Nutrient cycling studies in teak ecosystem

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Abstract

The productivity of any woodland ecosystem is dependent on the dynamics of nutrients that occur in that system. Being a deciduous tree, teak (*Tectona grandis Linn*.f.*)* favours for accelerated nutrient cycling and hence studies on nutrient dynamics under teak ecosystem warrants attention. Keeping these points in view, a field experiment was conducted in an eighteen year old teak plantation at Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, India during 2005-2007. Litter fall was collected at monthly intervals using litter traps and the contribution of nutrients through rainfall, stem flow and through fall and the loss of nutrient through runoff and erosion from the field were recorded during the study period.

Of the total annual litter fall recorded under the teak ecosystem, leaf litter contributed to 81.9 per cent. The highest litter fall was during January to June contributing to the tune of 77 per cent to the total annual litter fall. Stem flow, through fall and interception contributed for 14.87, 72.52 and 12.61 per cent respectively to the total effective rainfall. The loss of nutrients through runoff was the highest and the least was through sediments and the highest loss was recorded for Ca and lowest was for P. From the present study, it is concluded that the highest amount of nutrient gains occurred through litter fall than stem flow, through fall and rainfall. The nutrient loss through runoff and sediments was lower than the gains thus resulting in a positive balance of nutrients.

Media summary

Understanding nutrient dynamics in teak ecosystem will help to plan for better soil and nutrient management under plantation forestry.

Key words

Teak, litter fall, through fall, litter composition, nutrient dynamics.

Introduction

In natural forests and manmade protected plantations, cycling of nutrients is an important process and it involves various factors and processes in the ecosystem. The process of nutrient cycling includes nutrient gains and losses of nutrients within and outside the ecosystem. In a forest ecosystem, annual return of nutrients through litter fall and precipitation are the main sources of inputs to the nutrient cycling process. Teak (*Tectona grandis* Linn.f.), the tree species of the present study is a large deciduous tree with a rounded crown with large leaves and tall cylindrical bole under favourable conditions; rarely buttressed but older trees have fluted stems. Being a deciduous tree, it sheds leaves and accumulates more litter in the forest floor.

Nutrients are lost from an ecosystem through various processes like runoff and soil erosion, etc. Soil erosion is affected by the character of rainfall, soil type, relief, vegetation and management practices. Though a lot of information are available all over the world regarding the nutrient cycling or dynamics in different forest ecosystems and plantations, only very few literature are available with respect to teak ecosystem.

Methods:

Eighteen years old teak plantation planted at 4 m x 2 m in a red sandy loam soil (typic Ustropept) was selected for the present study. The litter was collected from the tree stands using litter traps of 1 m x 1 m size at monthly intervals for one year from January 2006 to December 2006. Thus collected litter was separated into leaves, twigs, flowers and fruits. Dry weight of each component was determined by drying to constant weight at 60^{o}C and the mean monthly value for each plot was worked out on a unit area basis (kg ha^{-1}). The litter samples were powdered in a Wiley mill and analysed for N, P, K, Ca and Mg adopting standard analytical methods.To quantify the amount of rainfall that is being intercepted by tree canopy, incident rainfall and through fall were measured using plastic collectors with plastic funnels having 200 cm^{2} collection area (Okeke and Omaliko, 1991).

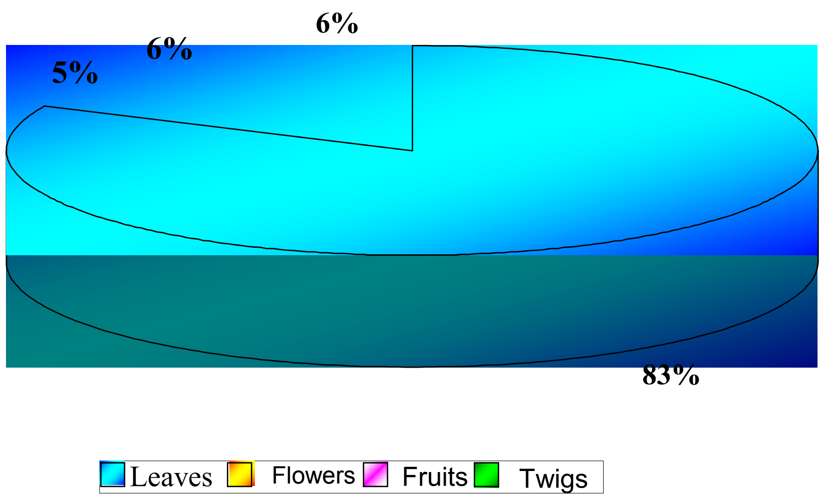
Stem flow was measured from the polythene funnel shaped collars, with plastic funnels fitted into the stem of selected trees in the plantation. The stem flow water was drained off into a collecting tank through a flexible polythene tube fixed on to the plastic funnels (Mishra and Yadav, 1978). Interception loss was computed by subtracting precipitation (through fall and stem flow) from the total precipitation (incident rainfall). Rain water samples from the open area, stem flow and through fall collected from study area were analysed for N, P, K, Ca and Mg contents. With regard to N, the ammoniacal and nitrate forms analysed and the N content was computed using standard procedures. In order to estimate the quantity of runoff from the field, the curve number method developed by the soil conservation service (SCS) of the United States Department of Agriculture (USDA) was applied. The soil loss was both predicted using RUSLE software and also actually assessed in the field using Coshocton – wheel runoff sampler. The collected runoff water and sediments were analyzed to evaluate the quantum of nutrients lost.

Results:

Studies on litter fall

Among the litter components, the leaf litter contributed the major share of 83 per cent to the total annual litter production (11,255 kg ha^{-1}) (Fig.1). More than 80 per cent of leaf litter fall occurred during the dry months of the year (January to June) to the total annual leaf litter production (9216 kg/ha^{-1}). The contribution by other litter components viz., flowers, fruits and twigs was only to a smaller extent.

Fig. 1. Per cent share of litter components to total litterfall



Nutrients return

The total N return through litter fall in teak was 110.26 kg ha^{-1} in a year (Table 1).

Table 1. Nutrients return through different components of litter (kg ha^{-1})

	Leaves	Flowers	Fruits	Twigs	Total
Total N return	74.38 ± 5.91	14.94 ± 1.88 (38.94)	10.83 ± 2.84 (34.83)	10.11 ± 1.61 (34.11)	110.26 ± 7.76
Total P return	12.51 ± 1.77	2.21 ± 0.28 (26.21)	1.88 ± 0.49 (25.88)	0.90 ± 0.15 (24.90)	17.50 ± 1.89
Total K return	27.95 ± 2.08	3.01 ± 0.38 (27.01)	2.92 ± 0.74 (26.92)	1.15 ± 0.19 (25.15)	35.03 ± 2.33
Total Ca return	311.91 ± 22.65	15.05 ± 1.87 (39.05)	10.50 ± 2.81 (34.50)	11.51 ± 1.86 (35.51)	348.97 ± 23.00
Total Mg return	65.95 ± 5.48	3.67 ± 0.44 (27.67)	3.85 ± 1.00 (27.85)	4.98 ± 0.84 (28.98)	78.46 ± 5.52

(Values in parenthesis are transformed values using X+2 transformation)

The total N return by the litter components was higher during March followed by February. Leaf litter alone contributed 67.5 per cent followed by flowers, fruits and twigs with respective values of 13.5, 9.8 and 9.2 per cent to the total annual N return. The total P return through litter fall was 17.50 kg ha^{-1} in a year. The return was higher through leaf litter (71.5%) than other components. The return of P was higher during January to June (79.0 %) than the rest of the year. The return was peak during February (2.47 kg ha^{-1}). Leaf litter alone contributed the highest share of 27.95 kg ha^{-1} to the total annual return of 35.03 kg ha^{-1} Other litter components viz., flowers, fruits and twigs contributed only 3.01, 2.92 and 1.15 kg ha^{-1}, respectively. The highest Ca return was recorded by leaf litter alone with the highest share of 89.4 per cent to the total annual return. Other litter components (flowers, fruits and twigs) contributed only 10.6 per cent to the total return. The total Mg return through the litter components was 78.46 kg ha^{-1} (84 %). Among the nutrients, Ca was returned in greater quantities (348.97 kg ha^{-1}) followed by N, Mg, K and P with respective values of 110.26, 78.46, 35.03 and17.50 kg ha^{-1}.

Nutrients return through stem flow, through fall and rainfall

The total annual contribution of N was 10.75 kg ha^{-1}, of which through fall accounted for 52.5 per cent, rainfall 27.3 per cent and stem flow 20.2 per cent. To the total annual P contribution of 8.35 kg ha^{-1}, the through fall, rainfall and stem flow accounted for 46.2, 39.2 and 14.6 per cent, respectively. In case of total K contribution, through fall, stem flow and rainfall accounted to 46.7, 26.8 and 26.5 per cent, respectively. For the total Ca contribution, through fall accounted for 61.8 per cent, stem flow 25.1 per cent and 13.1 by rainfall. To the total Mg contribution of 25.25 kg ha^{-1}, through fall accounted for 61.8 per cent, stem flow for 23.0 and rainfall for 15.2 per cent.

Nutrients loss through runoff and sediments

The results of the nutrients loss through runoff clearly brought forth that, the highest loss was for Ca, followed by N, Mg, K and P. In case of P only traces were lost through runoff samples. In case of sediments also, the loss was the highest for Ca, followed by K, Mg, N and the least for P (Table 2). The amount of nutrients loss was higher through runoff than by sediments.

Table 2. Loss of nutrients through runoff (kg ha^{-1}) and sediments (kg ha^{-1})

	Nutrients				
	N*	P	K	Ca	Mg

Runoff loss	88.55	-	23.34	111.94	39.73
Sediment loss	2.952	0.583	3.691	8.350	3.300

Total gains and losses of nutrients from teak ecosystem

In teak ecosystem, the contribution of litter fall to the total nutrient gains was the highest for all the nutrients viz., N, P, K Ca and Mg with a share of 91.1, 67.7, 76.7, 90.4 and 75.7 per cent, respectively. Among the nutrients, the return of Ca was the highest and the least was for P. Similar results were also reported by Rajagopal *et al*. (2005) in teak plantation. In case of nutrient losses, the major share was through runoff and only lesser quantities were lost through sediments.

Table 3. Total nutrient gains and losses from teak ecosystem (kg ha^{-1})

Parameters / Nutrients	**N**	**P**	**K**	**Ca**	**Mg**
I. Nutrient gains					
a) Litter (Leaves + flowers + fruits + twigs)	110.26	17.50	35.03	348.97	78.46
b) Rain (Rainfall + stem flow + through fall)	10.75	8.35	10.62	37.23	25.25
Total nutrient gains	121.01	25.85	45.65	386.20	103.71
II. Nutrient losses					
a) Runoff	88.55	Trace	23.34	111.94	39.73
b) Sediments	2.95	0.58	3.69	8.35	3.30
Total nutrient losses	91.5	0.58	27.03	120.29	43.03
Balance = Total nutrient gains – Total nutrient losses	**29.51**	**25.27**	**18.62**	**265.91**	**60.68**

As a whole, the balance of all the nutrients available for recycling by the trees was higher under teak ecosystem. The nutrients available for recycling followed the order of Ca > Mg > N > P > K. Since, the addition of Ca through litter fall and rainfall was superior, the soil was enriched with Ca and relatively higher quantities were available for recycling by the trees.

Conclusion

The nutrient gains were higher than the losses under teak ecosystem and the major share of nutrients returned was through litter components. In addition, stem flow and through fall also contributed a sizable amount of nutrients to0 the gains. These nutrients would be subjected to recycling by teak ecosystem for its growth and productivity.

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