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Original Article

Quantification and Dynamics of *Mesua ferrea* Leaf Litter in Avenue Plantation for a Sustainable Management Strategy

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Abstract *- Mesua ferrea (MF) is a widely planted avenue tree because of its evergreen canopy, vibrant spring leaves, and beautiful flowers. However, unlike other leaf litter, MF leaf litter is resistant to decomposition under natural conditions, accumulating on the ground surface for a longer time and posing a significant management challenge for both government and private organizations. Most conventional disposal methods, such as burning and landfill dumping, cause environmental pollution and result in the loss of essential nutrients and biomass. Therefore, in this study, an attempt has been made to quantify the MF leaf litter produced in the avenue plantation of the NERIST campus. The leaf litter collection was conducted over two years with the help of a well-designed leaf litter collection trap at the three selected experimental avenue plots. Results indicated that leaf litter production peaked in March in both years. Additionally, there was an annual increase in litter production, rising from 9.923 kg to 11.834 kg per tree in the later year, and the estimates suggest that the campus, with its 171 trees, produces approximately 1.86 tons of MF leaf litter annually. Therefore, the institute can develop an efficient and sustainable management strategy based on the leaf litter production capacity of the MF avenue trees. Further study could be carried out on converting MF leaf litter into compost or vermicompost, providing a viable solution for leaf litter management while addressing the increasing demand for biofertilizers.*

Keywords *- Avenue plantation, Leaf litter management, Mesua ferrea, Sustainable development.*

1. Introduction

Rising awareness about issues like impacts of deforestation, environmental pollution, global warming, climate change, and soil degradation, combined with government encouragement for afforestation through social forestry programs since 1976, has led to encouragement to plant trees in diverse spaces such as roadsides, backyards, bunds, government offices, schools, hospitals, public estates, etc. The strategic planting of trees along roadsides, highways, and pavements to improve the aesthetic, provide shade, and improve environmental conditions is referred to as avenue plantation [1-3].

This practice helps reduce air pollution, prevents soil erosion, and conserves biodiversity. Apart from promoting sustainable urban planning and improving the overall quality of life, avenue trees also serve functional purposes, such as acting as windbreaks and providing shelter for pedestrians and vehicles from harsh sunlight while beautifying the urban and rural landscape.

Moreover, the avenue plantation helps in carbon dioxide sequestration [4-6] and improves air quality by releasing oxygen into the atmosphere [7-10]. Furthermore, the ecological balance of a congested and polluted environment is crucially maintained in urban settings by avenue trees [11, 12]. Therefore, to combat excessive pollution due to urbanization, it has become necessary to add more green spaces by planting trees along the roadsides [13].

The selection of tree species for avenue plantation is generally based on the climatic factors of the planting region, in addition to its canopy and evergreen leaves. Primarily, perennial trees are preferred over non-perennial trees for avenue plantations as they remain covered with leaves throughout the year. *Mesua ferrea* (MF) is a perennial avenue tree commonly known as Nahar/Ceylon ironwood, and it is popular in tropical and subtropical regions [14].

Despite the tremendous advantage of avenue plantation, a significant challenge arises in leaf litter management across

every organization, as a large number of trees generate considerable leaf litter (i.e., solid biomass) throughout the year [15]. Likewise, mature MF trees can produce a substantial quantity of leaf litter, while monthly leaf litterfall may vary according to factors such as age, growth stage, species type, seasons, and climatic factors [16-19]. Additionally, there is an inherent problem associated with the MF leaf litter as it is resistant to the decomposition process in natural conditions, taking longer time due to low nitrogen, high lignin contents and the presence of phenolic compounds [20-23]. Thus, MF leaf litter is an important concern with respect to leaf litter management practices since it may continue to make the surrounding area aesthetically unpleasant, clogging the roadside drainage system if accumulated for a longer time. Many times, they end up in the surface water through the storm drains, leading to eutrophication [24] and flooding in the nearby area. Despite the encouragement for sustainable and eco-friendly management practices, it is observed that the most widely adopted practice for leaf litter management is either illicit burning or dumping in the landfills along with municipal waste, and very few organizations adhere to sustainable organic waste management practices, leading to severe negative environmental impacts and overall affecting the human health.

As per the recent study conducted on the urban leaf litter management approaches, it has been suggested that understanding litterfall dynamics is crucial to devising a sustainable management solution for metropolitan areas and eco-friendly management activities [25]. Similarly, in waste management, quantifying generated waste is the initial step in devising a proper strategy to manage it sustainably. Although litterfall dynamics have been studied extensively in forest ecosystems, very limited studies have been carried out in urban spaces to quantify the amount of leaf litter generated from a specific avenue tree. Therefore, in this study, an attempt has been made to document the dynamics and quantification of leaf litter produced by MF avenue trees in the NERIST (North Eastern Regional Institute of Science and Technology) campus to develop eco-friendly and sustainable management strategies.

2. Materials and Method

2.1. Description of the Study Site

The present study has been carried out in the avenue plantations on the NERIST campus at Nirjuli, Itanagar, Arunachal Pradesh (Figure 1). The institute campus is surrounded by lush green *Mesua ferrea* (MF) avenue trees, enhancing the scenic beauty in general.

2.2. Experimental Design for Leaf Litter Collection

Prior approval was obtained from the Dept. of Horticulture, NERIST, to conduct the field experiment on the standing avenue MF trees, and a field survey was carried out to count the actual number of standing MF trees in the institute campus, which was found to be 171. Since the number of MF trees in the avenue plantation was large, quantifying litterfall from each tree was practically a difficult and humongous task. Therefore, to ease the work, a smaller representative number was considered in the experimental design.

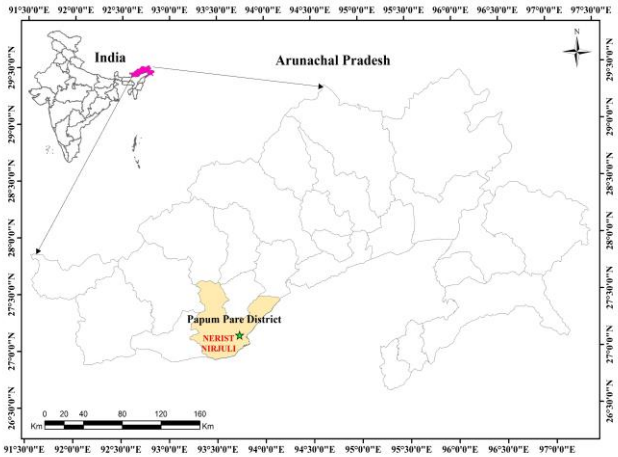

Fig. 1 Map of study area (NERIST Nirjuli, Arunachal Pradesh)

The experimental design for studying MF's leaf litter production dynamics in avenue plantations consisted of selecting a site with a minimum of 9 (nine) trees exposed to different environmental factors like sunlight, rainfall, and wind speed. Since this field study was to be conducted for two years (2017 to 2019), a less disturbed plantation site was considered to avoid maximum human interference in the sampling data. A total of three sampling sites were selected, each consisting of nine (9) trees aligned in a row within the avenue plantation. Additionally, the trees in each row were divided into three (3) sub-plots, forming rectangular plantation blocks to facilitate easy leaf litter collection. Each rectangular plantation block encompassed the entire tree canopy, with a total leaf litter catchment area of 440 m² (22 m × 20 m).

2.3. Construction of Leaf Litter Collection Trap (LLCT)

The construction of the Leaf Litter Collection Traps (Figure 2 and 3) in each plantation block was carried out in two steps. In the first step, Bamboo Structural Supports (BSS) were built in each block, covering the entire leaf litter catchment area, as described in the previous section. The BSS ran parallel on either side of the tree trunks, covering the whole leaf litter catchment area under the tree canopy. Each BSS had a sloping platform inclined towards the tree trunks, with the outer edge set at 5 feet and the inner edge at 3 feet to facilitate leaf litter collection. This design ensured leaf litter falling onto the platform gradually accumulated along the inner lower edge, making collection easier. The second step covered the BSS platform with an agro-net to trap the falling leaf litter.

Upon completing the construction of the LLCT, a field trial was conducted in March to evaluate its efficiency, as most of the studies conducted on litterfall dynamics failed to address the inefficacy of the collection system. Another factor in deciding the litterfall collection month was based on the previous report that the litterfall is highest in March and April for MF. It was observed that the LLCT could not capture all the litterfall from the MF trees due to environmental factors such as wind speed and rainfall.

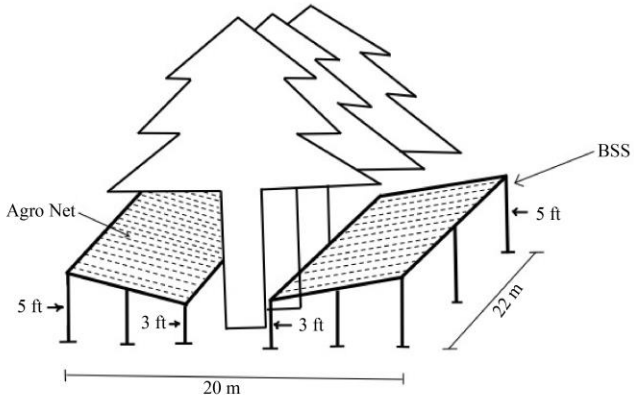

Fig. 2 Schematic illustration of the leaf litter collection system (LLCT) in a plantation block (*Not to scale*)

However, it was found that after a month of trial, the LLCT could efficiently collect approximately 85% of the litterfall, a significant amount (Figure 4). Consequently, the LLCT design was considered suitable for studying leaf litterfall dynamics over two years, with regular maintenance whenever deemed necessary.

Fig. 3 (a) and (b) LLCT in the MF plantation block

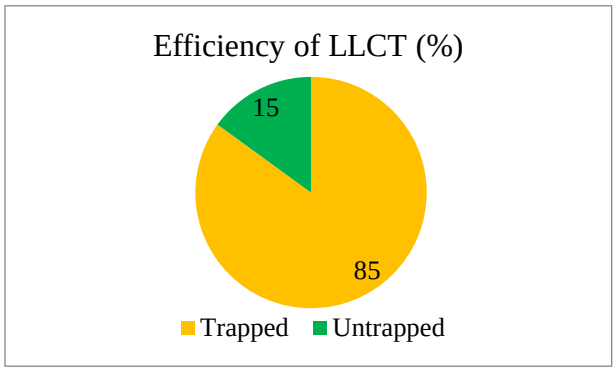

Fig. 4 Efficiency of Leaf litter Collection Trap (LLCT)

2.4. Collection and Quantification of MF Leaf Litter

The litterfall dynamics were recorded for two years, from April 2017 to May 2019. The fallen leaf litter trapped on the agro-net was collected twice a month (15-day intervals), and the sum of the 2 (two) sampling data was considered the total litterfall for the respective month. After collection, MF leaf litter was immediately transported to the laboratory, where leaves were manually separated from small branches, barks, flowers, and seeds presented in Figure 5. The leaf litter's dry weight was recorded after oven drying at 60°C for 24 hours to maintain the homogeneity of the result throughout the study.

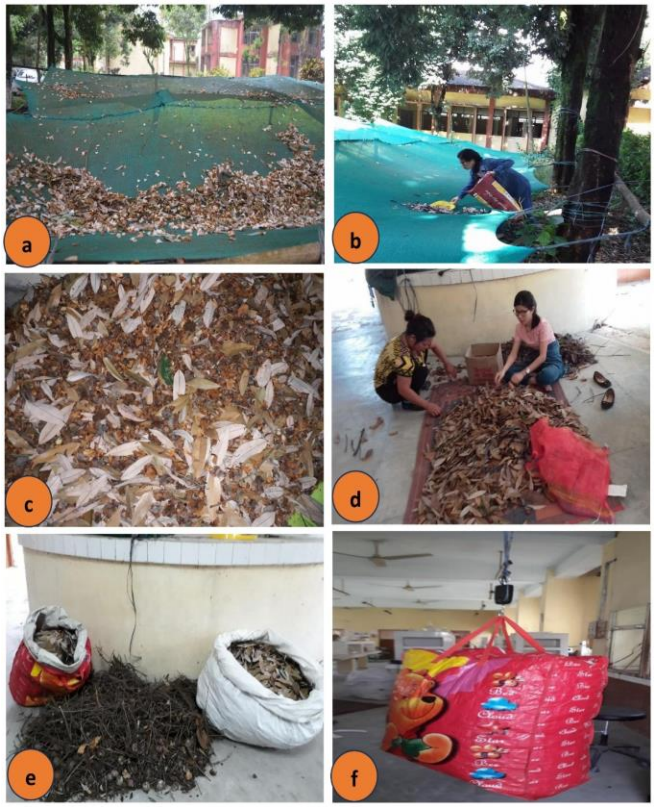

Fig. 5 (a) Litterfall trapped, (b) Collection, (c) Collected leaf litter with other twigs, dried flower and seeds, (d) Manual segregation of MF leaf litter, (e) Separated MF leaf litter, and (f) Quantification of MF leaf litter using digital weighing balance.

3. Results and Discussions

Based on the litterfall dynamics for May 2017- April 2018, it was observed that from May to January, there was no significant variation in the monthly leaf litterfall (Figure 6). However, a sudden and considerable increase in the litterfall was observed from the month of February till April.

Compared to the leaf litterfall dynamics of first-year, the second-year period from May 2018- to January 2019 showed an increase in the monthly leaf litterfall (Figure 7). However, the quantity of litterfall for three months (February, March, and April) showed lower leaf litter production than the first year's sampling period.

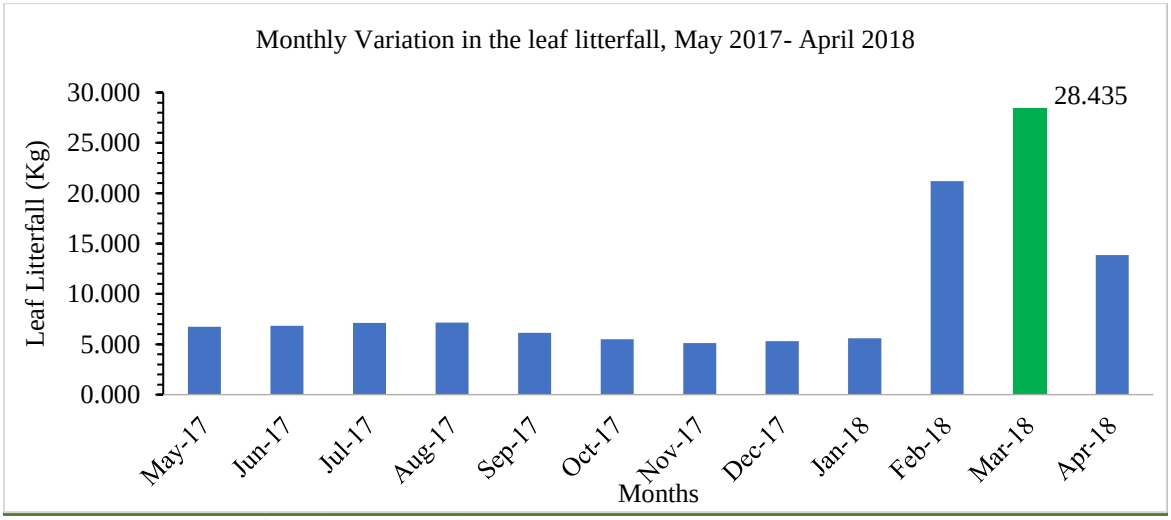

Fig. 6 Leaf litterfall dynamics of MF in the avenue plantations during May 2017- April 2018

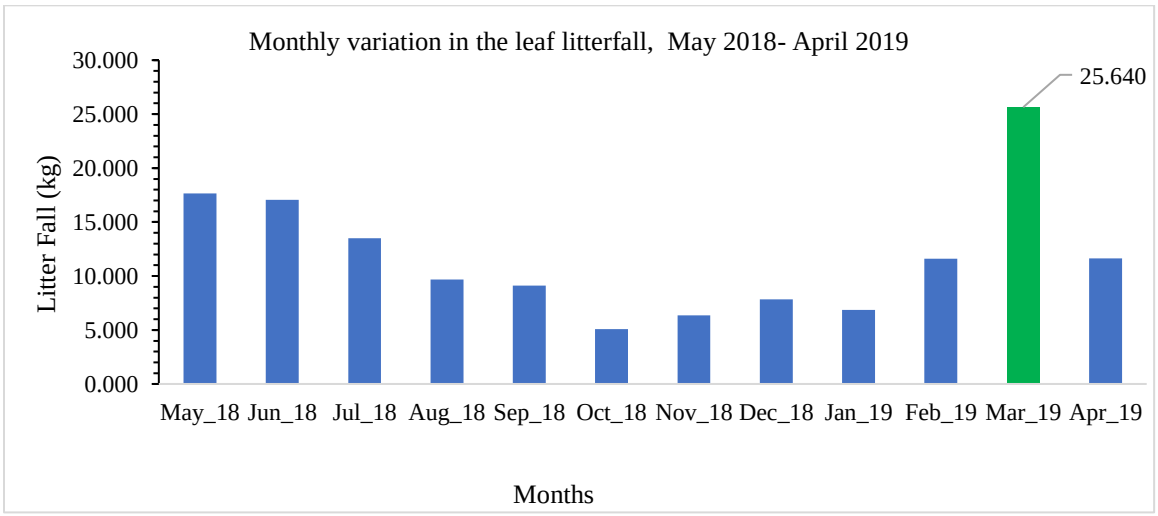

Fig. 7 Leaf litterfall dynamics of MF in the avenue plantations from May 2018 to April 2019

Table 1. Descriptive statistic analysis of the litterfall production over two years

	Leaf Litterfall (2017-18)	Leaf Litterfall (2018-2019)
Mean	9.923	11.834
Standard Error	2.163	1.704
Median	6.795	10.655
Mode	N/A	N/A
Standard Deviation	7.493	5.903
Minimum	5.115	5.070
Maximum	28.435	25.640
Confidence Level (95.0%)	4.761	3.751
Upper CI (95%)	14.684	15.585
Lower CI (95%)	5.162	8.083

According to the litterfall dynamics study, the greatest amount of leaf litterfall was collected in March for two consecutive years due to the high wind speed occurring during this month.

A comparative analysis was performed using a simple descriptive statistics method between the litterfall production over two years (Table 1).

There was a gradual annual increase in the amount of leaf litterfall, presented by the mean value of 9.923 in 2017-2018 and 11.834 in 2018-2019 (Table 2). The findings of results in this study confirm with other studies that leaf litter generation per tree increases with increasing plantation age [26, 27].

Based on the data generated from the three planation blocks (21 MF trees), the average accumulated value of leaf litterfall for the two consecutive years suggests that this tree species can produce approximately 14.50 kg per tree annually, considering the 85 % efficiency of LLCT.

Table 2. Average leaf litterfall per tree of MF for the two consecutive years

Year	MF Litterfall per Tree (kg)
2017-2018	13.23
2018-2019	15.78
Average	**14.50**

Based on the field study, 171 standing MF trees are on the institute campus, with a leaf litter production capacity of 2.48 tons per year, which is a significant amount of solid biomass. However, the actual amount of leaf litter generated would be much higher. Additionally, statistical analysis was carried out for the litterfall dynamics for the two years using ANOVA (Single factor), and it was found that there was no significant difference in the leaf litterfall between the two consecutive years.

4. Conclusion

Based on the present study, it can be concluded that the avenue plantations at the NERIST campus produce a considerable amount of MF leaf litter (biomass) every year and with the help of data generated, the institute can devise an efficient, sustainable and eco-friendly leaf litter management system to tackle leaf litter generated by MF trees without degrading the environmental components. Additionally, this data could be used to strategize the requirement for labour, time, and other activities involved in leaf litter management from the avenue plantations. Also, given the size and quantity of MF leaf litter produced, it becomes pertinent to find an eco-friendly and sustainable solution, as MF leaf litter is a potential source of solid biomass that could be converted into compost or vermicompost to meet the increasing demand for organic fertilizers as an alternative to chemical fertilizers additionally, the compost generated may be used in the agricultural or horticultural activities of the institute campus or can be sold in the market to generate revenue for the institute. However, further study on the efficient composting process of MF litter may be carried out to convert it into compost in the shortest duration.

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