The Bioscan 14(1): 015-018, 2019
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

# BIOMASS PRODUCTIVITY IN MAJOR ECOSYSTEMS OF COLD DESERTS OF HIMACHAL PRADESH

**POONAM* AND R. BAWA**
Department of Forest Genetic Resources, College of Forestry,
Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan - 173 230, Himachal Pradesh, INDIA
e-mail: Poonamwarpa008fty@gmail.com

**KEYWORDS**
Lahaul
Cold desert
Alpine pasture ecosystem
Agro ecosystem

**Received on :**
11.01.2019

**Accepted on :**
04.03.2019

***Corresponding author**

**ABSTRACT**
The present study was conducted at village Goshal, one of the largest villages of cold desert district (Lahaul spitti), in Himachal Pradesh, India, during 2010 to 2013. Biomass productivity was studied by classifying the study area into two major ecosystems viz; Alpine pasture ecosystem and agro ecosystem. *Aboveground and belowground biomass studies showed that* in alpine ecosystem *Agropyron longearistatum* had maximum total aboveground biomass 0.99 kg/m$^2$ among grasses and *Taraxacum officinale* had maximum total biomass 0.86 kg/m$^2$ among herbaceous species. While *Sassuria lappa* had maximum total biomass of 1.62 kg/m$^2$ among herbs in agro ecosystem and potato showed the maximum total biomass 7.29 kg/m$^2$ among crops in agro ecosystem. *Thus it was observed that* the species had higher biomass in agro ecosystem as compared to alpine pasture ecosystem.

## 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 in India cover an approximate area of 74.80 *km*$^2$ under 12 blocks (of total 131 desert area blocks in India), located in Leh and Kargil districts of Jammu and Kashmir and Lahaul and Spiti district with some parts of Chamba and Kinnaur districts of Himachal Pradesh. 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 30°C with July and August as the hottest months. January and February are the coldest months, with a mean temperature of -20.00°C (Sinha and Samant, 2006). The growing season in cold deserts is restricted to less than six months in a year. The key to settlement in cold deserts of Lahaul and Spiti is through the intelligent use of glacial melts. 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). At first glance, one would think that human survival is impossible in this harsh climate. Yet, the local people have learnt to make judicious and optimal use of their limited resources and have built a glorious civilization in the process. The local inhabitants' livelihood is mostly agropastoral. The steppe rangeland vegetation is characterized by the absence of tree layer. 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.

Presently, the biodiversity of Lahaul is under threat through both abiotic and biotic interferences. The main and immediate causes of biodiversity loss in Lahaul can be attributed to habitat loss, degradation and resource over exploitation and climate alteration. Of these by far the most important factor is habitat loss due to over grazing, lopping for fodder and fuel wood, construction of roads and other developmental projects, etc.

Thus we carried out our study to support the hypothesis that overgrazing and other developmental activities in alpine pasture results in the loss of biodiversity.

### Objectives

The objective of our study was to demarcate village area into major ecosystems (alpine pasture ecosystem and agro ecosystem) to carry out aboveground and belowground biomass studies in these ecosystems.

## MATERIALS AND METHODS

The present investigation was conducted during 2010 to 2013 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. Village Goshal in the Lahaul Valley is situated on the left bank of the river Chandra just before it merges with river Bhaga. Goshal village is located on a fan shaped alluvial deposits and occupies 28.90 ha of land. Above the agricultural fields, the area supports grazing lands. As the grazing land rise up, we find the invasion of shrubs. On higher reaches, the area supports conifer forest and above that the glacial level exists from where the melt flow down through gorges and feeds the entire village. The village is well known for its productive fields and farmers prefer to grow peas, potato, vegetables (cabbage), apple, barley and medicinal plants.

Ecosystem Classification: The residents of village Goshal follow agropastoral livelihood and with the age old experience had developed their own landuse pattern depending upon availability and quality of land, availability of water for irrigation plus their requirements for growing of crops, grazing areas for their husbandry and forest areas for other uses. 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: Forest ecosystem, Alpine ecosystem and Agro ecosystem.

**Site selection**

Each ecosystem (forest ecosystem, alpine pasture eco system and agro ecosystem) was divided into nine different grids for sampling. Sampling in each grid was carried out following quadrate method. Size of quadrate for forest ecosystem, alpine pasture ecosystem and agroecosystem was estimated following Species Area Curve as proposed by Oosting (1958). On the basis of Species Area Curve, the quadrate size was 1 × 1 m in both the ecosystems. Three quadrates were laid in each grid in both the ecosystems for recording of phytosociological data.

Biomass determination: Performance of various vegetational units was studied in terms of total biomass production for crops, grasses and herbaceous flora. Plant species were sampled at the peak biomass harvesting stage for each crop. The estimation was carried out through quadrates (1m x 1m) for aboveground biomass studies. Minimum of three quadrates and three monoliths each were taken from each sampled field. The aboveground samples were cut, packed separately in paper bags, brought to laboratory, dried in oven at 80°C till constant weight and weighed for biomass estimations. The belowground parts were first washed to remove all the adhering soil particles, packed collectively in paper bags, oven dried at 80°C and weighed. Belowground estimates were done through digging of monoliths (25cm × 25cm × 25 cm) on each site. The fine roots were separated by wet-sieving (Bohm, 1979). Proportions of live and dead fine roots were estimated following Persson (1982).

## RESULT

Biomass Production: Aboveground and belowground biomass production of grasses and herbs in alpine pasture ecosystem; and major crops, grasses and herbs in agro ecosystem was estimated through harvest method at peak biomass stage. The data was recorded from all the quadrates in each grid was averaged and the values obtained for each category are presented as below.

**Alpine Pasture Ecosystem**

**Grasses and herbs**

Alpine pasture is located just below the forest area grasses and herbaceous vegetation along with few shrubs species were found to be growing naturally even under intense grazing pressure. These areas did not receive any inputs from the local residents; however a large amount of plant biomass is grazed by the grazing animals which disturbs the present status of natural resources in alpine pasture ecosystem.

In alpine pasture ecosystem it was observed that during the harvest stage, maximum total aboveground biomass for grasses was 0.91 kg/m$^2$ for *Agropyron longearistatum* and minimum 0.61 kg/m$^2$ of *Festuca rubra*. Similarly the belowground biomass production ranged from 0.05 kg/m$^2$ for *Festuca rubra* to 0.08 kg/m$^2$ in case of *Agropyron longearistatum*. If we calculate the mean total of aboveground and belowground biomass of different individual grass species in all the nine grids, *Agropyron longearistatum* showed the maximum total biomass 0.99 kg/m$^2$ and minimum total biomass was reported for *Festuca rubra* 0.66 kg/m$^2$ (Figure 1).

In case of herbaceous flora, it was observed that maximum aboveground biomass productivity was depicted by *Taraxacum officinale* (0.79 kg/m$^2$) followed by *Podophyllum peltatum* (0.73 kg/m$^2$). However the belowground biomass productivity in case of herbaceous flora depicted that maximum production was by *Taraxacum officinale* (0.07 kg/m$^2$) and *Podophyllum peltatum* (0.07 kg/m$^2$).The mean total of aboveground and belowground biomass of different herbaceous species in all the nine grids depicted that *Taraxacum officinale* had maximum total biomass 0.86 kg/m$^2$ and minimum total biomass was reported for *Picrorhiza kurroa* 0.34 kg/m$^2$ (Figure 2).

**Agro Ecosystem**

**Grasses and Herbs**

The mean values depicted that the aboveground productivity of grasses ranged between 0.69 kg/m$^2$ in *Bromus asper* to 0.95 in kg/m$^2$ *Dactylis glomerata*; while belowground production was again least in *Bromus asper* with 0.06 kg/m$^2$ and maximum was in *Agropyron longearistatum* and *Dactylis glomerata* of 0.09 kg/m$^2$.The mean total of aboveground and belowground biomass of grasses in all the nine grids of agro ecosystem depicted that *Dactylus glomerata* had maximum total biomass 1.04 kg/m$^2$ and minimum total biomass was reported for *Brumus asper* 0.75 kg/m$^2$ (Figure 3).

In case of herbaceous flora the average values of nine grids for aboveground biomass depicted that the values ranged between 0.25 kg/m$^2$ in *Podophyllum emodi* to 0.85 kg/m$^2$ in *Aconitum heterophyllum*. The mean total of aboveground and belowground biomass of different herbaceous species in all the nine grids of agro ecosystem depicted that *Sassuria lappa* had maximum total biomass 1.62 kg/m$^2$ and minimum total biomass was reported for *Erigeron acer* 0.29 kg/m$^2$ (Figure 4).

**Crops**

The average aboveground biomass productivity in case of crops on grid basis depicted that the maximum aboveground biomass was reported for cabbage 4.25 kg/m$^2$ and rajmah (pulse) showed minimum aboveground biomass of 0.37

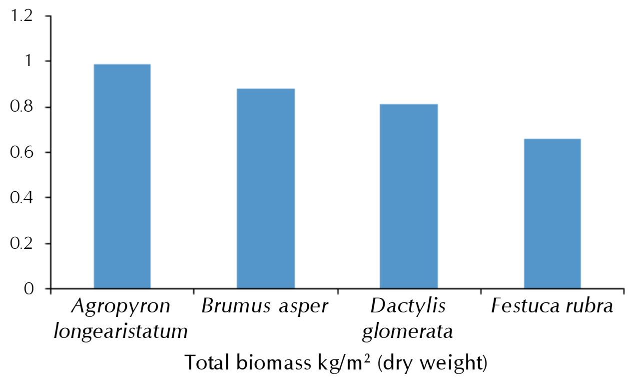


**Figure 1: Mean total of aboveground and belowground biomass of grasses in all the nine grids of alpine pasture ecosystem**

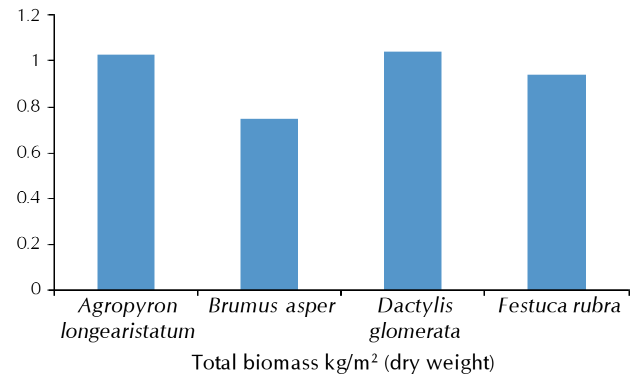


**Figure 3: Mean total of aboveground and belowground biomass of different grasses in all the nine grids of agro ecosystem**

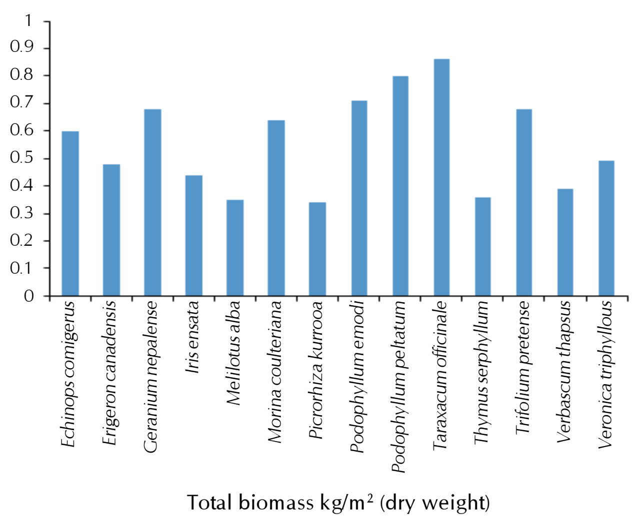


**Figure 2: Mean total of aboveground and belowground biomass of different herbaceous species in all the nine grids of alpine pasture ecosystem**

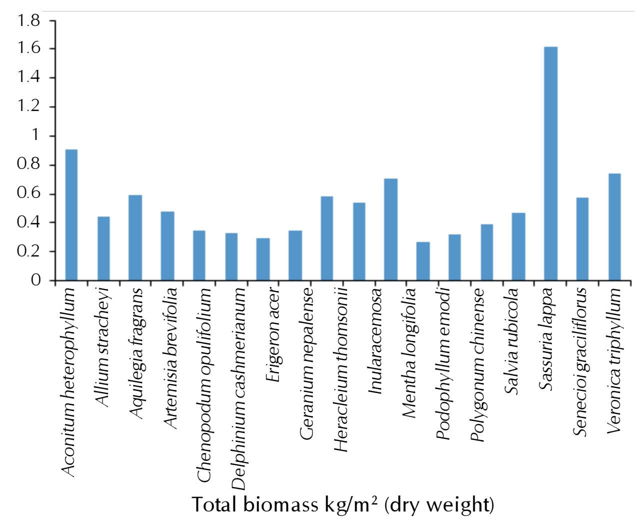


**Figure 4: Mean total of aboveground and belowground biomass of different herbaceous species in all the nine grids of agro ecosystem**

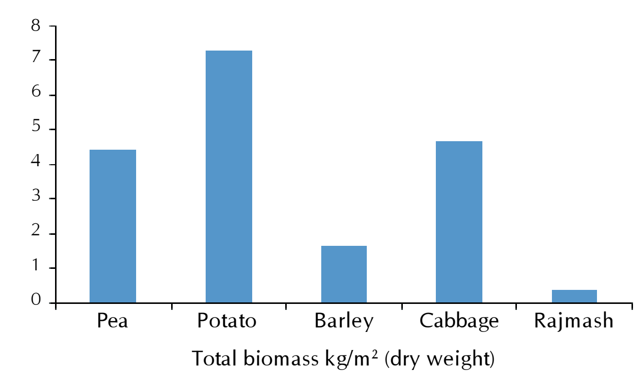


**Figure 5: Mean total of aboveground and belowground biomass of different crops in all the nine grids of agro ecosystem**

kg/m², While potato exhibited maximum belowground biomass of 6.34 kg/m². If we calculate the mean total of aboveground and belowground biomass of different crops in all the nine grids, potato showed the maximum total biomass 7.29 kg/m² and minimum total biomass was reported for rajmah 0.40 kg/m² (Figure 5).

## DISCUSSION

In a similar study on agroforestry ecosystem dynamics in Himachal Pradesh, Nayar (1989) assessed the aboveground plant biomass productivity 1.57, 2.25 and 47.8 t/ha/yr per common land, grassland and orchard, respectively. Among the agricultural crops *Lycopersicon esculentum* gave the higher productivity of 31.83 t/ha. Bijalwan (2009) found that there is reduction in yield of agricultural crop under fruit trees but this reduction is supplemented by fruit production which supports the rural community of hilly region of Garhwal Himalaya. Singh *et al.* (1985) studied the grass production under two age group of Chir pine (15 years and 30 yr) as well as in open grassland and reported that it is possible to harvest 4067.63, 3415.50 and 5004.35 kg/ha/yr herbage biomass, respectively. In a study of dry matter production of herbaceous vegetation in Chir pine forests in Central Himalayas Chaturvedi el. al. (1988) estimated 241 g/m net herbage productivity of which 175 g/m originated from aboveground biomass. They further reported that peak value of aboveground biomass of herbage species occurred during September and October. Sharma and Upadhyaya (2001) revealed the dominance of grasses and forbs in the forest floor vegetation after determininng the species composition, biomass, productivity and nutrient content of herbaceous vegetation of the forestry arboretum on the Aravalli hills in Jaipur, Rajasthan, India. Sahu *et al.* (2013) in their study reported total fine root biomass of vegetation between 4.80 t ha-1 and 9.81 t ha-1 under the teak plantation. Tokey *et al.* (1989) analyzed the species composition, biomass and productivity patterns of three types of traditional agroforestry systems namely: agri-silviculture, agri-horticulture and agri-horti-silviculsture in western Himalayas and reported that species composition in the system varied depending upon the size of land holding and the basic requirement of the farmer. While studying the biomass production patterns in traditional agroforestry systems in Western Himalayas, Mazumdar (1991) reported that horti-silvi-pastoral system gave the highest standing biomass (355.5 q/ha) as compared to horti-agricultural system (301.5 q/ha) and grassland (63.2q/ha). Kumar (1996) conducted bioeconomic appraisal of agroforestry systems in Himachal Pradesh and found that biomass productivity in different agroforestry systems followed the order agrisilvi > agrihortisilvi > agrihorti > sole cropping. As system yielded 1.1, 1.23 and 1.31 times higher biomass in maize and lentil cropping pattern and 1.09, 1.22 and 1.29 times in the soybean and wheat cropping pattern than AHS, AH and sole cropping, respectively. Sharma *et al.* (2014) in their biomass studies on *D. falcatum* found that the total biomass was maximum 3773kg $ha^{-1}$ for site -3, of which above ground biomass was 3376kg $ha^{-1}$ and below ground 397kg $ha^{-1}$.

## CONCLUSION

Aboveground and belowground biomass studies showed that in alpine ecosystem *Agropyron longearistatum* had maximum total aboveground biomass 0.99 kg/m$^2$ among grasses and *Taraxacum officinale* had maximum total biomass 0.86 kg/m$^2$ among herbaceous species. While *Dactylus glomerata* had maximum total biomass (1.04 kg/m$^2$) among grasses and *Sassuria lappa* had maximum total biomass of 1.62 kg/m$^2$ among herbs in agro ecosystem, potato showed the maximum total biomass 7.29 kg/m$^2$ among crops in agro ecosystem. *Thus it was observed that* the species had higher biomass in agro ecosystem as compared to alpine pasture ecosystem which is as a result of a continuous cultivation, frequent irrigation and the annual addition of farm yard manure and other fertilizers during the cropping season; associated with different annual crop rotation and long fallow period of nearly six months each year.Thus the present study was undertaken to generate a strong database, not only for estimating the biomass of various natural grass, herb and crop species growing in the cold deserts but would also be of great help for researchers working in such harsh areas in other parts of the world, planners and decision makers for drawing interlinked sustainable developmental plans for the area for better socioeconomic status and restricting further desertification.

## REFERENCES


**Anonymous. 2003.** United Nations University. UNU/IAS. Report.

***Bawa, R. 2000.*** Structural,functional and economic linkages between major ecosystems of cold deserts in Himachal Pradesh. UHF. Solan. p. 108.

**Bijalwan, A. 2009.** Effect of fruit trees on crop yield in hill and mountain agro-ecosystems of Garhwal Himalaya. *Current Advances in Agricultural Sciences*. **1(1):** 35-37.

**Bohm, W. 1979**. Methods of Studying Root Systems. Springer-Verlag,New York.

**Chaturvedi, O.P.,Saxena, A. K. and Singh, J. C. 1988.** Structural and functional analysis of grazing land under pine forests in Central Himalaya. *Acta Ecologica*. **9:** 167-168.

**Khosla, P. K., Chadha, T. R., Bawa, R. and Rana, K. K. 1993.** Action plan on cold deserts. An integrated approach for sustainable development Regional Centre National afforestation and Eco-development Board, UHF. Solan. HP. India.

**Kumar, M. 1996.** Bio-economic appraisal of agroforestry land use systems. M Sc. Thesis. UHF. Solan. HP India.

**Majumdar, H. K. 1991.** Biomass productivity and nutrient budgeting in different agroforestry systems. Ph.D. Thesis, UHF. Solan. HP.

**Mishra, C. 2000.** Socioeconomic transition and wildlife conservation in the Indian Trans-Himalaya. *Journal of the Bombay Natural History Society*. **97(1):** 25-32.

**Nayar, P. 1989**. Agroforestgry Ecosystem Dynamics in Himachal Himalaya Ph.D. Thesis. Punjab University, Chandigarh, India.

**Odum, E. P. 1971**. *Fundamental of Ecology*. W B Sauders Co.Publ. Philadelphia. p. 57.

**Oinam, S. S., Rawat, Y. S., Khoiyangbam, R. S., Khwairakpam, G., Kuniyal, J.C. and Vishvakarma, S. C. R. 2005.** Land use and land cover changes in Jahlma watershed of the Lahaul valley, cold desert region of the northwestern Himalaya, India. *Journal of Mountain Science*. **2(2):** 129-136.

**Oosting, H. J. 1958**. *The study of plant communities*. Witt Freeman & Co. San Francisco.

**Persson, H. 1982**. Changes in the tree and dwarf shrub fine roots after clear cutting in a mature Scots pine stand. Swed. Coif. For. Proj.Tech. Rep. **31:** 1-19.

**Sahu, K. P., Singh, L. and Jhariya, M. K. 2013.** Fine root biomass, forest floor and nutrient status of soil in an age series of teak plantation in dry tropics. *The Bioscan*. **8(4):** 1149-1152.

**Samant, S. S., Dhar, U. and Palni, L. M. S. 1998.** Medicinal Plants of Indian Himalaya: Diversity distribution potential values. Gyanodaya Prakashan, Nanital.

**Sharma, A., Shahi C., Bargali K, Bargali S. S. and Rawat Y. S. 2014.** Biomass and carbon stock of *drepanostachyum falcatum* (Nees) associated with oak forests at and around nainital. The *Ecoscan*. **8(1&2):** 105-108.

**Singh, D. K. and Hajra, P. K. 1996.** Floristic diversity. In: Gujral, G. S. and Sharma V. Eds. In: changing perspectives of biodiversity status in the Himalayas. British Councel Division. New Delhi.

***Singh, R. P., Gupta, M. K. and Mathur, H. N. 1985.*** *Effect of* ***Pinus roxburghii*** *plantations on the yield and composition of grasses in temperate region. Ind For.* ***111(10),*** *787-793.*

**Sinha, S. K. and Samant, S. S. 2006.** Climate change in the higher Himalayas - a case study in Lahaul Valley. ENVIS News letter: *Himalayan Ecology*. **3:** 3-4.

**Toky, O. P., Kumar, P. and Kumar, Prem. 1989.** Structure and function of traditional agroforestry systems in the western Himalaya: I. Biomass and Productivity. *Agroforestry Systems*. **9:** 47-70.

**Upadhyaya, K., Arunachalam, A., Khan, M. L. and Singh, N. D. 2001.** Ecological and social interactions in agroforestry. Sustainable-management-of-forests-India. pp. 395-408.