International Journal of Ecology and Environmental Sciences 34 (1): 19-28, 2008

Decomposition of Mixed Litter in a Kashmir Himalayan Grassland

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ABSTRACT

Because of being a key process in nutrient and carbon cycling in terrestrial ecosystems, decomposition of mixed litter in Kashmir Himalayan grassland was studied in relation to various biotic and abiotic factors. Litter decomposition rate was significantly higher in buried litter bags irrespective of their mesh size. Using the negative exponential model of litter breakdown, the decomposition constant (k) varied from ! 0.005 to ! 0.010 d^{-1} depending upon the placement (either on soil surface or buried into the soil) and mesh size of litter bags. Soil microbes, particularly saprophytic fungi, were of significance in the decomposition of mixed litter. The relationships between litter decomposition and some biotic and climatic factors examined through use of Pearson's correlation and stepwise regression analyses revealed that soil temperature together with soil fungi explained significant proportion of the variability in the mass loss of litter during the study period.

Key Words: Detritus, Decomposition Rate, Soil Enzymes, Microbial Activity, Abiotic Factors, Biotic Factors, Soil Respiration.

INTRODUCTION

The accumulation and decomposition of plant litter have long been considered as complex and important factors in controlling both vegetation structure (Facelli and Pickett 1991; Liu et al. 2004) and ecosystem function (Wardle et al. 1997; Xiong and Nilsson 1999). In particular, plant litter decomposition plays a critical role in nutrient cycling and organic matter turnover within ecosystems (Smith and Bradford 2003) and these processes are important determinants of plant productivity and ecosystem carbon storage (Aerts 1997; Akselsson et al. 2004). However, decomposition is a complex and often prolonged process and its rate is controlled by the nature of the substrate and characteristics of the environment (Singh and Gupta 1977; Smith and Bradford 2003). Detritus decomposition also encompasses interactions among many types of organisms and environmental variables (Reshi and Tyub 2006), each affecting quality of the litter as a substrate for the subsequent decomposers (Berg et al. 2003). Such an understanding has been largely obtained from litter decomposition studies of individual species but very recent studies (reviewed by Gartner and Cardon 2004) have clearly established that decomposition patterns of litter-mixes are not always predictable from litter dynamics of single species. It is because mixture of litter from different species with differing resource quality and leaf structure changes the chemical environment and physically alters the total litter surface where decomposition is occurring (Hector et al. 2000). These alterations can also affect decomposer abundance and activity (Hansen and Coleman 1998 and Wardle 2002). Thus, chemical and physical changes in leaf mixes can influence decomposition rates both directly as well as indirectly. Notwithstanding this importance, very few attempts have been made to study the decomposition of naturally occurring litter mixtures (Gartner and Cardon 2004) and hence the present study examines the decomposition rate of the surface placed or buried litter mixture using litter bag technique in a temperate grassland of Kashmir Himalaya. Besides, relationships between litter mass loss and biotic and abiotic factors such as, microbial community structure and activity elucidated through determination of counts of different physiological groups of microbes, soil respiration rate, soil microbial biomass and dehydrogenase activity, air temperature and soil moisture, were worked out for better understanding of the important process of litter decomposition in a grassland.

MATERIALS AND METHODS

Study Area

The present study was undertaken in a grassland located in the campus of the University of Kashmir, Srinagar, Kashmir at an altitude of about 1576 m (a.s.l) and within geographical co-ordinates of 34°5N to 34°6N N latitude and 74°8N to 74°9N E longitude). The completely fenced grassland, protected from any disturbance for last six years, was open and lacked any type of trees or large shrubs. The site was well drained and flat.

Climate of study area exhibits distinct seasonality and on the basis of variation in temperature and precipitation, the year is divided into four well marked seasons, spring (March to May), summer (June to August), autumn (September to November) and winter (December to February). Most precipitation, mainly in the form of snow, occurs in December, January, February and March.

Vegetation of the study area included 49 species, belonging to 20 families of monocots and dicots. Out of the recorded number of species, 11 (22.45 %) belonged to graminoid group, 7 species (14.28%) to legume group while 31 species (63.26%) were non-leguminous forbs. Poaceae included the highest number of species followed by Papilionaceae, Asteraceae and Brassicaceae and Caryophyllaeae, respectively.

Litter Decomposition

Mixed litter was collected in late autumn from the grassland and thoroughly bulked and air dried. Nylon litter bags of 1mm and 2mm mesh size were used. A weighed quantity of litter (5g fresh weight) was placed in litter bags of both mesh sizes and 144 bags were prepared (i.e. 72 bags of each mesh size). Half of the bags were placed on the surface of the soil and remaining bags were placed at a depth of approximately 5cm below the surface of earth. Dry weight of the litter samples was determined by drying five replicates of weighed quantity of litter (i.e. 5g of fresh weight) in oven at 80<C to constant weight.

Four bags from surface and four buried bags (2 of each mesh size) were recovered each month from the field and brought to laboratory. The material from individual bags was carefully washed with water to remove soil particles, then separation was achieved by decantation. The replicate litter samples were oven dried at 80<C to constant weight. The dry weight of litter on successive sampling dates was used to study the kinetics of litter decay using single negative exponential model (Olson 1963):

$$(M_0 / M_t) = e^{-kt}$$

where, M_0 is the initial mass of litter and M_t is the litter mass remaining at time t (days), k represents the rate constant at which litter is disappearing.

Microbial Activity

Microbial activity was determined through estimation of number of bacteria and fungi, soil respiration rate, microbial biomass, and dehydrogenase activity. Total number of culturable bacteria and colony forming units (cfu) of fungi were determined by serial dilution (test dilution) and plating on selective media. Serial dilutions of soil samples were made with sterilized double distilled water in 100 mL volumetric flasks and four dilutions were used. Plate counts of culturally viable bacteria were made on Nutrient agar medium and fungi on Rose Bengal agar medium. In addition, two physiological groups of microorganisms were studied using selective media which included proteolytic and cellulolytic microorganisms. The plates were inoculated aseptically with 1 mL of test dilution (three plates per dilution, which served as replicates) using pour plate technique and incubated at 25< C for 7 days in a BOD incubator. Plates containing media but without any inoculums served as control.

Soil respiration was measured by the method outlined by Anderson (1982). The following formula was used to calculate the amount of CO_2 evolved from the soil during exposure to alkali (Stotzky 1965).

$$\text{Milligrams of } CO_2 = (B\text{-}V)\ NE$$

where,

B = Volume (milliliters) of acid needed to titrate the NaOH in the jars from the control cylinders to the end point,

V = Volume (milliliters) of acid needed to titrate the NaOH in the jars exposed to the soil atmosphere to the endpoint,

N = normality of the acid, and

E = equivalent weight (E=22).

The data were finally expressed as milligrams of CO_2 per square meter per hour.

Soil microbial biomass was estimated employing the extraction method given by Vance et al. (1987).

Extractable carbon was calculated from the relationship expressed as: Biomass C = 2.64 E_C, where E_C is the difference between C extracted from the fumigated and non-fumigated treatments, both expressed as : g C g^{-1} oven dry soil. Dehydrogenase activity was determined by Triphenyl tetrazolium method given by Casida et al. (1964). Soil and reagent blanks were also run wherever necessary.

Soil Temperature

Soil temperature was recorded using a soil thermometer that was vertically inserted 10cm into the soil. Readings were taken three times a day on alternate days and average of all readings was considered as soil temperature for the month.

Soil Moisture

To determine the soil moisture, 5g of soil was taken in three replicates, three times a week and oven dried at 105°C to constant weight. Soil moisture was calculated as percentage of dry weight of soil.

Statistical Analysis

Data were analyzed using SPSS 10.0 (SPSS Inc. Chicago) employing GLM procedure to test the effects of mesh size and placement of litter on decomposition. Pearson correlation coefficients were calculated to explore relationships between litter decomposition with climatic variables like, mean monthly minimum and maximum temperature and precipitation and biotic variables such as, microbial counts, soil respiration rate, soil microbial biomass and dehydrogenase activity. Stepwise multiple regressions, using SPSS 10.0, were performed to find out the predictors that best explain the mixed litter decomposition.

RESULTS

Litter Decomposition

The mass remaining in litter bags decreased with time in both mesh sizes and positions. In case of 1mm mesh size litter bags placed on the surface of the ground, percent mass decreased from 95.5% (April) to 12.6% (January) and in case of buried bags mass loss ranged from 59.1% (April) to 5.9% (December). For 2mm mesh size bags percent litter decreased from 72.1% (April) to 16.3% (January) in surface bags and 65.7% (April) to 7.1% (December) in buried bags. No litter was recovered from either of mesh size bags buried in the soil during the month of January (Table 1). Analysis of variance (Table 2) reveals that placement of litter bags alone had a significant effect on mixed litter decomposition.

Table 1. Decomposition of mixed grass litter (Mean ± standard deviation) on soil surface and upon burial in 1mm and 2mm mesh litter bags.

Month	Surface				Buried			
	1mm		2mm		1mm		2mm	
	Litter mass remaining		Litter mass remaining		Litter mass remaining		Litter mass remaining	
	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
April	4.072 ± 0.1	95.5	3.074 ± 0.1	72.1	2.522 ± 0.07	59.1	2.802 ± 0.07	65.7
May	2.719 ± 0.2	63.8	2.948 ± 0.4	69.1	1.433 ± 0.2	33.6	1.624 ± 0.1	38.1
June	2.400 ± 0.2	56.3	2.208 ± 0.1	51.8	1.093 ± 0.2	25.6	1.505 ± 0.3	35.3
July	2.376 ± 0.1	55.7	2.056 ± 0.1	48.2	0.901 ± 0.2	21.1	1.350 ± 0.3	31.6
August	1.279 ± 0.07	30.0	1.766 ± 0.1	41.4	0.552 ± 0.2	12.9	0.711 ± 0.1	16.6
September	1.255 ± 0.4	29.4	1.552 ± 0.1	36.4	0.527 ± 0.07	12.3	0.385 ± 0.05	9.0
October	1.092 ± 0.4	25.6	1.327 ± 0.3	31.1	0.428 ± 0.1	10.0	0.375 ± 0.1	8.8
November	1.042 ± 0.3	24.4	1.230 ± 0.2	28.8	0.354 ± 0.1	8.3	0.342 ± 0.1	8.0
December	1.010 ± 0.03	23.7	0.832 ± 0.1	19.5	0.255 ± 0.02	5.9	0.305 ± 0.07	7.1
January	0.540 ± 0.02	12.6	0.695 ± 0.3	16.3	-	-	-	-

! = no litter recovered from the bags.

Table 2. Analysis of variance showing independent and interactive effect of mesh size and placement of litter bags on litter decomposition.

Source	Sum of square	df	Mean square	F	Sig.
Mesh size (MS)	0.075	1	0.075	0.096	0.758
Placement of litter bags (PB)	19.806	1	19.806	25.164	0.000
MS *PB	0.117	1	0.117	0.149	0.700
Error	59.82	76	0.787		
Total	206.008	80			

The change in weight loss of litter based on single negative exponential decay function, determined for both mesh sizes and positions of litter bags, showed a curvilinear pattern with higher decomposition rate during the initial stages followed by a decline in decomposition rate with time (Figure 1). Maximum weight loss occurred in buried bags in both mesh sizes indicating the effect of burial on decomposition rate. 1mm mesh size litter bags showed more decomposition than 2mm mesh size bags. The k values obtained for decomposition of litter in 1mm mesh size bags were !0.006 and !0.009 for surface and buried bags, respectively. For decomposition of litter in 2mm mesh size bags the k values were !0.005 and !0.01 for the surface and buried bags, respectively.

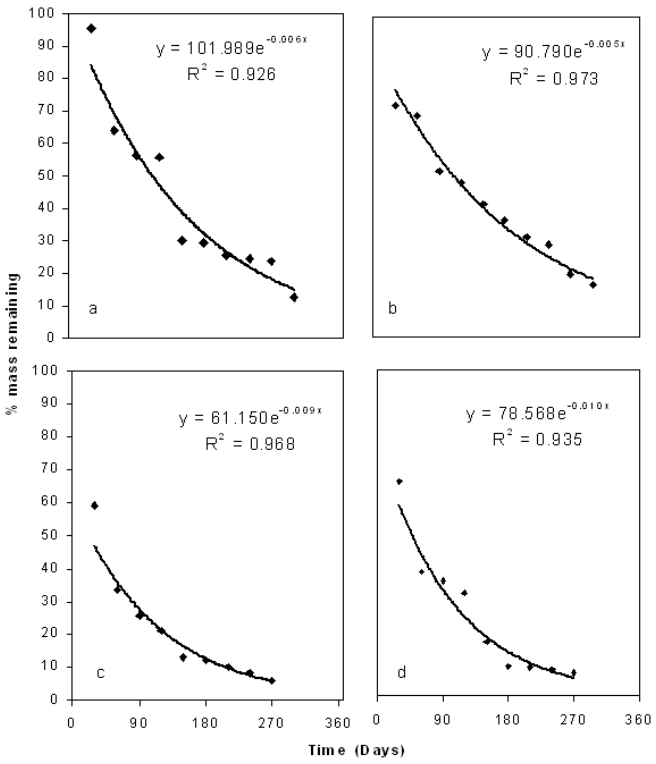

Figure 1. Decomposition of mixed litter in surface placed (top) and buried (bottom) 1 mm (a & c) and 2 mm (b & d) litter bags.

Table 3. Total microbial counts (Mean ± standard deviation) and of different physiological groups ($\times 10^4$ per gram of dry soil) during the study period.

Month	Total microbial counts		Proteolytic micro-organisms		Cellulolytc micro-organisms	
	Fungi	Bacteria	Fungi	Bacteria	Fungi	Bacteria
April	6.6±1.5	156.0±10.0	-	-	2.4±0.4	-
May	6.0±0.4	106.5±33.5	1.1±0.01	78.0±5.0	5.6±0.6	-
June	4.0±0.05	488.5±54.5	1.0±0.01	76.0±10.0	3.4±0.05	21.7±0.1
July	1.8±0.4	234.0±7.0	2.2±0.01	77.5±22.5	0.5±0.1	27.7±5.5
August	1.3±0.05	342.5±11.5	0.8±0.01	20.05±4.0	3.0±0.01	-
September	2.2±0.01	344.0±167.0	1.1±0.01	118.8±20.0	7.0±0.01	22.2±1.0
October	4.3±1.1	119.5±43.5	0.32±0.01	5.7±0.1	0.065±0.005	-
November	3.3±0.01	301.0±10.0	0.48±0.2	11.25±5.9	2.7±0.5	2.0±0.01
December	3.1±0.3	82.0±5.0	0.024±0.01	2.85±0.5	0.65±0.05	-
January	1.0±0.1	45.5±14.5	0.12±0.1	2.4±0.1	1.8±0.6	-

Microbial Counts/Estimates

Total soil microbial counts recorded during different months of the study period (Table 3) revealed higher fungal counts during the months of April (6.6×10^4 cfu) and May (6.0×10^4 cfu) and minimum during January (1.0×10^4 cfu). Total culturable bacteria were maximum during the month of June (488.5×10^4 cfu) and minimum during the month of January (45.5×10^4 cfu). The proteolytic fungi were maximum during July (2.2×10^4 cfu) and minimum during December (0.024×10^4 cfu) while culturable proteolytic bacteria were maximum during September (118.8×10^4 cfu) and minimum during January (2.4×10^4 cfu). No proteolyic microorganisms were observed during the month of April. The cellulolytic fungal count was maximum during the month of September (7.0×10^4 cfu) and minimum during the month of October (0.065×10^4 cfu). Maximum culturable cellulolytic bacteria were observed in the month of July (27.7×10^4 cfu) and minimum in the month of November (2.0×10^4 cfu). No cellulolytic bacteria were recorded in the months of April, May, August, October, December and January. Data on total microbial count revealed that culturable bacteria were dominant (Table 3) during the study period. Same was true for proteolytic microorganisms, but in respect of cellulolytic microorganisms fungi were dominant over bacteria. Out of two physiological groups studied proteolytic microorganisms out numbered cellulolytic microorganisms during the study period (Table 3).

Microbial Activity

Data on basal respiration rate, soil microbial biomass and dehydrogenase activity as measures of microbial activity during the study period are given in Table 4. Basal respiration rate or soil respiration was higher during May and July with values of 544.1 and 540.0 mg of CO_2 m^{-2} hr^{-1}, respectively. Minimum basal respiration rate of 33.2 and 36.6 mg of CO_2 m^{-2} hr^{-1} was recorded during January and December, respectively. Soil microbial biomass was maximum during May (782.5 mg of C g^{-1} soil) and September (730.4mg of C g^{-1} soil) and minimum during January and December with values of 100.7 and 117.4 mg of C g^{-1} soil, respectively. Dehydrogenase activity was maximum (506.1 mg TPF g^{-1} 24 h^{-1}) during July and minimum during June, May and April with values of 184.8, 185.5 and 186.6 mg TPF g^{-1} 24 h^{-1}, respectively.

Table 4. Basal respiration rate, soil microbial biomass and dehydrogenase activity (Mean ± standard deviation) during the study period.

Month	Basal respiration rate (mg of CO_2 m^{-2} hr^{-1})	Microbial biomass (µg C g^{-1} oven dry soil)	Dehydrogenase activity (µg TPF g^{-1} 24h^{-1})
April	171±4.4	181.1±47.6	186.6 ± 65.9
May	544.1±2.9	782.5±36.1	185.5 ± 38.7
June	480.3±3.7	180.8±43.0	184.8 ± 4.2
July	540.0±3.6	334.3±17.6	506.1 ± 57.7
August	252.2±5.0	171.9±45.3	346.1 ± 28.3
September	261.0±4.4	730.4±43.9	388.8 ± 37.8
October	98.8±3.8	473.3±43.0	415.1 ± 23.8
November	69.8±5.2	408.0±17.0	336.3 ± 26.7
December	36.6±5.8	117.4±10.0	220.4 ± 9.8
January	33.2±8.8	100.7±9.9	217.6 ± 12.7

DISCUSSION

The present study revealed that the mass loss of mixed litter occurred approximately exponentially with time (Figure 1). The single negative exponential model fitted to litter mass loss data predicts a curvilinear pattern, with relatively fast decomposition rate during the initial stages followed by slower rate of decomposition in the later stages. Such a pattern is attributed to leaching of relatively more labile or easily decomposable substrates in the litter in early stages of decomposition (Singh et al. 2004). Furthermore, increased activity of the decomposer community due to utilization of these labile compounds also contributes to faster decomposition rate (Neher 1999). During the present investigation striking differences in decomposition rate were not recorded between litter bags of different mesh sizes, thus, indicating that soil fauna do not play any significant role in decomposition in the present grassland (Table 2). These studies are in accordance with Anderson (1973), Aber et al. (1990), Beare et al. (1992) and Hackl et al. (2000) who also reported that decomposition rate does not vary in litter bags of different mesh sizes. But our observations are not in agreement with those of Gupta and Singh (1977), Arun Lekha (1987) and Setala and Huhta (1990) who reported more decomposition in litter bags accessible to soil faunas than in litterbags that exclude soil fauna. The observation of greater mass loss in

Table 5. Correlation matrix of percent litter mass remaining with different biotic variables.

Variable	Position of litter bags	Total fungi (cfu×10^4)	Total bacteria (cfu×10^4)	Proteolytic fungi (cfu×10^4)	Proteolytic bacteria (cfu×10^4)	Cellulolytic fungi (cfu×10^4)	Cellulolytic bacteria (cfu×10^4)	Soil respiration (mg CO_2 m^{-2} hr^{-1})	Microbial biomass (mg C per g dry soil)
Mass remaining in 1mm litter bags	Surface	0.732*	0.0909	0.1897	0.1819	0.1506	0.1508	0.539	0.064
Mass remaining in 1mm litter bags	Buried	0.781**	0.0521	0.050	0.0999	0.1954	0.0224	0.421	0.0772
Mass remaining in 2mm litter bags	Surface	0.708*	0.1857	0.3177	0.3386	0.3588	0.1381	0.683	0.291
Mass remaining in 2mm litter bags	Buried	0.715*	0.1102	0.1566	0.1281	0.122	0.1123	0.52	-0.0064

* = Significant at 5% level; ** = Significant at 1% level.

buried bags (Table 1) draws support from Beare et al. (1992) who also observed 1.4 times greater mass loss in buried bags as compared to surface bags, although Aber et al. (1990) reported no effect of placement of litter bags on decomposition rate. Gupta and Singh (1981a) in a study conducted in tropical grassland reported lower cumulative weight loss in case of surface bags than that of 5 cm deep placed bags. They attributed the more weight loss in buried bags to higher activity of microorganisms in deeper soil layer which may also hold true for present study.

The correlation matrix between litter decomposition and measured biotic and abiotic variables is given in Tables 5 and 6. Total soil fungal count and soil temperature during different months and litter decomposition showed significant positive relationship, irrespective of the placement and mesh size of the litter bags used in the present study. None of the microbial activity measures (soil respiration, microbial biomass and dehydrogenase activity) showed any significant correlation with litter decomposition. Stepwise multiple regression analysis (Table 7) revealed that the total fungal count and soil temperature explained more than 80% of variability in decomposition of litter in either 1 mm or 2mm bags placed on surface of soil or buried in soil. Thus, saprophytic fungi, among various

Table 6. Correlation matrix of percent litter mass remaining with different abiotic variables.

Variables	Soil temperature (°C)	Soil moisture (%)	Average monthly min aerial temperature (°C)	Average monthly max aerial temperature (°C)
Mass remaining in 1mm litter bags placed on surface	0.745**	-0.096	0.466	0.407
Mass remaining in 1mm litter bags buried in soil	0.593	0.204	0.247	0.178
Mass remaining in 2mm litter bags placed on surface	0.836**	-0.268	0.623*	0.604*
Mass remaining in 2mm litter bags buried in soil	0.708*	0.182	0.345	0.263

*$p < 0.05$; **$p < 0.01$.

Table 7. Results of a stepwise multiple regression analysis to test the relationship between litter mass remaining and different biotic and abiotic variables.

Dependent variable (y)	Terms in regression equation	R^2
Mass loss in 1mm surface place litter bags during different months	y = 15.055 (10.159) + 1.339* (0.423) (soil temp.)	0.556
	y = -2.452 (9.115) + 1.003* (0.315) (soil temp.) + 7.201* (2.351) (total fungal count)	0.810
Mass loss in 1mm buried litter bags during different months	y = -5.631 (8.026) + 7.116* (2.105) (total fungal count)	0.588
	y = -12.038 (6.893) + 5.632* (1.778) (total fungal count) + 0.573* (0.239) (soil temp.)	0.774
Mass loss in 2mm surface place litter bags during different months	y = 19.072 (6.267) + 1.126** (0.261) (soil temp.)	0.699
	y = 7.485 (5.022) + 0.903** (0.174) (soil temp.) + 4.766** (1.295) (total fungal count)	0.897
Mass loss in 2mm buried litter bags during different months	y = 0.485 (8.007) + 1.082* (0.334) (soil temp.)	0.568
	y = -12.915 (-7.454) + 0.825* (0.258) (soil tempt.) + 5.512* (1.923) (total fungal count)	0.801

Values in parentheses represent SE of constants and regression coefficients ; *$p < 0.05$; **$p < 0.01$.

microbial groups, were the dominant decomposers associated with litter in the present study (Table 3) and such an observation draws support from studies of Osono and Takeda (2001a,b, 2002) who established the primary importance of fungi in litter decomposition. Chapin et al. (2002) also stated that fungi are the main initial decomposes of terrestrial dead plant material and the same holds true for the present observations as well because initial higher rate of litter decomposition correlates well with higher total number of colony forming units (cfu) of fungi. Other studies (Aneja and Mehrotra 1978, 1980a, 1980b, Neher 1999) also revealed predominance of fungi as primary decomposers of plant litter with bacteria playing a secondary role. The minor role of bacteria in decomposition also holds true for the present study as well. However, bacteria out number fungi during summer (Table 3) when most of the labile compounds are already decomposed. The taking over of bacteria at second stage of degradation has also been shown by Gyllenberg and Eklund (1974) in easily decomposable polymeric compounds. The competitive edge of fungi over bacteria as initial decomposers may be attributed to the fact that fungi have the ability to decompose tissues even with low nutrient concentration by importing nutrients from other layers of soil. Among the physiological groups of microorganisms studied during the present investi-gation, proteolytic microorganisms were well repre-sented compared to cellulolytic (Table 3) with fungi outnumbering the bacteria in both the physiological groups. It further substantiates the dominant role of fungi in litter decomposition.

Apart from soil fungi, significant linear relationship between temperature and mass loss obtained in the present study is in agreement with studies of several workers, such as Godshall and Wetzel (1978), Woodwell (1978), Swift et al. (1979), Post et al. (1982), Aizaki and Takamura (1991), Jenkinson et al. (1991), Schimel et al. (1994), Kirschbaum (1995). However, most of them have worked out relations between aerial temperature and decomposition rate and in the present study relation of decomposition rate was worked out with both aerial and soil temperature, but significant relation was observed with soil temperature. In many decomposition studies, the temperature coefficient Q_{10} (van't Hoff 1898) is used to describe the dependence of decomposition on temperature (Katterer et al. 1998). However, several other functions have also been used to describe temperature responses

like, linear functions (Witkamp 1966; Froment 1972; Gupta and Singh 1981a), power functions (Kucera and Kirkham 1971; present study), Arrhenius-type functions (Howard and Howard 1979; Lloyd and Taylor 1994), S-shaped functions (DeNeve et al. 1996) and the heat sum concept (Andren and Paustian 1987, Honeycutt et al. 1988). Studies of Cortez (1998) also indicated significant role of temperature, particularly cold temperature, in litter decomposition but Paul (2001) reported that extreme temperatures coincide with periods of moisture limitation so decomposition is largely unaffected by temperature. The studies of Giardina and Ryan (2000), who compiled decomposition data from 5 continents, have found that forest mineral soil decomposition rates were remarkably constant across a global scale gradient in mean annual temperature. Their studies indicate that decomposition rates are not controlled by temperature and increased temperature alone will not stimulate the decomposition. Hence these observations do not hold true for present study. In the present study, soil moisture showed negative correlation with litter decomposition. This may be attributed to oxygen limitation due to excessive moisture with implications for microbial diversity and activity. Cortez (1998) and Agren et al. (1996) reported that soil moisture is not an important factor in determining rate of decomposition. According to studies of Haynes (1986) decomposition rate of mineral soil generally declines at soil moistures less than 30–50% of dry mass and at high soil moisture contents i.e. >100 to 150% of soil dry mass in mineral soil. However, Gupta and Singh (1981) reported that the combined effect of temperature and rainfall is more important in determining the decomposition rate than the effect of temperature or rainfall separately. Similarly, Gupta and Arun Lekha (1989) reported that a multiple correlation between mean relative decomposition rates and weather variables (temperature and rain per day and percentage of days with rainfall) indicated 13 to 39% variability for litter due to combined effect of temperature and rainfall.

Thus, the present study clearly brings out that the position of litter (on the surface of ground or buried under the soil) significantly influences the rate of decomposition and soil fungi are the dominant decomposers. Besides, soil temperature and soil fungal count are the best predictors of the decomposition of the mixed litter in the temperate grassland of the Kashmir Himalaya.

ACKNOWLEDGEMENTS

We are thankful to Head, Department of Botany, The University of Kashmir, Srinagar, Jammu and Kashmir, for proving the necessary laboratory facilities and the senior author (ST) is grateful to Director, Centre of Research for Development (CORD), The University of Kashmir, Srinagar, Jammu and Kashmir, for his support.

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