

Short Term Litterfall Allocation and Leaf Decomposition Rate of *Tectona grandis* Linn. f. in a Subtropical Broadleaf Forest of Zunheboto district, Nagaland

Toino K Sumi¹ , Wati Temjen², Maibam Romeo Singh^{*1}, Korimayum Reshma¹

¹ Department of Botany, Nagaland University, Lumami-798627, Nagaland, India

² Department of Botany, Fazl Ali College, Mokokchung-798601, Nagaland, India

*Corresponding author: romeomaibam@nagalanduniversity.ac.in

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ABSTRACT- Plantation litterfall and decomposition regulate the return of organic matter to soil, but site-specific data for teak plantations in Northeast India are limited. The study explores a seven-month dataset from a 20-year-old *Tectona grandis* plantation at Lumami, Nagaland, observed from October, 2017 to April, 2018. Litter was collected in five 1 m² traps and sorted into four components viz., leaves, woody material, seeds and miscellaneous material. Leaf decomposition was measured at monthly intervals with 1 mm mesh litter bags containing 5 g dry litter. Internally consistent seasonal summaries indicated 223.28 g m⁻² of litterfall during the observation window, equivalent to 2.23 Mg ha⁻¹ without annualization. Leaves contributed 77.40%, woody material 16.79%, seeds 3.13% and miscellaneous material 2.69%. Summer accounted for 52.41% of the maximum litterfall. Leaf litter lost 60.4% of its initial mass after seven months of decomposition. A single-exponential fit produced $k = 0.149 \text{ month}^{-1}$, a half-life of 4.64 months and $r^2 = 0.914$ on the log-relative-mass scale. The results show a leaf-dominated litter input and substantial short-term mass loss.

Keywords: decay coefficient; leaf litter; litter trap; Northeast India; plantation ecology; teak

1. INTRODUCTION

Litterfall is a principal pathway by which forest vegetation transfers organic matter and nutrients to soil (Bray and Gorham, 1964). The size and timing of this input influence forest-floor accumulation, microbial activity and nutrient cycling. Once deposited, litter is fragmented and chemically transformed, and its mass declines through leaching, respiration and the activity of decomposers (Olson, 1963; Krishna and Mohan, 2017). The rate of decomposition reflects interactions among climate, litter chemistry, physical structure and decomposer communities. Moisture and temperature affect biological activity, while leaf traits and compounds such as nitrogen and lignin alter substrate quality (Aerts, 1997; Cornwell et al., 2008; Zhang et al., 2008). Studies from Northeast India have shown strong species and seasonal differences in litterfall and mass loss, emphasizing the need for local measurements rather than transferring coefficients across forest types (Arunachalam et al., 1998; Pandey et al., 2007; Barbhuiya et al., 2008). *Tectona grandis* Linn.f. is widely planted in tropical and subtropical Asia. Its large, seasonally shed leaves can form a substantial and temporally concentrated forest-floor input. The litter layer is therefore relevant to soil carbon and nutrient dynamics, while teak monoculture can modify soil properties relative to more diverse forest stands (Mahmud et al., 2018). Teak litterfall has been identified as an important nutrient-return pathway in tropical dry deciduous stands, but its magnitude and timing differ with stand age, climate and management (Pande et al., 2002; Takahashi et al., 2012). Nevertheless, field estimates from Nagaland are very scarce. This study quantified and validated seasonal and component-level litterfall and estimated short-term leaf-litter decay in a 20-year-old plantation at Lumami under Zunheboto district of Nagaland, north-east India.

2. MATERIALS AND METHODS

2.1 Study site

The experiment was conducted in a 20-year-old teak plantation at Lumami in the Akuluto subdivision of Zunheboto district, Nagaland, India. The retained site record places the plot at approximately 260 12' N Latitude and 940 27' E Longitude and 727m above sea level, in a humid subtropical climatic condition. Reported mean annual rainfall was 1,435 mm. During October, 2017 to April, 2018, observation recorded atmospheric temperature ranged from 20.0 to 28.1 °C, soil temperature at 0-10 cm from 13.3 to 24.6 °C and relative humidity from 45% to 97%.

2.2 Litterfall collection

A 50 m x 50 m plot was established within the plantation. Five 1 m x 1 m litter traps were installed approximately 1 m above ground., four were placed around the plot margin and one near its centre. Litter was collected at monthly intervals, and dead insects

and bird droppings were removed before sorting. Material was oven-dried at 75 °C for 48 hours to constant mass and separated into leaves; woody material, including twigs, branches and bark less than 2.5 cm in diameter; seeds and other reproductive material and miscellaneous fragments.

2.3 Leaf litter decomposition

Freshly fallen, oven-dried intact teak leaves were placed in 20 cm x 20 cm nylon bags with 1 mm mesh at 5.00 g per bag. Forty-five bags were deployed randomly on the plantation floor beneath trees and pinned to the ground. Five bags were retrieved at each of seven monthly sampling dates. Adhering soil and extraneous material were removed, after which the remaining litter was dried at 75 °C for 48 hours and weighed. The field notes reported no displacement of bags during the observation period. The seven retrievals therefore provide 35 analysed bags.

2.4 Data validation and analysis

Decomposition was expressed as proportional mass remaining and fitted to $M_t/M_0 = \exp(-kt)$, where M_0 is initial dry mass, M_t is dry mass after t months and k is the monthly decay coefficient (Olson, 1963). The model was fitted by least squares through the origin after log transformation. Half-life was calculated as $\ln(2)/k$, and model fit was summarized as r^2 on the log-relative-mass scale.

3. RESULTS

3.1 Litterfall allocation

Litterfall over the seven-month observation period was 223.28 g m⁻² (2.23 Mg ha⁻¹). Leaves contributed 172.81 g m⁻² (77.40%), woody material 37.48 g m⁻² (16.79%), seeds 6.99 g m⁻² (3.13%) and miscellaneous material 6.00 g m⁻² (2.69%) as illustrated in Table 1. Thus, non-leaf fractions together represented 22.60% of the recorded input. The summer period accounted for 117.03 g m⁻² (52.41%), followed by winter with 86.18 g m⁻² (38.60%) and the post-monsoon period with 20.07 g m⁻² (8.99%). The seasonal summary retained average of 20.07±1.35 g m⁻² in post-monsoon, 86.18±3.88 g m⁻² in winter and 117.03 ±3.07 g m⁻² in summer. Leaves remained the principal component for each season, contributing 15.79±4.06, 64.39±10.55 and 92.63±8.55 gm⁻² during post monsoon, winter and summer respectively.

Table 1: Average litter components of *Tectona grandis* during the study period October, 2017 to April, 2018).

Grouping	Category	Litterfall data (g m ⁻²)	Share (%)
Litter Components	Leaves	172.81	77.40
	Woody material	37.48	16.79
	Seeds	6.99	3.13
	Miscellaneous	6.00	2.69
Season	Post-monsoon	20.07 ±1.35	8.99
	Winter	86.18 ± 3.88	38.60
	Summer	117.03 ±3.07	52.41

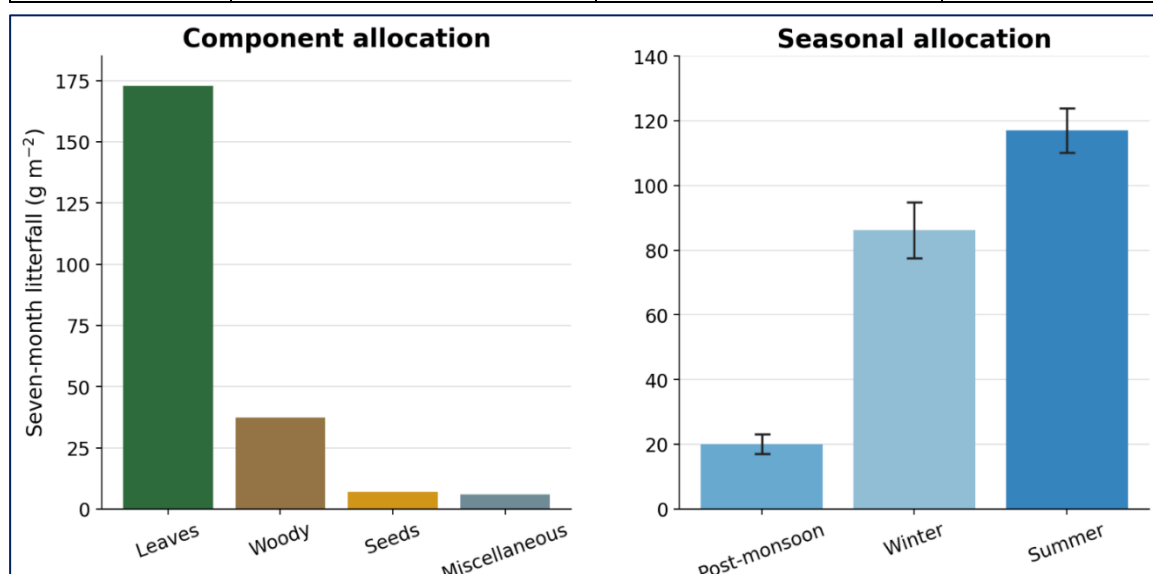


Fig. 1: Component and seasonal allocation of litterfall during the study period

3.2 Leaf litter decomposition

Mean mass remaining declined from 5.00 g at deployment to 4.23 g after one month and 1.98 g after seven months. This corresponded to cumulative mass losses of 15.4% and 60.4%, respectively (Table 2). One-third of the initial mass had been lost by the second month, and nearly half by the fourth month. Loss then continued through the final three retrievals, although the cumulative curve became less steep. The fitted exponential coefficient was 0.1494 month⁻¹, with an estimated half-life of 4.64 months. The model explained 91.4% of variation on the log-relative-mass scale.

Table 2: Teak leaf litter mass remaining and cumulative mass loss

Elapsed months	Mass remaining (g)	Relative mass (%)	Mass loss (%)
0	5.00	100.0	0.0
1	4.23	84.6	15.4
2	3.34	66.8	33.2
3	2.97	59.4	40.6
4	2.53	50.6	49.4
5	2.30	46.0	54.0
6	2.07	41.4	58.6
7	1.98	39.6	60.4

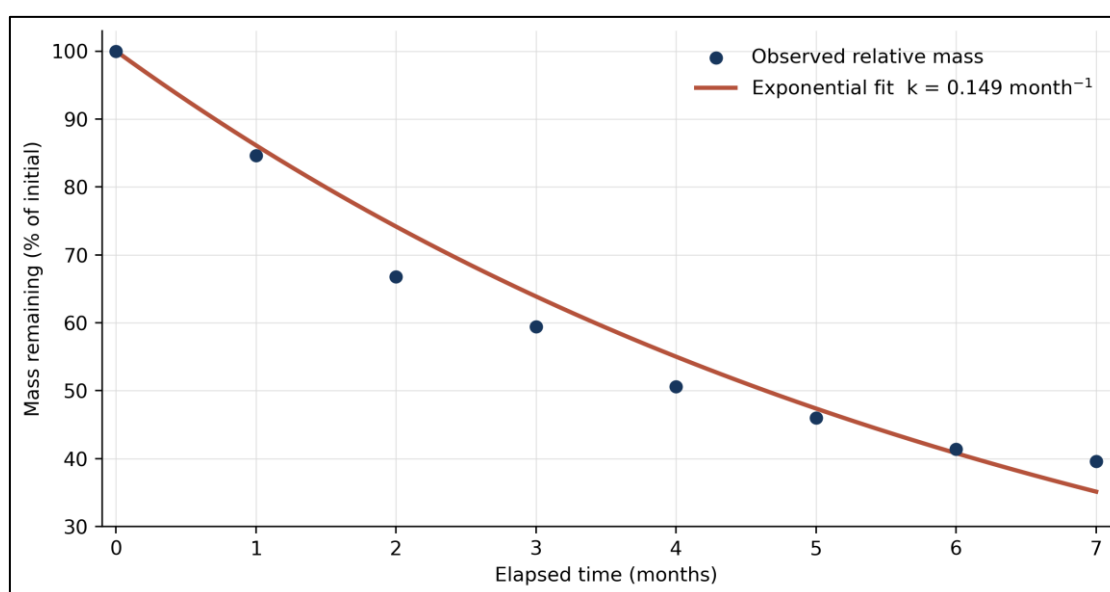


Fig. 2: Observed and modelled relative teak leaf mass during the seven-month decomposition experiment

3.3 Recorded site environmental conditions

Recorded environmental conditions showed the expected seasonal range for the site. Atmospheric temperature was highest in October (28.10C) and lowest in January (20.0 0C), while soil temperature at 0-10 cm ranged from 24. 0C in October to 13.3 0C in January. Relative humidity ranged from 97% in October to 45% in March. These data are retained to describe the conditions under which litterfall and decomposition were observed.

4. DISCUSSION

4.1 Litterfall allocation

Leaves dominated the validated litterfall total, accounting for more than three quarters of material collected. This dominance was maintained in the post-monsoon, winter and summer summaries, indicating that the seasonal shift in total litterfall did not alter the overall importance of foliage as the principal organic input. Foliar dominance is common in forest litterfall datasets and is important because leaves usually decompose more rapidly than woody material and carry a substantial fraction of biologically cycled nutrients (Bray and Gorham, 1964; Sundarapandian and Swamy, 1999). Teak studies in central India have likewise identified litter production as an important nutrient-return pathway in dry deciduous plantations (Pande et al., 2002). The 16.79% contribution of woody

material in the present record is also ecologically relevant: even when smaller in mass, woody fragments may persist longer and influence the physical structure of the forest-floor layer.

More than half of the seven-month total occurred in the summer category. A dry-season or transitional peak can reflect leaf senescence, moisture stress and phenology, although the present aggregates cannot identify a mechanism. The concurrent fall in relative humidity from the post-monsoon high to a March minimum provides a plausible seasonal backdrop, but it does not demonstrate a causal relationship. Seasonal litterfall responses differ among climates and stand structures; for example, forest and plantation studies have linked litterfall patterns to water availability and canopy dynamics (Valenti et al., 2008; Takahashi et al., 2012). Importantly, the 2.23 Mg ha⁻¹ value is a seven-month total, not an annual estimate, and should therefore not be compared directly with annual teak litterfall values reported elsewhere. Because the incompatible monthly table was excluded, the present result supports a seasonal allocation but not a month-specific peak.

4.2 Leaf mass loss

Teak leaf litter lost 60.4% of its mass in seven months (Fig. 2). The fitted half-life of 4.64 months indicates substantial early-stage turnover under the observed conditions. This coefficient is a compact description of the dataset rather than a constant that must persist through later decay stages. As labile compounds disappear, remaining litter can become increasingly controlled by lignin and other resistant constituents, and a single exponential model may over-simplify long-term decay (Aerts, 1997; Cornwell et al., 2008; Prescott, 2010). Regional studies show that climate, initial litter quality and stand conditions jointly influence decomposition in Northeast Indian forests (Arunachalam et al., 1998; Pandey et al., 2007; Barbhuiya et al., 2008). Decomposer communities are also a plausible part of this response. A study of banana-plantation rhizospheres in Nagaland documented culturable fungal diversity alongside variation in soil moisture, pH, organic carbon and available nitrogen (Temjen et al., 2022). That study did not examine teak litter and cannot explain the present coefficient; rather, it reinforces why local biological and soil measurements should accompany future litter-bag experiments. Measurements of rainfall, soil moisture, leaf carbon-to-nitrogen ratio, lignin and decomposer communities would therefore be needed to explain why mass loss changed through the study. The present observations establish the amount and trajectory of loss but do not isolate its drivers.

5. Conclusion

The 20-year-old teak plantation produced a 223.28 g m⁻² of litter during the study period from October, 2017 to April, 2018. This is a partial-period value and must not be presented as annual litterfall because the monsoon season was not observed. Leaves supplied 77.40% of the recorded input, while woody material, seeds and miscellaneous fragments together supplied 22.60%. Leaf dominance was evident in all three seasonal summaries, and the summer category contributed 52.41% of the total. The record therefore identifies a pronounced seasonal concentration of organic input, while avoiding an unsupported claim about a particular peak month or climatic driver. Teak leaves lost 60.4% of their initial mass over seven months. The single-exponential model produced a fitted decay coefficient of 0.149 month⁻¹, a half-life of 4.64 months and a strong fit to the relative-mass data. These values describe substantial short-term leaf turnover under the observed plantation conditions, but they should not be treated as a fixed long-term coefficient because litter chemistry and environmental controls can change during decomposition. The dataset provides a defensible, site-specific baseline for litter allocation and leaf mass loss of teak plantation in Nagaland. A future annual and long term study can retain all trap and litter-bag observations and measure rainfall, soil moisture, litter carbon-to-nitrogen ratio, lignin and decomposer communities. Such information would permit valid annual estimates, quantify uncertainty and test the mechanisms underlying the observed seasonal pattern of leaf litterfall and decomposition rate.

6. Data Availability

On request from the corresponding author

7. Acknowledgement

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