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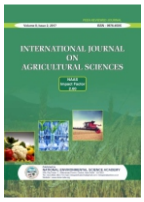

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LITTERFALL PRODUCTION, LITTER DECOMPOSITION AND NUTRIENT RELEASE PATTERN IN GMELINA ARBOREA (GAMHAR) BASED AGROFORESTRY SYSTEM IN RANCHI, JHARKHAND

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Research Article

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ABSTRACT

A field experiment was conducted during 2020-21 at agroforestry farm of Faculty of Forestry in Birsa Agricultural University, Ranchi, Jharkhand, India with two years old Gamhar (*Gmelina arborea*) trees intercropped with leguminous crops *viz*., Pigeon pea (*Cajanus cajan*), Cowpea (*Vigna unguiculata*) and Urad (*Vigna mungo*) under Gamhar based agroforestry system to estimate the litterfall produced by Gamhar tree and respective nutrient return associated with litter decomposition. The experiment was laid out in Randomized Block Design (RBD) with four treatment combinations *viz*., T1= *G. arborea* + *C. cajan*, T2= *G. arborea* + *V. unguiculata*, T3= *G. arborea* + *V. mungo*, T4= Sole *G. arborea* (control) which were replicated three times and statistically analyzed. The results indicate that the maximum litter from litter trap (342 kg ha-1) was found in month of February, the total annual litterfall was estimated to be 865 kg ha-1. Litter biomass was found to be high in *G. arborea* + *C. cajan* (892 kg ha-1), even the nutrient release pattern was found to be highest in *G. arborea* + *C. cajan viz.* 13.38 kg ha-1, 1.34 kg ha-1 and 10.08 kg ha-1 of total N, P and K respectively. The study concludes that Gamhar based agroforestry system has a good potential for nutrient cycling, particularly when Gamhar is intercropped with pigeon pea, it showed a positive influence on the nutrient release pattern.

Keywords: Agroforestry, Gmelina arborea, Litterfall, Litter decomposition, Nutrient release.

INTRODUCTION

Rural livelihoods in semi-arid regions of the world have been historically dependent on agroforestry systems with scatted trees on farmlands (Dhanya *et al.*, 2013). The species *Gmelina arborea* is a popular replacement for teak in the current forest economy. Litter production and decomposition have a significant impact on productivity and soil fertility. Nutrient cycling is greatly aided by the production of litter and the distribution of nutrients in forests and plantations. Litter includes leaves, twigs, fruits, bark, and small branches that fall to the forest floor. Woody perennials need nutrients that accumulate inside the plant body for carrying out various metabolic activities, growth, and development. Likewise, some nutrients are returned to the soil in the form of litter fall (Hasanuzzaman and Hossain, 2014).

Litter maintains nutrient and energy flow at the soil–plant interface, provides habitat for various soil organisms and protects soil from erosion. Litter production and decomposition varies with climate, season, substrate quality and type of vegetation. Knowledge of litter production and decomposition rates is important while estimating nutrient turnover (Sangha *et al.*, 2006). The litter in general increases the organic matter percentage of the soil and lead to enhanced productivity (Sharga *et al.*, 2020). Nutrients released during litter decomposition can supply 67-87% of the total annual requirement of essential elements for forest plants (Waring *et al.*, 1985). Studies on litter decomposition as well as nutrient contents in detritus leaves have not been conducted so far under *G. arborea* based agroforestry system particularly in

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Ranchi region of Jharkhand. Therefore, present study was carried out to examine the litter decomposition and the nutrients release pattern under *G. arborea* based agroforestry system in Ranchi district of Jharkhand.

MATERIALS AND METHODOLOGY

The present study was carried out in the Faculty of Forestry, Birsa Agricultural University, Ranchi, Jharkhand (23°17' N latitude and 85°19' E longitude with an elevation of 651m above mean sea level) during 2020-21. The site experienced warm humid tropical climate, with a mean rainfall of 1358 mm, most of which was received during the month August. The maximum and minimum temperatures during the cropping period were 35.22 and 5.29 respectively during 2020-21. The experiment consisted of various tree-crop combinations and design adopted was Randomized Block Design. It comprised of four treatments (T_1= *G. arborea* + *C. cajan*, T_2= *G. arborea* + *V. unguiculata*, T_3= *G. arborea* + *V. mungo*, T_4= Sole *G. arborea*) and each treatment was replicated three times.

Litterfall determination

Litter production was measured for a year continuously from January 2020 till December 2020. Litter collection was made using litter traps and 16 traps were randomly placed in under Gamhar based agroforestry system to represent an average of the total area. Each trap was 1 m x 1 m x 50 cm (l x b x h) to allow accumulation of falling litter. The randomly distributed litter traps was in accordance with the method suggested by New-bould, 1967 and Chapman, 1976. The traps were fixed about 80–100 cm above ground level by pegs at the corners. The litterfall was collected at monthly interval over the annual cycle. After collection the litter was oven dried at 60°C constant weight.

Litter decomposition

Decomposition of *Gmelina arborea* tree litter was studied using the standard litter-bag techniques (Falconer *et al.*, 1933). This study was carried out from January 2020 to December 2020. Freshly collection litter (only leaf) weighing 20g was placed in bags (20cm × 20 cm) made from nylon net (2.0 mm mesh size) and scattered at the Gamhar based agroforestry system. In total, there were 60 bags and three bags were removed randomly at monthly intervals. The bags were carefully tapered to remove adhering soil particles. The content was oven dried at 60°C and weighed rate of litter loss was determined based on remaining contents of bags.

RESULTS

Litter fall in *Gmelina arborea* based agri-silviculture system

The observations regarding litterfall is showed in Table 1. It is evident from the table that the maximum litter from litter trap (342 kg ha^{-1}) was found in month of February followed by (228 kg ha^{-1}) in January and the minimum leaf litter (25 kg ha^{-1}) was recorded in month of October in the year 2020. The total annual litterfall was estimated to be 865 kg ha^{-1}. The results also indicated that during the months of May, June, July, August and September the litterfall was almost nil.

Biomass of literfall

Evaluation of biomass of the litterfall resulted in understanding that the highest biomass of litterfall was found in T_1 (*G. arborea* + *C. cajan*, 892 kg ha^{-1}) and minimum in T_4 (Sole *G. arborea*, 836 kg ha^{-1}). T_1 (*G. arborea* + *C. cajan*) was estimated to be 6.7% higher than T_4 (Sole *G. arborea*), T_2 (*G. arborea* + *V. unguiculata*) was estimated to be 4.4% more than T_4 (Sole *G. arborea*), and T_3 (*G. arborea* + *V. mungo*) was estimated 2.87% more than T_4 (Sole *G. arborea*) in production of biomass of litterfall (Table 2).

Nutrient return due to litterfall by Gamhar tree under Gamhar based Agroforestry system.

Chemical constitution of decomposed leaf litter was evaluated on the basis of several parameters. Nutrient return *viz.*, N, P and K in decomposed leaf litter of *G. arborea* is presented in Table 2. The total N return in decomposed leaf litter was found maximum in T_1 (*G. arborea* + *C. cajan*, 13.38 kg ha^{-1}) and minimum in T_4 (Sole *G. arborea*, 12.54 kg ha^{-1}). The total P return in decomposed leaf litter was recorded highest in T_1 (*G. arborea* + *C. cajan*, 1.34 kg ha^{-1}) and minimum in T_4 (Sole *G. arborea*, 1.25 kg ha^{-1}). The total K return was also found highest in T_1 (*G. arborea* + *C. cajan*, 10.08 kg ha^{-1}) and minimum in T_4 (Sole *G. arborea*, 9.45 kg ha^{-1}) throughout the study period.

DISCUSSION

One of the important mechanism for transferring nutrients and carbon from vegetation to soil is litter production (Dawoe *et al.*, 2010). A mean total of 865 kg ha^{-1} yr^{-1} of litterfall dry weight has been estimated (Table 1) from Gamhar trees under Gamhar based Agroforestry system. In this study, litter production was highest (342 kg ha^{-1}) in the month of February which may perhaps be owing to higher leaf fall during the dry season and windy conditions in the sites as climate is the primary determinant of litter production (Facelli and Pickett, 1991). The majority of studies on leaf litterfall in tropical forests have shown that it is strongly seasonal, peaking during the dry season (Wieder and Wright, 1995; Lawrence and Foster, 2002). It has also been stated that physical factors, such as the dynamics of wind and rain or plant physiological reactions to environmental changes, may have an impact on litterfall (ICP Forests, 2004; Santiago and Mulkey, 2005). Several studies including e.g. (Wieder and Wright, 1995; Lian and Zhang, 1998; Yang *et al.*, 2003; Dawoe *et al.*, 2010) have reported that the seasonal pattern of litterfall largely depended on the factors responsible for leaf senescence and abscission.

The litter biomass on the floor of different treatments varied from 836 to 892 kg ha^{-1}. *G. arborea* + *C. cajan* had the highest litter biomass whereas Sole *G. arborea* had the lowest. The current study's findings on litter turnover rate are consistent with those found in a number of tropical and subtropical evergreen and deciduous forests (Vogt *et al.*, 1986). Because warm temperatures and higher moisture levels speed up litter decomposition (Anderson and Swift, 1983).

Table 1: Monthly litterfall produced by Gamhar trees under Gamhar based Agroforestry system.

Months	**Litterfall of Gamhar tree (kg ha-1)**
January	228
February	342
March	116
April	23
May	-
June	-
July	-
August	-
September	-
October	25
November	38
December	93
Annual (Total)	865
S.Em±	6.18
CD (p=0.05)	18.76
CV (%)	**8.67**

Table 2: Nutrient return due to litterfall by Gamhar tree under Gamhar based Agroforestry system.

	Biomass of Litterfall (kg ha^{-1})	**Total Nitrogen (kg ha^{-1})**	**Total Phosphorus (kg ha^{-1})**	**Total Potassium (kg ha^{-1})**
G. arborea + C. cajan	892	13.38	1.34	10.08
G. arborea + V. unguiculata	873	13.10	1.31	9.86
G. arborea + V. mungo	860	12.90	1.29	9.72
Sole G. arborea	836	12.54	1.25	9.45
S.Em±	17.15	0.26	0.03	0.19
CD (p=0.05)	52.84	0.79	0.08	0.60
CV (%)	6.11	6.11	6.11	6.11

The total amount and ratios of nutrients have a significant impact on how rapidly leaf litter decomposes (Berg and McClaugherty, 2008). Maximizing soil sustainability and crop productivity requires thorough understanding of the patterns of nutrient release from the leaf litter and organic matter decomposition (Mugendi *et al.*, 1999). In the present study, nutrient release of total N varied between 13.38 kg ha^{-1} to 12.54 kg ha^{-1}, total P varied between 1.34 kg ha^{-1} to 1.25 kg ha^{-1} and total K varied between 10.08 kg ha^{-1} to 9.45 kg ha^{-1}. Similar findings were reported by Singh *et al.* (1999) and Panwar and Gupta (2015). According to Kutsch and Dilly (1999), Scholes and Walker (1993), Vitousek and Matson (1984), soil type, microbial communities, and soil properties all play a role in the decomposition of litter and the release of nutrients. These types of nutrient changes may result from the ageing process, specifically the change from sapwood to heartwood (Orma and Will, 1960; Attiwill, 1980). N and lignin content are significant determinants of the rate of decomposition in plant material (Fogel and Cromack, 1977; Meentemeyer, 1978).

CONCLUSION

Gmelina arborea, a potential fast growing species, majorly planted in agroforestry system, this study summarizes that the average annual litterfall in Gamhar based agroforestry system is quiet considerable. Although the litter production was not seen in the months of May, June, July, August and September, the rest of months had a variable pattern of litterfall peaking in February. *Gmelina arborea* along with *Cajanus cajan* showed a very promising results in terms of litter biomass production as well as release of nutrients such as Nitrogen, Phosphorous and Potassium. However further studies regarding impacts of Gamhar on agricultural crops and vice versa is necessary.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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