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Litter dynamics under different pruning regimes of *Albizia procera* based agroforestry system in semi-arid region

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ABSTRACT

Agroforestry provides many direct and indirect benefits to the society. It not only meets the requirement of fuel, fodder, food, furniture, farm implements, employment etc. but also enriches soil, increases biodiversity, sequester C, prevent soil erosion, conserve water etc. For soil enrichment, trees capture nutrients from deeper layers and add to the surface soil through leaf shedding (litterfall) and incorporation of pruned biomass. Litterfall and pruned biomass consequent upon the decomposition, release nutrients and results cumulative build up and/or sustain soil fertility. Thus understanding the processes and mechanism of soil enrichment in tree based cropping systems is necessary. Therefore, the present study was undertaken at the research farm of National Research Centre for Agroforestry during 2006-2007. The results revolve that leaves formed the major component of the total litter followed by petiole, fruit and bark. Leaves formed 67.7, 67.8, 69.7 and 70.4 per cent of the total litter under *A. procera* un-pruned + fallow, *A. procera* un-pruned + cropping, *A. procera* pruned 50 per cent + cropping, and *A. procera* pruned 70 per cent + cropping, respectively. Annually, litter production under these systems varied between 6.32 – 26.0 kg tree^{-1}. It is observed that quantity of N, P and K addition through litter fall of MPTs depends on the nature of MPTs, amount of litter fall, season, nutrient composition, canopy structure/geometry and canopy positions underneath. In irrespective of *A. procera* based land uses and pruning regimes therein, maximum amounts of N, P and K addition in winter followed by summer and rainy season coincided with the amounts of litter fall in respective seasons.

Key words : Agroforestry system, Soil enrichment, Nutrient release, Litterfall, Pruned biomass

INTRODUCTION

Farmers have been raising and/or allowing trees in their crop fields in one or other forms since ages to meet multi needs of households. In recent times this practice was coined agroforestry. Amidst global climate change agroforestry has got more importance beyond livelihood security and recently for mitigation of climate change by way of sequestering C in both standing biomass and soil. Agroforestry provides many direct and indirect services to the mankind. Directly, it meets the requirement of fuel, fodder, food, furniture, farm implements, employment etc. of each farm household and also other households. Indirectly, it enriches soil, provides shelter, increases biodiversity, sequester C, prevent soil erosion, conserve water etc. For soil enrichment, trees capture nutrients from deeper layers and add to the surface soil through leaf shedding (litterfall) and incorporation of pruned biomass. Litterfall and pruned biomass consequent upon the decomposition release nutrients and results cumulative build up and/or sustain soil fertility.

Litter fall is a fundamental process in nutrient cycling and it is the main means of transfer of organic matter and mineral elements from the vegetation to the soil surface (Vitousek and Sanford, 1986, Regina *et al*., 1999). Litter is a general term for senescent plant parts. Litter contributes to forest and agro-ecosystem mainly by nutrient and carbon turnover during litter decomposition and thus maintaining biogeochemical cycling in the ecosystems. Litter cover acts as a protective layer for maintaining soil physical properties like retention of soil moisture (Ginter *et al*., 1979), buffering against soil temperature and compaction change (MacKinney, 1929), and soil conservation from erosion or leaching (Mo *et al*., 2003). It also provides habitats and substrates for soil fauna (Attignon *et al*., 2004) and flora (Ruf *et al*., 2006). Magnitude of soil enrichment depends upon the amount of litter fall and quality of the litter added. Both higher amount and quality of litter added in the system adds more nutrients and *vice versa* (Yadav *et al*., 2008). Litter fall depends upon nature of tree species, climate and tree management practices etc. resulting varying build up in soil fertility.

Hence, to understand the processes and mechanism of soil enrichment in tree based cropping systems, it is imperative to study the quantification of litter fall, effect of tree management practices on litter production and therein nutrient addition, pruned additions and their decomposition. Although intensive studies on litter dynamics, and soil enrichment in forest ecosystems have been carried out worldwide, but multipurpose trees, especially grown in farming situations in general with

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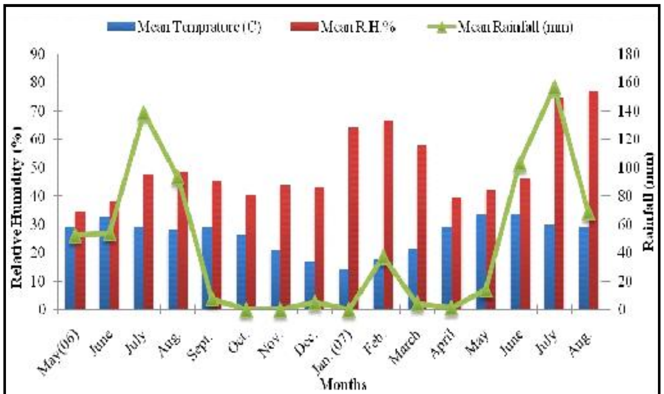
management practices and *A. procera* in particular, have received very little attention.Amongst many tree spp. in India under agroforestry, *A. procera* is one of the important multipurpose trees. It belongs to Leguminasae (Mimosoideae). This is large deciduous tree with a long clean bole, light crown; bark smooth, light yellowish or greenish grey. It is found all over Assam, Bihar. Northern M.P., A.P. and Central and eastern U.P. It is growing on a variety of soil ranging from alluvial soil, clayey, moderately alkaline and saline soils to red sandy and loamy soils. Its charcoal is considered very well. The wood is excellent for high class furniture. Bark is used for tanning. Its fodder is valuable supplement to pasture, sheep and goat. The foliage is a good green manure.

MATERIALS AND METHODS

Experimental site, soil and climate :

The present study was conducted at the research farm of National Research Centre for Agroforestry during 2006-2007. The site of the experimental field is situated at 25^0 27’ North latitude and 78^0 35’ East longitudes, 271 m msl in the semi arid region of the Central Indian Plateau. Average annual rainfall of the region is 806 mm, about 80 per cent of which occurs between June to September with intermittent dry spells. The mean monthly temperature is generally high, with high degree of variation between a maximum 39.8^0 C in May and June and minimum temperature of 5.8^0 C in December and January. In summer, temperature occasionally reached up to 48^0 C. The mean monthly evaporation in the region is highest in April- June (9.40-15.2 mm) and it ranges from 1.90-6.00 mm during other months of the year. The metrological variables during experimental period are given in Fig. A. During 2006, total rainfall received was 375.20 mm spread over 30 rainy days. During 2007 total rainfall received was 554.8 mm spread over 40 rainy days.



Source : IGFRI, Jhansi

Fig. A : Mean monthly meteorological parameters during study period (May 2006-August 2007)

The soil in the experimental field is Parwa representing inter-mixed black and red soil group of Bundelkhand region (U.P.), India, falling under the soil order *Alfisol*. It is medium in texture, moisture retentive and workability, prone to crust whenever drought spell exceeds 2-3 weeks even under mild evaporation situation. The experiment field was established as agrisilviculture (crop + tree) system in July, 2000 with *Albizia procera* as the tree component. In this study *A. procera*, blackgram – mustard crop sequence was selected.

Experimental details :

Cropping and plot history :

The experiment field was established as agrisilviculture (crop + tree) system in July, 2000 with *Albizia procera* as the tree component. *A. procera* was planted in at spacing of 8m x 4m in plot size of 576 m^{-2} (18 trees $plot^{-1}$) with three replications. This established experiment was used for the present investigation.Under *A. procera*, blackgram – mustard crop sequence was selected. General characteristics of the *A. procera* during the present study are presented in Table A.

Table A : General characteristics of *A. procera* under different pruning regimes (± Se, n=10).

Pruning regimes	DBH (cm)	Height (m)	Canopy diameter (m)
*A. procera*un-pruned + fallow	14.5 ± 0.15	8.09 ± 0.09	7.71 ± 0.23
*A. procera*un-pruned + crop	16.2 ± 0.20	9.26 ± 0.13	7.84 ± 0.31
A. procera pruned 50% + crop	16.0 ± 0.08	8.80 ± 0.08	6.25 ± 0.24
A. procera pruned 70% + crop	15.6 ± 0.10	8.39 ± 0.10	5.97 ± 0.07

Pruning regimes :

The present investigation was carried out in six year old *A. procera* based agroforestry system at research farm of National Research Centre for Agroforestry, Jhansi.*A. procera* was subjected to pruning to allow more penetration of sunlight for under storey crops. Trees were managed as un-pruned, pruning up to 50 % and 70 % height of the tree each year in the month of October/ November. In the established experiment, following pruning regimes and land uses were maintained-

– *A. procera*unpruned + fallow
– *A. procera*unpruned + crop
– *A. procera* pruned 50 % + crop
– *A. procera* pruned 70 % + crop.

Litter fall collection :

Litter fall was collected every month for one year period from 1 March 2006 to 1 February 2007 using specially designed square traps. Five litter traps of 0.50m^2 were placed randomly under the canopy of selected tree in each regime. Collected litter was brought to the laboratory and separated into different parts *viz.*, leaves, petiole, pods and bark. Each part was separately washed and oven dried (72^{0}C) till constant weight. Monthly litter fall values were summed to obtain total annual and seasonal litter yield.

Crown diameter :

To calculate the litter production**,** crown diameter of the trees was measured with the help of measuring tape. First, the spread of crown in East-West and North –South direction was marked. Afterwards, crown diameter was calculated with using following formula-

Crown diameter = (D_1+D_2) ÷ 2

where,
D_1 = Crown lengthin east - west direction.
D_2 = Crown lengthin north - west direction

Statistical analysis and interpretation of data :

The effect of *Albizia procera* based land uses and pruning regimes of on mean annual, seasonal and total litter production was tested by means of ANOVA using the General Linear Model of SYSTAT Ver. 9 (SYSTAT Inc. 1998). To ascertain the significant effect of *A. procera* based land uses and pruning regimes on litter fall. Afterwards, by calculating critical differences at 5 per cent probability significance of treatment means were tested.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Monthly litter production :

Data presented in Fig. 1 revealed that irrespective of pruning g regimes, monthly litter production varied widely with maximum production in the month of April followed by May. Minimum monthly litter production was obtained in June, September, February and February under 50 per cent pruning, 70 per cent pruning, un-pruned under cropping and un-pruned under fallow, respectively. Un-pruned *A. procera*+ fallow yielded highest litter production in the month of April followed by *A. procera*+ cropping, *A. procera* pruned 50 per cent + cropping and *A. procera* pruned 70 per cent + cropping, respectively. Further, lowest litter production was collected under *A. procera* pruned 70 per cent + cropping in the month of September.

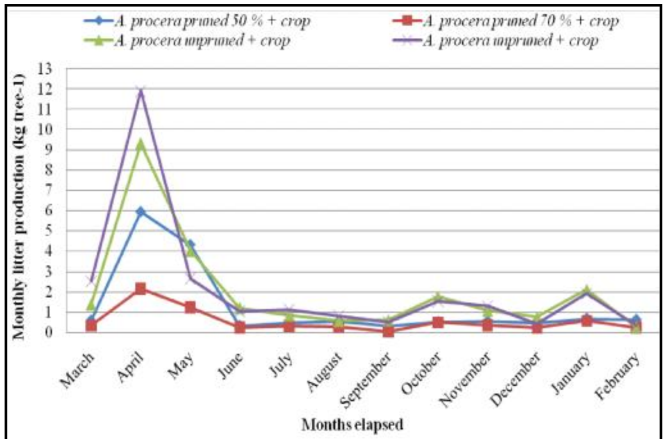


Fig. 1 : Monthly litter production (kg tree^{-1}) in A. procera under different pruning regimes and land uses

Seasonal production of litter :

It is evident from data presented in Table 1 that irrespective of pruning regimes, seasonally maximum litter production was collected in the summer season with minimum under rainy season except under control (un-pruned *A. procera* + fallow), wherein it was minimum in the winter season. Data further shows that leaves formed the major component of the total litter in each season followed by petiole. In summer, leaves formed 68.0, 67.6, 66.5 and 67.4 per cent of the total litter under *A. procera* pruned 50 per cent + cropping, *A. procera* pruned 70 per cent + cropping, *A. procera* un-pruned + cropping and *A. procera* un-pruned + fallow, respectively. Correspondingly, leaves formed 69.9, 69.6, 69.5, and 67.2 per cent in rainy season and 77.6, 79.1, 74.2 and 69.5 per cent of total litter in winter season.

Table 1 : Annual and seasonal production (kg tree^{-1}) of total litter in *A. procera* under different pruning regimes and land uses

Months	*A. procera* pruned 50% + crop	*A. procera* pruned 70% + crop	*A. procera* un-pruned + crop	*A. procera* un-pruned + fallow
Annual	15.2	6.32	23.6	26.0
Summer	11.1	3.92	15.8	18.1
Rainy	1.83	1.06	3.67	3.96
Winter	2.28	1.34	4.11	3.93

Annual litter production :

Annually, total litter production under *A. procera* based different land uses and pruning management was in the order: *A. procera* un-pruned + fallow >*A. procera* un-pruned + cropping >*A. procera* pruned 50 per cent + cropping >*A. procera* pruned 70 per cent + cropping. Data presented in Table 1 showed that leaves formed the major component of the total litter followed by petiole, fruit and bark. Leaves formed 67.7, 67.8, 69.7 and 70.4

per cent of the total litter under *A. procera* un-pruned + fallow, *A. procera* un-pruned + cropping, *A. procera* pruned 50 per cent + cropping, and *A. procera* pruned 70 per cent + cropping, respectively.

Annual Nutrient additions :

N, P and K addition :

Data presented in Table 2 on annual N addition by litter revealed that *A. procera* un-pruned + fallow (349 g tree^{-1}) added highest N followed by *A. procera* un-pruned + cropping, *A. procera* pruned 50 per cent + cropping, and *A. procera* pruned 70 per cent + cropping (87.1 g tree^{-1}). Data further showed that of the total litter, leaves contributed maximum to N return and was in the order: leaves > petiole > fruit > bark. Annually, leaves contributed 80.6, 79.9, 80.4 and 78.8 per cent of the total N addition under *A. procera* pruned 50 per cent + cropping, *A. procera* pruned 70 per cent + cropping, *A. procera* un-pruned + cropping and *A. procera* un-pruned + fallow, respectively.

Table 2 : Annual N addition (g tree^{-1}) by different components of litter in *A. procera* under different pruning regimes and land uses

Components	*A. procera* pruned 50% + crop	*A. procera* pruned 70%+crop	*A. procera* un-pruned + crop	*A. procera* un-pruned + fallow
Leaves	166	69.6	251	275
Petiole	28.6	10.3	45.1	47.8
Fruit	5.37	6.44	14.6	24.1
Bark	0.982	0.705	1.84	2.46
Total	201	87.1	312	349

It is seen from data presented in Table 3 that among pruning treatments, *A. procera* un-pruned + fallow added maximum P (43.3 g tree^{-1}). Annually; descending P addition in *A. procera* based land uses and pruning management was in the order: *A. procera* pruned 70 per cent + cropping <*A. procera* pruned 50 per cent + cropping <*A. procera* un-pruned + cropping <un-pruned + fallow. Data further showed that among the components of total litter, leaves contributed maximum to total P addition under different pruning regimes. Of the total annual P addition, leaves contributed 71.7, 71.4, 69.7 and 69.0 per cent under *A. procera* pruned 50 per cent + cropping, *A. procera* pruned 70 per cent + cropping, *A. procera* un-pruned + cropping and *A. procera* un-pruned + fallow, respectively.

Annually, *A. procera* un-pruned + fallow added maximum K (84.9 g tree^{-1}) followed by *A. procera* un-pruned + cropping, *A. procera* pruned 50 per cent + cropping and *A. procera* pruned 70 per cent + cropping (Table 4). Compartmentally, petiole added maximum K in all pruning regimes followed by leaves, fruit and bark. It is further evident that petiole added 58.5, 50.3, 57.1 and 53.6 per cent K annually of the total under *A. procera* pruned 50 per cent + cropping, *A. procera* pruned 70 per cent + cropping, *A. procera* un-pruned + cropping and *A. procera* un-pruned + fallow, respectively.

Table 3 : Annual P addition (g tree^{-1}) by different components of litter in *A. procera* under different pruning regimes and land uses

Components	*A. procera* pruned 50%+crop	*A. procera* pruned 70% + crop	*A. procera* un-pruned+ crop	*A. procera* un-pruned+ fallow
Leaves	18.0	7.57	27.2	29.9
Petiole	6.37	2.29	10.0	10.6
Fruit	0.486	0.584	1.32	2.18
Bark	0.233	0.167	0.436	0.584
Total	25.1	10.6	39.0	43.3

Table 4 : Annual K addition (g tree^{-1}) by different components of litter in *A. procera* under different pruning regimes and land uses

Components	*A. procera* pruned 50%+crop	*A. procera* pruned 70%+crop	*A. procera* un-pruned+ crop	*A. procera* un-pruned+ fallow
Leaves	16.0	6.41	24.1	26.7
Petiole	27.2	9.82	42.9	45.5
Fruit	2.45	2.74	6.54	10.7
Bark	0.794	0.570	1.49	1.99
Total	46.5	19.5	75.1	84.9

It is obvious from results presented above that *A. procera* under different pruning regimes and land use differed markedly in their litter production and the order of litter production in ascending order was: *A. procera* un-pruned + fallow >*A. procera* un-pruned + cropping >*A. procera* pruned 50 per cent + cropping > *A. procera* pruned 70 per cent + cropping. Annually, litter production under these systems varied between 6.32-26.0 kg tree^{-1}. These rates of litter production are very low compared to litter production of 35.8-57.4 kg tree^{-1} by *D. sissoo*, *P. cineraria*, *A. leucophloea* and *A. nilotica* based agroforestry systems at farmers' field under scattered plantation (Yadav *et al*., 2008).

Bray and Gorham (1964) concluded that the amount and pattern of litter production varied with the type of tree species, their growth pattern, age, density and canopy characteristics. Studies on litter fall rates in agroforestry systems involving MPTs and their management are scarce. Most of the studies on litter fall are made in forest ecosystems and that too in high density plantations. So it becomes difficult to correlate the litter of present study to findings of other ecosystems. Pruning is a recommended tree management practice in agroforestry to facilitate light infiltration for better productivity of understory crops. Lopping/pruning of MPTs affects the rate of litter fall production (George and Kumar, 1998).

Pruning response varies with tree spp. resulting into different rate of litterproduction. Canopy characteristics of a tree are altered by pruning the tree. Principally, pruning of trees delays canopy closure and/or reduces crown width resulting to yield less litter. The lower litter fall received in the present study compared to other agroforestry systems could be mainly explained due to pruning intensity, among other factors. Pruning *A. procera* each year by 50 and 70 per cent resulted into less canopy cover/diameter having lower biomass to fall in comparison to un-pruned *A. procera*.

It is obvious that quantity of N, P and K addition through litter fall of MPTs depends on the nature of MPTs, amount of litter fall, season, nutrient composition, canopy structure/geometry and canopy positions underneath. In present study; variation in N, P and K addition can be explained on the basis of results obtained on the amount of litter fall under *A. procera* based land uses and pruning regimes followed. Higher return of nutrients under un-pruned *A. procera* based system owed to higher litter fall as compared to *A. procera* pruned 50 and 70 per cent based system (Table 1). Further, irrespective of *A. procera* based land uses and pruning regimes therein, maximum amounts of N, P and K addition in winter followed by summer and rainy season coincided with the amounts of litter fall in respective seasons (Table 1). Nutrients recycled through litter fall followed the same trend as that of amount of litter fall under *A. procera* based land uses and pruning regimes therein.

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