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NUTRIENT UTILISATION BY HERBACEOUS FLORA IN COLD DESERT OF HIMACHAL PRADESH, INDIA

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ABSTRACT
The present study was conducted in Goshal, one of the largest villages of cold desert district of Lahaul in Himachal Pradesh, India, during 2012 to 2014 to study the nutrient utilisation by herbaceous flora in alpine pasture ecosystem and agro ecosystem of village Goshal. Sampling for estimation of different plant nutrient contents was carried out by dividing the area into nine grids in both the ecosystems. In alpine ecosystem it is found that among herbs *Erigeron canadensis* showed maximum aboveground nitrogen (2.17%) and minimum belowground nitrogen was reported in *Echinops* corniigerus (0.62%). In agroecosystem Nitrogen content among herbs in aboveground parts were found maximum in *Inula racemosa* (2.45%) and calcium contents was maximum of 0.23 per cent and 0.20 per cent in *Aconitum heterophyllum* in aboveground and belowground parts. We found that the nutrient content was slightly higher in agricultural ecosystem than alpine ecosystem which is as a result of a continuous cultivation and annual addition of farm yard manure and other fertilizers during the cropping season.

INTRODUCTION

An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the non living components of their environment (air, water, soil minerals, etc.), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycling and energy flow. Mountain ecosystems are highly fragile as simple degradation of forest cover leads to severe soil erosion and even changes in river courses (Anonymous, 2003). Cold deserts ecosystem is the lands at the polar fringes of the northern hemisphere continents and the ice covered water of Greenland and Antarctica (Khosla *et al.*, 1993). Cold deserts mainly occur in the interior of Asia and in the mountain zone of North America. The cold desert of India is located mainly in two states, viz., Himachal Pradesh and Jammu and Kashmir. In Himachal Pradesh, the cold deserts are restricted to the districts of Lahaul and Spiti, parts of Kinnaur (Sumdo side) and Pir Panjal in Chamba district. The region is characterized by low precipitation, a short growing season, low primary productivity and high stocking density (Mishra, 2000). Temperatures generally do not exceed 30ºC with July and August as the hottest months. January and February are the coldest months, with a mean temperature of -20.00ºC (Sinha and Samant, 2006). Dry land cultivation is not possible and the entire cultivated area depends on assured irrigation through long, winding streams from the upper mountain reaches (Oinam *et al.*, 2005). The vegetation cover is generally sparse and rarely exceeds one meter in height. Several species of herbs and graminoids such as Festuca, Poa, Stipa and few sedges constitute the forage biomass (Bawa, 2000). The vegetation of a *major part of the district is of dry temperate to dry alpine type.* The inhabitants in cold deserts have traditionally developed a peculiar landuse system by combining agri-silvi-pastoral system, which is both sustainable and environment friendly. During the past few decades with the upcoming of the developmental activities such as education and communication facilities, increase in grazing and browsing in alpine ecosystem the area experienced drastic change in the landuse pattern resulting in environmental and nutrient degradation. Alpine pasture is located just below the forest area, grasses and herbaceous vegetation along with few shrubs species are found growing naturally even under intense grazing pressure. These areas did not receive any inputs from the local residents; however some amount of nutrient is removed by the grazing animals which affect the nutrient storage in different species of alpine pasture ecosystem.Thus the present study was undertaken to support the hypothesis that nutrient storage in alpine ecosystem is continuously depleting as a result of grazing/browsing and developmental activities whereas in agro ecosystem nutrients get added to the soil through fertilisers and FYM. Therefore we carried out this study to estimate and compare the amount of nutrient stored in alpine ecosystem and agro ecosystem through different herbaceous species present in these areas and find out the difference in nutrient stored in these two ecosystems.

MATERIALS AND METHODS

The present investigation was conducted during 2012 to 2014 in village Goshal, located in Lahaul and Spiti district of Himachal Pradesh, India, between 32°33′15.52″N and 76°57′47.34″E at a mean altitude of 2,930 m amsl. Goshal is one of the largest villages in the district with maximum cropping diversity, abundant alpine pastures and adjoining forest area.Village Goshal in the Lahaul Valley is situated on the left bank of the river Chandra just before it merges with river Bhaga. The entire village area as per Revenue records and the adjoining alpine pastures and forest areas under the usage of village residents was differentiated as per the khasra number for Alpine ecosystem and Agro ecosystem. Each ecosystem was divided into nine different grids for sampling following quadrate method. Size of quadrate was estimated following Species Area Curve as proposed by Oosting (1958). Herbaceous species were sampled at the peak nutrient stage (rainy season). The estimation was carried out through quadrates (1x1m) for aboveground nutrient estimation. Below ground estimates were done through digging of monoliths (25 × 25 × 25 cm). Minimum of three quadrates and three monoliths each were taken from each sampled field. The samples from each quadrate were collected and brought to the laboratory for estimation of aboveground and belowground nutrients. For the estimation of the different plant nutrient contents, oven dried plant biomass samples were used. These samples were crushed and grinded in the Willy's mill to pass through 2 mm sieve. Grinded samples were packed separately and used for nutrient estimations. Grinded samples were packed separately and used for nutrient estimations. Nitrogen contents (%) were estimated through Micro Kjeldahl method (Black, 1968). Oven dried powdered plant material (1 g) was digested in sulphuric acid and perchloric acid (10:1 V/V) with a pinch of digestion mixture on a hot plate till the solution turned clear. Phosphorus (%) was determined through chlorostanate molybdophosphoric acid (Jackson, 1973) and the intensity of blue colour developed was read on Spectronic-20 at 660 nm against a blank. KH_2PO_4 was used to develop standard curve for further calculations. Estimations of K, Ca, and Na percentages were carried out through Flame Photometer using their respective filter following Richards (1968) method .

RESULTS AND DISCUSSION

Study area was classified into two ecosystems viz; alpine and agro ecosystem. Alpine pasture is located just below the forest area between 32°32ˡ54.48° N and 76°57ˡ48.47° E with mean elevation of 9,965 ft. Agro ecosystem lies below the alpine ecosystem. In agro ecosystem it was observed that even single field was cropped in parts by planting pea, potato, medicinal plants and vegetables, *etc*., and were regularly supplied with fertilizers (NPK) and Farm Yard Manure. Crops were reported to be grown in rotation in agricultural fields thus keeping the fields fallow for one growing season and planting next year to restore the nutrients. However alpine ecosystem was found uncultivable with minimum productive potential. Cows, sheep, goats, donkey, *etc*., are allowed to graze during the entire growing season (April to September). While estimating aboveground and belowground nutrient content in herbs in alpine ecosystem we found that *Erigeron canadensis* showed maximum aboveground nitrogen (2.17%) and minimum belowground nitrogen was reported in Echinops corniigerus (0.62%). For phosphorus the maximum percentage in aboveground parts 0.25 per cent was in *Podophyllum emodi* and *Podophyllum peltatum*, while the potassium contents showed a range of 0.32 per cent in Verbascum thapsus in aboveground parts to a minimum of 0.18 per cent in belowground parts of Iris ensata (Table 1). In agro ecosystem Nitrogen content among herbs in aboveground parts were found maximum in *Inula racemosa* (2.45%) and least aboveground (0.88%) and belowground (0.77%) nitrogen content were found in *Podophyllum emodi*. The sodium contents were found maximum in aboveground parts of Salvia nubicola (0.28%) and belowground parts of *Veronica triphyllous*. The calcium contents was found maximum of 0.23 per cent and 0.20 per cent in *Aconitum heterophyllum* in aboveground and belowground parts (Table 2). Alpine pasture which is located just below the forest area, reported to experiences intense grazing pressure. These areas did not receive any inputs from the local residents, however grazing is continuously carried out in this area due to which nutrient is continuously removed by the grazing animals affecting the nutrient storage in different species of alpine pasture ecosystem. Tripathi *et al*. (2007) also studied two forests and

Table 1: Nutrient contents in aboveground and belowground parts of herbs in alpine pasture ecosystem.

Species	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Calcium (%)	
	AG	BG	AG	BG	AG	BG	AG	BG	AG	BG
Echinops comigerus	0.96	0.62	0.18	0.17	0.23	0.19	0.26	0.22	0.22	0.21
Erigeron canadensis	2.17	1.7	0.19	0.18	0.25	0.24	0.22	0.2	0.18	0.15
Geranium nepalense	1.95	1.6	0.23	0.21	0.31	0.2	0.16	0.14	0.14	0.11
Iris ensata	1.27	1.11	0.22	0.2	0.18	0.16	0.14	0.11	0.19	0.17
Melilotus alba	1.65	1.27	0.21	0.2	0.31	0.27	0.25	0.22	0.17	0.14
Morina coulteriana	1.99	1.45	0.23	0.2	0.21	0.18	0.16	0.14	0.23	0.12
Picrorhiza kurrooa	1.98	1.68	0.17	0.16	0.27	0.26	0.31	0.27	0.17	0.16
Podophyllum emodi	0.89	0.66	0.25	0.23	0.31	0.27	0.28	0.26	0.24	0.22
Podophyllum peltatum	1.77	1.35	0.25	0.18	0.3	0.25	0.27	0.26	0.25	0.23
Taraxacum officinale	2.05	1.71	0.17	0.16	0.25	0.24	0.21	0.14	0.24	0.14
Thymus serphyllum Sensu	1.56	1.09	0.24	0.22	0.22	0.25	0.28	0.25	0.18	0.16
Trifolium pretense	1.86	0.98	0.21	0.18	0.21	0.2	0.22	0.18	0.25	0.21
Verbascum thapsus	0.96	0.62	0.18	0.17	0.32	0.29	0.26	0.22	0.22	0.21
Veronica triphyllous	2.17	1.7	0.19	0.18	0.25	0.24	0.32	0.28	0.26	0.15

Table 2: Nutrient contents in aboveground and belowground parts of herbs in agro ecosystem.

Species	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Calcium (%)	
	AG	BG	AG	BG	AG	BG	AG	BG	AG	BG
Aconitum heterophyllum	1.87	1.52	0.27	0.24	0.3	0.22	0.18	0.17	0.23	0.2
Allium stracheyi.	2.07	1.76	0.28	0.23	0.26	0.21	0.18	0.17	0.22	0.18
Aquilegia fragrans	1.76	1.46	0.3	0.29	0.27	0.23	0.24	0.22	0.18	0.14
Artemisia brevifolia	1.98	1.89	0.27	0.24	0.23	0.2	0.15	0.11	0.12	0.11
Chenopodium opulifolium	2.17	1.81	0.24	0.24	0.34	0.31	0.22	0.2	0.15	0.13
Delphinium cashmerianum	0.92	0.85	0.25	0.23	0.28	0.21	0.13	0.12	0.22	0.21
Erigerona acer	1.37	1.27	0.22	0.22	0.29	0.22	0.23	0.19	0.19	0.15
Geranium nepalense	1.69	1.52	0.26	0.21	0.26	0.19	0.19	0.17	0.21	0.19
Heracleum thomsonii	1.31	1.21	0.21	0.2	0.32	0.26	0.25	0.24	0.22	0.13
Inula racemosa	2.45	2.05	0.24	0.21	0.28	0.21	0.27	0.24	0.18	0.15
Mentha longifolia	1.86	1.38	0.22	0.2	0.33	0.31	0.19	0.16	0.18	0.15
Podophyllum emodi	0.88	0.77	0.31	0.28	0.25	0.23	0.31	0.23	0.18	0.15
Polygonum chinense	1.79	1.31	0.34	0.3	0.29	0.23	0.14	0.13	0.21	0.17
Salvia nubicola	1.45	1.38	0.25	0.21	0.25	0.18	0.28	0.23	0.15	0.12
Sassuria lappa	2.16	2.1	0.22	0.18	0.34	0.3	0.25	0.14	0.16	0.12
Senecio graciliflorus	1.44	1.3	0.34	0.31	0.25	0.23	0.14	0.13	0.17	0.13
Veronica triphyllous	1.49	1.63	0.27	0.26	0.22	0.16	0.27	0.26	0.16	0.14

two croplands, converted from the forest ecosystem for two years to quantify inorganic nitrogen, nitrification, nitrogen mineralization and microbial nitrogen. On an average, the pool of available nitrogen was slightly higher, while the microbial nitrogen was declined substantially after the conversion of forest into cropland. Cultivation reduced the mean annual net nitrification and net nitrogen mineralization, respectively by 50.71 per cent and 47.67 per cent, respectively. Our study is in line with the studies of Bakshi *et al*. (2015) who found that paddy straw mulch improved soil pH, EC and leaf nutrient status under rainfed conditions. The study of Guleria *et al*. (2002), on nutrient dynamics of grasses under Chir pine (*Pinus roxburghii*) stands in Solan, Himachal Pradesh (India) within the mid hills of Himalayas revealed that nitrogen, phosphorus and potassium increased up to September and declined in October. Minimal difference was observed in nutrient of grasses under Chir pine and open grassland. Our study is supported by the findings of Manga and Sen (2001) who studied the genotypes of *Prosopis cineraria and* observed highly significant differences among the genotypes for chlorophyll 'a', chlorophyll 'b', crude protein, sodium, potassium, calcium and phosphorus. Jain *et al*. (2002) observed significant differences in nutrient composition of leaves of *Azadirachta indica* among different provenances. Kaushal (1998) while working on component interactions in agroforestry systems reported that foliar N. P, K and S content of Morus alba decreased while Ca and Mg increased from July to October. Chapin (1980) studied nutrient uptake when buds break leaf and new foliage begins to grow, the leaf tissues often have high concentration of N, P and K. Kaushal (1998) while working on component interactions in agroforestry systems reported that foliar N, P, K and S content of Morus alba decreased while Ca and Mg increased from July to October. Tripathi and Singh (2007) while studying two forests and two croplands, converted from the forest ecosystem found that cultivation reduced the mean annual net nitrification and net nitrogen mineralization. Murovhi and Materechera *et al*. (2006) reported that the nutrient concentrations were consistently higher in soil from trees that were located in grazing land than croplands. The study of Guleria *et al*. (2002), on nutrient dynamics of grasses under Chir pine (Pinus roxburghii) stands revealed that nitrogen, phosphorus and potassium increased up to September and declined in October. Minimal difference was observed in nutrient of grasses under Chir pine and open grassland. Lower amount of nitrogen, phosphorus and potassium were recorded in belowground biomass compared to aboveground biomass. Overall northern aspect recorded higher amount of nitrogen, phosphorus and potassium under tree and open grasslands.Our study is supported by the findings of Manga and Sen (2001) who studied the genotypes of *Prosopis cineraria and* observed highly significant differences among the genotypes for chlorophyll 'a', chlorophyll 'b', crude protein, sodium, potassium, calcium and phosphorus. Jain *et al*. (2002) observed significant differences in nutrient composition of leaves of *Azadirachta indica* among different provenances. Jain and Bist (2002) reported that nitrogen, potassium and sodium content of poplar leaves differed significantly among selected clones of *Populus deltoides* after five months of plantation. The amount of nitrogen varied from 1.02 to 3.92 per cent, potassium from 0.79 to 2.35 per cent and sodium from 0.17 to 0.38 per cent. Marell *et al*. (2006) found that the N and P concentrations showed marked seasonal variations with peaks occurring from the middle of June to the end of July depending on species and snowmelt progression. The amount of nutrients taken up by the plants primarily depends upon the concentration of nutrient in the close proximity to the root surface (Black, 1968; Russell, 1973). Tripathi *et al*. (2007) found that the pool of available nitrogen was slightly higher, while the microbial nitrogen was declined substantially after the conversion of forest into cropland. Cultivation reduced the mean annual net nitrification and net nitrogen mineralization, respectively by 50.71 per cent and 47.67 per cent, respectively. Sahu *et al*. (2013) found the value of C, N and P% are higher in moderate age (23 years) teak plantation in comparison to value of K%, which found higher in the old age plantation (33 years). Ipsita das and singh (2014) in their field experiment found higher nutrient content in the plot treated with FYM and other organic fertilizers. Sundravalli and Kailash (2005) in their study found that the rate of belowground disappearance was higher than that of litter. The maximum concentration of nutrients occurred in the live shoot component followed by belowground parts. Marell *et al*. (2006) found that the N and P concentrations showed marked seasonal variations with peaks occurring from the middle of June to the end of July depending on species and snowmelt progression.

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