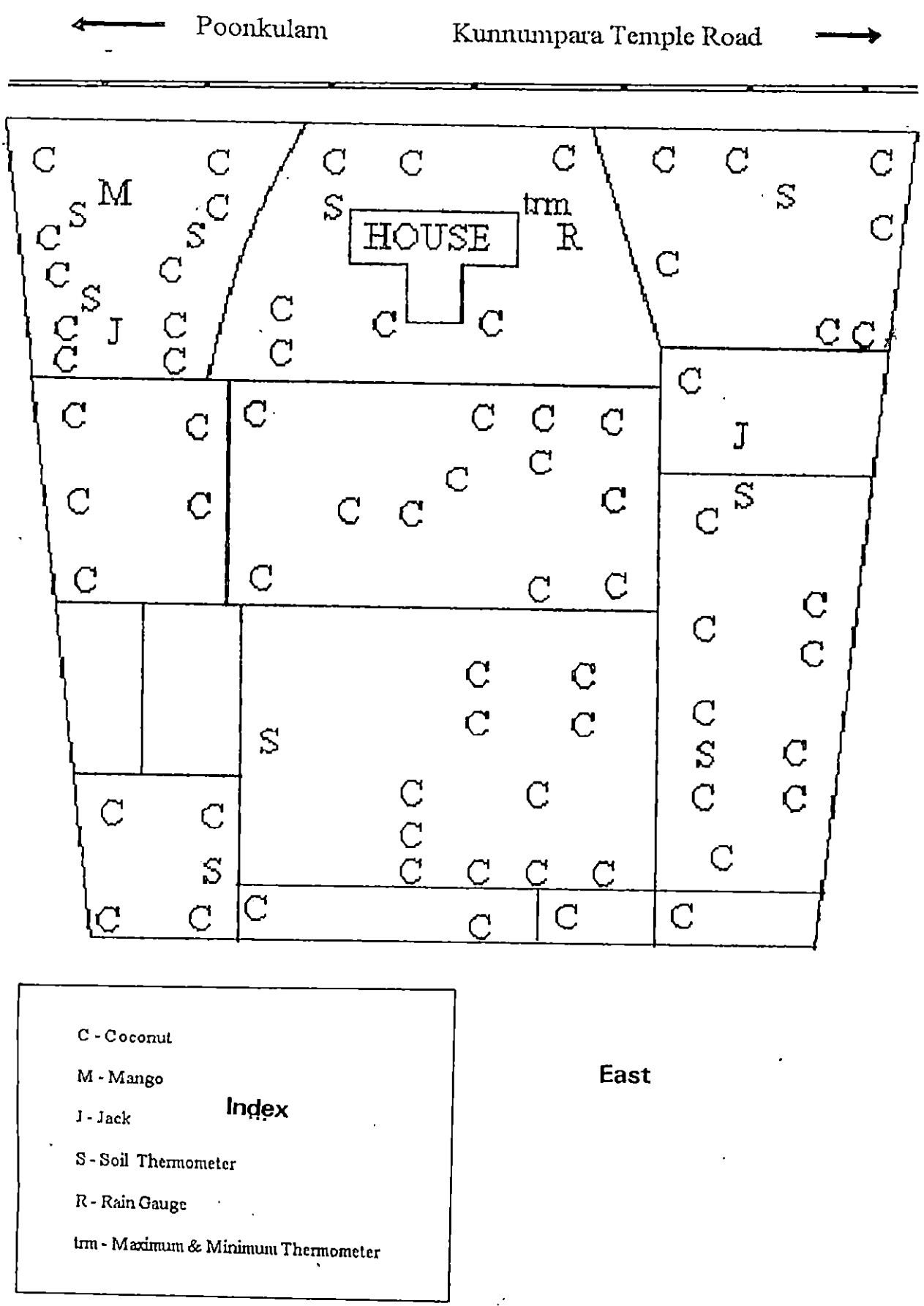
MATERIALS AND METHODS

Site of study:

The site selected for study was a tropical homestead, situated near Poonkulam on the way to Kunnumpara, 29 metres above mean sea level (8.5°N, 76.9°E) near the College of Agriculture, Vellayani (Fig. 1). The climate of the region is warm and humid. The rainfall is distributed over two seasons, mainly during south-west monsoon (June '94 - July '94 - 226.8 mm) and North east monsoon (October 94 - November 94 - 365.2 mm). The soil type is red laterite. The dominant tree species of the homestead includes jack, mango and coconut. The other tree components are Mahagony, Ailanthus, Cinnamon, Anona and Rose apple. The understorey was composed mainly of turmeric, ginger, and colocasia. The jack and mango trees selected for the study were 20 years old. The relative humidity recorded for jack was 92.3 per cent and mango was 89.5 per cent during the year 1994.

The meteorological data regarding temperature, humidity, rainfall were collected from the field station established by College of Agriculture, Vellayani, as a part of the ongoing research on Agronomy Resource Inventory, in the selected site. The effect of temperature, humidity and rainfall on the mycoflora with respect to leaf litter decomposition of mango and jack were studied.

Fig. 1 - Layout of the selected site



Method of collection

Leaf litter was collected from underneath the trees, where there was an accumulation of litter upto ten cm depth. An area of five metre square (5 m^2) was demarkated using wooden pegs and left undisturbed for periodic collection of litter. The leaf litter was collected during four seasons (1994-1995) viz., North east monsoon (October '94 - November '94), dry spell after North east monsoon (December '94) summer (March '95) and South-West monsoon (June '95 - July '95). The surface litter was collected in polythene bags and the representative sample of fully decomposed litter was collected from a depth of ten cm. The collection depths were arbitrarily arrived at after judging the rate of leaf fall and litter thickness.

Mycoflora associated with leaf litter of jack and mango

Fungi were isolated from leaf litter from different litter depths following the soil dilution plate technique. (Parkinson et al., 1971). The leaf litter of mango and jack was macerated in an ice cold blender and ten gram were suspended separately in 100 ml sterile water in 250 ml conical flask. The suspension was shaken thoroughly and further diluted to 10^{-3}. One ml of the suspension was transferred aseptically to five replicate sterile petri dishes and 20 ml of the medium used for isolation were dispensed in each dish. The medium used for isolation was Rose bengal streptomycin Agar (Appendix I). The

fungal colonies were counted after incubation at room temperature (30 ± 2°C) for four to seven days. The relative abundance of each taxon was calculated using the following formula (Mary and Sankaran, 1991)

$$\frac{\text{Number of isolates of a species}}{\text{Total number of isolates}} \times 100$$

2. Identification of mycoflora associated with jack and mango litter

The commonly occurring fungi from mango and jack leaf litter obtained were maintained on Potato dextrose agar slants.

These fungi were grown on Czapek's Dox agar in petri dishes and incubated at room temperature (28 ± 2°C) for fourteen days. Observations were made on the colony diameter, colony colour and pigmentation. The mycelial forms forming conidia were studied in detail using slide cultures (Riddel, 1950). Observations were made on the conidial dimensions and camera lucida drawings were made wherever possible. The enumerated characters were compared with those in relevant literature.

2.1 Preparation of slide culture

Ten ml plain agar medium was melted and poured into sterile 9 cm petri dish to form a layer two millimetre deep. After the medium solidified, one cm squares were cut out using a

sterile dissecting needle and a flamed glass rod. Using a sterile forceps a flamed microscope slide was placed under the cover of a petri dish lid, the inside of which was also flamed. The agar block was transferred rapidly to the centre of the cooled slide. A needle point inoculum of spores, or a small bit of mycelium was placed at the center of each edge of the agar block. With sterile forceps the cover slip was placed centrally upon the upper surface of the agar square and the slide was then transferred to a moist chamber. The earliest suitable time before excessive sporulation was chosen to terminate growth. The cover slip was lifted vertically from the agar block without twisting and was placed on a sterile microscope slide with a drop of lactophenol on it. The agar block was removed from the slide and a drop of lactophenol was placed on the slide. Then a clear cover slip was gently lowered over the above slide. Thus two permanent slides were prepared from a single slide culture and was observed under microscope.

3. Fungal succession during different stages of leaf litter decomposition

Fungal succession on mango and jack leaf litter was studied. Leaf litter was collected from the identified homestead near the College of Agriculture, Vellayani. It was filled in three separate cement troughs (1.5m x 1.5m) at the Department of Plant Pathology, College of Agriculture, Vellayani (Plate 1 & 2).

Plate No. 1 Fungal succession studies in jack leaf litter.

Plate No. 2 Fungal succession studies in mango leaf litter.

At first, the cement troughs were filled with soil upto five cm with soil collected from underneath respective mango and jack trees from the identified homestead. Over this the collected litter was spread upto fifteen cm height. The soil layer was moistened periodically. The leaf litter was collected from surface layer, then from ten cm depth and finally from the soil layer at bimonthly intervals for both jack and mango. The fungi were isolated by using soil dilution plate technique and by direct observation of leaf samples. The fungi were qualitatively enumerated to understand the fungal succession on jack and mango litter.

4. Effect of different temperature regimes on leaf litter decomposition (25°C, 35°C, 45°C)

Effect of different temperature on leaf litter decomposition were studied by using a modified version of the method adopted by Carriero and Koske (1992). Surface leaf litter of mango and jack were collected from the homestead. These were air dried separately for a weeks time. Fifty grams each of air dried samples of both jack and mango leaf litter were taken in five different paper bags separately and the openings were sealed. These paper bags were placed in three different temperatures. Five replicate of both mango and jack were placed preheated in ovens which were set at a temperature of 45°C and 35°C. Another set of five bags were placed at 25°C in an

incubator set at the required temperature. After six months of incubation, the paper bags were weighed and the weight loss was recorded which was an indication of litter degradation.

5. Celluloytic ability of isolated fungi

The celluloytic ability of fungus was studied by inoculating the fungus in cellulose incorporated agar medium. The basal medium used was Czapeks Dox Agar (Appendix I). Instead of using dextrose as carbon source, cellulose was incorporated on an equivalent weight basis. Fifteen ml media was poured in petri dishes. After solidi-fication of the media, the cultures of fungi were inoculated by placing a culture bit taken from a seven day old culture of the test fungus using a five mm cork borer. The same cultures were inoculated on normal Czapeks Dox Agar plates, which served as the control. The growth of the fungus from each dish was measured after incubation at room temperature for 14 days.

6. Weight loss studies

Under Field Condition

Two plots of 6 x 1.5 m were selected at the same site in the homesteads for conducting field studies on litter decomposition. The leaves were air dried to constant moisture content and the litter decomposition studies were carried out

following the Mesh bag technique for leaf litter decomposition (MBTLLD) suggested by Bococok and Gilbert (1957). Ten litter bags (20 x 20 cm size, mesh size 2 mm) containing 20 g of air dried leaf litter of individual tree species were prepared for mango and jack. During July 1995 this bags were spread randomly over the soil surface in seperate plots for each species. Sampling was done at monthly intervals. Two litter bags of each species were recovered at each sampling from the field. The litter samples were cleaned and oven dried at 60°C for 48 hour and dry weight determined. The weight loss of mango and jack litter was studied as an indication of litter degradation.

The analysis of variance for weight loss in jack and mango leaf litter was done.

Under <u>in vitro</u> condition

In July 1995, 20 g of air dried leaf litter of each species were transferred separately in nine cm diameter nylon mesh bags (mesh size 2mm) and the openings closed firmly by stitching. A total of ten bags each were prepared for jack and mango. The litter bags were incubated over 500 g of soil (of the respective species) taken separately in 19 x 8 cm plastic bowls kept in the laboratory. The soil was moistened to maintain a water holding capacity of 60-70%. Sampling was done at monthly intervals. Two litter bags of each were recovered at each sampling from the trays placed in the laboratory. The litter

samples were oven dried at 60°C for 48 hour and dry weight determined.

The decomposition constant (K) was determined by the equation.

$$X/Xo = e^{-k}$$

where 'Xo' is the original weight in the mesh bag, 'X' is the weight remaining after one year 'e' is the base of the natural logarithm (Olson, 1963).

The data obtained were statistically analysed to arrive at the decomposition parameter K (decay constant) and the time required for attaining 50 and 95 per cent weight loss using the model suggested by Olson (1963).

7. Inoculation studies

Fresh twigs of mango and jack was collected and kept dipped in deionised water in conical flasks. These were inoculated with spore suspensions of Fusarium spp, Colletotrichum gloeosporioides isolated during the course of the present study and incubated under humid conditions to study the pathogenicity of the fungi. Sclerotia from the culture of R. solani were also used for inoculation studies as mentioned above. The inoculated plants were observed for symptom expression.

Biochemical analysis

The samples (mango and jack leaf litter) were collected from the identified homestead. Each sample from three treatments viz., fresh litter, surface litter, and decomposing litter were collected in separate bags, oven dried, powdered and each sample was replicated thrice and used for biochemical analysis.

(a) Estimation of carbohydrate (Anthrone method)

The carbohydrate was estimated by anthrone method as per the procedure followed by Sadasivam and Manickam (1992). 100 mg of the litter were taken in a boiling tube and hydrolysed by keeping it in boiling waterbath for three hours with five ml of 2.5 N HCl was cooled and neutralised with solid sodium carbonate and the volume was made upto 100 ml and centrifuged. One ml of the aliquot was taken and four ml of anthrone reagent were added (200 mg anthrone was dissolved in 100 ml ice cold sulphuric acid). The standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard (ten ml of the stock solution - 100 mg glucose in 100 ml water, diluted to 100 ml with distilled water) and four ml of anthrone reagent were added to all tubes and heated for eight minutes in boiling water bath, cooled rapidly and read the green to dark colour at 630 mm. From the standard graph the amount of carbohydrate in the sample was expressed in percentage.

(b) Estimation of ash content (AOAC, 1960)

Two grams of litter were taken in a silica crucible, weighed and ignited in a muffle furnace at 600°C for four hours till ash was left behind. This was cooled in a desicator and the final weight was taken and the difference in weight was noted. The difference in weight gave the ash content of the sample and was expressed in percentage.

(c) Estimation of cellulose

The cellulose content of litter samples was estimated following the technique of Sadasivam and Manickam (1992).

Three ml acetic acid was added to known amount (0.5 g/1g) of the sample in a test tube and mixed in a vortex mixer. The tube was placed in a water bath at 100°C for half an hour. It was then cooled and the contents were centrifuged for 15-20 minutes. The supernatant solution was discarded. The residue was washed with distilled water. Ten ml of 67% H_2SO_4 acid was added and was allowed to stand for one hour. One ml of the above solution was diluted to 100 ml. To one ml of this diluted solution, ten ml of anthrone reagent were added and mixed well. The tubes were heated in a boiling water bath for ten minutes. The tube was then cooled and colour measured at 630 nm. A blank with anthrone reagent and distilled water was set up. 100 mg of cellulose was taken in a test tube and the entire procedure from addition of H_2SO_4 acid was repeated. Instead of just taking

one ml of the diluted solution a series of volumes were taken from 0.4 to 2 ml corresponding to 40-200 ug of cellulose and the colour was developed and read the green to dark green colour at 630 nm. From the standard graph the amount of cellulose in the sample was calculated.

(d) Estimation of Total Nitrogen (AOAC, 1960)

The estimation of total nitrogen was carried out using kjeldahl nitrogen method. One gram of well powdered sample was taken in the digestion tube. Kjeltabs were added to each of the digestion tube with the sample to be analysed. Concentrated sulphuric acid was added from dispenser and mixed carefully by swirling the tube by hand or by using a test tube mixer. Hydrogen peroxide was added slowly along the sides of the tube. The tube was shaken slightly after each addition. The tube stand with the prepared samples was placed beside the digestor and the exhaust manifold was fitted on top of it. The vaccum source was then turned on to maximum air flow. The stand with tubes and exhaust manifold was placed on the preheated digestor, at 420°C. The heat shields were hooked on stand. Then it was digested for 3-5 minutes with maximum air flow through the exhausted manifold. After that the flow was adjusted until the fumes were just contained. The air flow through the exhaust manifold was increased and the stand with tubes and exhaust was lifted and the entire assembly was placed in the cooling stand beside the digester. When the sample solutions were cooled sufficiently, it

was diluted with water and mixed. Cooling was speeded up by blowing air between the tubes with a small fan. The Kjeltec 1026 distilling unit was started. About 25 ml boric acid was measured and poured into receiver flasks corresponding to the number of digestion tubes used. Kjeldahl programme was selected by setting the thumb-wheels for alkali, delay time and steam time on the point panel. The digestion tube was put in position in the distilling unit. A receiver flask was placed on the platform of the distilling unit and the plat form was raised to the upper position. The safety door was closed. The distillation procedure was run automatically according to the thumb-wheel setting. When the distillation was completed the digestion tube was removed with the residue. The receiver flask was removed and put it in place in the basket. Then the distillation procedure was continued with the next sample. A stirrer bar was added and the receiver flask solution was titrated to neutral grey. The added amount of titrant was written down. The appropriate blank value was also noted down. The nitrogen and titrated using the formula:

$$\% \ N = \frac{14.01 \times (\text{ml of titrant of sample}) - (\text{ml of titrant of blanks} \times M \text{ of Std. Acid of blanks})}{\text{Gram of sample} \times 10}$$

RESULTS

RESULTS

Mycoflora associated with leaf litter decomposition

The relative abundance of fungi isolated during the course of the study from the mango and jack litter samples are presented in Table 1.

Mycoflora associated with Mango leaf litter decomposition

The primary colonizers isolated from the fresh litter included Penicillium citrinum, Penicillium islandicum and Aspergillus spp. Aspergillus niger was isolated both from fresh and decomposing leaf litter. Other fungi isolated from fresh litter were Trichoderma harzianum, Pestalotia sp and Colletotrichum gloeosporioides. C. gloeosporioides was also isolated from decomposing leaf litter. P. islandicum was the predominant species isolated from the fresh litter, during October-November. The population of A. niger was more on decomposing leaf litter, occurring mainly during June-July while C. gloeosporioides was isolated during summer season (March-April).

Mycoflora associated with Jack leaf litter decomposition

The primary colonizers isolated from the leaf litter included Penicillium oxalicum, P. citrinum, P. islandicum and Aspergillus sp. Both the species were isolated from fresh and decomposing leaf litter, but the population of Aspergillus was

Table No. 1 RELATIVE ABUNDANCE (%) OF FUNGI FROM MANGO AND JACK LEAF LITTER

MANGO

ORGANISM	October - November (NORTH-EAST)		June-July (SOUTH-WEST)		December-January (DRY SPELL)		March-April (SUMMER)	
	FL	DL	FL	DL	FL	DL	FL	DL
Aspergillus niger	6.41	-	-	87.5	-	55.55	-	-
Aspergillus flavus	-	-	-	-	-	16.66	-	16.66
Trichoderma harzianum	6.41	-	-	-	5.55	-	-	-
Pestalotia palmarum	12.82	-	12.5	-	-	-	-	-
Colletotrichum gloeosporioides	-	-	-	-	-	-	16.66	22.22
Mucor hiemalis	-	1.47	-	-	-	22.22	-	22.22
Curvularia lunata	-	-	-	-	-	-	-	22.22
Penicillium spp.	69.74	-	-	-	-	-	-	-

JACK

Aspergillus niger	2.59	-	8.5	10.67	-	-	5	-
Aspergillus flavus	-	-	-	12.76	-	-	10	-
Aspergillus ochraceous	-	-	-	-	-	-	5	-
Aspergillus tamarii	-	-	-	-	-	-	-	5
Aspergillus candidus	-	-	-	-	-	-	2.5	7.5
Pestalotia palmarum	5.19	-	-	-	25	-	-	-
Colletotrichum gloeosporioides	-	-	4.25	29.78	-	-	-	-
Curvularia lunata	-	-	4.25	-	-	-	-	-
Mucor hiemalis	-	-	-	12.76	-	-	-	10
Cladosporium cladosporioides	5.19	-	-	-	-	-	-	40

more on decomposing leaf. The Penicillium count was less on decomposing litter when compared with its count on fresh litter. The occcurence of A. niger was observed mainly during June-July. Penicillium spp., were isolated during October-November. A. flavus, A. ochraceous, A. candidus were isolated from fresh litter during summer season (March-April) Pestalotia palmarum, and Cladosporium cladosporioides was isoolated during October-November from fresh litter. During March-April (summer) Aspergillus tamarii, Aspergillus candidus, Trichoderma viride, T. harzianum and Mucor hiemalis were isolated from decomposing leaf litter. Among these T. viride, T. harzianum and M. hiemalis were also isolated from decomposing leaf litter during June-July. C. gloeosporioides was isolated during June-July both from fresh and decomposing leaf litter. Fusarium solani was isolated during June-July from decomposing leaf litter.

Effect of environmental factors on the mycoflora of mango and jack leaf litter

Statistical analysis showed that the effect of different seasons, type of litter (fresh/decomposed), host (jack/mango) and the interactions of these factors had significant effect on the leaf litter mycoflora of jack and mango (Table 2).

Table No. 2 Effect of seasons on fungal population ($X10^3/g$) with respect to host (jack/mango) and type of litter [fresh litter (FL)/decomposing litter (DL)]

	JACK	MANGO	FL	DL	
NORTH-EAST MONSOON (October-November)	18.50	7.50	22.50	13.0	13.0
December (Dry Spell)	6.0	8.33	1.50	13.33	7.42
SUMMER (March)	20.0	8.50	6.0	22.50	14.25
SOUTH-WEST (June-July)	21.83	8.0	5.0	24.83	14.92
	16.58	8.21	8.75	16.04	

CD (litter) $_{0.05}$ = 1.39 CD = MxL = 1.92

Table No. 3 Effect of litter type, season (M_1, M_2, M_3, M_4)* on fungal $X10^3/g$ population with respect to host (jack/mango)

		JACK	MANGO
L1 (Fresh litter)	M_1	31.0	14.0
	M_2	2.0	1.0
	M_3	9.0	3.0
	M_4	8.0	2.0
L_2 (Decomposing litter)	M_1	6.0	1.0
	M_2	10.0	16.67
	M_3	31.0	14.0
	M_4	35.67	14.0

CD = $1.3176 \times t_{24}$ = 2.72

* M1 - North-East Monsoon (October-November)
M2 - December (Dry spell)
M3 - Summer (March)
M4 - South-West (June-July)

The maximum fungal counts (21.83) were observed during June-July in the case of jack litter (Table No. 2) while the minimum count (6.0) was recorded during December. There was significantly higher fungal populations (8.50) in mango leaf litter during the month of March. Fresh litter of either plant type harboured significantly higher population of mycoflora (22.50) during October-November, while the maximum mycoflora count (24.83) was recorded during June-July in the decomposed litter of either species. Jack leaf litter whether fresh (31.0) or decomposed (35.67) was found to harbour significantly higher populations of mycoflora when compared with mango leaf litter, fresh (14.0) or decomposed (16.67) (Table 3 Figs. 2&3).

There was a negative correlation between the mycoflora count and the maximum temperature for both mango (-0.2868) and jack (-0.2844) fresh litter indicating the low fungal counts at higher temperature. The effect of maximum temperature on the mycoflora count in decomposed litter was positive in both mango (0.2995) and jack (0.3300) leaf litter showing that at higher temperatures the fungal counts increase in the decomposed leaf litter of both trees. Minimum temperature was found to be negatively correlated with mycoflora counts in the surface litter of both jack (-0.8080) and mango (-0.8763) while this parameter had positive correlation with mycoflora count in mango (0.8389) and jack (0.1303) decomposing litter (Table 4a, b).

Table No. 4(a) Influence of weather parameters on mycoflora of leaf litter

Month	Weather parameters					Fungal population ($X10^3$/g)			
	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		JACK Litter*		Mango Litter	
	Maximum	Minimum		Maximum	Miniumum	Fresh	Decomposing	Fresh	Decomposing
Oct-Nov	29.45	23.05	1947	91.60	75.96	31	6	14	1
December	30.16	24.36	9	90.5	83.5	2	10	1	16.66
March	32.65	23.57	5	91	51.9	9	31	3	14
June-July	29.17	23.64	186.15	89.62	77.26	8	35.66	2	14

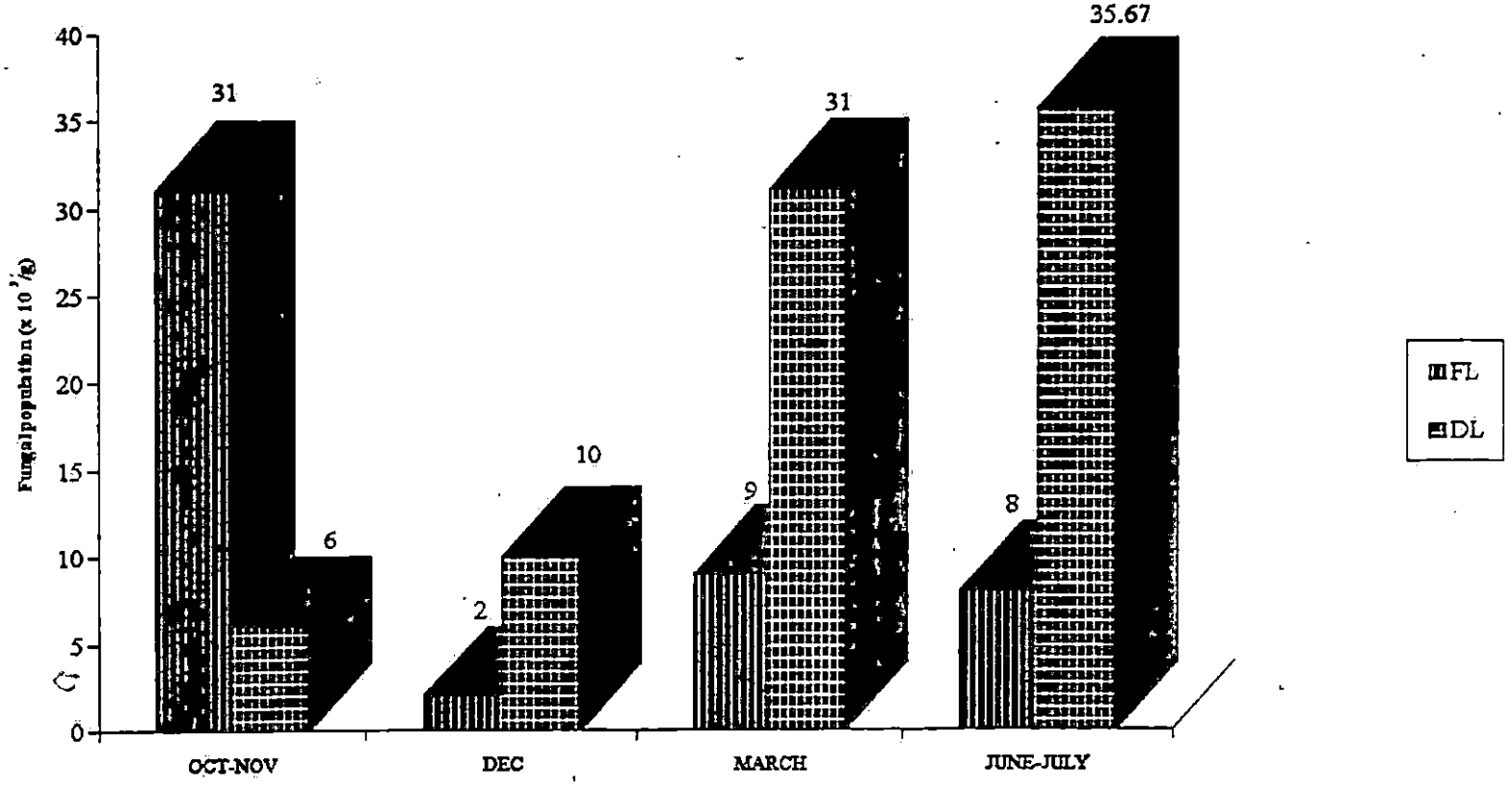
* Average of three replications

Table No. 4(b) Influence of environmental factors on the mycoflora of mango and jack leaf litter

Sl.No.	Relation between	Coefficient of correlation			
		JACK FL	MANGO FL	JACK DL	MANGO DL
1.	Maximum temperature x Mycoflora	-0.2844	-0.2868	0.3300	0.2995
2.	Minimum temperature x Mycoflora	-0.8080	-0.8763	0.0103	0.8389
3.	Rainfall x Mycoflora	0.6482	0.5857	-0.2226	-0.6508
4.	Relative humidity x Mycoflora				
	at 8.30 A.M.	-	0.7472	-0.6421	-0.6880
	at 3.30 P.M.	-	0.0547	-0.4962	-0.0641

Significant at 0.01 level

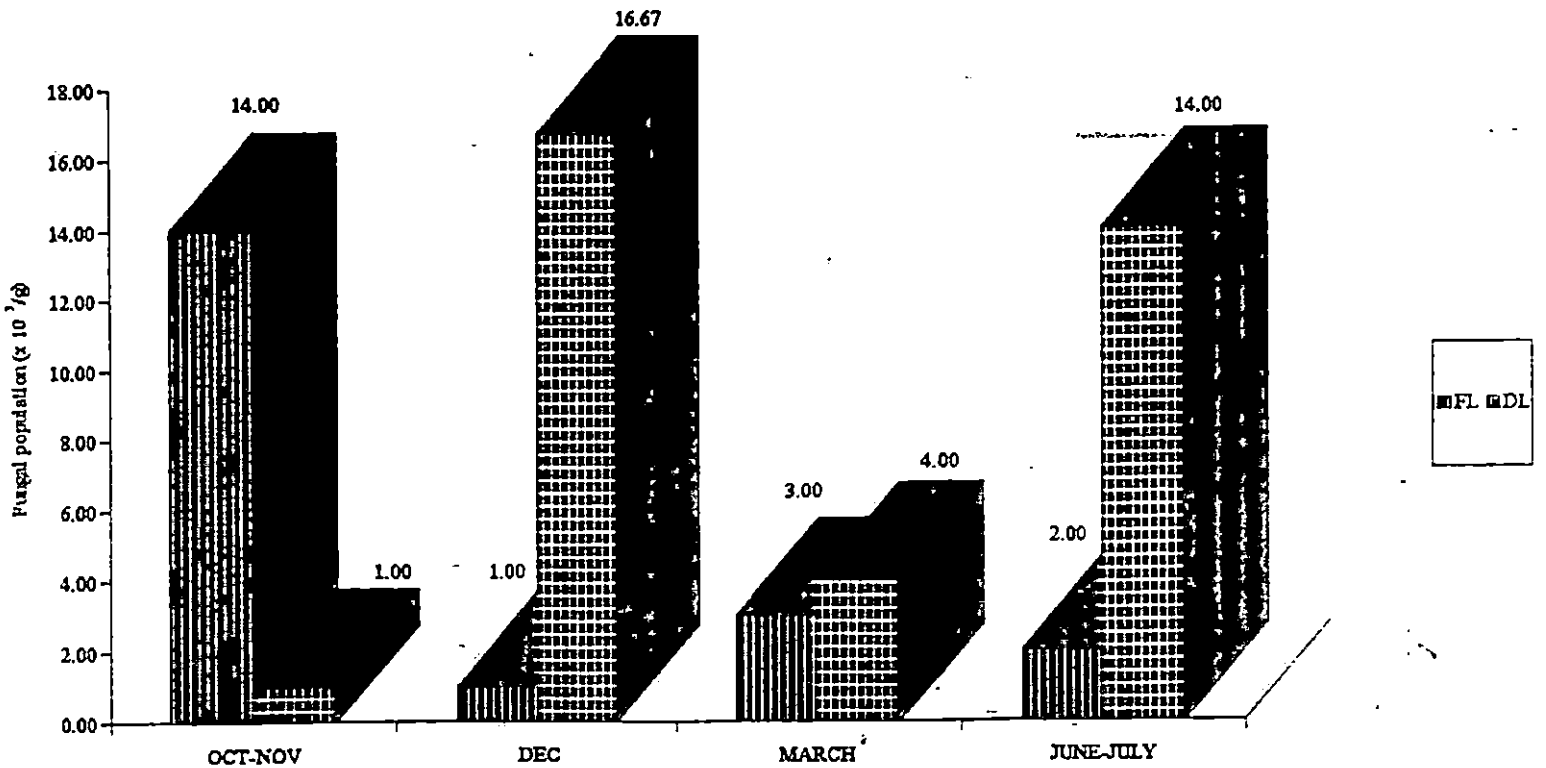
Fig2: **Effect of season on fungal population of Jack leaf litter**



FL - Fresh Litter
DL - Decomposed Litter

Fig. 2

Fig 3 **Effect of season on fungal population of Mango leaf litter**



FL - Fresh Litter
DL - Decomposed Litter

Fig. 3

Rainfall was found to be positively correlated with mycoflora counts in surface litter of mango (0.5857) and jack (0.6482) indicating the increased fungal counts during periods of high rainfall. This condition was reversed in the decomposed litter of both mango and jack where there was a negative correlation between the rainfall and fungal counts (0.6508, 0.2226). Table (4a, b). The excess moisture at the lower decomposed layers may be involved in causing anaerobic conditions thus reducing the decomposed litter mycoflora.

Relative humidity at both time intervals were found to be negatively correlated with mycoflora counts of decomposed litter in jack and mango indicating the role of relative humidity on establishment and survival of fungi on leaf litter.

Fungal succession on mango leaf litter

The fungi isolated from mango leaf litter belonged to ten genera. The dominant primary colonizers of the litter were Penicillium spp, Aspergillus spp. Aspergillus niger could be isolated on all the occasions of sampling, and were the most frequent and dominant species. The relative abundance of A. niger was highest during South-West monsoon. P. islandicum, and P. citrinum were the most predominant fungus on freshly fallen litter. The population of Penicillia decreased during the course

of decomposition A. flavus, Curvularia lunata, F. solani, F. oxysporum, T. viride and Chaetomium globosum and Verticillium theobromae were the most frequent and dominant secondary colonizers. The members of the Zygomycetes viz., Mucor hiemalis, Cunninghamella elegans, and Choanephora cucurbitarum, mostly appeared at the advanced stages of decomposition. The fungal species isolated during different stages of decomposition are presented in Table 5. Few Basidiomycetes were also isolated from decomposing leaf litter viz., Calocybe indica, Coprinus comatus and Volvariella diplasia.

Fungal succession on Jack leaf litter

The fungi isolated from jack leaf litter belonged to seven genera (Table 6). The dominant primary colonizers were P. islandicum, P. citrinum, P. oxalicum and Aspergillus spp, which were identified as the most frequent and dominant genus on the litter throughout the study. Other primary colonizers were Cladosporium cladosporioides, Colletotrichum gloeosporioides, Rhizoctonia solani and Pestalotia sp. Penicillium populations fluctuated during the course of decomposition, the lowest numbers were recorded during the advanced stages of decomposition. Among the secondary colonizers of the litter, Aspergillus flavus, A. niger, Curvularia lunata, Fusarium solani and Fusarium oxysporum were most frequent and dominant. An other secondary colonizer

Table No. 5 Fungal succession during different stages of mango leaf litter decomposition

PRIMARY COLONIZERS (Surface litter)	SECONDARY COLONIZERS (Partially decomposed)	TERTIARY COLONIZERS (Decomposing leaf litter)
Aspergillus flavus	*Alternaria alternata*	*Calocybe indica*
Aspergillus niger	*Aspergillus flavus*	*Choanephora cucurbitarum*
Penicillium citrinum	*Chaetomium globosum*	*Coprinus comatus*
Penicillium islandicum	*Colletotrichum gloeosporioides*	
Trichoderma harzianum	*Curvularia lunata*	*Cunninghamella elegans*
Trichoderma viride	*Penicillium citrinum*	*Mucor hiemalis*
	Pythium aphanidermatum	*Volvariella diplasia*
	Thamnidium elegans	
	Verticillium theobromae	
	Geotrichum	

Table No. 6 Fungal succession during different stages of jack leaf litter decomposition

PRIMARY COLONIZERS (Surface litter)	SECONDARY COLONIZERS (Partially decomposed)	TERTIARY COLONIZERS (Decomposing leaf litter)
Aspergillus flavus	Aspergillus flavus	Calocybe indica
Aspergillus niger	Aspergillus niger	Coprinus comatus
Cladosporium cladosporioides	Colletotrichum gloeosporioides	Trichoderma harzianum
Colletotrichum gloeosporioides	Curvularia lunata	Trichoderma viride
Penicillium citrinum	Fusarium oxysporum	Mucor hiemalis
Penicillium islandicum	Fusarium solani	Volvariella diplasia
Penicillium oxalicum	Rhizoctonia solani	
Pestalotia palmarum	Verticillium theobromae	
Rhizoctonia solani		

observed was Verticillium theobromae. The Zygomycete, Mucor hiemalis was present during the advanced stages of decomposition. Trichoderma harzianum and Trichoderma viride were also prevalent during the advanced stages of decomposition. The different fungal species isolated are presented in Table 6. The Basidiomycetes viz., Calocybe indica, Coprinus comatus, and Volvariella diplasia were isolated from decomposing leaf litter.

Description of fungi obtained from mango and jack leaf litters

(1) Alternaria alternata

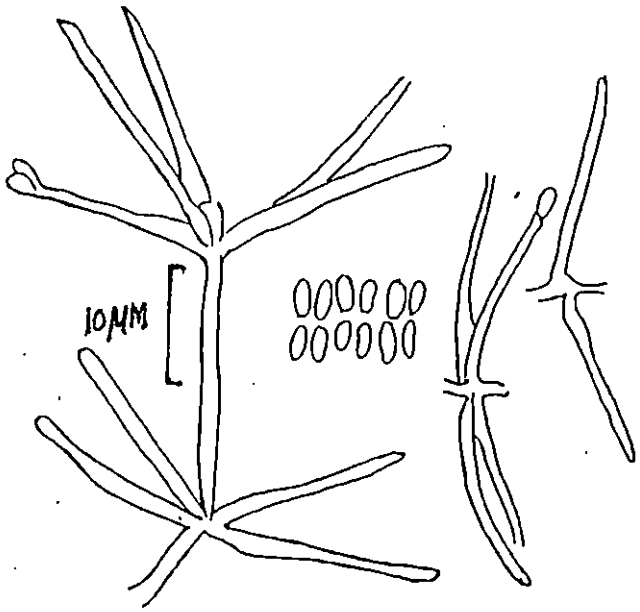
Colony diameter reaching 6 cm in ten days, conidiophores and conidia usually medium golden brown. Conidia formed in long branching chains, ovoid, obclavate with a conspicuous basal pore (18-63 x 7-18 um) (ML) (Fig. 6).

(2) Aspergillus candidus Link

Colonies persistently white becoming cream on ageing Conidia colourless globose to subglobose (2.5 - 3.5 or 4 um) (JL) (Fig. 4).

(3) Aspergillus flavus Link

Colonies reaching 3-7 cm diameter in ten days, characteristically yellow green. Conidia globose to subglobose, finely roughened to echinulata. (4 x 5 um) (JL and ML).



Alternaria alternata

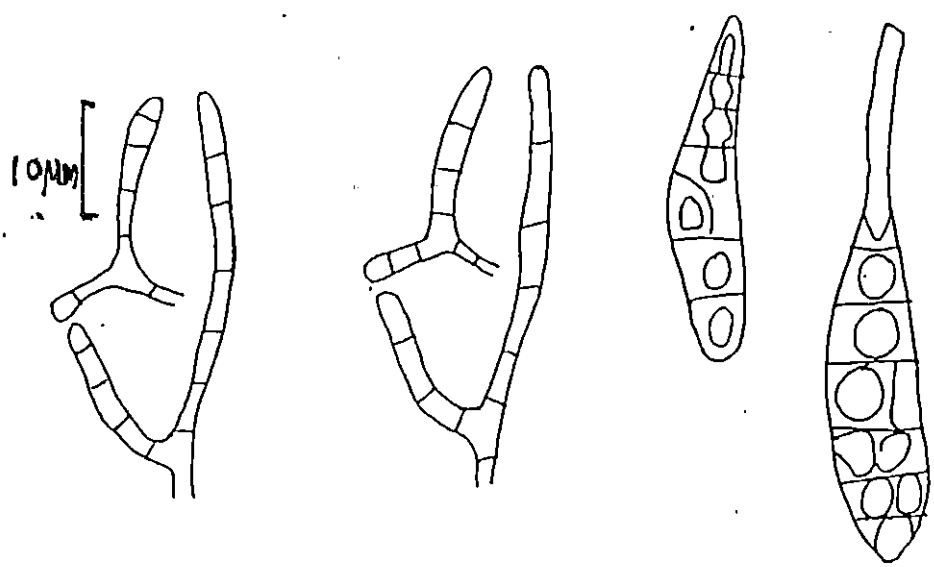


FIG6

(4) Aspergillus fumigatus Fresenius

Growing at 45°C colonies white at first becoming green with the development of heads often becoming dark green to black in age. Conidia dark green in mass, echinulate, globose (2.5 - 3 um) (JL and ML) (Fig. 4).

(5) Aspergillus niger var Tieghem

Colony diameter reaching 2.5 - 5 cm in ten days, typically black, powdery conidiophores arising from long, broad, thick walled brownish. Conidia irregularly roughened (2.5-4 um) (JL and ML) (Fig. 4).

(6) Aspergillus ochraceous Withelm

Colony diameter 2.5-5 cm in ten days, typically yellow. Conidia globose, more or less echinulate. (3.5 - 5 um) (JL).

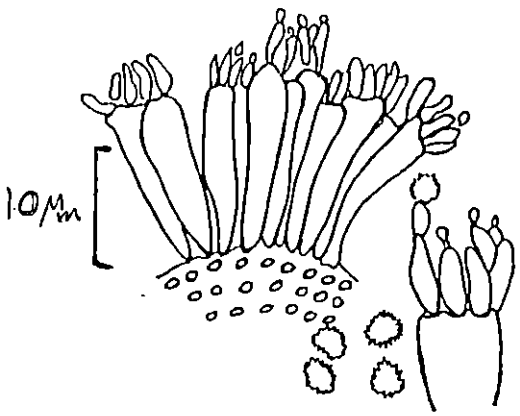
(7) Aspergillus tamarii Kita

Colonies spreading broadly at room temperature orange yellow shades to brown in old colonies. Conidia pyriform, subglobose to globose conspicuously roughened. (8 um in diameter) (JL) (Plate 3).

(8) Calocybe indica B & C

Sporophores growing solitary in soil, robust in size, centrally stipitate, fleshy, white coloured. Pileus 10-14 cm in diameter. Gills distinctly formed, crowded, white, attenuated toward the margin of the pileus. (JL and ML).

Aspergillus niger



Aspergillus candidus

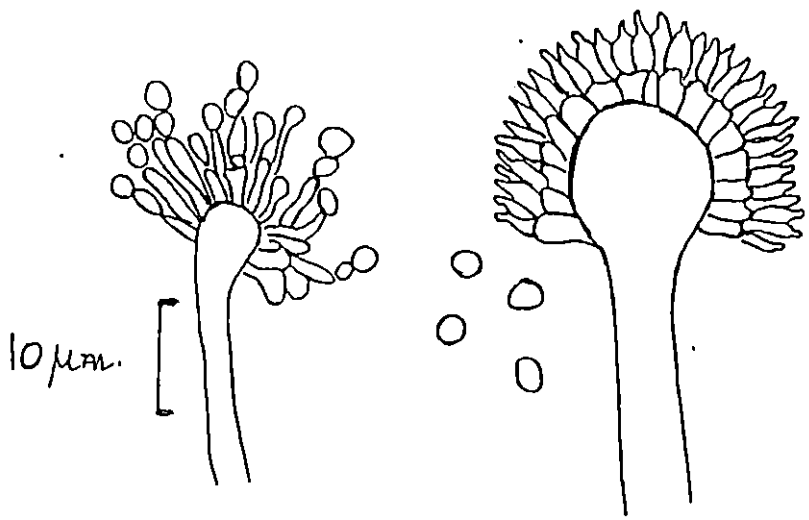
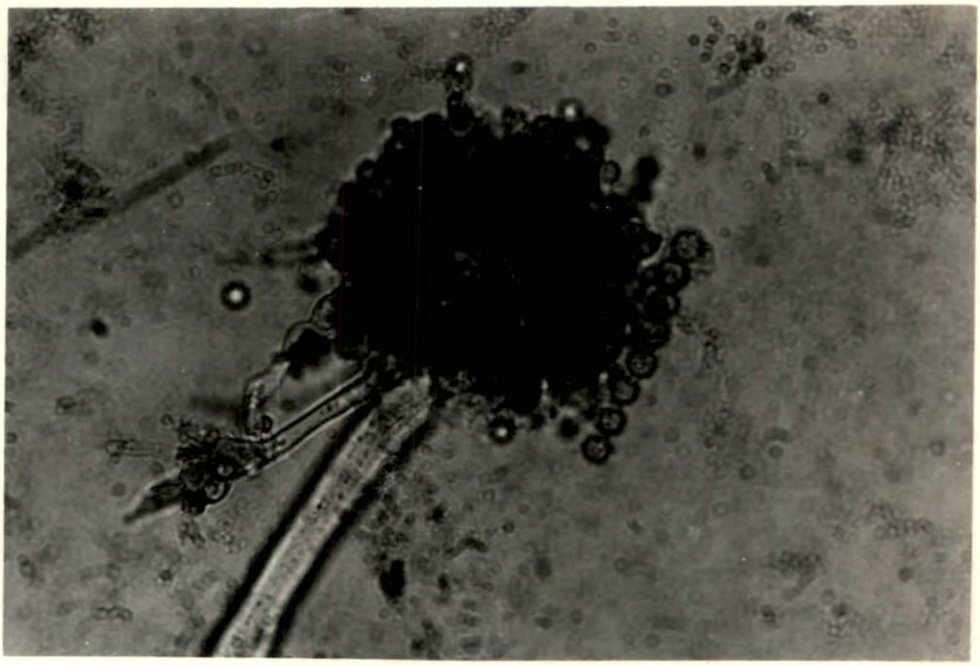


FIG.4

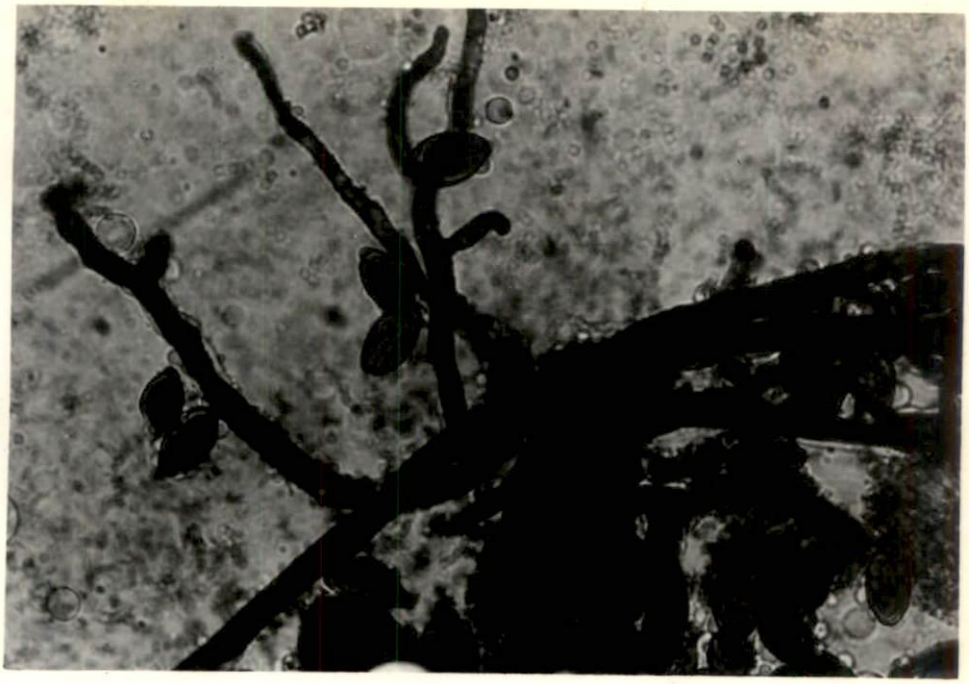
Plate No. 3 Fungi isolated from leaf litter of mango and jack.

Aspergillus tamarii

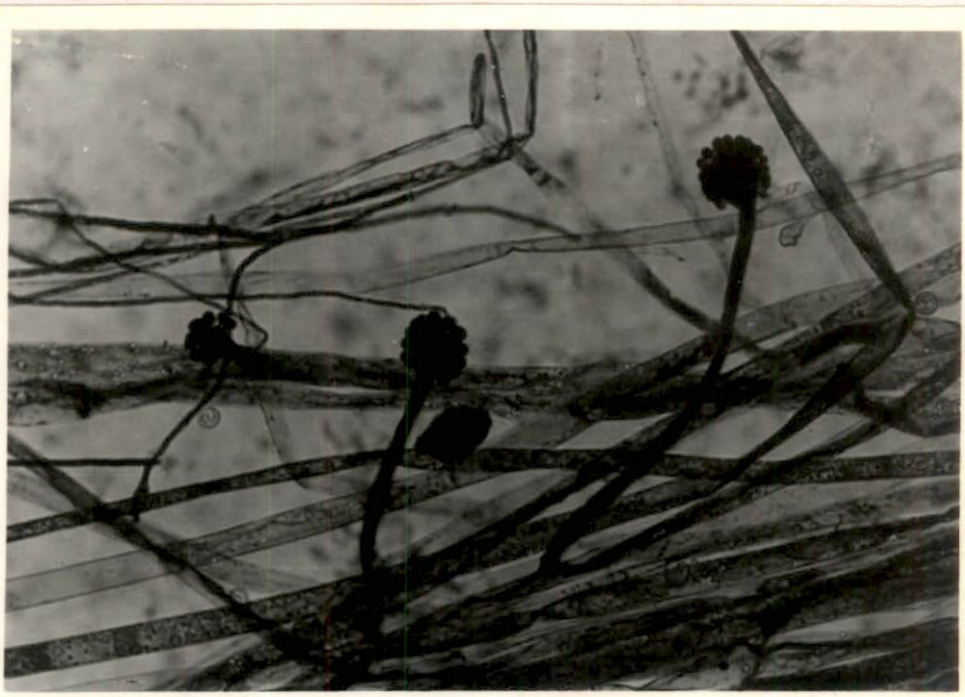


Chaetomium globosum

Choanephora cucurbitarum



Cunninghamella elegans



(9) Chaetomium globosum Kunze

Colonies reaching 4.5 to 5.5 cm diameter in ten days. Ascomata dark; brown to black globose to subglobose. Ascospores are lemon shaped 4 to 6 um diameter (ML) (Plate 3, Fig. 5).

(10) Choanephora cucurbitarum (Berk. & Rav.) Thaxter

Colonies dull white, extensive and growing rapidly in culture, conidia one-celled, brown, ellipsoid. Sporangiospores avoid to ellipsoid to almost triangular, 18-27 x 9-12.6 (22.2 x 10.8) um. (ML) (Plate 3).

(11) Cladosporium cladosporioides (Fres.) Vries

Colonies reaching 3 to 4 cm diameter in ten days, olivaceous green. Conidia ellipsoidal, smooth walled (2 to 11 x 2 to 5 um. (JL) (Fig. 5).

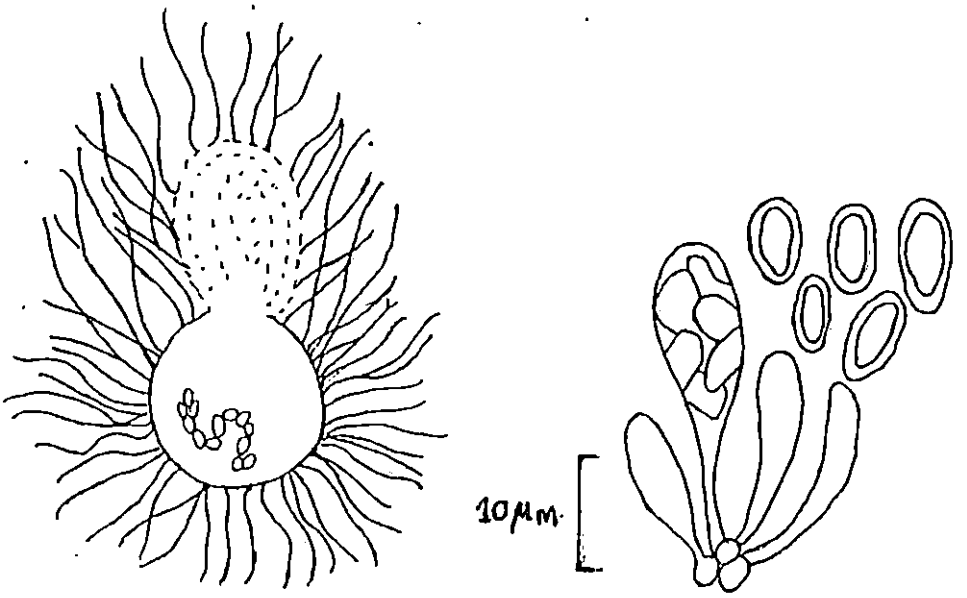
(12) Colletotrichum gloeosporioides (Pers. ex Fr.) Grove

Colonies reaching 4.5 - 4.8 cm diameter in four days. Conidia falcate with a minutely truncate base, hyaline, one-celled (18-30 x 3-5 um). (JL and ML)

(13) Coprinus comatus (Fries) S.F. Gray

Cap 4-6 cm white turning pink at margin then black, cylindrical when young upto 20 cm tall. Sporophores growing singly. (JL and ML).

Chaetomium globosum



Cladosporium cladosporioides

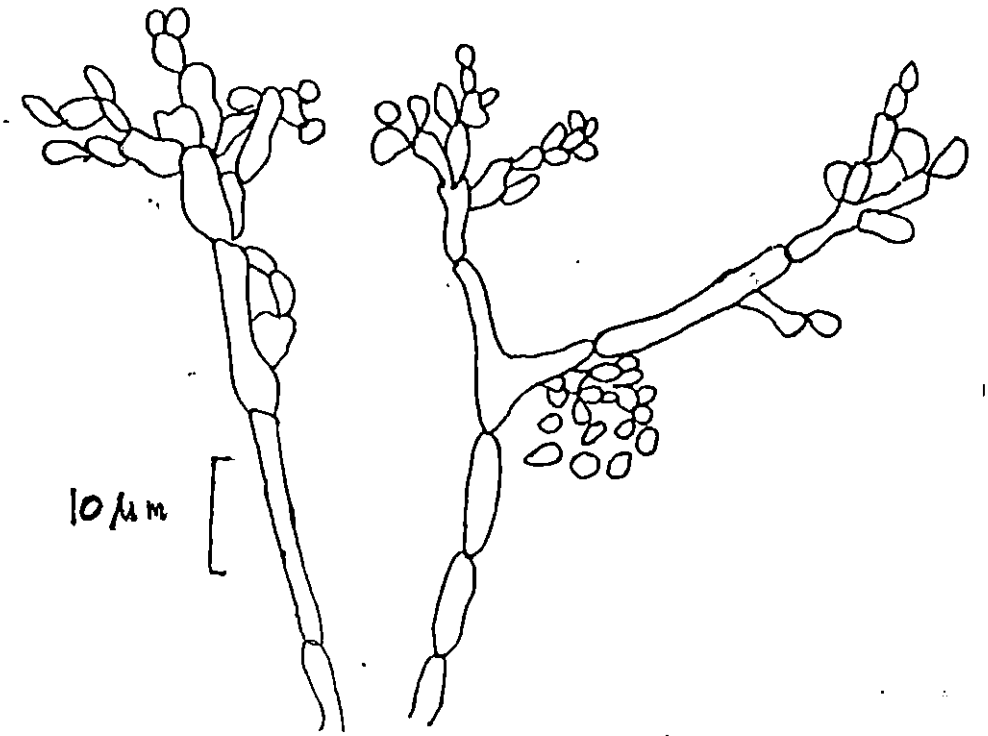


FIG 5

(14) Cunninghamella elegans Lendner

Colonies turf white to silver. Terminal conidia lemon shaped bearing spicules after seperation from vesicle (12 um long x 9 um in width) very finely echinulate. Lateral conidia ovate in varying degrees (6 um wide x 10 um in length) non spiculate, very finely echinulate (ML). (Plate 3, Fig. 8).

(15) Curvularia lunata (Wakker) Boedijn

Colonies effuse, grey reaching 4 to 6 cm in diameter in ten days. Mycelium immersed in the medium, Conidia formed solitary with three or more transverse septa. (18 to 32 x 9 to 15 um) (ML and JL).

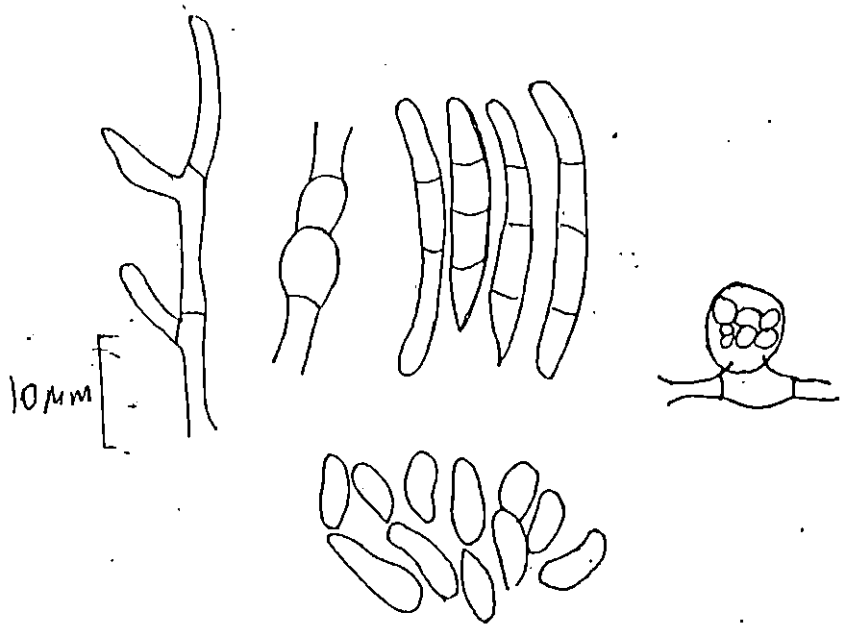
(16) Fusarium oxysporum Schlecht.

Colonies reaching 4-5 cm diameter in four days at 25°C, white or peach, but usually with a purple or violet tinge. Micro conidia ellipsoidal straight (5-12 x 2.3 - 3.5 um). Macro conidia fusiform, moderately curved, pointed at both ends. (JL). (Fig. 9).

(17) Fusarium solani (Mart.) Sacc.

Colonies reaching 3.2 cm in four days, green to bluish brown. Micro conidia usually abundant produced on elongate, sometimes verticillate, conidiophores. Macroconidia moderately. Curved, with short blunt apical cell and indistinctly pedicellate basal cells, 3-seplate, (30 x 4.5 um) conidia with 5 septate (36 x 4.8 um) (JL). (Fig. 9).

Fusarium oxysporum



Fusarium solani

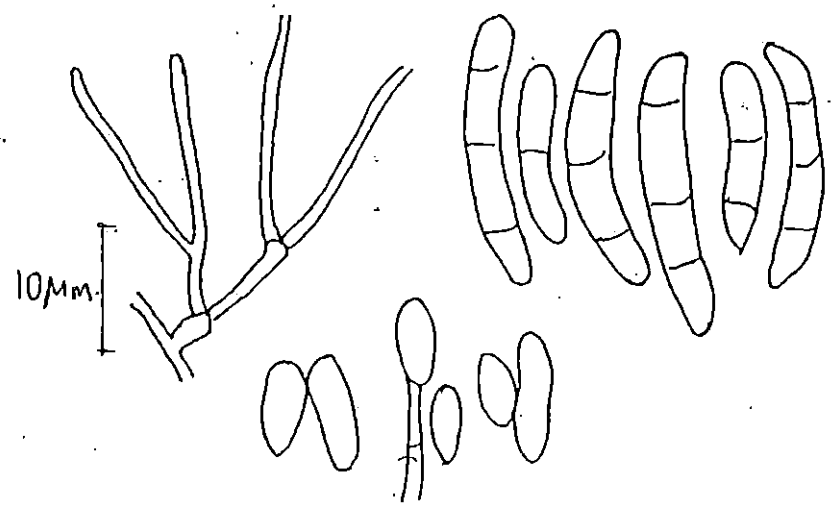


FIG9

(18) Geotrichum sp.

Is characterized by creeping mostly submerged, septate hyphae. The hyphae fragment into arthroconidia, which remain cylindrical. Blastoconidia are sometimes formed laterally on the hyphae (5-10 x 4 um). (ML) (Fig. 7).

(19) Mucor hiemalis Wehmer

Colonies 15 mm high, buff, reverse greyish in darkness. Sporangia at first yellowish later becoming dark brown. Sporangiospores ellipsoidal sometimes flattened at one side. Spores unequal, ellipsoid 7 x 3.2 um. (ML and JL) (Fig. 8).

(20) Penicillium citrinum Thom

Colonies reaching 2-2.5 cm diameter in 10-14 days, blue green, reverse bright yellow conidia globose to subglobose, smooth walled. (2.4 - 3 um or 3.5 um). (ML and JL).

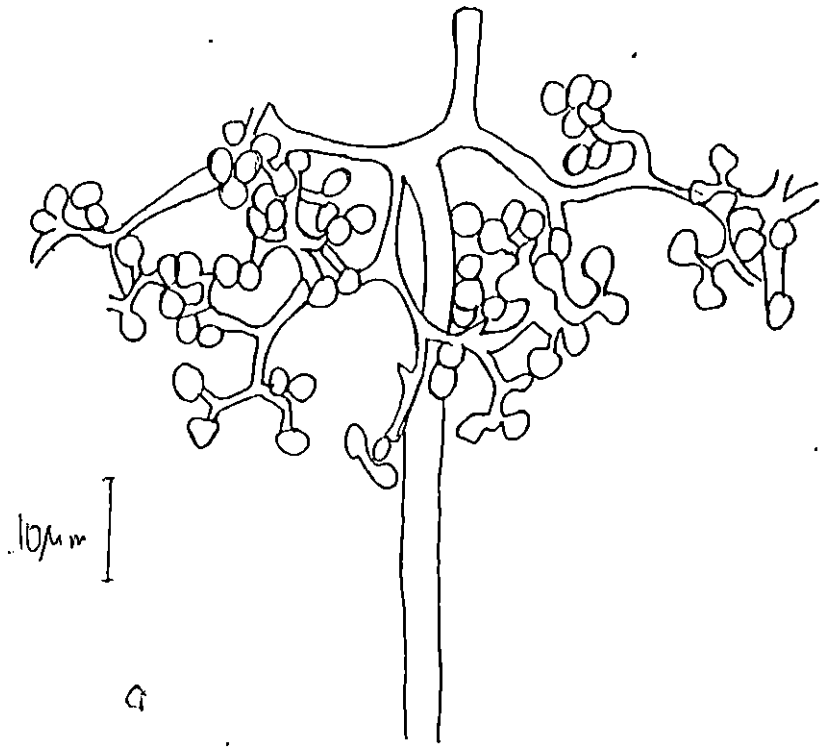
(21) Penicillium oxalicum Thom

Colonies reaching 3.5-5 cm in diameter in ten days, dull green, reverse uncoloured or pink. Conidia, strongly ellipsoidal and smooth walled. (4.5 - 6.5 x 3-4 um). (JL).

(22) Penicillium islandicum Sopp

Colonies reaching 2.5 - 3 cm in diameter, consisting of a feet of orange to red encrusted mycelium. Conidia ellipsoidal, smooth and thick walled (3.0 - 3.5 x 2.5 - 3.0 um) (ML and JL).

Thamnidium elegans



Geotrichum sp

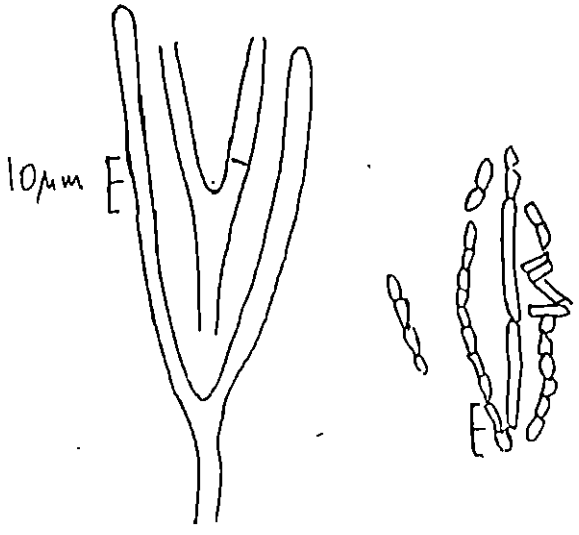


FIG7

(23) Pestalotia palmarum (Cooke) Steyaert.

Colonies reaching 4.5 - 5 cm diameter in four days. The spores are four celled. The apical cell bears one to three, bristles. The terminal cells are lighter coloured than the intervening cells. Conidia (29-37 x 6-9 um).

(24) Pythium aphanidermatum (Edson) Fitz

Colonies reaching 2.5 - 3 cm in diameter, white in colour. Oogonia mostly terminal, spherical, oospores aplerotic, moderately thick walled, antheridia usually monoclinous, intercalary or terminal. Sporangia irregularly lobed (ML).

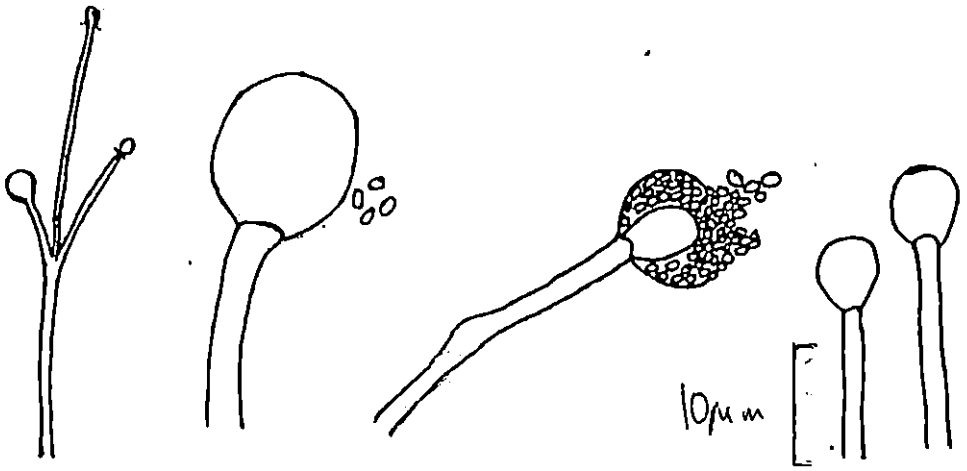
(25) Rhizoctonia solani Kühn

The hyphae are colourless when young, becoming yellowish brown when old, 8-12 um in diameter. Sclerotia are superficial, becoming brown, round in shape. (JL).

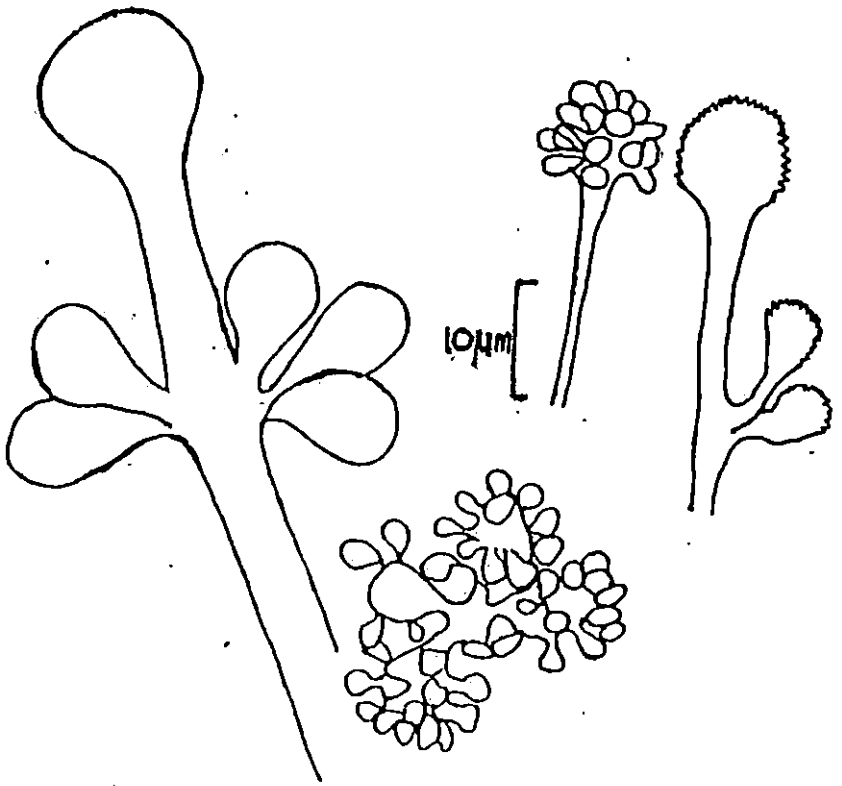
(26) Thamnidium elegans Link

Colonies reaching 5 cm in diameter in thirteen to nineteen days, at first olive grey, later becoming darker olive grey with a similar reverse. Sporangiospores oval to ellipsoidal. Spores are of same size in all sporangia (6-8 um wide x 8-12 um long). (ML) (Fig. 7).

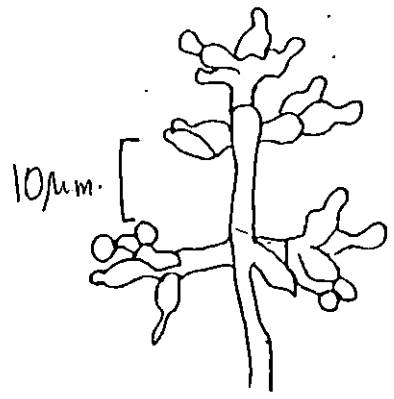
Mucor hiemalis



Cunninghamella elegans



Trichoderma harzianum



Trichoderma viride

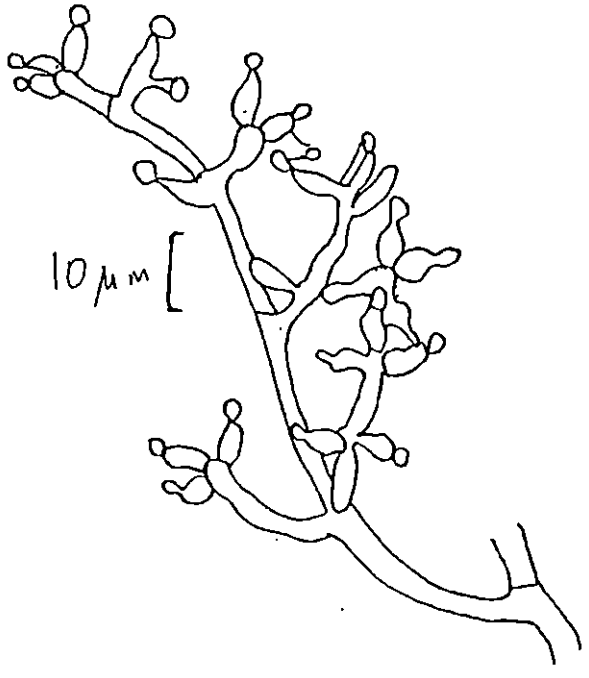


FIG10

(27) Trichoderma harzianum Rifai

Colonies reaching over 9 cm diameter in five days, light green colonies conidia subglobose to short oval (2.8 to 3.2 x 2.5 to 2.8 um). (ML and JL) (Fig. 10).

(28) Trichoderma viride Pers ex. Gray

Colonies reaching 4.5 to 7.5 cm in diameter in five days. Conidiophores have short branches. Phialides in divergent groups, slender. Conidia globose (3.6 to 4.5 um) in diameter, surface roughened. (ML and JL) (FIg. 10).

(29) Verticillium theobromae

Colonies growing moderately fast, reaching 1.8 - 2.7 cm diameter in ten days; white in colour and floccose conidia ellipsoidal short cylindrical, hyaline and one celled and very small. (2-3 x 2 um) (ML and JL) (Fig. 6).

(30) Volvariella diplasia Ber & Br.

Medium sized species with cap fleshy and regular. The gills are free and becoming deep pink. Stipe is central with a distinct volva but no ring. The flesh of the cap and stipe not continuous. (ML and JL).

Effect of different temperature regimes (45, 35 and 25°C) on litter degradation

The leaf litter of mango and jack were incubated at different temperatures and their corresponding weight loss was

studied and presented Table 7. Weight loss is considered as an indicator of litter degradation. At 45°C, the percentage average weight loss of Mango litter was 3.80 per cent and Jack was 2.75 per cent. At 35°C the average weight loss of Mango was 0.38% and Jack was 0.05 per cent. There was no difference in weight for litters which were incubated at 25°C. The weight loss was greater at 45°C when compared to 35°C. The fungal species Aspergillus fumigatus was isolated from the litter placed at 45°C. The rate of weight loss of mango leaf litter was 1.26 while the rate of weight loss of jack leaf litter was 2.30 at 45°C indicating the faster decomposition of jack leaf litter at the higher temperature.

Weight loss studies

Significant effects were observed for the type of hosts (jack/mango), incubation condition (Laboratory/field) and the period of incubation on the weight loss of jack and mango leaf litter. Both the jack (15.104) and mango (14.42) litter were found to lose weight significantly under field conditions as compared with the laboratory condition (Table 8). Between the two plants the weight loss was more pronounced in jack (15.7, 14.42) than in mango (15.12, 15.104) under both conditions. After each period of incubation, there was significant weight loss in the leaf litter of both jack and mango under both laboratory and field conditions. At the end of the sixth month

Table No. 7 Effect of different temperature regimes (45, 35, 25°C) on litter degradation

Treatment	Temperature	Initial weight (g)	Weight after 2nd month (g)	Percentage weight loss	Weight after 3rd month	Percentage weight loss	Weight after 6th month	Percentage weight loss	Rate of loss over a period of 6 mon
Jack	45°C	250	246	1.6	245.10	1.96	243.10	2.75	2.30
	35°C	250	-	-	-	-	249.88	0.05	0.04
	25°C	250	-	-	-	-	-	-	-
Mango	45°C	250	244.80	5.20	242.80	2.88	246.20	3.80	1.26
	35°C	250	-	-	249.70	0.12	249.05	0.38	0.32
	25°C	250							

Table No. 8 Influence of *in vitro* and *in vivo* conditions on jack and mango leaf litter decomposition

	Mango	Jack	
Lab	15.12	15.7	15.91
Field	15.104	14.42	15.181
CD (Mango, jack) = 0.313			CD = 0.221
	15.612	15.06	
CD (Mango, jack) = 0.221			

Table No. 9 Effect of incubation conditions and different seasons on decomposition of leaf litters of jack and mango

	Mango	Jack
Laboratory		
August	20	20
September	18.94	18.3
October	15.2	16.96
November	13.88	12.76
January	12.58	12.5
Field		
August	20	20
September	18.2	17.3
October	14.28	13.74
November	13.6	11.22
January	12.42	9.84
CD = 2.06		

Fig.11-

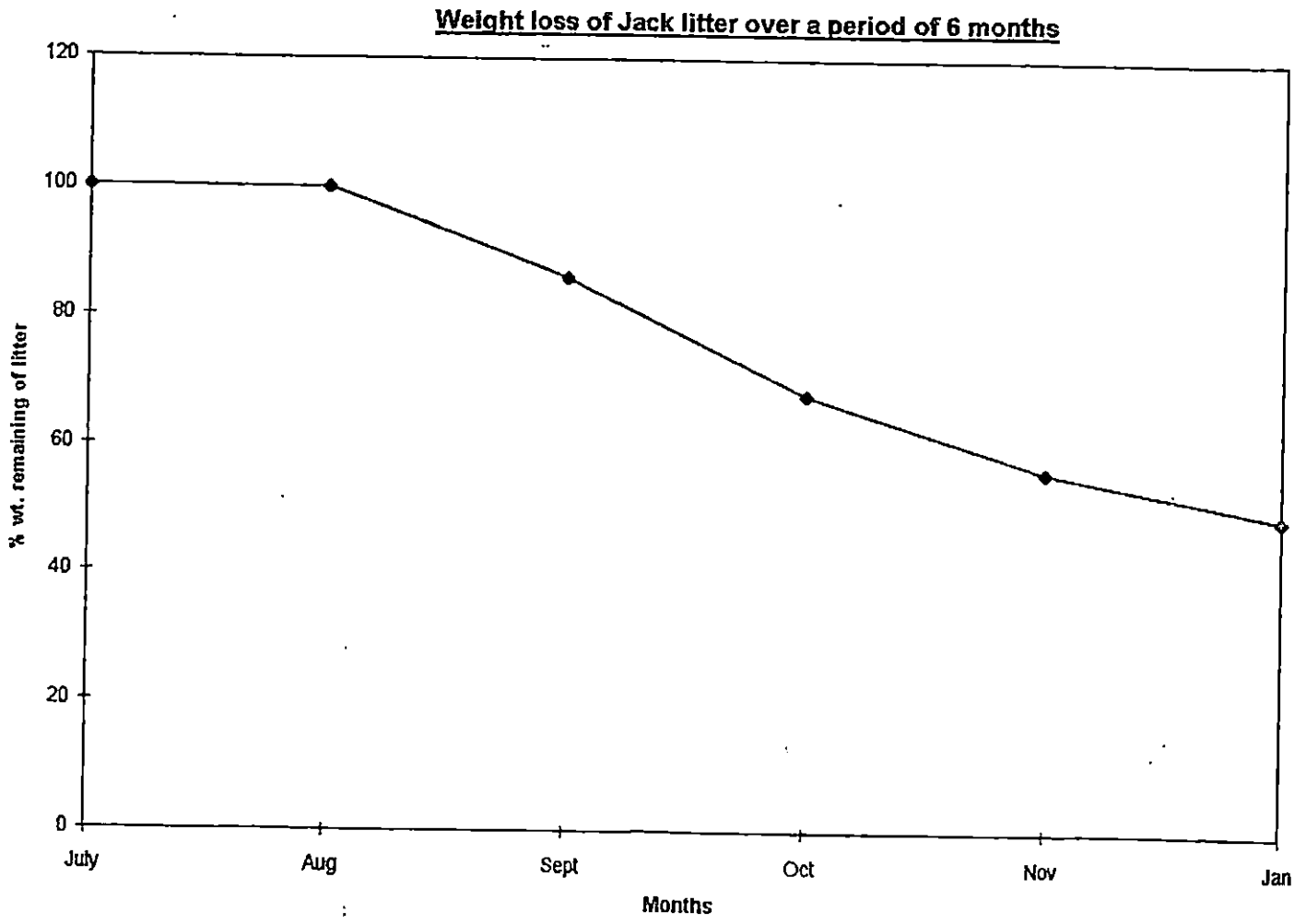

Weight loss of Jack litter over a period of 6 months
120
100
80
60
40
20
0
% wt. remaining of litter
July
Aug
Sept
Oct
Nov
Jan
Months

Fig:12 **Weight loss of Mango litter over a period of 6 months**

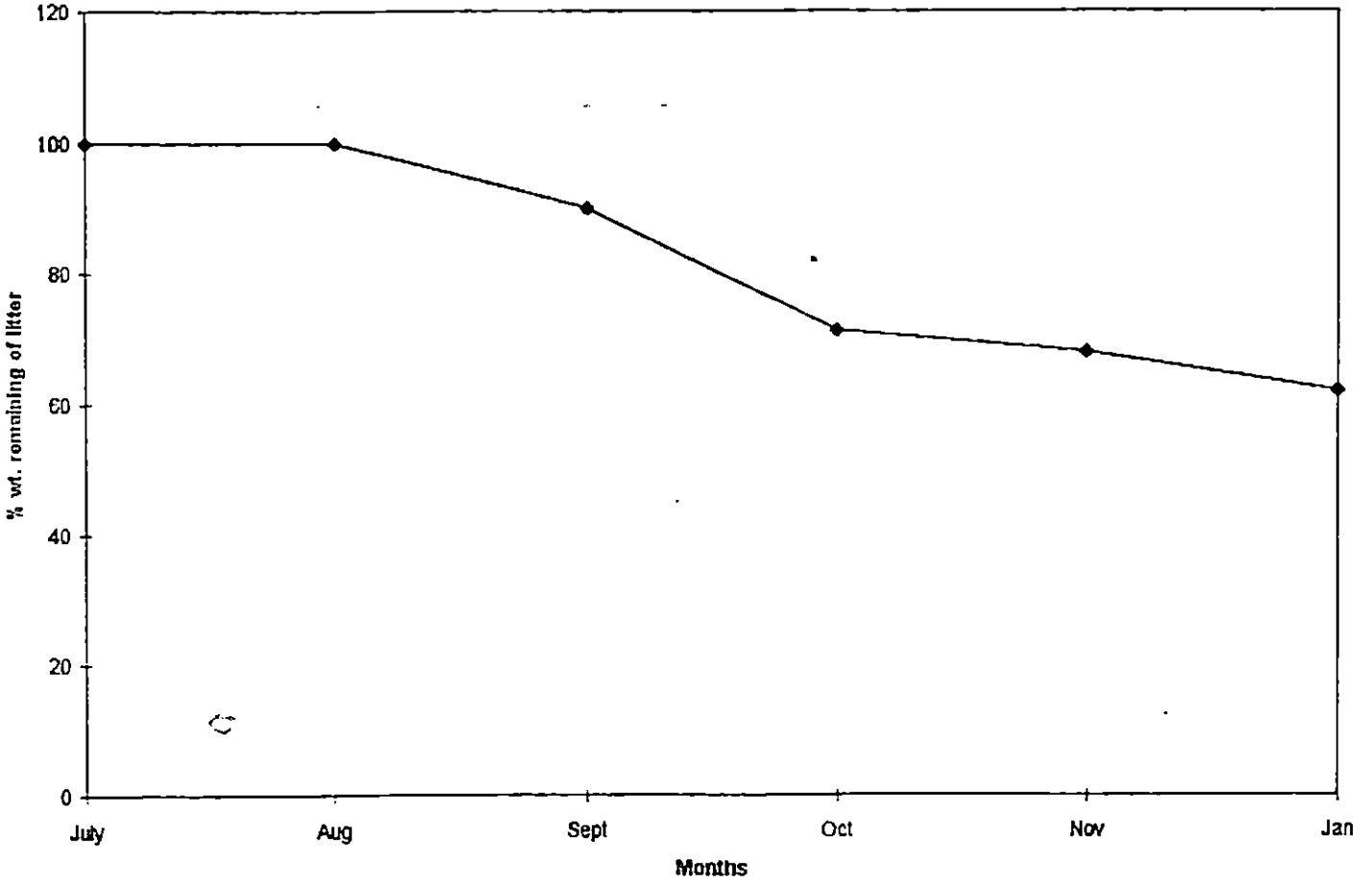


Fig. 12

the weight loss was significantly higher for jack, under both *in vitro* (12.5) and *in vivo* (9.84) conditions when compared with mango the weight loss in jack leaf litter under *in vitro* (12.58) and *in vivo* (12.42) conditions. (Table 9, Figs. 11&12).

Effect of environmental factors on weight of mango and jack litter

A strong negative correlation was observed between maximum temperature and weight of litter both in mango (-0.7691) and jack (-0.7206) indicating the greater weight loss at higher temperatures. A positive correlation between minimum temperature and weight loss was also noted for both mango (0.7287) and jack (0.7889) indicating that at lower temperature the weight loss also was reduced. There was a strong negative correlation between rainfall and weight loss for both mango (-0.1816) and jack (-0.1905) indicating the role of higher rainfall in increased weight reduction of leaf litter (Table 10a, b).

A strong positive correlation existed between relative humidity values at morning and evening on the weight loss in mango (RH_1 - 0.9168 RH_2 - 0.7690) and jack (RH_1 - 0.9035 RH_2 - 07569) leaf litter (Table 10a, b).

Table 10(a) Effect of weather parameters on dry weight of leaf litter during decomposition

Month	Weather parameters					Weight of litter (g)			
	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		Laboratory		Field	
	Maximum	Minimum		Maximum	Miniumum	Jack	Mango	Jack	Mango
AUGUST	29.06	24.09	58.80	89.96	76.92	20	20	20	20
SEPTEMBER	28.5	24.03	83.5	90.13	82.84	18.3	18.94	17.3	18
OCTOBER	30.27	23.95	113.9	84.87	73.94	16.96	15.2	13.74	14.28
NOVEMBER	30.40	22.45	246	85.47	73.37	12.76	13.88	13.6	11.22
JANUARY	29.75	19.69	Nil	80.41	70.11	12.5	12.58	9.84	12.46

Table No. 10(b) Effect of environmental factors on weight of mango and jack litter

Sl. No.	Relation between	Coefficient of correlation	
		JACK	MANGO
1.	Maximum temperature x weight	-0.7206	-0.7691
2.	Minimum temperature x weight	0.7889	0.7287
3.	Rainfall x weight	-0.1905	-0.1816
4.	Relative humidity x weight		
	at 8.30 A.M.	-0.9035	-0.9168
	at 3.30 P.M.	-0.7969	-0.7690

Significant at 0.01 level

The decomposition constant (K) for jack was 1.52 as against a lower K value of 1.03 for mango. This indicates the faster decomposition of jack litter compared with mango litter.

Table No. 11 Decomposition parameter and time required for various levels of decay of jack and mango leaf litter

Species	Weight remaining % of original	Decomposition parameters	t (years) half time	t (years) 95%
Mango	35.8	1.03	0.67	2.91
Jack	21.81	1.52	0.46	1.97

The time required for half decay and 95% decay are also correspondingly lower in the case of jack (0.46, 1.97) as compared with mango (0.67, 2.91) as the decay process is faster in jack indicating the higher efficiency of decomposition in the case of jack litter.

Celluloytic ability of isolated fungi

Most of the fungi grew well on Czapek's Dox agar medium, and also on Cellulose amended medium. Few fungal species viz., Aspergillus candidus, Aspergillus tamarii put forth poor growth on cellulose amended medium where as Trichoderma harizanum and T. viride grew well on cellulose amended medium when compared with the growth on Czapeck's Dox agar medium (Table 12, Plates 4a, b & 5). The fungi, Aspergillus flavus and Penicillium islandicum did not grow on the cellulose amended medium.

Biochemical Analysis

The results of the biochemical analyses are presented in (Table 13, Fig. 13, 14, 15, 16).

The Analysis of variance for nitrogen content indicated significant differences among the different leaf litters. The jack decomposing litter had the highest nitrogen content while jack fresh litter and jack surface litter did not differ significantly in the nitrogen content. The least nitrogen content was observed in mango surface litter.

The ash content was found to differ significantly among the different leaf litters studied. The jack decomposing litter and mango decomposing litter were on par in their ash content being higher than all the same in all other litters. The least

Table No. 12 Cellulolytic ability of isolated fungi

NAME OF THE FUNGUS	(CELLULOSE) Czapek's Dox Agar			Czapeck's Dox Agar		
	R_1	R_2	R_3	R_1	R_2	R_3
Aspergillus candidus	3.5cm	3cm	3.5cm	9cm	9cm	9cm
Aspergillus flavus	-	-	-	9cm	9cm	9cm
Aspergillus niger	9cm	9cm	9cm	9cm	9cm	9cm
Aspergillus ochraceous	6cm	7cm	6.5cm	9cm	9cm	9cm
Aspergillus tamarii	3cm	3cm	3cm	9cm	9cm	9cm
Penicillium islandicum	-	-	-	9cm	9cm	9cm
Penicillium oxalicum	9cm	9cm	9cm	9cm	9cm	9cm
Penicillium citrinum	9cm	9cm	9cm	9cm	9cm	9cm
Trichoderma harzianum	9cm	9cm	9cm	3.5cm	3.5cm	3.5cm
Trichoderma viride	9cm	9cm	9cm	5cm	4.5cm	4.5cm
Chaetomium globosum	9cm	8cm	8.5cm	5cm	6cm	7cm

Fig: 13 **Percentage of Nitrogen in Mango & Jack leaf litter**

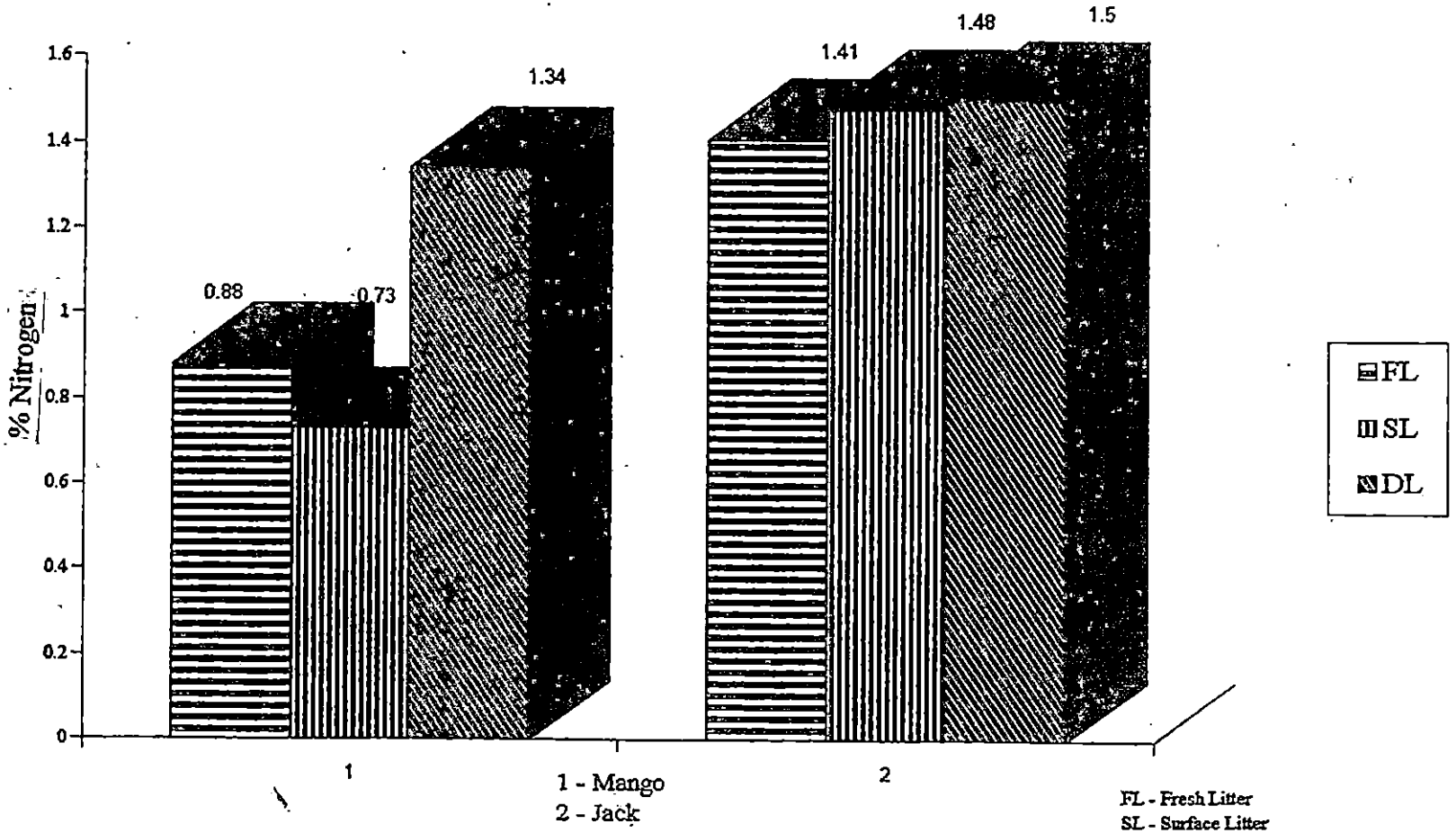


Fig. 13

Fig: 14

Percentage of Ash in Mango & Jack leaf litter

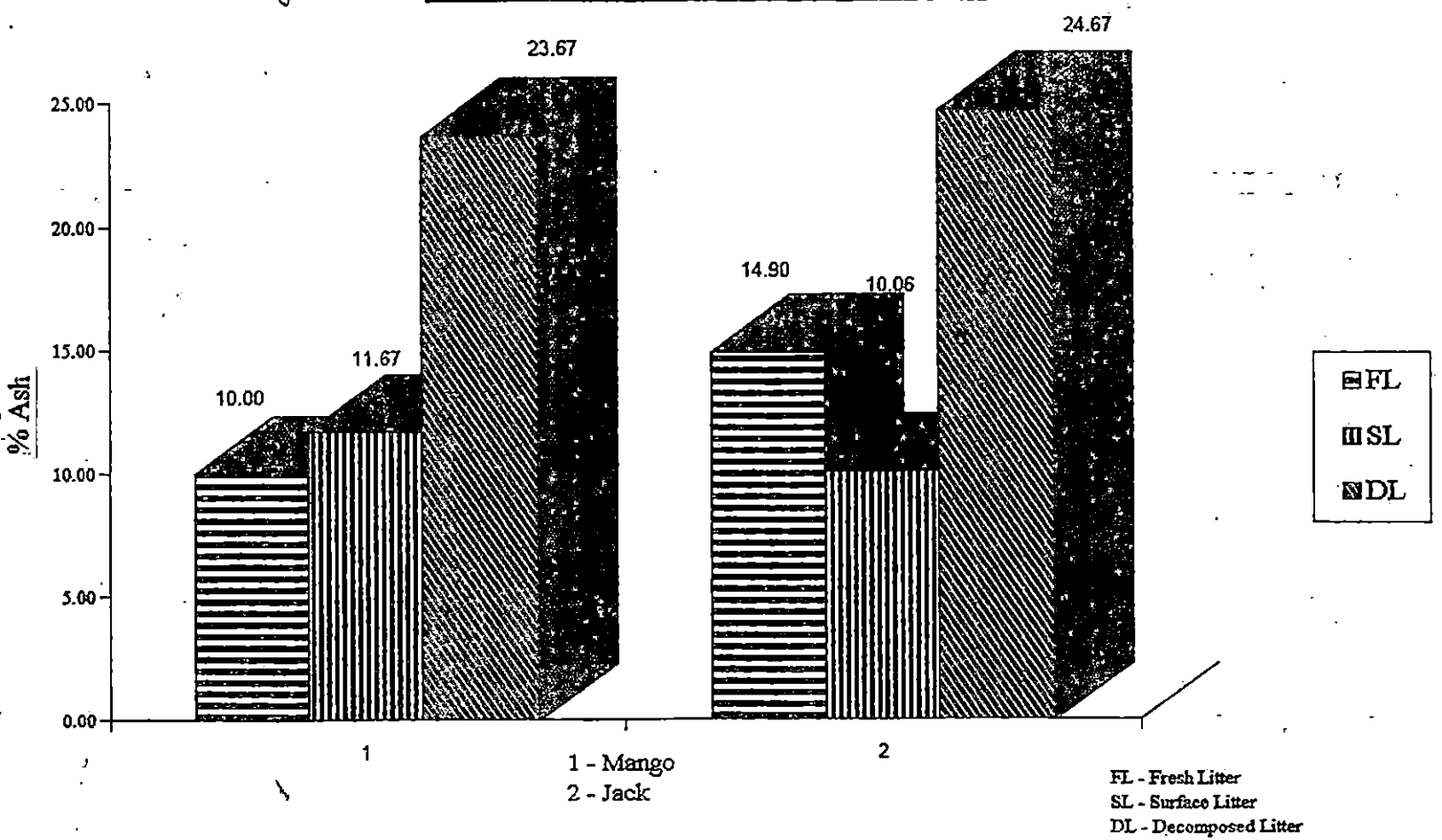


Fig. 14

Fig : 15 Carbohydrate content of Mango & Jack leaf litter

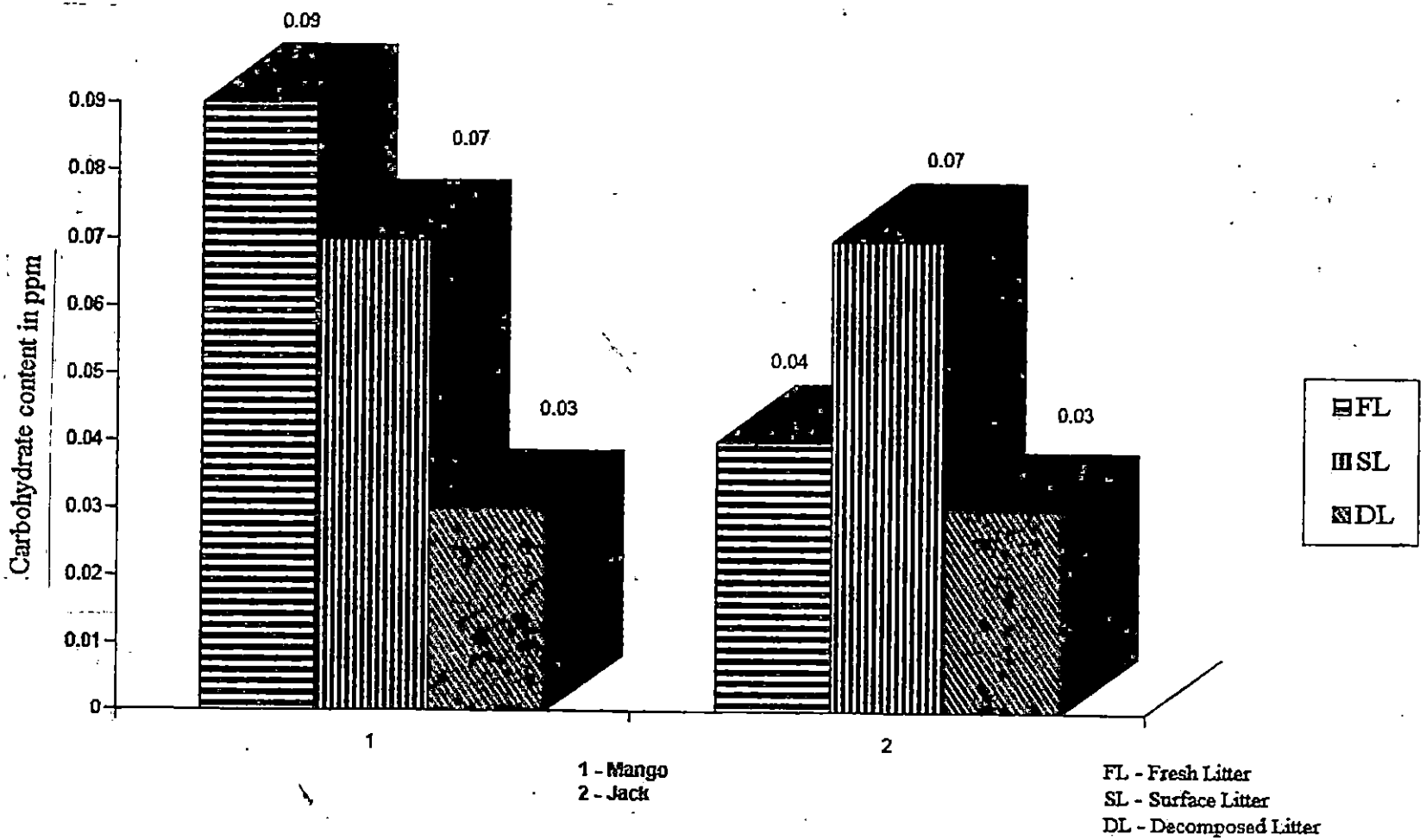


Fig. 15

Fig: 16

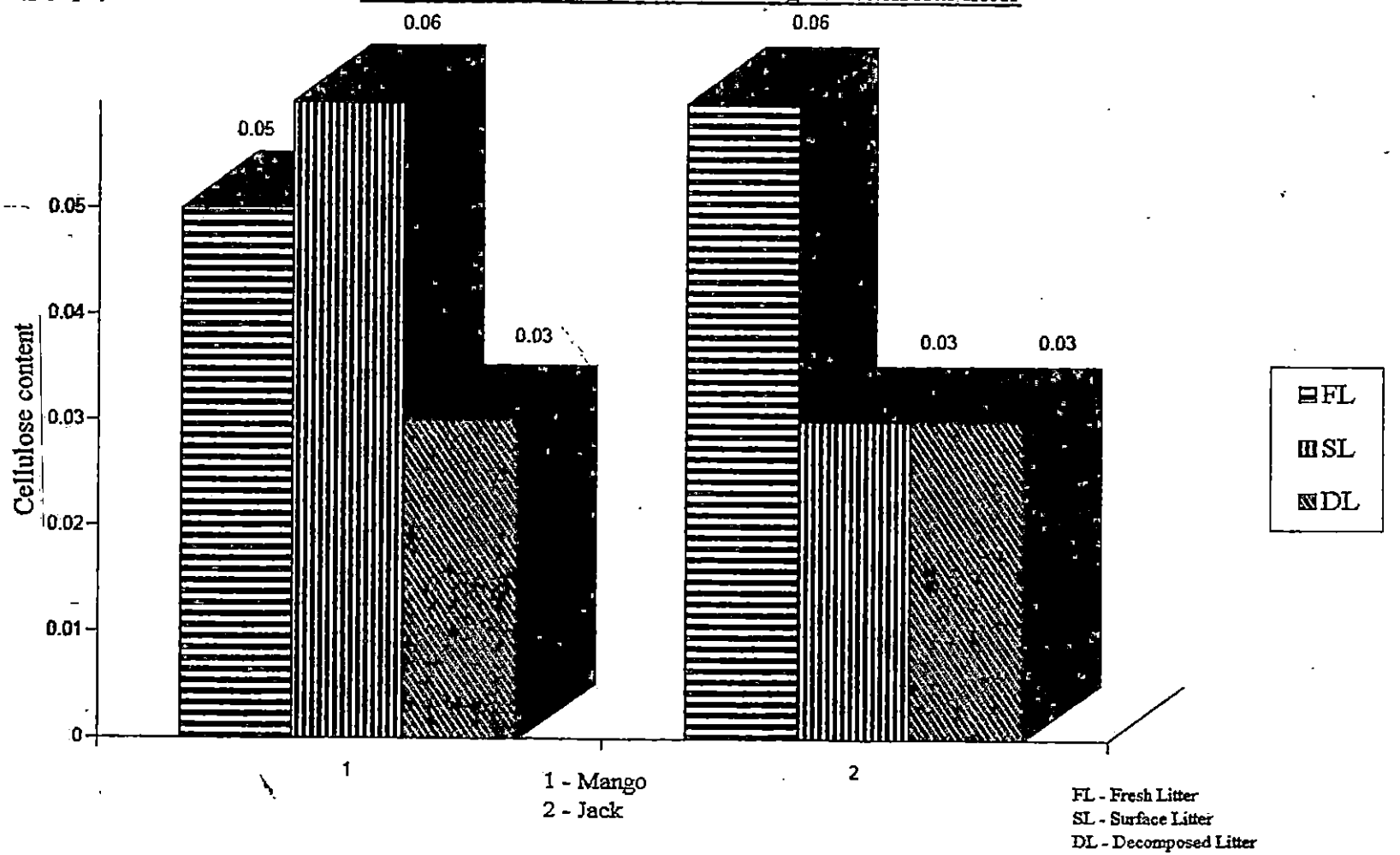
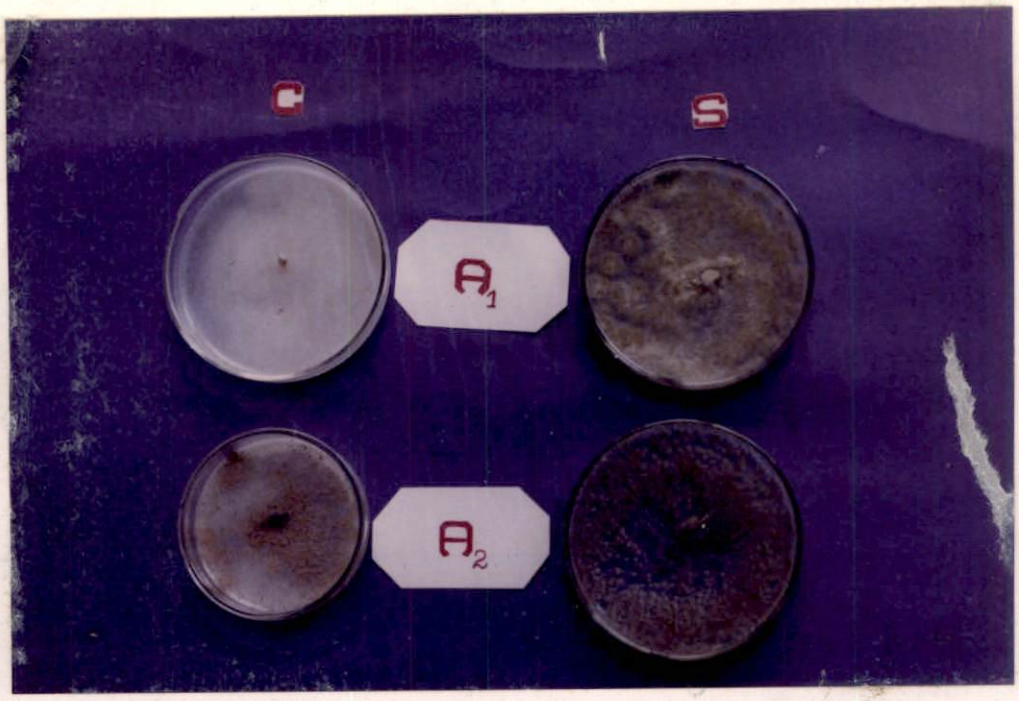

Amount of cellulose present in Mango & Jack leaf litter
0.06
0.06
0.05
0.03
0.03
0.03
Cellulose content
0.05
0.04
0.03
0.02
0.01
0
1
2
1 - Mango
2 - Jack
FL
SL
DL
FL - Fresh Litter
SL - Surface Litter
DL - Decomposed Litter

Fig. 16



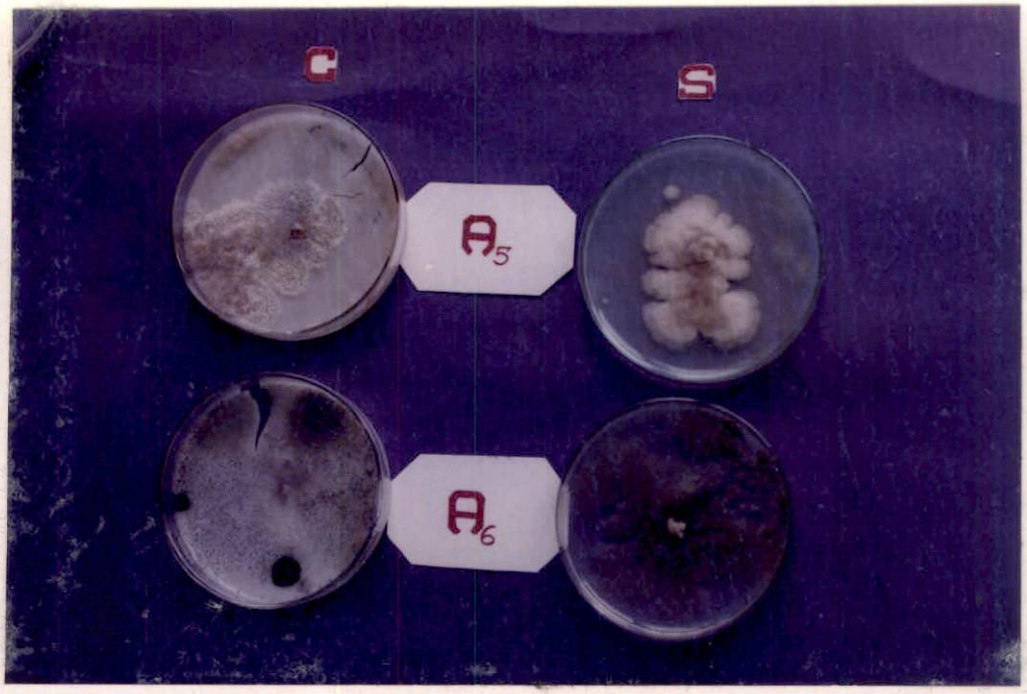
A_1- **Aspergillus flavus**

A_2- **Aspergillus niger**

A_3- **Aspergillus ochraceous**

A_4- **Aspergillus tamarii**

Plate No.4(a) Cellulolytic ability of Aspergillus spp.

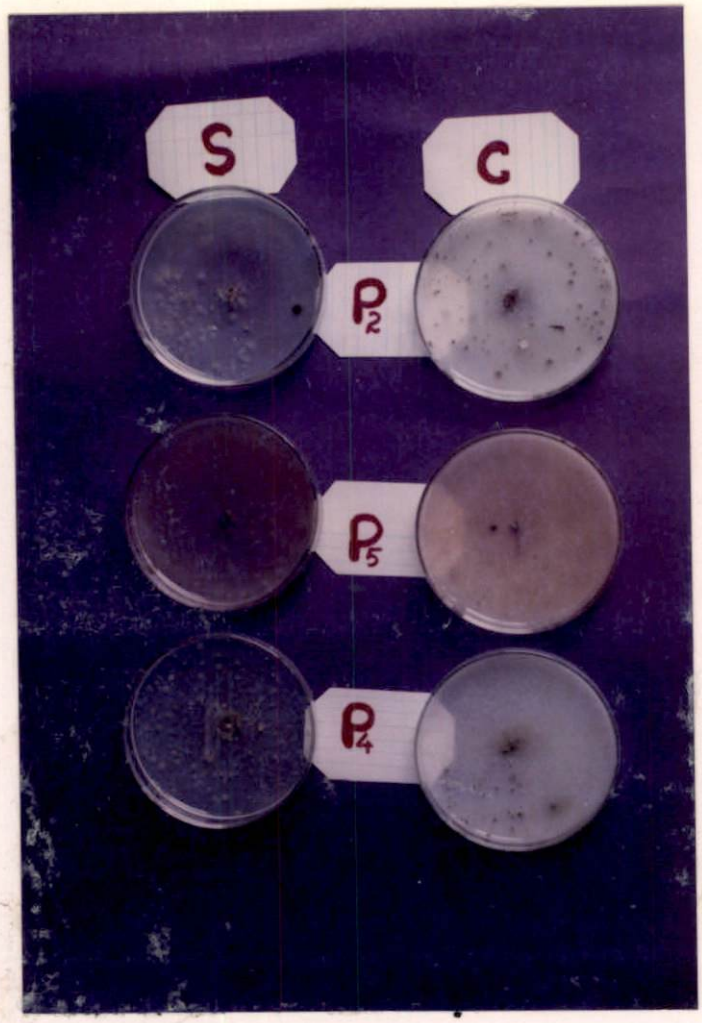


A_5- **Aspergillus candidus**

A_6- **Aspergillus niger**

A_7- **Aspergillus flavus**

Plate No.4(b) Cellulolytic ability of Aspergillus spp.



P_2 - Penicillium citrinum

P_5 - Penicillium islandicum

P_4 - Penicillium oxalicum

Table No. 13 Biochemical changes during decomposition of leaf litter

Treatment	% Nitrogen	% Ash content	CHO (ppm)	Cellulose (ppm)
MFL	0.87	9.72	0.09	0.05
MSL	0.74	11.72	0.07	0.06
MDL	1.31	23 39	0.03	0.03
JFL	1.41	14.9	0.07	0.06
JSL	1.47	8.55	0.04	0.03
JDL	1.55	24.55	0.03	0.03
F Value	163.80**	81.205**	22.67**	2.844
CD	0.081	2.372	0.016	0.027

ash content was observed in jack surface litter and mango fresh litter, where as the ash content of mango fresh litter was on par with that of mango surface litter.

The litter studied were found to exhibit significant difference in their carbohydrate content as indicated by the analysis of variance for carbohydrate content. The highest carbohydrate content was noticed in mango fresh litter, followed by mango surface litter and jack fresh litter. Lowest carbohydrate content was observed on mango decomposing litter and jack decomposing litter, thus indicating that the carbohydrate content decreased with decomposition.

The cellulose content of leaf litter studied exhibited, statistically insignificant results. The cellulose content was found to decrease as decomposition proceeded. The cellulose content of mango fresh litter was 0.05 ppm and that of decomposing litter was 0.03 ppm. The cellulose content of jack fresh litter was 0.07 ppm and that of jack decomposing litter was 0.03 ppm.

Inoculation studies

Out of the three fungi inoculated, two of them viz. Fusarium spp. and Rhizoctonia solani did not produce any symptoms on either mango and jack leaves after 10-14 days under humid conditions. Thus the results indicate the saprophytic nature of

these fungi on mango and jack. However Colletotrichum gloeosporioides when inoculated, produced typical symptoms on both mango (Plate 6) and jack (Plate 7) leaves. Thus the results indicate the pathogenic nature of these fungi on mango and jack and their subsequent survival on leaf litter, as saprophytes. Leaves showed oval, greyish brown spots, which coalesced to cover larger area of the leaf. The affected leaf tissues dry and shred.

Plate No. 6 Symptoms produced by Colletotrichum gloeosporioides on mango leaf.

DISCUSSION

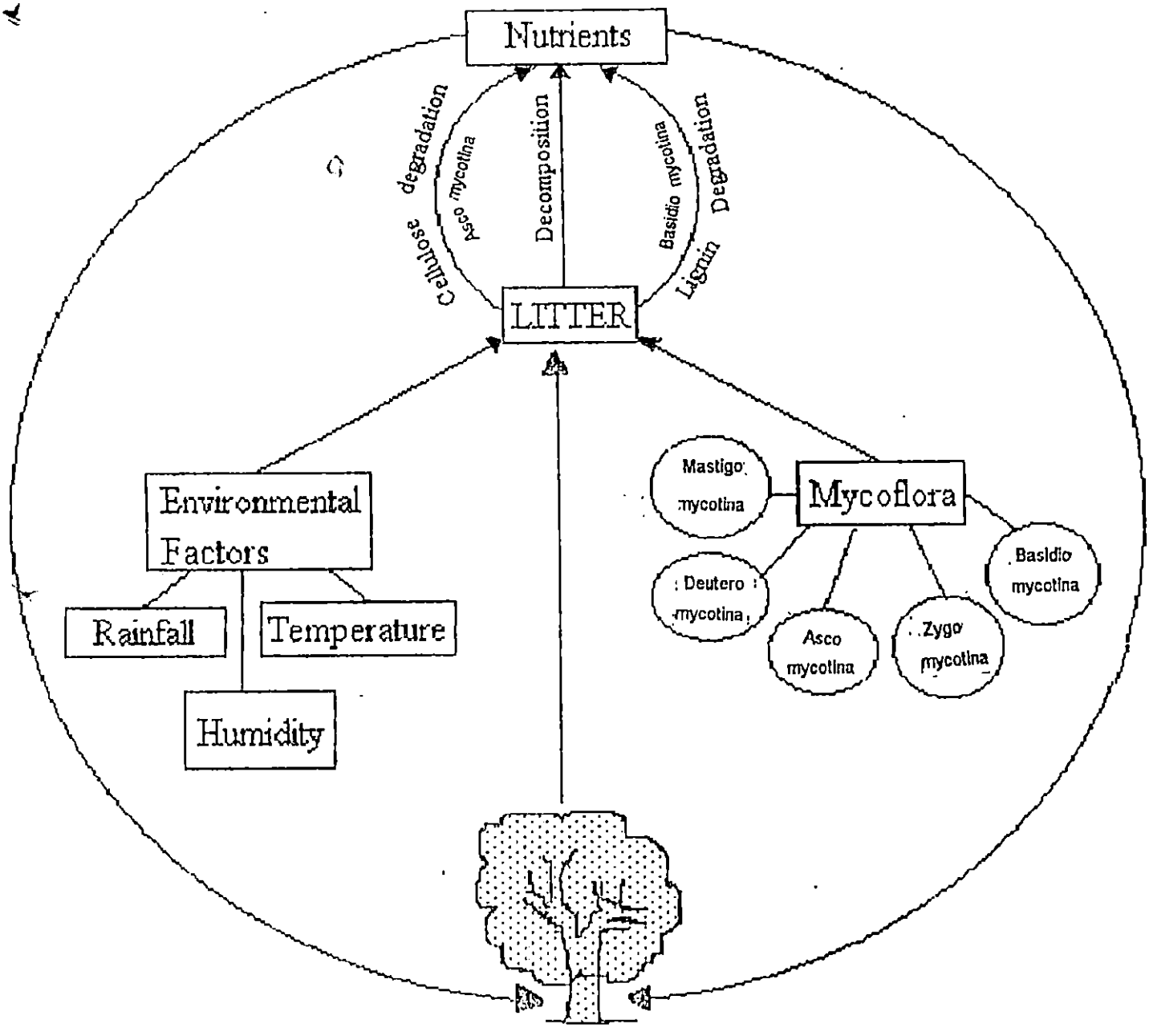
DISCUSSION

The concept of fungal successions on plant remains has now been exhaustively documented (Hudson, 1968; Hayes, 1979). The results of the present study aimed at a better understanding of mycoflora involved in the leaf litter degradation in jack and mango has revealed a basic pattern in the occurrence and distribution of fungi at different intervals of time. A schematic representation of the results of this study has been attempted (Fig. 17).

Leaf litter of diverse plant types have been examined and the occurrence of fungi belonging to different taxonomic groups have been recorded by many workers (Hering, 1967; Eicker, 1973; Jensen, 1974; Visser and Parkinson, 1975; Sankaran, 1991). It is now understood beyond any doubts that litter decomposition is mediated by an array of biotic factors including microflora comprising bacteria, fungi and actinomycetes and microfauna (Jensen, 1974; Swift et al., 1979). The dominant role of fungi as chief colonisers and decomposers among the biotic factors affecting litter degradation has been documented (Dickinson and Pugh, 1974).

Nine genera of fungi were frequently isolated from mango leaf litter during different intervals of time at different stages of decomposition of which eight belonged to Deuteromycotina and one to Zygomycotina. The number of fungi/g

Fig. 17 - A schematic representation of leaf litter degradation in homesteads.



of litter ranged between 1 x 10^3 -14 x 10^3 during different periods of observation.

Thirteen genera of fungi were frequently isolated from jack leaf litter at different stages of decomposition during different intervals of time of which twelve belonged to Deuteromycotina and one to Zygomycotina. The number of fungi/g of litter varied between 1 x 10^3 - 26 x 10^3, during different intervals of observation.

The preponderance of conidial fungi as primary saprophytes of leaf litter has been well documented (Meredith, 1962; Sharma and Dwivedi, 1972; Pugh, 1974; Shukla et al., 1978; Macauley, 1979; Sinha and Dayal, 1983; Sankaran, 1994; Vijaya and Naidu, 1995). This predominance of the profusely sporulating Deuteromycotina fungi can be attributed to their high spore loads in comparison with other Ascomycotina and Basidiomycotina fungi as opined by Warcup (1955), Parkinson and Williams (1961), Williams and Parkinson (1965) and Christensen (1989). Majority of fungi belonging to Deuteromycotina are recognised as very active cellulose decomposers which also accounts for their increased levels in this ecological niche (Domsch et al., 1980).

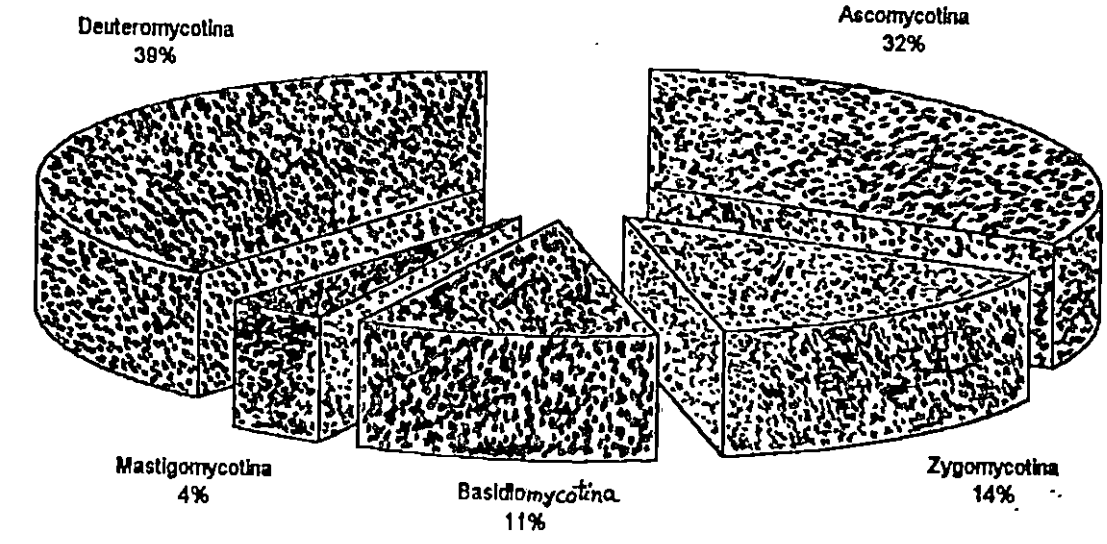
Species of Aspergillus and Penicillium were frequently isolated from both jack and mango at different intervals and from litter at different stages of decomposition. This can be attributed to their extreme adaptability to diverse conditions

(Soni, 1985). The occurrence of Aspergillus spp. in abundance even at later stages of decomposition may be due to the fact that these fungi play an active role in the degradation of plant flavonoids and tannins during the later stages of litter decomposition (Lewis and Starkey, 1969). Pugh (1958) and Macauley and Thrower (1966) have observed that members of Zygomycotina are more frequent during final stages of litter decomposition which has been observed in the present study also. A general picture of the occurrence of different major groups of fungi on jack and mango leaf litter is presented in Fig. 18.

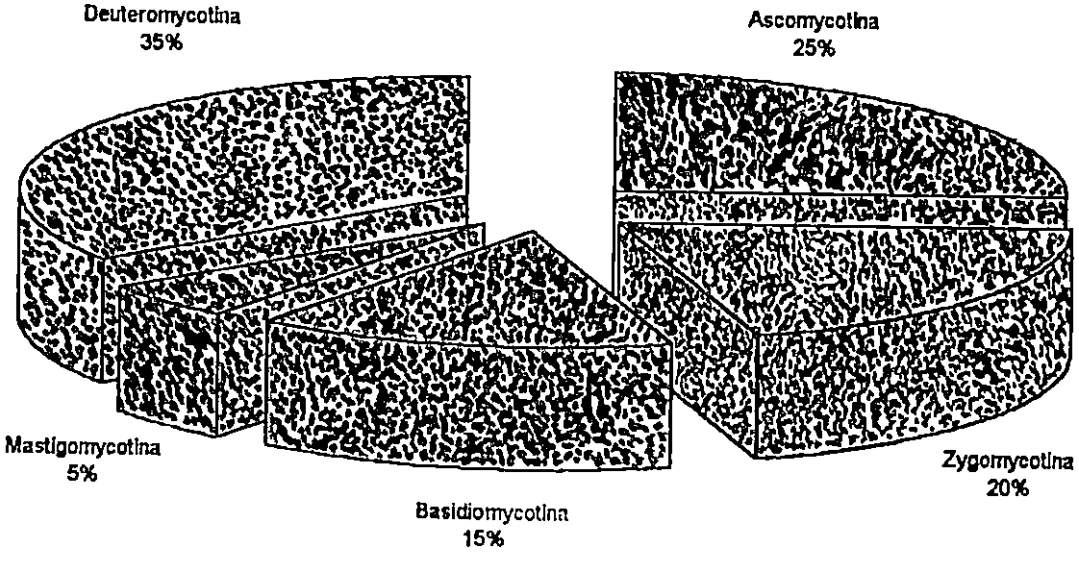
The occurrence of fungal successions on decomposing plant leaf litter has a natural sequence which is often influenced by the complex interactions between the fungus and the substrate and different levels of competition between different fungi (Macauley and Thrower 1966). Species of Aspergillus and Penicillium were isolated as primary colonisers from the surface litter of mango and jack during the study on fungal succession. This can be attributed to their ability to colonise a wide variety of substrates at diverse temperature regimes, pH levels, moisture content, soil temperatures etc. (Pugh, 1974).

Other primary colonisers of jack and mango leaf litter include Colletotrichum gloeosporioides and Trichoderma spp. in common while Cladosporium cladosporioides and Rhizoctonia solani were present as primary colonisers on jack leaf litter alone.

A general picture of occurrence of different major groups of fungi on Jack and Mango leaf litter.



Jack



Mango

Fig. 18

The occurrence of Trichoderma spp. as primary colonisers on pine, spruce and sugar maple has been reported (Widden and Abitbol, 1980; Widden and Hsu, 1986). Colletotrichum gloeosporioides is a foliar blight pathogen which affects mango (Sattar and Malik, 1939) and jack (Balakrishnan and Menon, 1970) and has been observed to survive in the leaf litter during the course of the present study.

The secondary colonisers on partially decomposed mango litter were Alternaria alternata, Chaetomium globosum, Curvularia lunata, Pythium aphanidermatum, Thamnidium elegans and Verticillium theobromae. Most of these are common phylloplane fungi which may persist as a spill over from the surface litter. Their survival is related to their cellulolytic ability. From among these fungi, the imperfect forms produce conidia profusely and are capable of faster growth having powerful enzyme system to break down senesced plant remains for their survival (Siu, 1951; Smit and Weiringa 1953).

The secondary colonisers of jack leaf litter included Fusarium spp., Curvularia lunata and Verticillium theobromae. The slight variations observed between the litter mycoflora of the two tree species can be attributed to the difference in their nutrient status and substrate quality. This has been reported by Sankaran (1994) in the case of mycoflora of eucalypt and teak leaf litter.

During the final stages of litter decomposition, members of Zygomycotina and Basidiomycotina were found to predominate mango and jack leaf litter. The preponderance of Basidiomycetes during the final stages of litter decomposition has been reported by Hudson (1968). The role of Zygomycetes as secondary sugar fungi growing along with cellulolytic and lignolytic forms during litter decomposition has been highlighted (Pugh, 1958; Macauley and Thrower, 1966; Hudson, 1968). On a comparitive basis, the results of the present study are in line with the generalised scheme proposed for the ecology of fungi on above ground plant litter proposed by Hudson (1968) (Table 14).

Influence of weather parameters on mycoflora

The maximum fungal counts were observed in jack litter during June-July while the same was during March in the case of mango litter. This difference can be attributed to the leaf shedding and regeneration pattern which is distinct for different plant types.

Increase in temperature caused a lowering of fungal population in both jack and mango leaf litter in the case of surface litter while the reverse was the case with respect to decomposed litter where there was an increase in fungal counts with increase in temperature.

Similar results have been observed by Carreiro and Koske (1992) in the case of leaf litter of a mixed deciduous

Table No. 14 Comparative occurrence of mycoflora in the present study vis a vis Hudson's scheme

STAGE-I	STAGE-II	STAGE-III
Senescent tissue weak parasite primary sugar fungi	Cellulose decomposers Associated Secondary Saprophytic sugar fungi	Lignin decomposers and Associated fungi
RESULTS OF THE STUDY		
MANGO LEAF LITTER		
Aspergillus flavus	*Alternaria alternata*	*Calocybe indica*
A. niger	*A. flavus*	*Choanephora cucurbitarum*
Penicillium citrinum	*Chaetomium globosum*	
P. islandicum	*Colletotrichum gloeosporioides*	*Coprinus comatus*
Trichoderma harzianum	*Curvularia lunata*	*Cunninghamella elegans*
T. viride	*Penicillium citrinum*	*Mucor hiemalis*
	Pythium aphanidermatum	*Volvariella diplasia*
	Thamnidium elegans	
	Verticillium theobromae	
	Geotrichum sp.	
JACK LEAF LITTER		
A. flavus	*A. flavus*	*Calocybe indica*
A. niger	*A. niger*	*Coprinus comatus*
Cladosporium cladosporoides	*Colletotrichum gloeosporioides*	*Trichoderma harzianum*
Colletotrichum gloeosporioides	*Curvularia lunata*	*Trichoderma viride*
Pencillium citrinum	*Fusarium oxysporum*	*Mucor hiemalis*
P. islandicum	*Fusarium solani*	*Volvariella diplasia*
P. oxalicum	*Rhizoctonia solani*	
Pestalotia sp.	*Verticillium theobromae*	
Rhizoctonia solani		

forest in Kingston, Rhode Island. The effect of temperature on the competitive interactions among fungi have been well documented. (Griffin, 1972; Tronsmo and Dennis, 1978; Widden 1984; Widden and Hsu, 1986).

Increased fungal counts of mycoflora on fresh/surface litter as against mycoflora counts in decomposing litter has been recorded during the present study. This sort of variation in fungal counts on fresh or decomposed leaf litter has been recorded in the case of Albizia amara by Vijaya and Naidu (1995). The increase in fungal counts of surface litter during high rainfall periods can be attributed to the congenial atmospheric and soil condition and increased moisture content of leaf litter during this period as suggested by other workers also. (Witkamp, 1966; Sinha and Dayal, 1983).

Weight loss studies at different temperature regimes

The weight loss for both jack and mango litter were maximum at the highest temperature (45°C) incubation while there was no appreciable reduction in weight at 25°C. The per cent reduction in weight after a period of six months at 45°C under laboratory condition was 2.75 in the case of jack litter and 3.8 in the case of mango litter. The fungus isolated predominantly from litter incubated at 45°C was A. fumigatus, a thermophile active at higher temperature regimes.

A. fumigatus has been described as a thermotolerant fungus from mushroom compost (Chang, 1967). The thermotolerant nature of this fungus, often associated with human chest diseases has also been well documented (Fergus, 1964; Festenstein et al., 1965, Gregory and Lacey, 1963).

The role of temperature in the decomposition of aspen leaf litter has been exhaustively studied by Lousier and Parkinson (1976). They have reported that litter temperatures below 30°C may not have a significant effect on organic matter decomposition while higher temperature near or above 80°C significantly increased the rate of decomposition of aspen leaf litter in temperate woodland ecosystem Careiro and Koske (1992) have also reported that variations in temperature causes significant differences in the leaf litter microcosms.

Weight loss studies under lab and field condition

The weight loss studies conducted over a period of six months indicated that the initial weight loss during the first month was limited while in the succeeding months the weight loss became more pronounced in both mango and jack litter. The weight loss was more in mango litter compared with jack litter at the same intervals indicating faster decomposition in the case of mango litter. This can be attributed to the role of substrate quality

in litter degradation as reported by Sankaran (1994). The weight loss was more pronounced under field conditions as against laboratory conditions for both types of litter. Similar results have been documented by Vijaya and Naidu (1995) in the case of Albizia amara leaf litter. The difference in the decomposition rate under field conditions is evidently due to the differences in the environmental factors as against the laboratory conditions. The factor including litter moisture content, atmospheric temperature, soil temperature, relative humidity and activity of soil microflora and fauna vary considerably under field conditions causing faster decomposition of leaf detritus.

The role of temperature in the microbial breakdown of Appalachian forest leaf/litter has been documented (Shanks and Olson. 1961). This was reflected in the decreasing weight loss of comparable leaves with increase in elevation.

Effect of environmental factors on weight loss

Significant weight loss has been observed under field condition as compared with weight loss under in vitro conditions for both jack and mango leaf litter. This type of environmental effect during weight loss studies has been documented by other workers for different tree species (Mary and Sankaran, 1991; Vijaya and Naidu, 1995). These workers have also documented that the increased rates of decomposition at higher temperature and rainfall regimes. In another study, Carriero and Koske (1992)

have observed that as temperature increased (0, 10 and 20°C) the dry weight loss of leaf litter from a mixed deciduous forest at Kingston, Rhode Island was 13.5, 19.0 and 30.7 per cent respectively indicating increased weight loss at higher temperatures.

Weight loss

The decomposition parameter (K) was higher for jack (1.52) as against a lower K value (1.03) in the case of mango indicating the faster decomposition in jack litter. Variations in K values depending on the degradability of different plants has been documented in the case of Sal (1.67), Teak (1.65) and Eucalyptus (1.17) by Pandey (1986). In another study involving Dalbergia sisoo and Bombax ceiba, the latter took less time (1.8 years) for ninety five per cent decay with the K value of 1.67 as against 1.32 (2.27 years) for Dalbergia sissoo (Singh et al., 1994).

Cellulose utilisation by litter fungi

Many of the litter fungi mainly belonging to Deuteromycotina were found to be efficient in utilising cellulose as their sole carbon source. The fungi included Aspergillus niger, A. ochraceous, A. tamarii, P. oxalicum, P. citrinum, Trichoderma harzianum, T. viride and Chaetomium globosum.

As cellulose constitutes 20-40 per cent of the leaf litter, the primary colonisers of the substrate are invariably cellulolytic and they indicate the onset of degradation. The ability for cellulose utilisation has often been regarded as essential for saprophytic fungi Melin (1948). Reese (1947) has reported the cellulolytic activity of Chaetomium globosum causing 14 per cent loss of cellulose in three days at 30°C under shake culture condition. Various species of Trichoderma have been documented to produce cellulases, thereby becoming very efficient primary colonisers of cellulose rich substrates (Mandels, 1975, Domsch et al., 1980). The cellulolytic nature of Aspergilli has been reported by Bell (1974) based on his studies on herbaceous litter under temperate conditions.

Biochemical aspects of Mango and Jack litter

There were significant variations in the per cent nitrogen, per cent ash and carbohydrate content of mango and jack leaf litters. This difference was reflected between the surface litter, fresh litter and decomposed leaf litter of both the trees. However, the per cent cellulose content of mango and jack litter did not show any significant variations.

The biochemical changes in the litter are mainly dependent on the chemical composition of initial litter and type of microflora colonising at different stages of decomposition. The decrease in carbohydrate content of leaf litter has been

recorded (Chang, 1967; Panwar and Sharma, 1981). This can be attributed to the occurrence of efficient cellulolytic fungi as primary colonisers of leaf litter.

The increase in nitrogen content observed in this study may be attributed to the initial low nitorgen status as reported by Bartholomew (1965). The increase in ash content with advance in degradation has been recorded by Reddy et al. (1990) in the leaf litter of Calycopteris floribunda.

The increase in concentration of N during the decomposition process has been noted in the case of balsam and aspen leaf litter (Lousier and Parkinson, 1978). This increase in nitrogen content has been attributed to microbial fixation of atmospheric nitrogen (Olsen, 1932; Remacle, 1970, 1971; Lemee and Bichan 1973; Anderson, 1973; Gosz et al., 1973; Wood, 1974).

SUMMARY

SUMMARY

The present investigation was conducted with a view to assess the importance of fungi in biodegradation of leaf litter. The study was conducted during 1993 September to 1995 March, on decomposition of litter from jack and mango.

Nine genera of fungi were frequently isolated from mango leaf litter during different intervals of time at different stages of decomposition of which eight belonged to Deuteromycotina and one to Zygomycotina. The number of fungi/g of litter ranged between $1x10^3$ - $14x10^3$ during different periods of observation.

Thirteen genera of fungi were frequently isolated from jack leaf litter at different stages of decomposition during different intervals of time of which twelve belonged to Deuteromycotina and one to Zygomycotina. The number of fungi/g of litter varied between $1x10^3$ - $26x10^3$, during different intervals of observation.

Species of Aspergillus and Penicillium were isolated as predominant primary colonisers from the surface litter of mango and jack. Other primary colonisers of jack and mango leaf litter include Colletotrichum gloeosporioides and Trichoderma spp in common while Cladosporium cladosporioides and Rhizoctonia solani were present as primary colonisers on jack leaf litter alone.

The secondary colonisers on partially decomposed mango litter were Alternaria alternata, Chaetomium globosum, Curvularia lunata, Pythium aphanidermatum, Thamnidium elegans and Verticillium theobromae.

The secondary colonisers of jack leaf litter included Fusarium spp, Curvularia lunata and Verticillium theobromae, Fusarium oxysporum and Fusarium solani were isolated from decomposing litter of jack.

During the final stages of litter decomposition, members of Zygomycotina and Basidiomycotina were found to predominate both in mango and jack leaf litter. Mucor hiemalis was the only common Zygomycete, present on both jack and mango decomposing litter. Coprinus comatus, Calocybe indica, Volvariella diplasia were the basidiomycetes observed on jack and mango decomposing leaf litter.

There was a negative correlation between the mycoflora count and the maximum temperature for both mango and jack fresh litter indicating the low fungal counts at higher temperature. At higher temperatures the fungal counts increased in the decomposed leaf litter of both trees. Rainfall was found to be positively correlated with mycoflora counts in surface litter of mango and jack indicating the increased fungal counts during periods of high rainfall. This condition was reversed in the decomposed litter of both mango and jack.

Identification and description of 30 fungi isolated from the mango and jack litter were made based on slide culturing.

The weight loss studies conducted at different temperature regimes (45, 35, 25°C) of both mango and jack leaf litter, showed a maximum weight loss at higher temperature (45°C) incubation while there was no appreciable reduction in weight at 25°C.

The weight loss studies conducted over a period of six months under in vitro and in vivo conditions indicated that the weight loss was more in jack litter compared with mango litter, indicating faster decomposition in the case of jack litter. The weight loss was more pronounced under field conditions as against laboratory conditions for both types of litter. An increased rate of decomposition was observed at higher temperature and rainfall regimes.

The decomposition constant (K) for jack was 1.52 as against a lower K value of 1.03 for mango, thereby indicating a faster decomposition of jack litter compared with mango litter. The time required for half decay and 95% decay are also correspondingly lower in the case of jack (0.46, 1.97) as compared with mango (0.67, 2.91) as the decay process is faster in jack indicating the higher efficiency of decomposition in the case of jack litter.

Many of the litter fungi mainly belonging to Deuteromycotina were found to be efficient in utilising cellulose as their sole carbon source. The fungi included Aspergillus niger, A. ochraceous, A. tamarii, P. oxalicum, P. citrinum, Trichoderma harzianum, T. viride and Chaetomium globosum.

There were significant variations in the per cent nitrogen, per cent ash and carbohydrate content of mango and jack leaf litters. This difference was reflected between the surface leaf litter, fresh leaf litter and decomposed leaf litter. Nitrogen and ash content was more in decomposing leaf litter, thereby indicting that, with the progress of decomposition, there was an increase in nitrogen and ash content. The per cent cellulose content of mango and jack litter did not show significant variations. The carbohydrate content in fresh litter of mango and jack was highest and in decomposing leaf litter, the carbohydrate content was less, showing that with the progress of decomposition there was a decrease in carbohydrate content.

The inoculation studies were done on fresh leaves of both jack and mango. Colletotrichum gloeosporioides produced characteristic symptom on the leaves of both mango and jack.

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* Originals not seen

MYCOFLORA ASSOCIATED WITH LEAF LITTER DECOMPOSITION IN HOMESTEADS

By

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ABSTRACT OF A THESIS

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ABSTRACT

Fungi play an inevitable role in the biodegradation of leaf litter. The present investigation was carried out to assess the role of mycoflora in the degradation of jack and mango in the identified homestead. Many litter decomposing fungi were isolated from both jack and mango leaf litter. The period of study was during September 1993 to March 1995.

Nine genera of fungi were frequently isolated from mango leaf litter of which eight belonged to Deuteromycotina, and one to Zygomycotina.

Thirteen genera of fungi were frequently isolated from jack leaf litter at different stages of decomposition, of which twelve belonged to Deuteromycotina and one to Zygomycotina.

The common primary colonizers isolated were Aspergillus niger, A. flavus, Penicillium citrinum, P. oxalicum, P. islandicum, Pestalotia palmarum, Colletotrichum gloeosporioides, Trichoderma viride and T. harzianum. The common fungi isolated from decomposing leaf litter of both trees were Mucor hiemalis. Members of Basidiomycotina were also isolated from decomposing leaf litter.

At higher temperature the fungal counts were lower in the fresh litter but higher in decomposed leaf litter of both trees. At higher rainfall the fungal count was more in surface litter but the same was lower in decomposed leaf litter.

Identification and description of 30 fungal species were carried out following slide culture technique.

The weight loss was more at 45°C, when compared with weight loss at 35°C and 25°C of both mango and jack leaf litter. The weight loss was more pronounced in the field condition as against laboratory conditions. Higher temperature and higher rainfall led to an increased rate of litter decomposition.

The decay process was faster in jack indicating the higher efficiency of decomposition in the case of jack litter as compared with mango. The decomposition constant (K) for jack was 1.52 as against a lower K value of 1.03 for mango. This indicates the faster decomposition of jack leaf liter when compared with mango litter.

Trichoderma viride, Trichoderma harzianum, Chaetomium globosum, Verticillium theobromae, Aspergillus niger, A. ochraceous, A. tamarii, Penicillium oxalicum were found to be efficient in utilising cellulose as their sole carbon source.

There was an increase in nitrogen and ash content in the decomposing leaf litter when compared with fresh litter. The carbohydrate content was more in fresh litter and the same decreased with the progress of decomposition.

Inoculation studies with common plant pathogens isolated from jack and mango leaf litter were done and Colletotrichum gloeosporioides was found to infect mango and jack leaf litter producing characterisitc symptoms on mango and jack.

APPENDICES

APPENDIX - I

The list of culture media used are given below:-

(1) Potato Dextrose Agar

Agar	-	17.0g
Potato (Peeled & sliced)	-	200.0g
Dextrose	-	20.0g
Distilled water	-	1000.0ml
pH	-	6.0 - 6.5

(2) Czapek - Dox - Agar

Agar	-	15.0g
$NaNo_3$	-	2.0g
$K_2H\ PO_3$	-	1.0g
$MgSO_4.7H_2O$	-	0.5g
Kcl	-	0.5g
$FeSo_4.7H_2O$	-	10.0g
Sucrose	-	30.0g
Distilled water	-	1000.0ml

(3) Cellulose amended medium

Agar	-	15.0g
$NaNo_3$	-	2.0g
K_2HPO_3	-	1.0g
$MgSO_4.7H_2O$	-	0.5g
Kcl	-	0.5g
$FeSO_4.7H_2O$	-	10.0g
Cellulose (Powder)	-	30g
Water (Distilled)	-	1000.0ml

(4) Rose - bengal streptomycin agar

Dextrose	-	10g
Deptone	-	5g
Potassium dihydrogen phosphate	-	1g
Magnesium sulphate	-	0.5g
Rose bengal	-	1 part in 30,000 parts of the medium
Agar	-	20g
Distilled water	-	1000 ml

APPENDIX - II

ANOVA TABLE

Fungal population (Mango)

SOURCE	df	SS	MSS	F
A (Between jack and Mango)	1	841.68	841.68	193.30**
FL VS. DL	1	638.02	638.02	146.53**
AB	1	9.18	9.18	2.11**
Error-1	8	34.83	4.35	
C-(between Season)	3	419.39	139.79	53.68**
AC	3	516.23	172.07	66.07**
BC	3	2861.89	953.96	366.32**
AVC	3	417.73	139.24	53.48**
Error	24	62.5	2.60	

Weight loss studies

SOURCE	df	SS	MSS	F
(Mango & Jack) A	1	10.49	10.49	38.49**
Lab Vs Filed B	1	27.67	27.67	101.45**
AB	1	9.99	9.99	36.63**
Errir-1	16	4.36	0.27	
Month (C)	4	960.09	240.02	1214.31**
AC	4	18.48	4.62	23.38**
BC	4	11.62	2.90	14.70**
ABC	4	6.9	1.63	8.22**
Error	64	12.65	0.19*	

* - Significant at 0.05 level
** - Significant at 0.01 level

Correlation matrix

1.000						
0.0909	0.9999					
-0.7706	-0.6695	1.00				
0.2997	-0.5127	-0.0684	1.0004			
-0.8811	0.3268	0.3829	-0.2987	1.000		
-0.2844	-0.8763	0.6482	0.6972	-0.0015	1.000	
-0.2868	-0.8080	0.5857	0.7446	0.0547	0.9705	1.0000

Corresponds to Table 4 (a) (b)

Correlation Matrix

Mango

1.000					
-0.3308	1.000				
0.5137	0.2926	1.000			
-0.6645	0.8644	0.1583	1.000		
-0.7983	0.7338	0.0153	0.8903	1.000	
-0.7691	0.7287	-0.1816	0.9168	0.7690	1.000

Corresponds to Table 10 (a) (b)

Correlation Matrix

JACK

1.0000					
-0.3308	1.000				
0.5137	0.2926	1.000			
-0.6645	0.8644	0.1583	1.000		
-0.7983	0.7338	0.0153	0.8903	1.000	
-0.7206	0.7889	-0.1905	0.9035	0.7569	1.000

Corresponds to Table 10 (a) (b)

Abstract of ANOVA

Source	df	Nitrogen			Ash			Carbohydrate			Cellulose		
		SS	MSMS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment	5	1.68	0.34	163.80**	721.56	144.31	81.20**	0.0094	0.008	22.69**	0.003	0.0006	2.84
Error	12	0.024	0.002	21.33	1.77	0.001	0.00008	0.002	0.0002				
Total	17	1.71		742.88		0.01			0.005				

Corresponds to Table 13