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Research Article

Nutrient dynamics of *Acacia nilotica* in an open dry scrubland forest of Rajasthan

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ABSTRACT : A study was conducted in an open dry scrubland forest of Bhilwara, Rajasthan named Sanjadia during 2008 to study the nutrient concentration in *Acacia nilotica* (the most dominant tree species in an open scrubland 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 and litter, and to explore nutrient content *i.e.*, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, chloride, sodium and organic carbon in soils at different depths 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 : *Acacia nilotica*, Nutrient dynamics, Tropical forest, Rajasthan

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INTRODUCTION

Most trees vary in the efficiency with which they use the nutrients, depending on the nutrient availability. Trees take up large quantities of the nutrients from the soil system and much of the nutrient uptake is returned to the soil by the litter fall, large amount of nutrients are also removed when trees are harvested. 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 *Acacia nilotica* in dry open scrubland forest of Rajasthan as the nutrient dynamics studies in these forests of India have not been extensively studied compared to the other forest types.

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EXPERIMENTAL METHODS

The site was located between 25.20° to 51.64° N Latitude

and 74.38° to 15.12° E Longitude in Bhilwara of Rajasthan. The climate of the area is sub tropical and monsoon. The average temperature ranges from 4^0C to 45^0C. The soil is alluvial, yellowish brown to deep medium black in colour and loamy with rocky beds. The area is consists of luxuriant growth of thorny plants.

The composite plant sample were 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 (December 2007 to February 2008).Composite samples of each component of the selected tree species were 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 suitable polythene bags, were labeled clearly and packed properly and were then stored in the moisture free environment. The samples were also stored away from the chemicals, chemical solutions and fertilizers. Composite soil samples were also collected at different depths viz., (0 to 10.00cm, 10.00-20.00 cm and 20.00cm-30.00 cm). Soil samples were collected from the three different positions and then 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 the leaf litter as well as the twig litter was collected separately and these both were weighed separately on site. After that the samples were dried at 30^0C to constant weight, and then it was ground and passed through the 2mm mesh screen. Thereafter, required amount of sub-samples of litter 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, 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 30.00 cm depth. The standing state of the nutrients in trees was computed by multiplying the dry weight of each component by respective nutrient concentrations.

EXPERIMENTAL RESULTS AND ANALYSIS

The highest concentration of nitrogen was recorded the percentage nitrogen content ranged from 0.1624 per cent in the lateral root to the 1.28 per cent in the leaves and the total amount of nitrogen content varied between 7.4 kg/ha in the bark to the 845.7 kg/ha in the bole wood for the month of December-2007. During February 2008 the percentage nitrogen content ranged from 0.17 per cent in the lateral root to 1.29 per cent in the leaves and the value ranged from 8.41kg/ha, for the bark to 909.478 kg/ha for the bole wood. By comparing the two month's data it was found that the nitrogen content increased in the *Acacia nilotica* from one month to the another month. The total nitrogen content for the month of December in terms of concentrations equal to 4.57 per cent for the month of December and for the month of February it came to be equal to 4.71 per cent and in terms of kg/ha the total nitrogen content for the month of December came equal to 1823.2 kg/ha and for the month of Feb. 2179.0kg/ha. In *Acacia nilotica* the percentage phosphorus content ranged from 0.01 per cent bark and cork to 0.05 per cent (leaves) and the total amount of phosphorus content varies between 0.14 kg/ha(bark) to 25.00kg/ha (bole wood)for the month of December and, however, for the month of the February the percentage phosphorus content ranged from 0.01 per cent (bark)- 0.05 per cent (leaves) and in terms of kg/ha it ranged from 0.19kg/ha (bark)- 25.81kg/ha (bole wood). The phosphorus content also increases from one month to another. The total phosphorous concentration and the content for the month of December came equal to be 0.17 per cent and 0.18 per cent and for the month of February. The total amount of the phosphorus in terms of percentageage came to be equal to 66.98 kg/ha and 75.32kg/ha. In *Acacia nilotica*, the percentage potassium concentration ranged from 0.05 per cent in lateral root to 0.29 per cent in leaves and the potassium content ranged between 1.59 kg/ha in bark to 49.17 kg / ha in leaves for the December month and for the month of February, its percentage ranged from 0.07 per cent in lateral root to 0.26 per cent in leaves. The total quantity of the potassium stored in it increased from December, 2007 to February, 2008. The total potassium stored by it was 0.87 per cent or 331.478 kg /ha in December and 0.92 per cent or 370.19 kg / ha in February. 2008

showing that the potassium storage increased from one month to another month. In *Acacia nitotica*, the percentage sodium ranged from 0.05 per cent lateral root to 0.12 per cent in foliage. The percentage of the total sodium content was not much more different from December to February, however, the total content of sodium increased from one month to the another month indicating the accumulation of the sodium in various plant components. In *Acacia nilotica* the percentage calcium ranged from 1.68 per cent (lateral root) to 2.8 per cent (leaves) and in terms of kg/ha it varied between 38.5632kg/ha (bark) - 2249.59kg/ha (bole wood) for the month of December and for the month of the February the calcium content ranged from 1.84 per cent (in both lateral root and cork)-2.96 per cent (leaves) and in terms of kg/h it ranged from 34.44 kg/h (bark) -2419.2 kg/h (bole wood) . The calcium content also increased from one month to another month. The total calcium concentration and content for the month of the December came equal to be14.16 per cent and 5425.3774 kg/h and for the month of February the total amount of the calcium in the terms of the percentage came to be equal to 15.12 per cent and 6126.146 kg/ha. The Magnesium content ranged from0.245 per cent (bole wood) – 1.029 per cent(bark) and in terms of kg/ha it ranged from 16.533 kg/ha (bark) -517.345 per cent kg/ha (branches) for the month of the December and for the month of the February the magnesium content ranged from 0.441 per cent(bole wood) - 1.0785 per cent(bark) and in terms of the kg/ha it ranged from23.5612 kg/ha (bark)-571.47 kg/ha (branches). The magnesium content also increases from one month to another. The total magnesium content for the month of December came to be equal to 4.753 per cent and 1463.833kg/ha and for the month of February the total amount of the magnesium in terms of percentage came to be equal to 5.39 per cent and1803.5282 kg/ha. The sulphur content ranged from 0.179 per cent (lateral root) - 0.539 per cent (Cork) and in terms of kg/ha,it ranged from the3.9205 kg/ha (bark) -213.5034 kg/ha (bole wood) for the month of the December and for the month of the February the sulphur ranged from 0.205 per cent (lateral root)-0.604 per cent(cork) and in terms of kg/ha it ranged from 4.2249 kg/ha (bark) -263.25 kg/ha (bole wood). The sulphur content also increased from one month to another month. The total sulphur concentration and content for the month of December came equal to 2.167 per cent and 765.5157 kg/ha and for the month of February the total amount of sulphur in terms of percentage came to be equal to 2.388 per cent and 880.6689 kg/ha. These were the results obtained for the selected plant species named *Acacia nilotica* of the study area Sanjadia Bhilwara for the month of December 2007 and February 2008.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. Similar results were reported by Bargali *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 varies from one part of plant to another (Table 1 and 2).

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 Sanjadi, it was observed that the soil nutrient concentration decreased with increase in the depth of the soil. The decreasing order of the amount of the nutrients present at the three different depths is shown below-

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

The nitrogen concentration ranged between 0.0448 per cent - 0.0616 per cent and in terms of content it ranged between 334.506kg/ha to 459.946kg/ha for the month of December and for the month of February it ranged between 0.0392 per cent to 0.0672 per cent in terms of concentration and content wise, it ranged between 292.693kg/ha - 0.501.76kg/ha. The overall range was between 0.0392 per cent - 0.0672 per cent and in terms of kg/ha 292.693kg/ha – 501.76kg/ha. The highest concentration of nitrogen was 0.0672 per cent and was found in 0 – 10.00 cm layer in the February, 2008 and in terms of kg/ha, it was highest in 501.76 kg/ha for the same soil layer. The total nitrogen content and concentration was found to be greater in the December. 2007 and thus the nitrogen content of the soil decreased from December 2007 to February 2008. The phosphorus concentration ranged between 0.00262 per cent - 0.00286 per

Table 1 : Concentration(%) of various nutrients in different parts of *Acacia nilotica* in an open dry scrubland forest of Rajasthan

Component	N		P		K		Na		Ca		Mg		S	
	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008
Leaves	1.28	1.29	0.05	0.05	0.29	0.26	0.12	0.11	2.8	2.96	0.784	0.882	0.449	0.501
Branches	1.03	1.05	0.03	0.03	0.14	0.15	0.10	0.11	1.84	2.00	0.784	0.833	0.269	0.282
Bark	0.46	0.50	0.01	0.01	0.10	0.11	0.04	0.05	1.92	2.08	1.029	1.078	0.244	0.257
Cork	0.64	0.66	0.01	0.03	0.10	0.12	0.08	0.09	1.76	1.84	0.637	0.735	0.539	0.604
Bole wood	0.81	0.84	0.02	0.02	0.12	0.13	0.08	0.09	2.16	2.24	0.245	0.441	0.205	0.244
Main root	0.18	0.19	0.03	0.02	0.07	0.08	0.07	0.08	2.00	2.16	0.735	0.833	0.282	0.295
Lateral root	0.16	0.17	0.02	0.01	0.05	0.07	0.05	0.06	1.68	1.84	0.539	0.588	0.179	0.205
Total	4.57	4.71	0.17	0.18	0.87	0.92	0.54	0.59	14.16	15.12	4.753	5.39	2.167	2.388

Table 2 : Content (kg/ha) of various nutrient in different parts of *Acacia nilotica* in an open dry scrubland forest of Rajasthan

Component	N		P		K		Na		Ca		Mg		S	
	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec 2007	Feb 2008
Leaves	2.20	2.32	8.80	9.32	49.17	46.43	20.80	19.64	423.36	532.282	135.343	158.12	77.51	86.488
Branches	679.9	718.40	16.50	20.53	92.40	102.65	66.00	75.27	1214.179	1368.36	517.345	571.47	177.5	193.463
Bark	7.40	8.40	0.14	0.19	1.59	1.88	0.635	0.8545	38.5632	34.44	16.533	23.5612	3.9205	4.2559
Cork	197.20	210.40	4.29	8.24	30.62	38.016	24.5	28.512	539.045	582.912	195.097	232.84	165.082	191.34
Bole wood	845.70	909.50	25.00	25.81	125.00	140.33	83.33	97.15	2249.59	2419.2	255.16	476.28	213.5034	263.52
Main root	66.70	73.30	9.14	9.03	25.18	30.10	25.19	30.1	719.664	806.112	264.476	310.87	101.472	110.09
Lateral root	24.10	26.70	3.11	2.20	7.518	10.784	7.518	9.243	240.976	382.84	79.879	30.387	26.5278	31.512
Total	1823.2	2179.0	66.98	75.32	331.478	370.19	227.973	260.7695	5425.377	6126.146	1463.833	1803.528	765.5157	880.6689

Table 3 : Concentration (%) and content (kg/ha) of various nutrients in soil of an open scrubland forest of Rajasthan

Depth (cm)	Organic carbon		N		P		K		Ca		Mg		S		Na	
	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008
Concentration (%)																
0-10	0.48	0.48	0.0029	0.0029	0.003	0.003	0.91	0.89	0.481	0.481	0.392	0.441	0.071	0.044	0.23	0.21
10-20	0.45	0.42	0.0028	0.0029	0.003	0.003	0.84	0.78	0.361	0.361	0.343	0.343	0.062	0.039	0.23	0.21
20-30	0.42	0.36	0.0026	0.0027	0.003	0.003	0.63	0.55	0.2	0.28	0.196	0.196	0.044	0.038	0.21	0.2
Total	1.35	0.013	0.0082	0.0085	0.0082	0.009	2.38	2.22	1.042	1.122	0.931	0.98	1.042	1.122	0.67	0.62
Content (kg/ha)																
0-10	3584	3584	21.952	21.354	21.354	21.952	6795	6645.3	3591.17	3591.2	2926.9	3292.8	527.15	327.78	1717	1568
10-20	3360	3136	21.802	20.981	20.981	21.802	6272	5824	2693.38	2693.4	2561	2561.1	459.94	290.45	1717	1568
20-30	3136	2688	19.928	19.562	19.562	19.928	4704.0	4106.7	1496.3	2090.6	1463.5	1463.5	322.53	284.48	1568	1493
Total	10080	9408	63.682	61.897	61.897	63.682	17770.	16576	7780.84	8375.2	6951.4	7317.4	7780.8	8375.2	5002	4629

cent and in terms of content, it ranged between 19.562kg/ha – 21.354kg/ha for the month of December and for the month of February it ranged between 0.280 per cent - 0.48096 per cent in terms of concentration and content wise it ranged between 2090.666kg/ha – 3591.168 kg/ha . The overall range was between 0.2004 per cent – 0.48096 per cent and in terms of kg/ha 1496.3 kg/ha – 3591.168kg/ha. The concentration of phosphorus was 0.00294 per cent was found in 0 – 10 cm layer in February 2008 and in terms of kg/ha it was highest in the same layer and was equal to 21.952 kg/ha The total phosphorus concentration and content both was found to be greater in the month of February 2008 and thus the phosphorus content of the soil increased from the December 2007 – February 2008. Soil nutrient concentration decreased from one month to another month possibly as a consequence of uptake and leaching of the nutrients in the forest. The highest amount of potassium was found in the 0-10.00 cm depth soil layer in the month of December 2007 and the lowest was value was observed in 20.00-30.00 cm depth layer in the month of February 2008. The sodium followed the same trend, however the loss of the sodium was due to its accumulation by the plants present there. The percentage sodium ranged between 0.20 per cent to 0.23 per cent and 1493.3 kg / ha to 1717.3 kg / ha. The percentage of the total sodium was not much more different from one month to another month; however, it slightly reduced because of its uptake and accumulation by the plants. The calcium concentration ranged between 0.2004 per cent - 0.48096 per cent and in terms of content, it ranged between 1496.3 kg/ha – 3591.168 kg/ha for the month of December and for the month of February it ranged between 0.280 per cent - 0.48096 per cent in terms of concentration and content wise it ranged between 2090.666 kg/ha – 3591.168 kg/ha. The overall range was between 0.2204 per cent - 0.48096 per cent and in terms of kg/ha 1496.3 kg/ha – 3591.168 kg/ha The highest concentration of calcium was 0.48096 per cent and was found in between 0 – 10.00 cm layer in the both months *viz.,* December 2007 and February 2008 and in terms of kg/ha it was highest in the same layer and was equal to 3591.168 kg/ha. The total calcium concentration was found to be greater in February 2008 and content wise it was found to be greater in the same month and thus the calcium content of the soil increased from December 2007 to February 2008.The magnesium concentration ranged between 0.196 per cent-o.392 per cent for the month of December and for the month of February it ranged between 0.196 per cent -0.441 per cent and content wise it ranged between 1463.5 kg/ha - 3292.8 kg/ha. The highest concentration of magnesium was 0.441 per cent and was found in the 0-10.00 cm depth of February month and content wise it was highest in the same layer (3292kg/ha).The total magnesium concentration was recorded greater in February 2008 and thus the magnesium content of the soil was found to increase from the December 2007 to February 2008. The sulphur concentration ranged 0.0449 per cent-0.706 per cent and in terms of content it ranged between328.53 kg/ha - 527.146kg/ha for the month of December 2007 and for the month of February it ranged between 0.0381 per cent – 0.0439 per cent in terms of concentration and content wise it ranged between 284.48 kg/ha – 327.786 kg/ha. The overall concentration was between 0.0381 per cent - 0.0706 per cent and in terms of kg/ha 284.48 kg/ha – 527.146 kg/ha. The highest concentration of sulphur was 0.0706 per cent and was found in 0 – 10.00 cm in the December 2007 and in terms of kg/ha it was highest in the same layer and was equal to 527.146 kg/ha. The total sulphur concentration was found to be greater in December month and the sulphur content of the soil decreased from the December 2007 to February 2008. The highest concentration of organic carbon was 0.48 per cent and was found in 0 – 10.00 cm layer in both the month December 2007 and February 2008 and in terms of kg/ha it was highest in the same layer and was equal to 3584 kg/ha. The total organic carbon concentration was found to be greater in December month and the content wise it was also found to be greater in the same month thus the organic carbon content decreased from the December 2007 to February 2008.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

Table 4 : Concentration (%) and content (kg/ha) of various nutrients in litter of an open scrubland forest of Rajasthan

Component	N		P		K		Na		Ca		Mg		S	
	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008	Dec. 2007	Feb. 2008
Concentration (%)														
Leaves	0.504	0.039	0.0086	0.0065	0.04	6.03	0.04	0.02	1.92	1.76	2.352	1.225	0.141	0.131
Branches	0.028	0.0168	0.0158	0.014	0.02	0.01	0.03	0.01	2.00	1.92	1.715	0.441	0.147	0.143
Total	0.532	0.0558	0.0244	0.0205	0.06	6.04	0.07	0.03	3.92	3.68	4.067	1.666	0.288	0.274
Content (kg/ha)														
Leaves	14.6	11.31	2.494	1.885	11.60	8.70	11.60	5.80	556.8	510.40	682.08	355.25	40.89	37.99
Branches	5.04	3.024	2.844	2.52	3.60	1.80	5.40	1.80	360.00	345.60	308.70	791.38	26.46	25.74
Total	19.64	14.334	5.338	4.405	15.20	10.50	17.00	7.60	916.8	856.00	990.78	1146.63	67.35	63.73

distribution is in agreement with the reports of Lodhiyal and Lodhiyal (1997).

Table 4 summaries 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 was 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 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 were also observed that the nutrient concentration in the litter decreased from December 2007 to February 2008 due to the transfer of the various nutrients to the soil by the process of decomposition and leaching.

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