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Litter decomposition and nutrient release pattern in two nitrogen fixing shrubs (*Flemingia macrophylla* and *Tephrosia candida*) growing in SALT farm in Lunglei district of Mizoram

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Abstract

We studied litter decomposition and nutrient release patterns in different components of two nitrogen (N) fixing shrub species, (*Flemingia macrophylla* and *Tephrosia candida*) planted on sloping agriculture land technology (SALT) farm in 2002 and 2010. The two sites were 10 yrs old and 2 yrs old farms at the beginning of this study, i.e. July 2012. Sites were within the same permanent agriculture farm having similar climatic conditions. We collected different litter components (leaves green and senesced, wood and roots fine and coarse) of two species having different ages. Known amount (7 g) of all litter components were enclosed in nylon net mesh bags and placed in their respective habitats for decomposition and these samples were retrieved periodically to assess the rate of change of mass and nutrient. Our results suggest that the mean relative decomposition rates of different litter were maximum in the rainy season and minimum in the summer season for both sites and species. Among the litter components, fine roots (<2 mm) of both species showed higher rates of organic matter decomposition and rates of nutrient release to the soil. The rate of release of organic matter and nutrient was slightly greater in *F. macrophylla* than the *T. candida*. Annually, these species added significant amount of organic matter and nutrients to the soil that supported considerably higher production compared to shifting cultivation sites on sustained basis.

Key words: Leaf decomposition; *Flemingia macrophylla;* nutrients; SALT; *Tephrosia candida.*

Introduction

The balance between plant litter deposition and decomposition controls the accumulation of detrital organic matter within the ecosystem.[1] The type of plant litter may dramatically affect the type of soil organic matter formed.[2] Substrate quality and microbial population are mainly responsible for organic matter mineralization in the early phase of soil development. Plant residues with different chemical composition show variable mineralization potential and

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decomposition behavior.[3]

Two groups of factors mainly regulate decompositions: climate and chemical nature of 'substrate quality' of the litter.[2] Among the climatic variables influencing decomposition, rainfall and its associated variables are the major factors in the dry tropical regions.[4] High temperature and low moisture condition often limit plant growth,[5-6] and reduce decomposer activity.[7]

In Mizoram agriculture is mainly done on hill slopes by jhum cultivation under rain fed condition.[8] Jhum cultivation is the form of agriculture in which a piece of land is slashed, burnt and cropped without tilling the soil, and the crop land is subsequently fallowed to attain pre-slashed forest status through natural succession.[9] This has resulted in large scale forest degradation, decreasing soil fertility, and increasing invasion by weeds species, which leads to degrading the environment and disruption of the ecological balance of this region. Considering the above disadvantages and constraints of the shifting cultivation system, a new profitable and sustainable agriculture system like permanent agriculture farming system is being practiced in Lunglei district of Mizoram. Different varieties of crops were grown along with two Nitrogen fixing shrub species, *Flemingia macrophylla* planted in hedgerows to prevent soil loss and *Tephrosia candida* between two hedgerows on sloping agriculture land technology (SALT).

MATERIALS AND METHODS

Study site

The study site is located at Pukpui area, Lunglei district of Mizoram (22° 53' 30'' N- 92° 50' 00'' E) which is 10 km away from Lunglei. It has received an annual rainfall of about 3,000 mm and the Temperature varies from 12°C in winter to about 32°C in summer.

Sloping agriculture land (SALT) technology practiced in the farm was started on the year 2002 with 1 ha area of land; the area was increased every year successively up to 2010 down the hill slope. The crops planted on the farm were; banana, maize, turmeric, citrus fruits, passion fruits, mangoes and pineapple. Nitrogen fixing shrub species (*Flemingia macrophylla* and *Tephrosia candida*) are planted as hedgerows along slope contour and a different kind of crops are cultivated between the hedgerows. The hedgerows are trimmed back to 1m height every year for the availability of the sun light to the crops. To maintain soil fertility, the pruned debris like dead and pruned leaf, twig and branch wood materials were used for mulching to conserve soil moisture and for nutrient enrichment and nutrient recycled.

Measurement of litter decomposition

Two different species of nitrogen fixing shrubs *viz. F. macrophylla* and *T. candida* were selected from two different sites (10 yrs and 2 yrs) in the same farm. For determination of plant litter decomposition rate, different part of the plant i.e. mature senesced leaves attached to the plant, freshly fallen leaf litter samples and recently dead wood branches still attached to the culm were collected during June 2012. At the same time fine roots ($\leq$2 mm in diameter) and coarse roots ($\leq$5-10 mm in diameter) were collected by digging out soil monoliths and then dried in an oven at 35°C for three days to a constant weight. After adjusting for the initial moisture content all litter samples (equivalent to 7 g dry weight) were enclosed in a nylon net (mesh size: 2 mm) bags (15 X 15 cm).

A total of 200 bags were prepared for different litter categories, 20 bags each for different litter categories. The litter bags technique was used to quantify decomposition rates.[10] Nylon net bags (15x15 cm, 2 mm mesh) containing 7 g air dried leaf and wood litter were randomly placed on the plantation floors just above the soil surface and bags containing roots were buried in the soil to a depth of 10 cm in July 2012. Five bags containing decomposing litter were randomly recovered at three-month intervals from each plantation site. The recovered litter materials were air dried, brushed to remove adhering soil particles, and finally dried at 80°C for 24 h and weighed.

Collected litter material was ground in a Willeymill and passed through a 0.5 mm sieve for chemical analyse. Total N and organic carbon was analysed by CHN Auto-analyzer at Central Instrumental Laboratory, Mizoram University.

The daily instantaneous decay rate (k) of litter and root materials for the entire study period wasb calculated through the negative exponential decay model of Olson [1]:

$W_t/W_0 = \exp(-kt)$

where W_0 = initial weight and W_t = weight remaining after time t. As suggested by Olson,[1] the time required for 50% and 95% weight loss was calculated as $t_{50} = 0.693/k$, $t_{95} = 3/k$.

Results and Discussion

Mass loss during decomposition

Highest mass loss was observed during the period between the placement of the litter bag and the first recovery (0-3 months) in all sites for all litter components (Figure 1). Decomposition

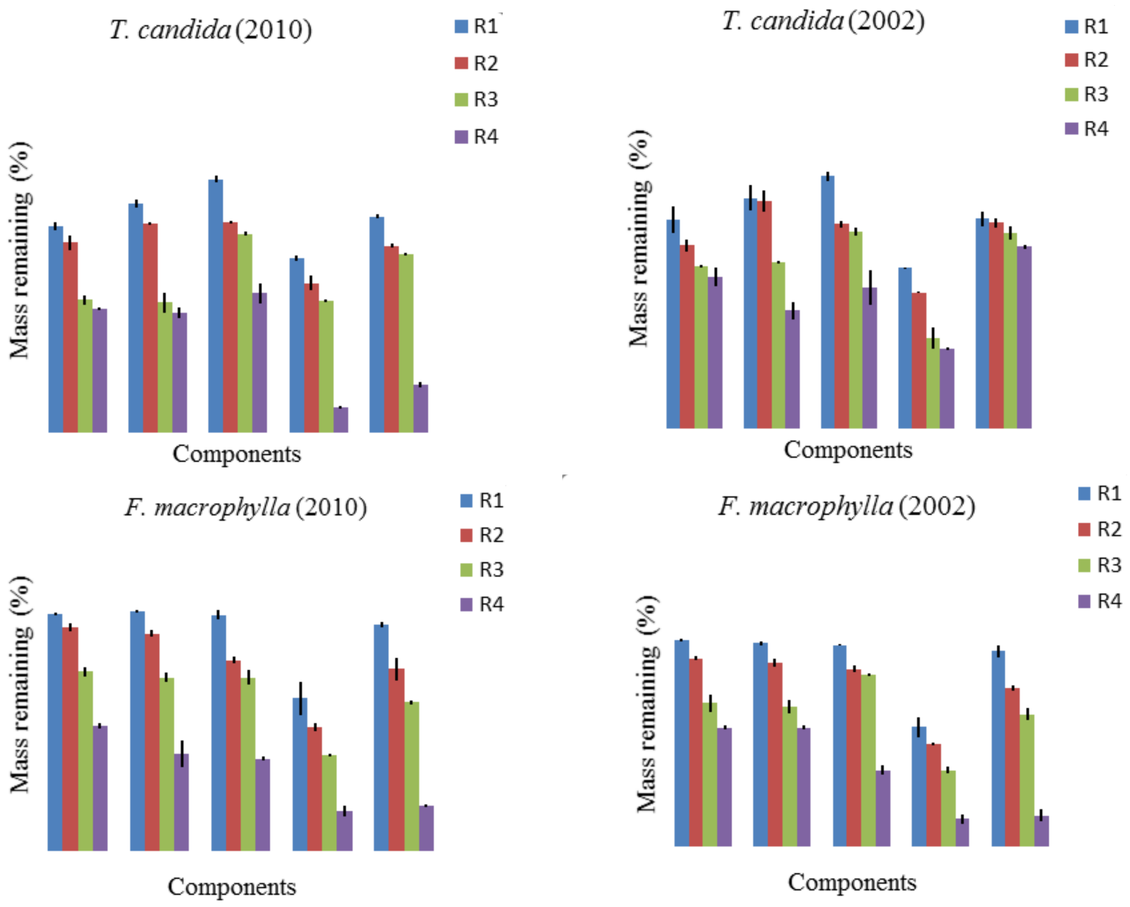

Figure 1. Mass remaining (%) to initial at 4 different stages (R1, R2, R3 and R4) of recovery on different components of both *F. macrophylla* and *T. candida* litter in the two study sites. Vertical lines indicate standard error. GL=Green leaf, LT=Leaf litter, BR=Branch/Wood, FR=Fine root, CR=Coarse root. R1 to R4 represents stages of recovery which is 90 days intervals.

during the first stage was rapid because the molecules are easy to breakdown and rich in energy and the period of incubation is monsoon season and the rainfall influenced the rate of decomposition enhancing the activity of decomposer organisms as compared to other climatic variables.[4] However, the later stage of litter decomposition was lower because the breakdown of lignin was much slower (due to very large and complex molecules) and the period of decomposition was post monsoon, winter and summer where precipitation was not enough to support decomposition.[11]

The maximum mass loss was observed in fine root litter and minimum in wood litter of both *T. candida* and *F. macrophylla* in both the sites. About 59% mass loss on fine root litter in both species and 32% and 28% of wood litter of *T. candida* and *F. macrophylla* was observed in 10 yrs old farm respectively during the first stage of recovery. However, mass loss of about 51-52% was observed in fine root litter and 30% weight loss in wood litter of *T. candida* and *F. macrophylla*, respectively, in 2 yrs old farm during the first stage of recovery. Roots have been reported to decompose faster than leaves.[12] Ostertag and Hobbie[11] also reported that roots decompose faster than other plant parts in two sites in three tropical montane forests at natural fertility gradient.

Table 1. Decomposition parameters for mass loss and time required for 50% and 95% decay (t_{50} and t_{95}).

Sites	Litter components	Mass remaining (% initial) 1 yr	Annual decay rate (k)	t_{50} (days)	t_{95} (days)
2002	*T. candida* Green leaf	17.5	1.74	133.81	628.23
	Leaf litter	10.71	2.23	104.42	490.24
	Branch	21.42	1.54	151.40	710.83
	Fine root	4.85	3.02	77.10	362.01
	Coarse root	7.24	2.03	89.37	414.92
	F. macrophylla Green leaf	21.42	1.54	155.4	710.83
	Leaf litter	20.42	1.54	151.40	710.83
	Branch	14.28	1.94	119.8	562.71
	Fine root	7.14	2.63	88.37	414.92
	Coarse root	6.57	2.33	99.99	328.61
2010	*T. candida* Green leaf	18.9	1.66	150.12	657.85
	Leaf litter	17.92	1.66	140.12	657.85
	Branch	28.21	1.26	184.32	865.37
	Fine root	2.85	3.5	65.60	307.98
	Coarse root	7.14	2.63	88.37	414.92
	F. macrophylla Green leaf	18.92	1.66	140.12	657.85
	Leaf litter	17.5	1.74	133.81	628.23
	Branch	16.28	1.94	119.8	562.71
	Fine root	3.57	3.33	69.99	328.61
	Coarse root	10.71	2.23	104.42	490.24

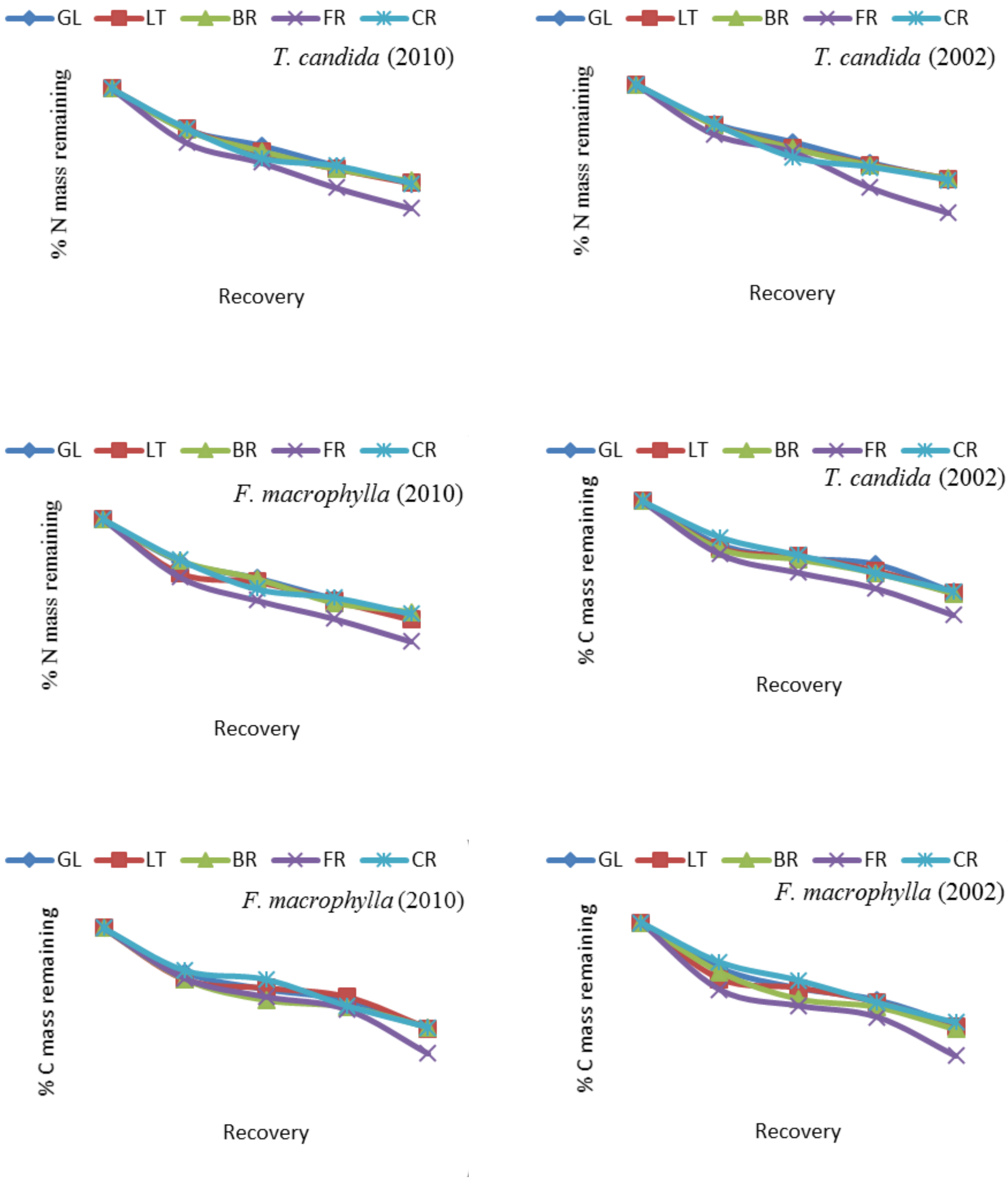

Figure 2. Temporal changes in the amount of carbon and nitrogen stock in different litter components during the course of decomposition. GL=Green leaf, LT=Leaf litter, BR=Branch/Wood, FR=Fine root, CR=Coarse root. R1 to R4 represents stages of recovery which is 90 days intervals.

The percentage mass of litter material remaining at two sites at the end of the study ranges: 2-7% for fine roots (<2 mm), 4-11% for roots (5-10 mm), 14-28% for branch, 10-21% for leaf of both species. The instantaneous annual decay rates (*k*) for different litter categories varied from; 2.6-3.5 for fine root and 1-2.6 for other categories (Table 1). On the basis of *k* values, the time projections for 50% weight loss varied from 65-88 days for fine 89-155 days for coarse roots and for other components (Table 1).

Nutrient release pattern through decomposition

High reduction of carbon (C) and nitrogen (N) released occurred at the first recovery for all litters. About 30-50% on C and N remained at the end of recovery for all litter types with highest released pattern was observed in the fine root categories of both species in both site (Figure 2).

Nutrient released through decomposition was faster in roots particularly in the smaller diameter classes compared to the other litter categories. Among the litter component fine root of *F. macrophylla* shows comparatively greater amount of C release pattern than *T. candida* in both the study sites, although no significant differences were observed between the C and N released pattern among all litter type among the two plant species. These suggest the similar effect of both these species in adding significant amount of organic compound or nutrients through decomposition of various body parts of the plant. The litterfall and fine roots are the main source of C and N input to soil.[13-14] Significant amounts of organic matter and nutrients are transferred to the soil through fine roots mortality in our study; however, fine root is also believed to be the most important source of nutrients which speed up the process of successions in tropical forest ecosystems.[15]

Conclusion

It may be concluded from the present study that the roots of *T. candida* and *F. microphylla* show maximum rate of decomposition and nutrient release as compared to the branch and leaves of the plants. This may be due to the fact that fine roots are the most dynamic parts of the plant and their turnover rate is also very high. This revealed that decomposition and nutrient supply is also contributed greatly by root decomposition in addition to leaf litter in these two sites. This study also suggested that the rates of decomposition of the two nitrogen fixing species showed more or less similar decomposition pattern and both of them are equally important in maintaining soil fertility of the farm through litter decomposition.[15-16]

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