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RESEARCH ARTICLE

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Nutrient dynamics of teak (*Tectona grandis*) in a dry tropical teak forest of Rajasthan

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ABSTRACT

A study was conducted in a dry tropical forest at Udaipur, Rajasthan, India during 2008 to study the nutrient concentration in teak (*Tectona grandis*), the most dominant tree species in the teak forest), litter and soil. Observations were recorded to determine the nutrient content *i.e.,* nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, chloride and sodium in the different parts such as lateral roots, tap root, bark, cork, bole, branches, leaves, flowers/fruits/seeds and litter, and to explore nutrient content *i.e.*, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, chloride, sodium and organic carbon in soils at different depth like 0.00-10.00cm,10.00-20.00cm and 20.00-30.00cm in the same LSE. It was found that the highest amount of the nutrients was present in the foliage and poorer concentration of the nutrients was recorded in the lateral roots. The concentration of the nutrients in the tree components was in the order: reproductive parts > leaf > branch > bole wood > cork > bark in the above ground parts and main root > lateral root in the below ground parts. Greatest amounts of the nutrients were recorded in the 0-10.00cm depth layer while as the lesser or poorer amounts were recorded in the lower layer. The upper layer of soil was found to contain more number of nutrients because of the high organic content present in the upper layer. The leaf component of the plant was found to be the most metabolically active part and it accumulated the high amount of the nutrient. It was observed that the concentration of the nutrients in the soil decreased while as the concentration of the nutrients in the trees increased indicating the accumulation of the nutrients by the plant. There was the reduction in the nutrient concentration of the litter leaves as well as branch litter indicating the transfer of the nutrients from the litter to the soil.

KEY WORDS : Teak, Nutrient dynamics, Tropical forest, Rajasthan

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INTRODUCTION

The tendency of human populations to concentrate in drier climates has hastened the rate of dry forest degradation and the functioning of the ecosystems, particularly with regard to primary production, is generally influenced by the availability of nutrients, and this in turn depends on their distribution and rates of cycling at the ecosystem level. The litter fall and decomposition are two primary mechanisms through which nutrient pool of forest ecosystem gets maintained. If the nutrients are not available to the tree species to an optimum in a forest, the forest is liable to get disturbed. The present investigation was an initial attempt to study the nutrient dynamics of teak (*Tectona grandis*) in dry tropical forest of Rajasthan as the nutrient dynamics studies in dry tropical forests of India have not been extensively studied compared to the other forest types.

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MATERIALS AND METHODS

The site was located between 24.580^{0}N Latitude and 73.680^{0}E Longitude in Udaipur of Rajasthan. It has an average elevation of 598 meters (1961 feet). The climate of Udaipur is tropical with the mercury staying between a maximum of 42.3^{0}C and a minimum of 28.8^{0}C during summers. Winters are a little cold with the maximum temperature rising to 28.8^{0}C and the minimum dipping to 2.5^{0}C. The annual total rainfall received at Udaipur is 61 cm. The forest type is dry tropical forest and the area is totally hilly with undulating terrain.

The composite plant sample was collected from different parts of plants like leaves, twigs, flowers, fruits, seeds, bole (cork and bark) for 10-15 trees. The samples

for the components of roots (main root and lateral root) were collected by digging out roots to 0.5m depth. The samples were taken for two months (January 2008 and March 2008).Composite samples of each component of the selected tree species were oven dried at 30^0C to constant weight and were ground to a fine powder and then taken for the nutrient analysis. The total storage of nutrients in the selected tree species was computed by multiplying the dry weight of the components by their mean nutrient concentration. The values of storage of nutrients in different components were summed up to obtain total storage of nutrients in the selected tree species. After grinding of the plant samples, they were transferred to the polythene bags, were labeled and packed and were stored in the moisture free environment. The samples were stored away from the chemicals, chemical solutions and fertilizers. Composite soil samples were collected at different depths (0 to 10.00cm, 10.00 to 20.00cm and 20-00-30.00cm). Soil samples were collected from the three different positions and were mixed together to form the final sample. The amount of the nutrients estimated for different strata were summed to obtain total nutrient content down to 30 cm depth.

Litter samples were collected from the randomly selected plots of 1m x 1m area and leaf litter and twig litter were collected separately and were weighed separately on site. After that the samples were dried at 30^0C to constant weight, and were ground and passed through the 2mm mesh screen and were taken for nutrient analysis.

For the calculations of the biomass, the selected tree species of the average GBH was selected and was harvested. After the harvesting the leaves, branches, twigs, etc were collected and were weighed separately. The bark, cork and wood were separated from each other using various tools and these were also weighed separately. The main root and the lateral roots were collected by digging to the 1.5m depth or more so that the full root was exposed and was taken out and then weighed. The main root and the lateral roots were weighed separately.

The amount of nutrients(N,P,K and Na) in the soil was determined by the micro-Kjeldhal technique for N(Peach and Tracy, 1956),flame photometry for K and Na and P was determined by Phospho-molybdic blue colorimetric method (Jackson, 1958). Organic carbon, Ca, Mg, Cl and S were determined following Narwal *et al.* (2007).The amount of nutrients in the each stratum of soil was estimated from bulk density, soil volume and nutrient concentration values. The volume of soil per hectare for a soil stratum multiplied by the bulk density gave the weight of soil, which in turn multiplied by corresponding nutrient concentration yielded the nutrient content in that particular stratum. The amount of nutrients estimated for different layers were summed up to obtain total nutrient content down to 30cm depth. The standing state of the nutrients in trees was computed by multiplying the dry weight of each component by respective nutrient concentrations.

RESULTS AND DISCUSSION

The highest concentration of nitrogen was recorded in leaves (1.66%) where as the poorer concentration was recorded in the lateral root. The total nitrogen content increased (0.207%) from one month to another month due to the accumulation of nitrogen in various plant components (Table 1). Despite the lower concentration than foliage, the greatest amount of the nitrogen resided in the bole due to higher proportion of biomass found in it. The percentage phosphorus ranged between 0.04% in lateral root to 0.13% in the leaves. The percentage phosphorous was not much more different from January 2008 to March 2008; however, it increased from one month to another month. Greater amounts of the potassium were recorded in leaves and poorer amounts were recorded in the lateral root. The potassium content ranged between 575.5 kg/ha in lateral root to 5388.3 kg/ha in branches (Table 2). The poorer amount of the sodium was recorded in the lateral root (0.12%). The overall range of sodium was between 0.12-0.13%. The greater amount of sodium was recorded in the leaves. The percentage of total magnesium content ranged from 0.83% in cork to 3.03% in the bark. Despite the lower nutrient concentration, the greatest amount of magnesium resided the bole wood. Highest amounts of sulphur content was recorded in the bole wood, (5.34%) followed by the leaves (5.21%) and branches (5.15%). Content wise the sulphur ranged between 5663.1 kg/ha – 26962.5 kg/ha. N, P, K, Na, Ca, Mg, S and chloride concentration are summarized in Table 2. The nutrient concentration in the various parts of the selected species showed the following trend: leaf > branch > bole wood > cork > bark in the above ground parts and main root > lateral root in the below ground parts. Same observations were reported by Bargaly *et al.* (1992) for Eucalyptus plantation, Perala and Rolfe (1982) for populous, pine and picea stands. In each part of the plant, the concentration of the various nutrients varied from one part of plant to another.

By analyzing the soil samples from the three different depths *viz.,* 0-10.00cm, 10.00-20.00 cm and 20.00-30.00 cm from the study area namely teak forest, it was observed that the soil nutrient concentration decreased with an increase in the depth of the soil. The decreasing

Table 1 : Concentration(%) of various nutrients in different parts of the teak (*Tectona grandis*) in dry tropical forest of Rajasthan

Component	N		P		K		Na		Ca		Mg		S		Cl	
	January 2008	March 2008	January 2008	March 2008	January 2008	March 2008	January 2008	March 2008	January 2008	March 2008	January 2008	March 2008	January 2008	March 2008	January 2008	March 2008
Leaves	1.66	1.65	0.13	0.13	1.07	1.01	0.23	0.20	2.00	1.92	2.00	1.96	35.21	5.12	0.15	0.12
Branches	1.30	1.31	0.11	0.11	1.01	1.03	0.29	0.21	2.48	2.64	1.02	1.22	5.11	5.15	0.08	0.14
Bark	0.66	0.67	0.05	0.05	0.80	0.82	0.16	0.18	3.84	4.08	2.89	3.03	4.94	4.97	0.04	0.07
Cork	0.77	0.77	0.06	0.06	0.89	0.91	0.17	0.19	2.96	3.12	0.83	0.93	4.15	4.2	0.07	0.12
Bole wood	0.91	0.94	0.07	0.07	0.93	0.95	0.18	0.21	3.68	3.84	2.79	2.98	5.34	5.42	0.028	0.05
Main root	0.27	0.29	0.05	0.05	0.70	0.72	0.16	0.18	1.68	1.84	1.76	1.81	4.46	4.51	0.32	0.41
Lateral root	0.20	0.21	0.04	0.05	0.44	0.43	0.12	0.13	1.84	2.00	1.66	1.17	4.33	4.35	0.07	0.12
Total	5.77	5.84	0.51	0.52	5.84	5.87	1.31	1.3	18.48	19.44	12.95	13.10	63.54	33.72	0.758	1.03

Table 2 : Content (kg/ha) of various nutrient in different parts of the teak (*Tectona grandis*) in dry tropical forest of Rajasthan

Component	N		P		K		Na		Ca		Mg		S		Cl	
	Jan 2008	March 2008	Jan 2008	March 2008	Jan 2008	March 2008	Jan 2008	March 2008	Jan 2008	March 2008	Jan 2008	March 2008	Jan 2008	March 2008	Jan 2008	March 2008
Leaves	5360.07	5514.00	448.8	457.30	3455.00	3371.20	743.00	667.60	6458.00	6408.60	6487.00	6542.10	16849.00	17323.30	504.00	423.90
Branches	6435.00	6884.50	543.00	585.90	4984.00	5388.30	1431.0	1098.60	12237.00	13810.80	5078.00	6408.40	25240.00	26962.50	419.00	742.90
Bark	684.00	758.00	54.00	60.40	822.00	917.30	164.00	201.30	3946.00	4563.90	2971.00	3398.30	5076.00	5559.40	44.00	79.40
Cork	923.00	971.60	77.00	81.20	1064.00	1136.40	203.00	237.30	3540.00	3896.30	996.00	1162.60	4963.00	5245.00	85.00	158.60
Bole wood	5071.00	5384.60	430.90	449.70	51.30	5407.40	994.30	1195.30	20328.00	21857.30	15428.50	17013.30	29498.10	30873.30	156.00	318.80
Main root	557.20	621.60	105.70	109.20	1423.50	1511.90	325.40	378.00	3416.50	3863.70	3587.30	3807.00	9070.00	9472.50	650.80	863.00
Lateral root	270.70	289.70	64.10	68.30	575.50	587.70	156.90	177.70	2406.50	2733.40	2178.90	2343.90	5663.10	5945.00	92.90	173.60
Total	19300.97	20424.0	1723.5	1812.0	12375.3	18320.20	4017.6	3955.80	52332.00	57134.00	36726.70	40675.60	96359.20	101381.0	1951.7	2760.2

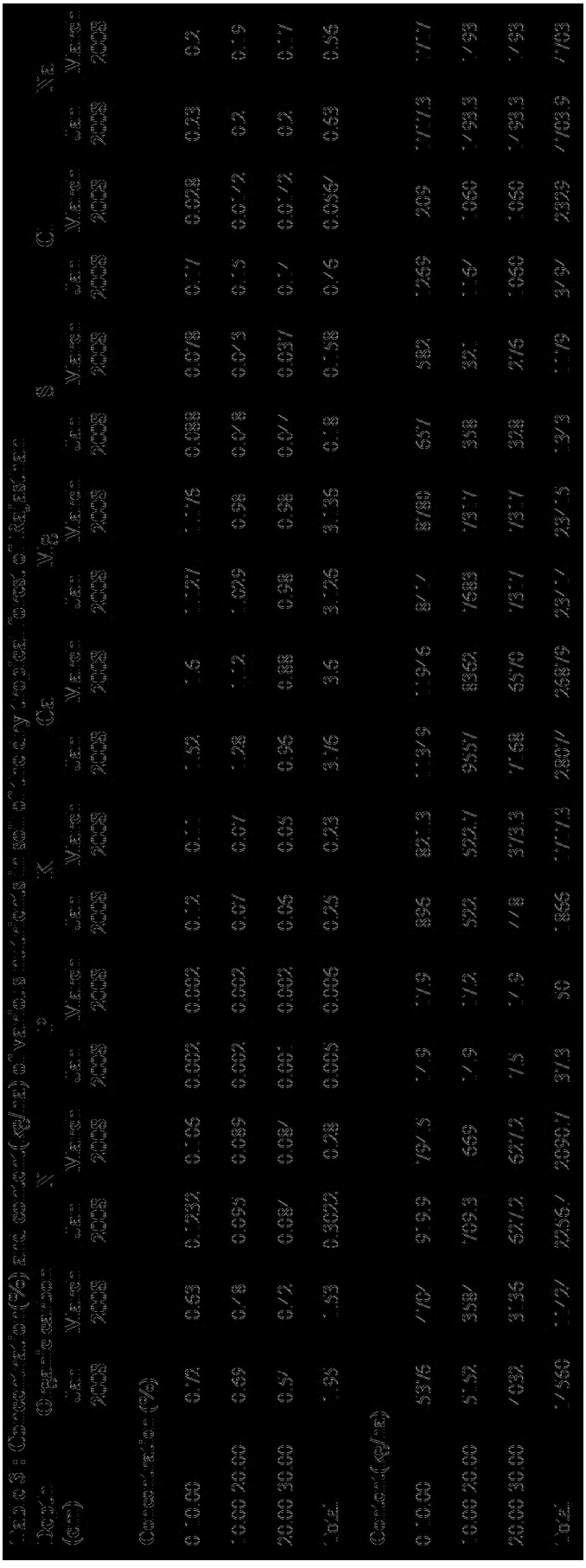
order of the amount of the nutrients present at the three different depths has been shown below-

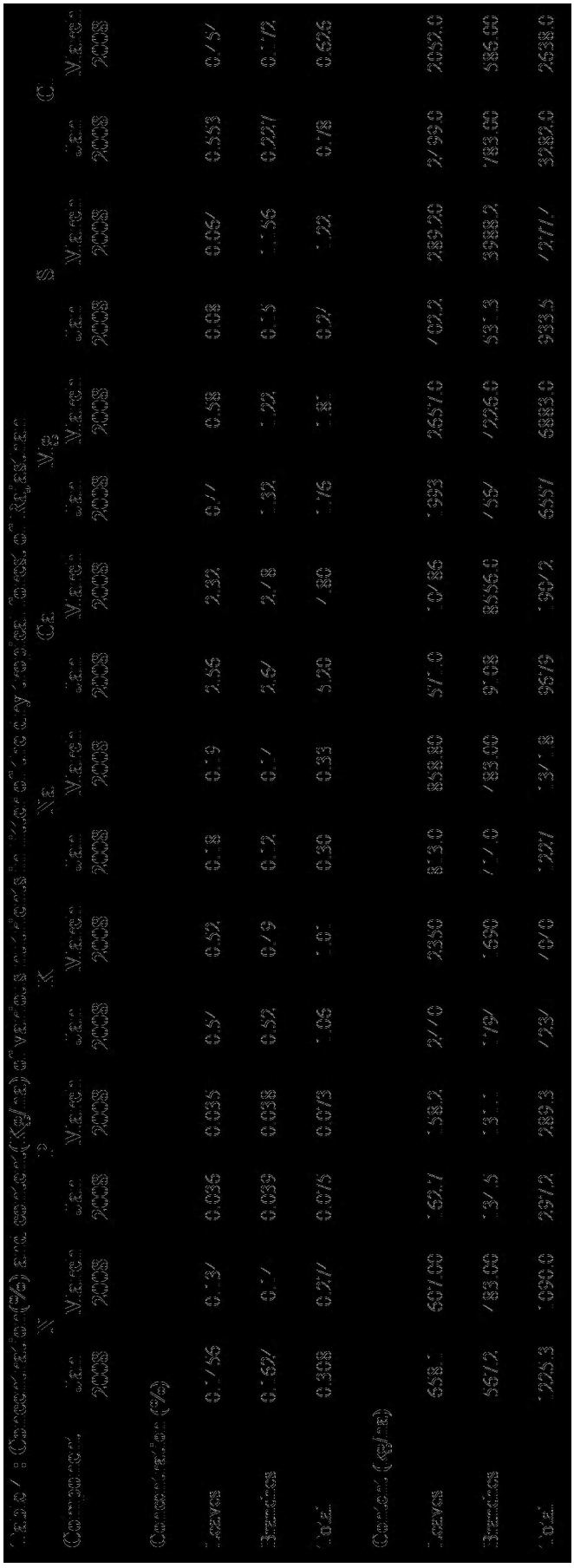
0-10.00 cm depth > 10.00-20.00 cm depth > 20.00-30.00 cm depth

The percentage nitrogen content varied from 0.08% – 0.12%. Higher amounts of nitrogen recorded in the 0-10.00 cm depth layer. Poorer amounts of the phosphorus were recorded from the 20.00-30.00 cm. The phosphorous content ranged from 0.001% - 0.002%. The phosphorus content increased from one month to another month. The calcium content in term of the kg/ha ranged between 6570 kg/ha – 11946 kg /ha. Poorer amounts of the calcium were recorded for the March 2008 as compared to January 2008. The highest amount of the potassium was recorded by the 0-10.00 cm depth layer and was equal to 0.12%. The potassium content also became poorer from one month to another month. The percentage of total sodium content varied greatly from one month to another month and it ranged between 0.17 %– 0.23%. Greater amounts of the magnesium were recorded for the 0-10.00 cm depth and the percentage magnesium depth and the percentage magnesium ranged between 0.98 %– 1.176%. Sulphur content varies from 276 kg/ha – 657 kg/ha and the reduced amounts of the sulphur were recorded for the month of March, 2008. The chloride content varies between 0.0142 - 0.17%. The lower concentration of the chloride was recorded in the month of March 2008 indicating the uptake of the chloride by the plants. The organic carbon of the soil also decreased from one month to another month. Greater amounts of the organic carbon was recorded for the 0-10.00 cm depth layer while as the poorer amount was recorded for 20.00-30.00 cm layer (Table 3).

In the present study, greater proportion of nutrients occurred in surface soil (Table 3) reflecting the massive inputs of nutrients to the soil through litter fall. Soil nutrient concentration decreased with lower down the depth. This pattern of nutrient distribution is in agreement with the reports of Lodhiyal and Lodhiyal (1997).

Table 4 summarizes the total quantity of the various nutrients present in the leaf litter as well as the branch litter. It was observed that the higher amount of the nutrients is present in leaf litter as compared to the branch litter. The high amount of magnesium was present in the branch litter as well as leaf litter followed by the chloride and nitrogen. As expected, the leaf litter and also the branch litter was poorer in nutrient concentration than the healthy green plant, but at the same time it was also observed that the nutrient concentration in the litter decreased from January 2008 to March 2008 due to the transfer of the various nutrients to the soil by the process of decomposition and leaching. Table (4) summarizes the





concentration of N, P, K, Na, Ca, Mg, S and Cl in the leaf litter and twig litter. The percentage of the nitrogen varied from 0.14 %– 0.1456%. Greater amount of the potassium was recorded in the litter leaves (0.52%-0.54%), while as the poorer amount was recorded for the litter twigs. The highest amount of phosphorus content was recorded for branches (0.039%), while as the poorer or the lesser amount of phosphorus was recorded for leaves (0.035%). In terms of the kg/ha the sodium varies between 0.12% (branch) – 0.19% (leaves) and in terms of kg/ha it ranges between 414 kg/ha-858.8 kg/ha. The calcium, magnesium and sulphur contents showed the same trend with higher concentration of nutrients in the branches than the twig. In contrast to it, the higher value of the chloride in the leaf litter was recorded. The overall range of chloride in litter was recorded to be equal to 0.172% - 0.553%.

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