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ROLE OF MICROORGANISM AND MICROFAUNA IN PLANT LITTER DECOMPOSITION

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ABSTRACT
Though the fungi play a very significant role in the plant litter decomposition, studies revealed that the bacteria colonize the litters in the initial stages of decomposition. It has been observed that leaf species with low C:N ratio harbored higher number of bacteria than the more resistant species. The results of various workers outlined the development of the bacterial flora after litter fall due to improved moisture conditions but there is no change in the species composition. The plant litter decomposition by Streptomyces flavovirens has been evidenced by using radioactive CO_2. The bacterial population development was observed in the L2 layer following penetration by the microflora, after that, the pine needles were actively tunneled by the enchytraeids, sciarid larvae and oribatid mites and at the same time, were nibbled on the epigenic earthworms. The role of fungi and soil animals in the process of pine litter decomposition revealed that the late decomposition phase after the collapse of the fungal community might be controlled by the utilization of refractory components such as lignin material by microbial and animal populations. Since the lignin degrading fungi need another carbon source to degrade lignin, the microbial activities in the late decomposition phase might be supplied by the cellulose exposed by the combination of soil animals.

KEYWORDS: Microorganism, microfauna, plant litter, decomposition.

INTRODUCTION

MICROORGANISMS FOR PLANT LITTER DECOMPOSITION

Though the fungi are believed to play a pre-dominant role in the process of litter decomposition, active involvent of other groups of microorganisms is also important. A number of workers have noted a rise in the bacterial population of litter in the initial stages of decomposition (Marten and Pohlman, 1942; Witkamp, 1960; Mangenot, 1966; Minderman and Daniel, 1967; Tanaka, 1993). Witkamp (1963, 1966) observed that leaf species with low C:N ratio harboured higher number of bacteria than the more resistant species and Hobara *et al* (2014) experimentally concluded that fungi & bacteria play significant role in soil stabilization and C:N preservation: whereas Gusewell & Gessner (2009) experimentally proved that the rate of cellulose decomposition is dependent on N:P composition of the plant litter (Singh and Charaya, 2010). Singh *et al* (2015) investigated that addition of nitrogen and phosphorus increased the decomposition of wheat crop residues. With progressive decay, the influence of tree species decreased, and environmental influence increased. Kara *et al* (2014) investigated the influence of microbial decomposition of litter under different environmental conditions. The decomposition of wood by bacteria was proven by Courtois (1966) and Greaves (1969). Jensen (1974), taking into account the results of various workers till then, outlined the development of the bacterial flora after litter fall as follows: initially, a considerable increase in bacterial population occurs due to improved moisture conditions but there is no change in the species composition. In easily decomposable litter, the numbers may reach a very high value within a short time and then may decrease gradually. In more resistant litter, the development is slower; and the number may increase gradually over a long period. Thus, the initial large differences between different types of litter get diminished as the decomposition progresses. During the later stages, the litter may be invaded by soil bacteria.

Relatively little information is available on the actinomycetes which probably is due to the use of inappropriate isolation techniques and lack of sustained studies by microbiologists (Goodfellow and Cross, 1974). Grossbard (1971), using radioactive CO2, has obtained evidence for the utilization of plant residues by *Streptomyces flavovirens*. It is believed that though actinomycetes play a minor role in the decomposition of the total litter added to the soil (Gray and Williams, 1971), these form an integral part of a balanced community of extremely diverse microflora (Goodfellow and Cross, 1974; Kang *et al*., 1995). It is evident that both bacteria and fungi are important players in plant litter decomposition and their antagonistic interaction is controlling factor for microbial colonization and decomposition of plant litter (Lindblom and Tranvik, 2003).

THE ROLE OF MICROFAUNA

It has been observed that grazing by animals can increase plant diversity through reduction of dominant competitors (Brown *et al*., 1988; Brown and Gard, 1989). McLean *et al*. (1996) tried to work out whether litter fungi-mesofauna system also behaves similarly or not. Pine needle litter was taken as the experimental material, with *Oppiella nova* (mite) and *Onychiurus subtenuis* (collembola) as grazers. Grazing by these animals was not found to affect the litter fungal community directly, perhaps due to the following reasons:

(i) Soil inhabitants consume only a small percentage of the fungal biomass (Schaefer, 1990; Wardle and Yeates, 1993);

(ii) The distribution of fungi is highly aggregated (in patches) thereby reducing the chances of being grazed to extinction or competitive exclusion;

(iii) The fungal mycelia penetrate the litter tissue, thus, becoming inaccessible to the microfauna (Kendrick and Burges, 1962); (iv) the mesofauna do not completely restrict themselves to the grazing of a specific fungal species and shift from one fungal species to another with the result that only a few changes are observed in fungal frequency of occurrence.

Ponge (1991) worked out the succession of fungi and fauna during decomposition of pine needles. Some interesting features of his studies are:

(i) A bacterial development was observed in the L2 layer following penetration by the microfauna. After that, pine needles were actively tunneled by the enchytraeids, sciarid larvae and oribatid mites and, at the same time, were nibbled on by the epigeic earthworms (L2 and Fi layers);

(ii) When the fine root system of pine developed through the accumulated old needles (F1 layer), mycorrhizal fungi penetrated the needles and seemed to impede any further bacterial development.
Hasegawa and Takada (1996) also studied the role of fungi and soil animals in the process of decomposition of pine needle litter. They found that fungal colonisation of the pine litter was characterized by three stages : (i) growth (3-9 months); (ii) steady state (12-18 months); and (iii) collapse (21-48 months). According to them, the late decomposition phase after the collapse of the fungal community might be controlled by the utilization of refractory components such as lignin material by microbial and animal populations (Berg, 1986). Since the lignin- degrading fungi need another carbon source to degrade lignin (Kirk *et al.,* 1976), the microbial activities in the late decomposition phase might be supplied by the cellulose exposed by the combination of soil animals.

Dilly and Irmler (1998) studied the succession in the food web during the decomposition of leaf litter in a black alder- *Alnus glutinosa* (Gaertn.) L. forest. They found the process of decomposition to be divided

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in two phases, separated by the summer dryness. During the first phase cellulolytic bacteria, omnipotent and minor potent fungi were present together with mycetophagous, saprophagous and humiphagous soil fauna. During the second decomposition phase, the number of food paths was reduced. Only fungi without lignolytic potential persisted and saprophagous fauna predominated.

Helfrich *et al* (2015) studied the role of actinomycetes and soil fungi in maize plant litter decomposition by the extracted phospholipid fatty acids (PLFAs). The study suggested the formation of macroaggregates in soil that driven litter decomposition.

Thus, a better understanding of the pattern of colonisation of decomposing litter by microorganisms is likely to emerge in the near future which would throw light on the involvement of bacteria, actinomycetes and microfauna also in the process.

A number of articles, reviews and books have appeared from time to time to discuss the varied aspects of microbiology of plant litter decomposition. These included that by Chesters (1949), Garrett (1950, 1951, 1956, 1963), Subramanian (1960), Hudson (1968), Dickinson and Pugh (1974), Swift (1977), Hayes (1979), Cooke and Rayner (1984), Hattori *et al*. (1989), Reddy *et al.*, (1990), Weyman *et al.* (1992), Conn and Day (1997), Agrawal and Agrawal (1998), Charaya and Mehrotra (1998), Mukerji and Bansal (1999), Bansal and Mukerji (2002), Berg and McClaugherty (2003), Charaya and Singh (2005), Singh *et al* (2015a,b,d), Rani *et al* (2015) to mention only a few.

A number of studies have been made of the microbiology of decomposition of wheat crop residues as well. Sadasivan (1939) and Walker (1941) conducted preliminary studies on the colonization and succession by soil fungi of decomposing wheat straw in different soils but they concentrated their attention on colonization by *Fusarium culmorum*. Butler (1953 a, b, c; 1959) studied the ability of *Helminthosporium sativum*, *Curvularia ramosa*, *Ophiobolus graminis* and *Fusarium culmorum* to colonize and survive on wheat straw saprobically. Burges and Griffin (1967) studied the effect of temperature on the competitive saprophytic colonization of wheat straw by four fungi i.e., *Cochliobolus sativum*, *C. spicifer*, *Gibberella zeae* and *Fusarium culmorum*. These studies were concerned with the survival of pathogenic fungi and no attention was paid to saprobic fungi. Lal and Yadav (1964) compared the saprophytic flora of *Triticum vulgare* and *Andropogon sorghum*. Chang (1967) as well as Chang and Hudson (1967) conducted ecological, biochemical and physiological studies on the fungi of wheat straw compost.

Fermor and Wood (1979) as also, Moubasher *et al*. (1982 a, b) studied the microbiology of wheat straw compost. Fermor and Wood (1979) found that thermophilic bacteria and thermophilic actinomycetes were present throughout composting. Mesophilic fungi occurred in the outer cooler zones and were common air fungi. Moubasher *et al*. (1982 a, b) found that wheat straw, before composting, was already invaded by *Aspergillus spp.*, *Penicillium spp.*, *Alternaria alternata*, *Curvularia spicifera* etc. All the fungi were completely checked between 4-11 days due to high temperature (50°-67°C). After 12 days, fungi began to reappear due to fall in temperature. *Aspergillus fumigatus* was the best colonizer. Singh *et al.* (1979) studied the mycoflora of wheat straw but they did not study the succession of fungi at different stages of decomposition. Charaya (1985) conducted a comparative study of the pattern of fungal colonisation of wheat straw decomposing above ground, at ground surface and underground in normal as well as waterlogged conditions. Broder and Wagner (1988) conducted a comparative study of microbial colonisation and decomposition of corn, wheat and soybean residues. Singh and Charaya (2003) studied the fungal colonization of decomposing wheat crop residues *viz* internode, leaves, chaff and mixed straw.

CONCLUSION

The knowledge of bacteria, actinomycetes and microfauna in the process of plant litter decomposition is very much significant to develop a technique for recycling the organic wastes. The domestic, industrial and agricultural wastes create a big problem to environment and human health, a better understanding of the pattern of colonization of decomposing plant litters by these organisms will be helpful to manufacture the products of industrial importance.

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