

ECOLOGICAL STUDIES ON THE MICROBIAL AND BIOCHEMICAL ASPECTS OF FOREST LITTER DECOMPOSITION AT HIGHER AND LOWER ALTITUDES OF MEGHALAYA

ABSTRACT

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The study was conducted in order to find out the effect of altitudinal variation and vegetational cover on microbial succession, decomposition and enzymes under forest ecosystem. The study sites were situated at two altitudes i.e. at higher altitude (1500m MSL) at Shillong and at lower altitude (100m MSL) at Byrnihat. At each altitude two forest stands of different regenerational stages were selected. Two plant species, dominant and codominant, were selected in each forest stand. At lower altitude, Ageratum conizoides and Mal-lotus philippinensis in young stand and Holarrhena antidysenterica and Vitex glabrata in old stand were selected. At higher altitude, Alnus nepalensis and Pinus kesiya were selected in old forest stand whereas, Myrica esculenta and Pinus kesiya were taken from young stand.

Quantitatively the bacterial population was more than the fungal population at both the altitudes. Bacterial and fungal populations were less in the beginning of litter decomposition but increased with the progress of decomposition. Microbial population was minimum at the end of litter decomposition. At lower altitude, A.conizoides litter harboured maximum fungal and bacterial populations followed by M.philippinensis, V.glabrata and H.antidysenterica. In young and old stands the microbial (fungal and bacterial) population attained its peak in May-June. The litters at lower altitude harboured more microbial population than at higher altitude.

At higher altitude, litter of A.nepalensis supported more fungal and bacterial population compared to M.esculenta and P.kesiya. A marked seasonality in microbial population was observed on all the litters. Bacterial population exhibited peaks in July and September, while the fungal population showed its

peaks in June and September. During winter months, the litter harboured minimum microbial population.

Eighteen fungal species were isolated from litter at higher altitude and twenty five species at lower altitude. Penicillium chrysogenum was dominant at lower altitude, while Trichoderma viride at higher altitude. The weedy leaf litter harboured more of phycomycetous fungi compared to its woody counterparts where the primary colonizers were mainly deuteromycetes followed by ascomycetes and few phycomycetes.

Fungal and bacterial populations showed significant positive correlation with the moisture content of litter at both the altitudes.

The herbaceous litter decomposed faster ($K=2.930$) at lower altitude compared to woody litters of M.philippinensis ($K=1.587$), H.antidysenterica ($K=1.279$) and V.glabrata ($K=1.139$). The decomposition of plant litter at higher altitude was slow than at lower altitude. Litter of A.nepalensis ($K=0.810$) decomposed faster than M.esculenta ($K=0.526$) and P.kesiya ($K(\text{old})=0.398$ and $K(\text{young})=0.372$). The relative weight loss of all the litters except M.philippinensis was correlated significantly with fungal population and bacterial population.

The litter at lower altitude were less acidic than at higher altitude which became more acidic towards the end of decomposition. The moisture content of litters ranged from 17.8 to 66% at lower altitude and 13.9 to 72% at higher altitude.

Quantitatively organic constituents were maximum in the early stage of decomposition than its final stage. The amount of cellulose, hemicellulose, total soluble sugars and amino acids was more in A.conizoides than M.philippinensis, H.antidysenterica and V.glabrata litters. The lignin content was, however, more in V.glabrata. Lignin degradation started towards the later part of litter decomposition. At higher altitude the lignin content was maximum

in pine litter and minimum in A.nepalensis. The latter had more cellulose, hemicellulose, total soluble sugars and amino acids. At both the altitudes the absolute weight loss of different litters showed a significant negative correlation with the weight remaining of different organic constituents. While lignin content was correlated positively with absolute weight loss.

The initial nitrogen content was more in A.conizoides followed by M.philippinensis, H.antidysenterica and V.glabrata. The phosphorus content, however, was maximum in H.antidysenterica and minimum in A.conizoides. At higher altitude A.nepalensis had maximum initial nitrogen and phosphorus contents followed by M.esculenta and P.kesiya. Unlike nitrogen, which was retained for some time in the litter, phosphorus was released along with the decomposition of litter at lower altitude. At higher altitude, however, the retention of nitrogen and phosphorus was for longer period. The absolute weight loss of different litters showed negative correlation with their nitrogen and phosphorus contents.

Both amylase and cellulase activities were less in the beginning of decomposition and increased with time, while a reverse pattern was observed for invertase. At lower altitude, the cellulase activity was more in M.philippinensis followed by H.antidysenterica, V.glabrata and A.conizoides. Amylase activity was more in M.philippinensis and H.antidysenterica followed by V.glabrata and A.conizoides. Unlike amylase and cellulase, the invertase activity was more in A.conizoides and less in V.glabrata. All the enzymes showed a marked seasonal variation. Cellulase and amylase showed a significant positive correlation with fungal and bacterial populations of litter. A positive correlation was established between cellulase, amylase and absolute weight loss of different litters. The invertase activity, however, showed a negative correlation with fungal and bacterial populations and absolute weight loss. Maximum cellulase, amylase and invertase enzymes were extracted from the litter of A.nepa-

lensis followed by M.esculenta and P.kesiya at higher altitude. The seasonal variation in microbial enzymes was similar to lower altitude. Cellulase and amylase activities showed a significant correlation with fungal and bacterial populations. However, absolute weight loss showed a positive correlation with cellulase and negative correlation with amylase activity. A negative correlation was also observed between weight remaining of cellulose and cellulase. The invertase activity showed a positive correlation with fungal and bacterial populations. The weight remaining of total soluble sugars was correlated significantly with invertase activity of all the litters.

Litter of H.antidysenterica decomposed faster than P.kesiya under laboratory conditions. The rate of decomposition showed a negative correlation with temperature. The optimum temperature for decomposition was observed at 25°C. The mixture of the two test fungi i.e. T.viride and P.chrysogenum ameliorated the decomposition compared to their individual rate. The decomposing ability of different fungal species varied significantly ($P < 0.05$) at different temperatures. Maximum weight loss in litter of H.antidysenterica occurred after 120 days at 5°C and 15°C, while after 90 days at 25° and 35°C. On the contrary, it could be achieved after 150 days at 5° and 15°C and after 120 days at 25° and 35°C respectively in P.kesiya litter.

Litter quality had a marked effect on the rate of decomposition. The duff decomposed much faster than either fresh fragmented or intact litter. Maximum loss of duff (partially decomposed litter) occurred after 60 days in H.antidysenterica and 90 days in P.kesiya. Intact litter of H.antidysenterica and P.kesiya took more than 90 and 120 days respectively. The decomposition constant (K) of duff, fresh fragmented and intact litters varied significantly. The test fungi differed in their decomposing ability. Sugars and amino acids along with cellulose and hemicellulose were microbially degraded rapidly in the beginning of decomposition. The decomposition of different organic con-

stituents was faster at 25°C compared to 5°C, 15°C and 35°C. Lignin decomposition took place only towards the end of the biodegradation process.

Total sugars and amino acids, hemicellulose and cellulose were estimated less in duff compared to fresh litter. However, lignin was more in partially decomposed litter than fresh ones. The decomposition of lignin in partially decomposed H. antidysenterica litter started after 90 days while in case of P. kesiya litter it began after 120 days.

Maximum endo- β -glucanase and β -glucosidase were produced on 15th day of microbial inoculation after which it decreased gradually. Production of exo- β -glucanase was, however, maximum on 10th day of fungal inoculation. The p^H of the medium inoculated with T. viride, F. oxysporum and mixture became more acidic while in P. chrysogenum inoculated medium slight increase in p^H was observed. The dry weight of mycelium of all the test fungi increased with increase in the length of incubation. It was maximum for T. viride. The maximum xylanase activity was recorded on 10th day of incubation in all the test fungi. Mycelial dry weight was minimum on 5th day which increased till 10th day and declined again. The maximum mycelial dry weight was obtained in culture filtrates of T. viride and F. oxysporum.

Different test fungi showed different p^H optima for the production of cellulases. Endo- β -glucanase activity was maximum at $p^H - 5.5$ for all the test fungi, while the production of exo- β -glucanase varied with p^H . T. viride and P. chrysogenum produced maximum exo- β -glucanase at $p^H - 6.0$, while F. oxysporum and the mixture respectively at $p^H - 6.5$ and 5.5 . T. viride, F. oxysporum, P. chrysogenum and their mixture produced optimum β -glucosidase respectively at $p^H - 5.0$, 5.5 , 6.5 and 5.0 . Maximum soluble protein was produced at $p^H - 5.5$ by T. viride and at $p^H - 6$ by F. oxysporum and P. chrysogenum. The variation in cellulase production at different test p^H was statistically significant. The mixture of these fungi preferred slightly more acidic condition ($p^H - 5.5$) for

the optimum production of protein. At all the different test p^H , the p^H of the medium drifted towards acidity. Mycelial dry weight varied from p^H to p^H and the specific test fungi.

Fungi showed differential xylanase activity at different p^H . T.viride produced maximum xylanase at p^H -5.5 whereas, P.chrysogenum and F.oxysporum at p^H -6.5 and their mixture at p^H -6. Like cellulases, even in xylanase the p^H of the test medium became acidic towards the end of the sampling period. The mycelial dry weight, produced by different fungal species growing on a medium supplemented with xylan as a carbon source, varied with p^H and fungal species.

All the test fungi produced minimum cellulases and xylanase at 5°C. Cellulases and xylanase activities increased with increase in temperature till 25°C. At the highest temperature i.e. 35°C, the activities again declined. T.viride produced maximum cellulases, followed by mixed inoculum, F.oxysporum and P.chrysogenum. Besides, T.viride also produced maximum xylanase as compared to other test fungi. Optimum amount of soluble protein and mycelial dry weight was also obtained at 25°C. A significant variation was observed in the xylanase and cellulase activities, both due to different temperatures and different test fungi.

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