Proc. Indian natn. Sci. Acad., **B62**, No. 4, pp. 281-286 (1996)

Nutrient Dynamics in High Altitude Shrubs of Central Himalaya

S C GARKOTI

Department of Botany, Kumaun University, Naini Tal 263 002

(Received on 9 November 1995; after revision 20 June 1995; Accepted on 7 August 1996)

Dynamics of three macro-nutrients were studied in shrubs of three high altitude forests previously investigated for dry matter dynamics. The nutrient concentration in different plant components were of the order foliage>stem>root whereas the standing state of nutrients were of the order stem > root > foliage. Across the forests the turnover time for different nutrients were 1.3-2.4 yr; these estimates are lower than that of low-altitude shrubs of central Himalaya.

Key Words : Nutrient concentration, Nutrient accumulation, Nutrient Use Efficiency (NUE)

Introduction

Nutrient elements play an important role in physiological activities of plants. The primary production of forest ecosystems is influenced by the availability of nutrients and this in turn depends on distribution and rates of cycling. The concentration of nutrients within any part of an ecosystem usually depends upon a functional balance within the system. This paper deals with information on concentration, standing state, uptake, return, turnover, cycling of nutrients and nutrient use efficiency of shrubs in the high altitudes of central Himalaya.

Materials and Methods

Three forests were selected in between 2750 and 3300 m altitude in Nanda Devi Biosphere Reserve (79° 40′ - 80° 50′ E long., 30° 17′ -30° 41′ N lat.) of the central Himalaya. The study area is in the Indian monsoon region characterised by three main seasons: summer, rainy and winter.

The snow-free period is between May and October, during which rainfall amounts to 2170 mm (Garkoti & Singh 1994). During the snow-free period the mean monthly temperature at 3250m range from 7°C in October to 13°C in June. The mean annual temperature declines from 12.7°C at 2750m to 10.3°C at 3300 m (Singh et al. 1994). Soil temperature at 5cm depth varies from 6°C (October) to 11°C (August). Solar radiation on a clear day reaches 2592 $Jm^{-2}d^{-1}$. The mean relative humidity is high (70%) and seldom declines below 50%, even

during the relatively rainless early summer. Sunshine here declines with an increase in altitude, because of an increase in cloudiness (Müller 1982). The bed rock is made up of schists, highly folded mica plates and phyllites and this formation is known as Pindari formation (Valdiya 1979). Soil is loamy brown earth type, and is slightly acidic in nature (*p*H 5.0-5.63).

The present study was conducted on shrubs of maple (*Acer cappadocicum* Gled.), birch (*Betula utilis* D. Don) and rhodod- endron (*Rhododendron campanulatum* D. Don) forests. The vegetation was sampled by using ten 5×5m quadrate placed randomly. For biomass estimation six individuals representing all dgh (diameter at ground height, i.e. 10cm above the ground) classes were harvested for different species. The harvested individuals were separated into stem (Main stem + branch + twig), foliage and root. Sub-samples (about 200g) for different aboveground and belowground components were brought to the laboratory and oven dried at 80°C to constant weight. The sample shrub data on component weights were converted into stand values using logarithmic regression of each component weight on dgh (Garkoti 1995). Net primary productivity (NPP) represented the net change in biomass of different components in a year (Garkoti 1995). Samples were ground with a Wiley mill to pass through a 0.85 mm mesh stainless steel sieve. Total nitrogen in vegetation and soil was measured with the micro-Kjeldhal method (Peach & Tracey 1956, Misra 1968). Phosphorus was determined by phosphomolibdic blue colorimetric method (Jackson 1958) and potassium by flame photometry (Jackson 1958).

Results and Discussion

Total number of shrub species encountered were four in maple, three in birch, and four in rhododendron forest (table 1), *Thmanocalamus spathiflera* was dominant species in maple (IVI = 183.4) and birch (IVI = 209.5) forests, and *Berberis umbellata* (IVI = 129.1) in rhododendron forest (table 1).

Nutrient Concentrations

The concentrations of nutrients in soil, reflecting the impact of litter fall input on nutrient distribution in soil in general, decreased from surface to deeper soils (Garkoti 1992).

Among the nutrients in plant tissues, N concentration was highest, followed by K and P (table 2). In general, in all species leaf nutrient concentrations were highest and the root nutrient concentrations lowest. These values are comparable with certain mid and high altitude shrubs of central Himalaya (Singh & Singh 1992). The foliage to root nutrient concentration ratio was between 1.2 and 3.5; which were similar to those reported for the low and mid altitude forests of central Himalaya (Singh et al. 1987, Rawat & Singh 1988). Consistent with the observation from the low and mid altitude forests of central Himalaya the low leaf to root concentration ratios in the present species reflected relatively higher values of root nutrients with little differences in leaf nutrient concentrations. It appears that nutrient accumulation in perennial parts is a common nutrient conservation strategy of Himalayan woody plants of all altitudes (Singh et al. 1985).

Standing State of Nutrients

The nutrient accumulation in soil and vegetation was not correlated with altitude, the values for N, P and K accumulation

Table 1 *Shrub structure in different high altitude forests of central Himalaya*

Components	Density shrubs/100 m^2	Frequency (%)	A/F ratio	TBA* cm^2 ha^{-1}	IVI
Maple Forest					
Thamnocalamus spathiflera (Trin) Munro	93.05	65	2.20	149.80	183.41
Sarcoccoca salinga Muel Arg.	70.35	100	0.70	13.94	105.56
Viburhum nervosum D. Don.	0.10	10	0.10	0.05	5.49
Leptadermis laceclata Wall.	0.10	10	0.10	0.02	5.49
Birch Forest					
T. spathiflera	154.00	20	7.700	117.04	209.46
Rosa sericea Lindl.	7.50	40	0.469	4.57	48.31
Berberis umbellata Wall. Ex G. Don	1.10	40	0.069	1.92	42.23
Rhododendron Forest					
B. umbellata	2.30	60	0.006	3.96	129.08
Cotohiaster bacillaris Wall.	2.50	50	0.100	1.47	88.08
R. sericea	1.80	40	0.112	1.01	65.04
Lonicera wabbiana Wall. Ex DC.	0.30	20	0.075	0.11	17.79

*TBA = Total basal area

being highest in birch forest (at 3150 m), followed by maple (at 2750 m) and rhododendron forest (at 3300) (table 3). The greatest amounts of nutrients resided in the stem followed by roots and foliage (table 3). These were similar to the values reported by Rawat and Singh (1988); and Rawat et al. (1994).

The uptake of nutrients in vegetation showed the same patterns as for standing state of nutrients. Trees extract the required nutrients from the soil in proportions that vary from species to species. Nutrient uptake is usually directly proportional to the size

Table 2 *Nutrient concentration (% ± ISE) in different shrub components*

Components	N	P	K
Thamnocalamus spathiflera			
Stem	0.64 ± 0.031	0.03 ± 0.002	0.56 ± 0.049
Foliage	1.18 ± 0.140	0.10 ± 0.008	0.60 ± 0.053
Root	0.52 ± 0.031	0.04 ± 0.002	0.35 ± 0.030
Sarcoccoca salinga			
Stem	0.89 ± 0.072	0.04 ± 0.007	0.50 ± 0.050
Foliage	1.54 ± 0.130	0.12 ± 0.009	0.49 ± 0.042
Root	0.81 ± 0.076	0.06 ± 0.004	0.41 ± 0.039
Berberis umbellata			
Stem	0.56 ± 0.039	0.05 ± 0.003	0.49 ± 0.036
Foliage	1.61 ± 0.131	0.02 ± 0.001	0.92 ± 0.076
Root	0.53 ± 0.041	0.05 ± 0.003	0.33 ± 0.023
Rosa sericea			
Stem	0.58 ± 0.036	0.05 ± 0.004	0.37 ±0.029
Foliage	1.41 ± 0.116	0.14 ± 0.013	0.58 ± 0.046
Root	0.55 ± 0.036	0.04 ± 0.002	0.28 ± 0.018

of net primary production (Rodin & Bazilevich 1967). The values of nutrient uptake in the present study are much lower than the values reported for low altitude forests of central Himalaya (Rawat & Singh 1988).

Nutrient turnover time showed a marked difference among elevation zones (table 3) and was lower than that of low altitude shrubs of central Himalaya (Singh & Singh 1992).

Nutrient Use Efficiency

The production efficiency in terms of dry weight per unit foliage nitrogen was higher for birch (99g g^{-1} leaf N Yr^{-1} compared to rhododendron (86g g^{-1} leaf N Yr^{-1}) and maple (66g g^{-1} leaf N yr^{-1}) (table 4). These values are comparable with those of *Lantana camera* (81g g^{-1} leaf N Yr^{-1}) and lower than those of *Arundinaria falcata* (328g g^{-1} leaf N Yr^{-1}) of low altitude forests of central Himalaya (Rawat et al. 1994).

Table 3 *N, P and K budget in shrub layers*

Compartment Pool (kg $ha^{-1}yr^{-1}$)	N	P	K
Maple			
Stem	9.5	0.5	8.3
Foliage	1.4	0.1	0.7
Root	1.9	0.1	1.1
Soil (to 30 cm depth) (t ha^{-1})	7078.0	176.06	2396.0
Birch			
Stem	9.3	0.5	8.1
Foliage	1.4	0.1	0.7
Root	2.9	0.2	1.8
Soil (to 30 cm depth) (t ha^{-1})	8988.0	370.0	3008.4
Rhododendron			
Stem	0.3	0.26	0.02
Foliage	0.1	0.002	0.1
Root	0.1	0.013	0.1
Soil (to 30 cm depth) (t ha^{-1})	6190	166.1	1841.7
Maple			
Stem	2.8	0.1	2.4
Foliage	1.7	0.1	0.8
Root	1.5	0.1	0.9
Birch			
Stem	5.9	0.3	5.2
Foliage	2.1	0.2	1.1
Root	1.4	0.1	0.9
Rhododendron			
Stem	0.1	0.01	0.01
Foliage	0.3	0.01	0.12
Root	0.1	0.01	0.04
Turnover time of nutrients (yr)	N	P	K
Maple	2.1	1.8	2.4
Birch	1.4	1.4	1.5
Rhododendron	1.3	1.5	1.7

Shrubs of birch forest required less root biomass for a given unit of nutrient uptake than the shrubs of remaining two sites (table 4). It seems that the higher nutrient availability in the soils of birch forest compensates for lower root biomass, otherwise, the trade-off between nutrient acquisition and carbon cost may not have favoured those species in that altitude with low temperature.

Table 4 *Nutrient use efficiency in different forests*

Parameter		Maple forest	Birch forest	Rhododendron forest
NPP of shrub layer per unit of foliage N mass (g g^{-1} leaf N Yr^{-1}) (NPP/ foliage N mass)		66	99	86
NPP/Nutrient uptake	N	143	147	86
	P	2867	2300	1433
	K	210	192	187
Root biomass/	N	50	53	60
nutrient uptake	P	1000	833	1000
	K	73	69	130

Net primary productivity per unit nutrient uptake indicates the nutrient use efficiency. Among the forests studied, in general the shrubs of maple were more efficient than birch and rhododendrons (table 4).

References

Garkoti SC 1995 Shrub layer productivity in central Himalayan high elevation forests; *Indian natn. Sci. Acad.* **B 61** 45-50

———, Garkoti S C and Singh S P 1994 Nutrient cycling in three central Himalayan forests ranging from close canopied to open canopied treeline forests, India; *Arctic and Alpine Research* **26** 339-348

Jackson M L 1994 *Soil Chemical Analysis*. Prentice Hall Inc., U.S.A. pp. 498

Misra R 1968 *Ecology Work Book* pp 244 (Calcutta : Oxford and I.B.H. Publishing Co.)

Müller M J 1982 *Selected Climatic Data for a Global set of Standard Stations for Vegetation Sciences*; (The Hague, The Netherlands : W. Junk

Peach K and Tracey M V 1956 Modern methods of plant analysis. Vol. I. (Berlin L Springler-Verlag)

Rawat Y S, Bhatt Y D, Pandey P and Singh S P 1994 Production and nutrient cycling in *Arundinaria falcata* and *Lantana camara*: the two converted ecosystems in central Himalaya; *Tropical Ecology* **35** 53-67

——— and Singh J S 1988 Structure and function of oak forests in central Himalaya. II. Nutrient dynamics; *Annals of Botany* **62** 397-411

Rodin L E and Bazilevich N I 1967 Production and Mineral Cycling in *Terrestrial Vegetation* pp 294. (Edinburgh, London : Oliver and Boyd)

Singh J S and Singh S P 1992 Forests of Himalaya : Structure, functioning and impact of man. pp 294 (Naini Tal : Gyanodaya Prakashan)

Singh S P, Khanna R K and Singh J S 1985 Accumulation in wood: A nutrient conserving strategy of tropical forests; *Environ Conserv.* **12** 170-173

——— Adhikari B S and Zobel D B 1994 Biomass, productivity, leaf longevity and forest structure in the central Himalaya; *Ecological Monograph* **64** 401-421

Valdiya K S 1979 An outline of the structural setup of the Kumaun Himalaya; *J. Geol. Soc. India* **20** 143-157