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MONTHLY VARIATION IN PLANT BIOMASS AND NET PRIMARY PRODUCTIVITY OF A MIXED DECIDUOUS FOREST AT FOOTHILLS OF KUMAUN HIMALAYA

Bhasker JOSHI[1*], Suresh Chandra PANT[2]

[1)] Department of Science, Surajmal Agarwal Pvt. Kanya Mahavidyalaya, Kichha (Kumaun University, Nainital), Uttarakhand, India

[2)] Kumaun Kesari Pt. Badri Dutt Pandey Govt. P.G. College, Bageshwar, District: Bageshwar - 263640, Uttarakhand, India

Abstract

Variation in plant biomass and net primary productivity of a forest grazing land vegetation was analyzed in Tarai of Kumaun Himalaya near Kashipur. The vegetation was studied at monthly intervals from April 2007 to April 2008. Aboveground green biomass, dead biomass, litter biomass and belowground biomass were recorded as 216.93±42.42 g·m^{-2}, 15.30±8.65 g·m^{-2}, 5.52±2.31 g·m^{-2} and 132.91±41.70 g·m^{-2} respectively. Average total plant biomass was 365.15±70.23 g·m^{-2}. The aboveground, belowground and litter production were 372.33 g·m^{-2}, 339.70 g·m^{-2} and 13.91 g·m^{-2} respectively. Total net primary production was 712.03±23.07 g·m^{-2}. The turnover rates were 1.17, 1.20 and 1.47 for aboveground, litter and belowground parts respectively. Based on system transfer function, the net surplus of organic material as the rate of disappearance was moderately half than the rate of dry matter accumulation.

Keywords: *Forest floor vegetation; Kumaun Himalaya; plant biomass; primary productivity; net production; system transfer function.*

Introduction

The Uttarakhand Himalaya especially the Tarai and Bhawar regions of Kumaun have high floristic diversity [1]. The forest ground vegetation under different forest in Himalayas is extensively used as grazing grounds [2]. No more information is reported on biomass and productivity of forest grazing land vegetation in Tarai region of Kumaun Himalaya. Thus, the present is aimed to determine the monthly variation in biomass, net primary productivity and turnover of dry matter of herbaceous vegetation in forest grazing land vegetation at Tarai of Kumaun Himalaya near Kashipur Uttarakhand.

Geographical Location

The study was carried out in the forest of Tarai area of Kumaun in the foothills of Shivalik mountain of the outer Himalaya adjacent to Kashipur of district Udham Singh Nagar that lie between 29º 14-43.6 N longitude and 79º 03-22.6 E latitude at an elevation of 253.4 m ASL (Fig. 1). The study was conducted from April 2007 to April 2008. The forest area of study area was 558.38 ha (Source: Office of Tarai West Forest Division, Kumaun, Ramnagar, Uttarakhand). The climate is monsoonic with 1414.70±185.24 mm annual rainfall. The average

* Corresponding author: bhaskerjoshiphd@yahoo.com; Phone: +091-9760358365, 09808971254

monthly maximum temperature ranged from 16.7±2.26°C to 38.0±0.70°C and minimum temperature was in the range of 8.2±1.20 to 23.4±0.98°C (Table. 1).

Fig. 1. Map of India and the study area (Udham S. Nagar District)

Table 1. Monthly values of microclimatic data of study area (± Standard Deviation)

Month	Atmospheric Temperature Mean °C		Relative Humidity (%)	Rain Fall (mm)
	Maximum Temperature	Minimum Temperature		
April (2007)	36.2±0.95	20.3±0.87	51.5±9.32	56.4±9.93
May	37.9±1.04	22.7±1.55	46.8±10.21	17.2±2.10
June	38.0±0.70	22.8±1.02	68.8±5.98	187.0±22.75
July	34.3±0.96	23.4±0.98	82.4±7.89	470.8±28.46
August	29.8±1.12	22.4±1.35	86.3±4.87	480.4±36.26
September	34.0±2.49	22.9±0.96	81.6±3.89	179.8±20.45
October	30.4±1.52	17.8±1.24	65.7±7.89	11.2±4.83
November	28.3±1.32	13.6±1.15	66.1±4.35	0.0±0.00
December	23.1±1.29	9.8±0.75	65.2±6.48	1.0±0.00
January	16.7±2.26	8.2±1.20	59.8±7.81	3.0±0.00
February	20.4±1.38	9.3±1.08	61.2±5.79	1.1±0.55
March (2008)	30.0±1.38	17.4±1.31	49.6±8.22	0.0±0.00
Average	**29.9±6.86**	**17.5±5.87**	**5.4±12.93**	**127.99±185.24**
	Total			**1407.9±185.24**

Materials and methods

The aboveground, belowground and litter plant biomass were estimated as the method described by Singh and Yadava [3].

Aboveground net primary productivity was estimated by “Sum of positive changes in biomass plus mortality” method [3-7]. Belowground net primary production and net litter primary production were estimated by method of Singh and Yadava [3]. The total sum of aboveground net primary production (ANP) and belowground net primary production (BNP) was considered as total net primary production (TNP).

Productivity (Rate of Production) on $g\cdot m^{-2}\cdot day^{-1}$ was calculated by dividing the net community production by the number of days in which growth took place. Thus, the rate of production on a yearlong basis was obtained by dividing the annual net community production by 366 days.

The turnover rate of aboveground parts and litter was calculated by the following equation [8-10].

Turnover rate (K) = Aboveground or net production or net litter production/Maximum aboveground biomass or litter biomass

The turnover rate of belowground biomass was calculated as Dahlman and Kucera [11].

Turnover = Belowground Net Production/Maximum Belowground Biomass

Dry matter Dynamics was calculated by method described by Singh and Yadava [3]. With the help of figure 2, some sort of annual balance sheet of dry matter was prepared for different compartments in table 9.

Analysis of variance (ANOVA), standard deviation and regression were used for statistical analysis.

Results

Total aboveground green plant biomass was 2820.21±42.42 $g\cdot m^{-2}$ (Table 2). It varied from 164.22±39.94 $g\cdot m^{-2}$ to 309.88±84.46 $g\cdot m^{-2}$. Analysis of variance indicated a significant difference between the samples collected in different months (F = 2.92, d.f. = 12, 117, LSD = 91.89, P < 0.01).

Table 2. Monthly Variation in the aboveground green plant biomass ($g\cdot m^{-2}$), aboveground dead plant biomass ($g\cdot m^{-2}$), litter biomass ($g\cdot m^{-2}$) and belowground plant biomass ($g\cdot m^{-2}$) of herbaceous vegetation throughout the year (± Standard Deviation)

Months	Above ground green plant biomass	Above ground dead plant biomass	Belowground plant biomass	Total Biomass	Litter biomass
April 2007	169.40±99.81	13.77±13.64	126.52±74.12	309.69±40.05	11.54±7.88
May	276.44±131.01	34.24±13.62	229.57±154.12	540.26±57.36	8.17±2.05
June	164.22±39.94	16.84±8.01	92.74±51.85	273.80±62.45	5.78±2.27
July	200.86±50.96	5.87±2.67	133.71±23.97	340.44±51.63	2.78±0.61
August	205.16±77.56	10.83±7.40	81.32±28.29	297.31±95.22	4.48±1.61
September	309.88±84.46	6.01±4.16	163.98±46.91	479.87±107.41	4.55±2.20
October	192.92±37.18	6.75±3.06	96.21±32.49	295.88±73.15	5.07±2.18
November	199.87±65.55	15.47±8.55	114.52±34.05	329.86±71.29	2.65±1.31
December	255.84±97.06	29.89±14.00	115.50±32.54	401.23±120.37	5.10±2.08
January	189.25±23.92	11.36±3.37	194.29±180.23	394.90±4.46	5.59±2.45
February	219.22±38.01	11.04±2.34	130.41±28.19	360.67±70.60	5.22±3.03
March	238.88±113.74	18.31±10.23	111.58±27.78	368.77±102.96	6.63±3.52
April 2008	198.26±74.28	18.59±14.23	137.58±13.89	354.43±56.05	4.27±2.25
Average	**216.93±42.42**	**15.30±8.65**	**132.91±41.70**	**365.15±70.23**	**5.52±2.31**
Total	**2820.21±42.42**	**198.97±8.65**	**1727.96±41.70**	**4747.14±913.03**	**71.83±2.31**

The standing dead matter biomass was 198.97±8.65 $g\cdot m^{-2}$. I varied from 5.87±2.67 $g\cdot m^{-2}$ to 34.24±13.62 $g\cdot m^{-2}$. Analysis of variance indicated a significant difference between the samples collected in different months (F = 8.70, d.f. = 12, 117, LSD = 10.86, P < 0.01).

Litter biomass was 71.83±2.31 $g\cdot m^{-2}$ (Table 2). It was recorded in a range of 2.65±1.31 $g\cdot m^{-2}$ to11.54±7.88 $g\cdot m^{-2}$. Analysis of variance indicated a significant difference between the samples collected in different months (F = 5.68, d.f. = 12, 117, LSD = 3.60, P < 0.01).

Total Belowground plant biomass was 1727.96±41.70 $g\cdot m^{-2}$ and varied form 81.32±28.29 $g\cdot m^{-2}$ to 194.29±180.23 $g\cdot m^{-2}$. Analysis of variance indicated a significant difference between the samples collected in different months (F = 3.09, d.f. = 12, 117, LSD =

87.77, $P < 0.01$). Total biomass was 4747.14±913.03 g·m^{-2} and recorded in a range of 273.80±62.45 g·m^{-2} to 540.26±57.36 g·m^{-2}. Standing dead/green biomass ratio was minimum in September (0.01). In the remaining months this ratio fluctuates and maximum in May (0.12). In present study, 98.09% living shoot parts contributes in formation of maximum total shoot standing crop in September and in remaining months, it fluctuates. 88.97 % living shoot parts contributes in formation of minimum total shoot standing crop in May. Root/shoot ratio was less in August as 0.37 and higher in January as 0.96 (Table 3).

Table 3. Variation in total shoot (Live + Dead shoot), dead/living (D/L) shoot ratio, contribution of live shoot parts (% plant parts) and Root/Shoot ratio to total shoot of herbaceous vegetation throughout the year (± Standard Deviation)

Month	Total Shoot (Living + Dead)	D/L Shoot Ratio	Contribution of Live Shoot (%)	Root/Shoot ratio
April 2007	183.17±110.04	0.08	92.48	0.69
May	310.69±171.26	0.12	88.97	0.73
June	181.06±104.21	0.10	90.69	0.51
July	206.73±137.87	0.02	97.15	0.64
August	215.99±137.41	0.05	94.98	0.37
September	315.89±214.86	0.01	98.09	0.51
October	199.67±131.64	0.03	96.61	0.48
November	215.34±130.39	0.07	92.81	0.53
December	285.73±159.77	0.11	89.53	0.40
January	200.61±125.78	0.06	94.33	0.96
February	230.26±147.20	0.05	95.20	0.56
March	257.19±155.96	0.07	92.88	0.43
April 2008	216.85±127.04	0.09	91.42	0.63

Net aboveground green production was 336.40 g·m^{-2}. Maximum production was highest in October (116.96 g·m^{-2}) and minimum in April (40.62 g·m^{-2}). From July to September, no dry matter was added. However, dry matter was increased in June and January as 112.23 & 66.59 g·m^{-2} respectively. Loss of dry matter was higher in May (-107.05 g·m^{-2}) and lower in August (- 4.30 g·m^{-2}).

Net aboveground dead production was 35.93 g·m^{-2}. Highest aboveground standing dead production was recorded in January (18.53 g·m^{-2}) and minimum in February (0.32 g·m^{-2}). Loss of dry matter was higher in May (-20.47 g·m^{-2}) and minimum in April 2008 (-0.28 g·m^{-2}).

Table 4. Monthly productions (g·m^{-2}) in aboveground biomass and Monthly productions (g·m^{-2}) and rate of productivity (g·m^{-2}·day^{-1}) in litter biomass of herbaceous vegetation

Months	Aboveground green production	Standing dead production	Total aboveground production	Litter	
				Productivity	Rate of Production
May 2007	-107.05	-20.47	-107.05	+3.37	+0.10
June	+112.23	+17.40	+129.63	+2.39	+0.07
July	-36.64	+10.97	-36.64	+3.00	+0.09
August	-4.30	-4.96	-4.30	-1.70	-0.05
September	-104.72	+4.82	-104.72	-0.07	-0.00
October	+116.96	-0.74	+116.96	-0.52	-0.01
November	-6.95	-8.72	-6.95	+2.42	+0.08
December	-55.97	-14.42	-55.97	-2.45	-0.07
January	+66.59	+18.53	+85.12	-0.49	-0.01
February	-29.97	+0.32	-29.97	+0.37	+0.01
March	-19.66	-7.33	-19.66	-1.41	-0.04
April 2008	+40.62	-0.28	+40.62	+2.36	+0.07
Production	**+336.40**	**+35.93**	**+372.33**	**+13.91**	

Litter production and rate of productivity was 13.91 g·m^{-2} and 0.03 g·m^{-2}·day^{-1} respectively (Table 4). Maximum production and rate of productivity was recorded in May

(3.37 g·m^{-2} and 0.11 g·m^{-2}·day^{-1} respectively) and minimum in February (0.37 g·m^{-2} and 0.01 g·m^{-2}·day^{-1} respectively).

Net aboveground primary production and rate of productivity was 372.33±212.46 g·m^{-2} and 1.02 g·m^{-2}·day^{-1} respectively (Table 5). Maximum production and rate of productivity was recorded in June (129.63 g·m^{-2} and 4.32 g·m^{-2}·day^{-1} respectively), while minimum in April 2008 (40.62 g·m^{-2} and 1.35 g·m^{-2}·day^{-1} respectively).

Table 5. Monthly productions (g·m^{-2}) and rate of production (g·m^{-2}·day^{-1}) in aboveground, belowground and total net production of herbaceous vegetation

Month	Aboveground		Belowground		Total Net Production	
	Production	Rate of Production	Production	Rate of Production	Production	Rate of Production
May 2007	-107.05	-3.43	-103.05	-3.32	-210.10	-6.77
June	+129.63	+4.32	+136.83	+4.56	+266.46	+8.88
July	-36.64	-1.18	-40.97	-1.32	-77.61	-2.50
August	-4.30	-0.10	+52.39	+1.69	+52.39	+1.69
September	-104.72	-3.49	-82.66	-2.75	-187.38	-6.24
October	+116.96	+3.77	+67.77	+2.18	+184.73	+5.95
November	-6.95	-0.23	-18.31	-0.61	-25.26	-0.84
December	-55.97	-1.93	-0.98	-0.03	-56.95	-1.83
January	+85.12	+2.74	-78.79	-2.54	+85.12	+2.74
February	-29.97	-1.03	+63.88	+2.20	+63.88	+2.20
March	-19.66	-0.63	+18.83	+0.60	+18.83	+0.59
April 2008	+40.62	+1.35	-26.00	-0.86	+40.62	+1.35
Total	**+372.33**		**+339.70**		**712.03±23.07**	

Net belowground production and rate of productivity was 339.70 g·m^{-2} and 0.92 g·m^{-2}·day^{-1} respectively. Maximum and minimum production and rate of productivity was estimated in June and March amounting 136.83 g·m^{-2} and 4.56 g·m^{-2}·day^{-1}; 18.83 g·m^{-2} and 0.60 g·m^{-2}·day^{-1} respectively (Table 5).

Net production and rate of productivity was 712.03±23.07 g·m^{-2} and 1.94 g·m^{-2}·day^{-1} respectively. Maximum and minimum production and rate of productivity was recorded in June and March amounting 266.46 g·m^{-2} (8.88 g·m^{-2}·day^{-1}) and 18.83 g·m^{-2} (0.59 g·m^{-2}·day^{-1}) respectively (Table 6).

In present study, aboveground turnover was 1.17, litter turnover was 1.20 and belowground turnover was recorded as 1.47 (Table 7).

Table 6. Productions and rate of production of herbaceous vegetation

Net aboveground primary productions	Production (g·m^{-2})	372.33
	Rate of Production (g·m^{-2} ·day^{-1})	1.02
Net belowground primary productions	Production (g·m^{-2})	339.70
	Rate of Production (g·m^{-2} ·day^{-1})	0.93
Net litter productions	Production (g·m^{-2})	13.91
	Rate of Production (g·m^{-2} ·day^{-1})	0.03
Total net primary productions	Production (g·m^{-2})	712.03
	Rate of Production (g·m^{-2} ·day^{-1})	1.94

Table 7. Turnover of herbaceous vegetation

Aboveground turn over	Aboveground Net Production (g·m^{-2})	372.33
	Maximum Aboveground Biomass (g·m^{-2})	315.89
	Turn Over	1.17
Litter turn over	Net Production (g·m^{-2})	13.91
	Maximum Litter Biomass (g·m^{-2})	11.54
	Turn Over	1.20
Belowground turn over	Belowground Net Production (g·m^{-2})	339.70
	Maximum Belowground Biomass (g·m^{-2})	229.57
	Turn Over	1.47

System Transfer Function

Based on Table 8 it is clear that annually transfer of TNP to ANP compartment was (0.52). Transfer of dry matter from TNP to BNP was (0.47). Transfer of ANP to SD was (0.13). The value for the transfer of SD to L compartment was (1.09). Transfer of dry matter from ANP to L compartment was (0.15). The value for the transfer of L to LD compartment was (0.37). Transfer of dry matter from BNP to RD was (1.03). Transfer of TNP to TD compartment was (0.52).

Table 8. System transfer functions (annual) of herbaceous vegetation

Total net primary productivity to Aboveground net primary production	0.52
Total net primary productivity to Belowground net primary production	0.47
Aboveground net primary production to Standing dead	0.13
Standing dead to Litter	1.09
Aboveground net primary production to Litter	0.15
Litter to Litter disappearance	0.37
Belowground net primary production to Belowground biomass disappearance	1.03
Total net primary productivity to Total disappearance	0.52

Dry Matter Dynamics

In present study, TNP was estimated to 712.03 $g{\cdot}m^{-2}\,yr^{-1}$ (Fig. 2 and Table 9). The ANP and BNP were estimated to 372.33 $g{\cdot}m^{-2}\,yr^{-1}$ and 339.70 $g{\cdot}m^{-2}\,yr^{-1}$. Annually 52.03 $g{\cdot}m^{-2}\,yr^{-1}$ dry matter was transferred to standing dead compartment from ANP. However, input from standing dead to litter (56.89 $g{\cdot}m^{-2}\,yr^{-1}$) was recorded more than that from ANP to SD. Belowground net production (339.70 $g{\cdot}m^{-2}\,yr^{-1}$) to below ground disappearance (350.78 $g{\cdot}m^{-2}\,yr^{-1}$). Litter (56.89 $g{\cdot}m^{-2}\,yr^{-1}$) to litter disappearance (21.18 $g{\cdot}m^{-2}\,yr^{-1}$) ratio (0.37) was comparatively lower than SD (520.33 $g{\cdot}m^{-2}\,yr^{-1}$) to L (568.53 $g{\cdot}m^{-2}\,yr^{-1}$) ratio (1.09). Total disappearance showed that 371.96 $g{\cdot}m^{-2}\,yr^{-1}$ organic matter (52.23% of TNP) was utilized by heterotrophic consumption during study period.

Table 9. Annual balance sheet of dry matter ($g{\cdot}m^{-2}$) of herbaceous vegetation

Above Ground Net Primary Production	
Initial biomass (April 2007)	183.17
Above ground net production	372.33
Total input into the system	555.50
Transfer to standing dead	52.04
Biomass at the end (April 2008)	216.85
Total output	268.89
Unaccounted for	286.61
Below Ground Net Primary Production	
Initial biomass (April 2007)	126.52
Below ground net production	339.70
Total input into the system	466.22
Disappearance of biomass	350.76
Biomass at the end (April 2008)	137.58
Total output	488.34
Unaccounted for	-22.12
Standing Dead	
Initial biomass (April 2007)	13.77
Production of standing dead	52.04
Total input into the system	65.81
Transfer to litter	56.89
Biomass at the end (April 2008)	18.59
Total output	75.48
Unaccounted for	-9.67
Litter	
Initial amount of litter (April 2007)	11.54
Litter production	13.91
Total input into the system	25.45
Litter disappearance	21.18
Litter at the end (April 2008)	4.27
Total output	25.45
Unaccounted for	0.00

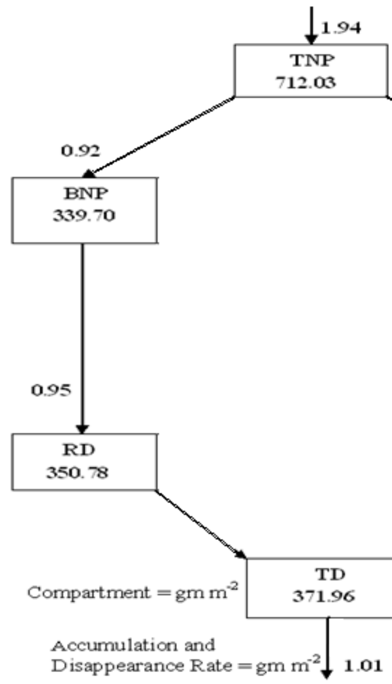

Fig. 2. Net primary production, accumulation and disappearance rates of herbaceous vegetation during whole year (Number of Days = 366): *TNP - Total net primary production, ANP - Aboveground net primary production, SD - (Production of standing dead), L - Litter production, LD - Litter disappearance, TD - Total disappearance from the system, RD - Disappearance of belowground plant biomass, BNP - Belowground net primary production. Values on the arrows give the net accumulation or disappearance raters on a per-day basis.*

Discussions

In the present study, the green biomass shows variations throughout the year. The vegetation growth starts with the onset of monsoonal rainfall (June) and build up of live biomass occurred from July to September and early October, when moisture was adequate and temperature remained favorable. In rainy season, maximum plant species contributed significantly to the total herbage. Following this, the biomass of live shoot declined because of death of shoot [12] and the bulk of biomass is made up of a few important species [3, 13].

Results of present study were similar as studied by Pandey [14] estimated aboveground green and dead biomass as 59.12 $g\cdot m^{-2}$ and 28.01 $g\cdot m^{-2}$ respectively in oak-conifer forests of Himalaya. Rawat [15] estimated average aboveground herbaceous green and dead biomass in *Quercus semecarpifolia* forest of Kumaun Himalaya amounting as 80.96 $g\cdot m^{-2}$ and 38.28 $g\cdot m^{-2}$ respectively.

The dead shoot/live shoot ratio for the forest vegetation showed the impact of precipitation on the vegetation characteristics. The D/L ratio was highest during summer season and minimum during rainy, which indicates that the dead biomass production was maximum in summer and minimum in rainy season. The percent contribution of live shoot for aboveground biomass was maximum during September and minimum during winter and summer, which indicates that green biomass production is directly proportional to the amount of moisture present in the soil. Billings [16] reported that 96 to 98% of living plant material during summer remains underground in the arctic region.

The root/shoot ratio minimum in months of rainy season due to increase in green biomass because heavy rainfall, high moisture and maximum humidity favorable for increase aboveground biomass, however maximum root/shoot ratio was recorded in months of winter season.

The total aboveground biomass was increased in rainy season and then fluctuated in remaining seasons. Aboveground herbaceous biomass in oak forest of Kumaun Himalaya was in the range of 49.0-57.0 $g \cdot m^{-2}$ [17]. Rana *et al.* [18] reported above ground biomass of herbs from different forests of Kumaun Himalaya in a range of 66.0 to 127.6 $g \cdot m^{-2}$. Rawat [15] estimated 119.24 $g \cdot m^{-2}$ aboveground biomass in oak forest of Uttarakhand Himalaya. Lodhiyal *et al.* [19] reported aboveground herbaceous biomass in *Dalbergia sisso* forest as 181.0-220.0 $g \cdot m^{-2}$. Pathak [20] estimated aboveground biomass in range of 160.0 $g \cdot m^{-2}$ to 230.0 $g \cdot m^{-2}$ in forest types of Kumaun Himalaya.

The below ground biomass of herbaceous species contains number of perennial structures, including underground stems, rhizomes which help to propagate them in next growing season [15]. In present study, belowground biomass was varied from 81.32±28.29 $g \cdot m^{-2}$ to 194.29±180.23 $g \cdot m^{-2}$. Similar results was recorded by Rana [21], Khanna [22], Rawat [15] and Pathak [20] as 82.0 $g \cdot m^{-2}$ to 140.0 $g \cdot m^{-2}$, 59.8 $g \cdot m^{-2}\ yr^{-1}$ to 140.1 $g \cdot m^{-2}\ yr^{-1}$, 171.01 to 391.90 $g \cdot m^{-2}$ and 64.0 $g \cdot m^{-2}$ to 117.0 $g \cdot m^{-2}$ respectively in different forest types of Kumaun Himalaya. The aboveground, belowground and total plant biomass was related to the amount of rainfall in different months ($y = 0.834x + 226.4$, $R^2 = 0.005$; $y = -0.946x + 139.5$, $R^2 = 0.007$ and $y = -20.16x + 249.9$, $R^2 = 0.200$ respectively).

Litter biomass was fluctuated throughout the year. The fluctuation for litter throughout the year is the net result of litter production and disappearance [3].

Aboveground productivity of present study was higher as compared by Pandey [14] in Oak-Conifer forest of Central Himalaya as 108.87 $g \cdot m^{-2}\ yr^{-1}$. Rana *et al.* [18] estimated net aboveground production in different forests of Kumaun Himalaya as 66.0–127.6 $g \cdot m^{-2}\ yr^{-1}$. Adhikari [23] estimated aboveground productions in Kharsu Oak forest and Silver fir forest as 82.68 $g \cdot m^{-2}\ yr^{-1}$ and 101.1 $g \cdot m^{-2}\ yr^{-1}$ respectively.

In present study, belowground net primary productivity was estimated was 339.70 $g \cdot m^{-2}\ yr^{-1}$. Sims and Singh [24] described that photosynthates are translocated downwards to storage regions in the roots and thus help to increase the productivity of belowground parts. Sundriyal and Joshi [25] also reported a similar trend in their study. Rana [21] and Khanna [22] estimated belowground production in different forest types of Kumaun Himalaya in range of 76.0 $g \cdot m^{-2}$ to 140.0 $g \cdot m^{-2}$ and 52.70 $g \cdot m^{-2}\ yr^{-1}$ to 176.19 $g \cdot m^{-2}\ yr^{-1}$ respectively.

In present study, net primary productivity was 712.03±23.07 $g \cdot m^{-2}\ yr^{-1}$. Rawat [15] estimated 305.09 $g \cdot m^{-2}$ net production in oak forest of Kumaun Himalaya. Net production was observed by Rawat [17] as 164.4-198.0 $g \cdot m^{-2}\ yr^{-1}$ and Rana *et al.* [18] as 233.5-277.4 $g \cdot m^{-2}\ yr^{-1}$ forest of Kumaun Central Himalaya. Khanna [22] estimated net primary production in a range of 124.82 $g \cdot m^{-2}\ yr^{-1}$ to 308.0 $g \cdot m^{-2}\ yr^{-1}$ in different forest types of Kumaun Himalaya.

Litter production recorded greatest during the dry season. The greatest daily productions of total litter occurred between the end of the rainy season and the beginning of the dry season. This period represents the beginning of a phase of high temperature associated with torrential rains and strong wind [16]. In present study, litter production lowers as compared to oak-conifer and oak forest of Kumaun Himalaya as 385.16 $g \cdot m^{-2}$ and 174.1 $g \cdot m^{-2}$ respectively [14, 15].

The turnover rates were 1.17, 1.20 and 1.47 for aboveground, litter and belowground parts respectively. The observed high turnover rates of the aboveground parts (1.17) indicate their complete replacement within a year [26].

The system transfer function is the quantity by which the system block multiplies the input to generate the output [27] and reflects the orientation of the functioning of an ecosystem in space and time [24]. In present study, total input of 1.94 $g \cdot m^{-2} \cdot day^{-1}$ production into the system, about 52% and 47% were channeled to live shoots and below ground. About 13% of aboveground net production was transferred to dead shoots and 109% to litter. Transfer of live shoots into dead shoot compartment and that of dead shoots into the litter compartment was about 122%. Thus, there was a net accumulation in the live shoot compartment that occurred during the one year of present study. The rate of disappearance of litter was 0.05 $g \cdot m^{-2} \cdot day^{-1}$ and that of belowground was 0.95 $g \cdot m^{-2} \cdot day^{-1}$. The sum of these values is the total disappearance of 1.01 $g \cdot m^{-2} \cdot day^{-1}$. In present study net surplus of organic material as the rate of disappearance was moderately half than the rate of dry matter accumulation.

Conclusions

It is clear from the above results that biomass and primary productivity of forest grazing land vegetation is higher as compared to various forests grazing land vegetation of Central Himalaya (Oak and Pine forests). Maximum biomass and productivity in this area are due to the geography of this area. Tarai area is a transition zone between great Himalaya and Gangiatic plain, and throughout the year, this area is lush green due to high moisture and nutrients content of soil. Various valuable and rare plant species are present in this area. Uttarakhand is an emerging state of India and various industries are well established in Tarai of Uttarakhand. Unfortunately, it leads various anthropogenic activities in forests like collection of soil for construction of industries. In addition, collection of minerals from river, deforestation and excessive grazing cause removal of forest floor. Therefore, immediate conservation of these forests should be necessary for enrich soil nutrient supply as well as biomass and productivity of forest grazing land vegetation.

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References

[1] B. Joshi, *The Magical Herb "Euphorbia hirta* L.*" An Important Traditional Therapeutic Herb for Wart Disease among the Vangujjars of Forest near Kashipur, Uttarakhand,* **New York Science Journal, 4** (2), 2011, pp. 96-97.
[2] S.C. Pant, S.C. Tiwari, *Aboveground biomass of temperate forest grazingland vegetation at Gopeshwar, Garhwal Himalaya,* **Geobios, 19** (1),1992, pp. 29-32.
[3] J.S. Singh, P.S. Yadava, *Seasonal variation in composition of plant biomass and net primary productivity of a tropical grassland at Kurukshetra, India,* **Ecological Monographs, 44**, 1974, pp. 351-376.
[4] J.M. Kelley, G.M. Van Dyne, W.F. Harris, *Comparison of three methods of assessing grassland productivity and biomass dynamics,* **The American Midland Naturalist, 92,** 1974, pp. 357-369.
[5] J.T. Gray, H.S.William, *Biomass, Production and litter fall in the coastal sage scrub of Southern California.* **American Journal of Botany, 68** (1), 1981, pp. 24-33.
[6] M.K. Mishra, B.N. Mishra, *Biomass and primary production in an Indian grassland,* **Tropical Ecology, 25,** 1984, pp. 239-247.
[7] G.B. Pradhan, M.C. Dash, *Seasonal variation in plant biomass and net primary productivity of a savanna type hill ecosystem of Sambalpur, India,* **Tropical Ecology, 25,** 1984, pp.172-178.
[8] H. Jenny, S.P. Gessal, F.T. Bingham, *Comparative study of decomposition rates of organic matter in temperate and tropical region,* **Soil Science, 68,** 1949, pp. 419-432.
[9] J.S. Olson, *Energy storage and balance of producers and decomposers in ecological systems,* **Ecology, 44,** 1963, pp.322-331
[10] M.R. Koelling, C.L. Kucera, 1965. *Productivity and turnover relationship in native tall grass prairie Iowa State,* **Journal Science, 39,** 1965, pp. 387-392.
[11] R.C. Dahlman, C.L. Kucera, *Root productivity and turnover in native prairie,* **Ecology, 46,** 1965, pp. 84-89.

[12] J.S. Singh, M.C. Joshi, *Primary production*, **Grassland Ecosystems of the World: The Analysis of Grassland and their Uses** (ed. Coupland R.T.), Cambridge University Press, 1979, pp 197-218.
[13] J.S. Singh, *Net aboveground community productivity in grasslands at Varanasi*, Proceedings of the Symposyum on **Recent Advances in Tropical Ecology** (eds Misra R. and Gopal B.), ISTE, Varanasi, 1968, pp. 631-654.
[14] U. Pandey, *Leaf fall, leaf litter decomposition and nutrient release in a mixed Oak-Conifer forest*, **PhD Thesis**, Kumaun University, Nainital, India, 1979.
[15] L. Rawat, *Forest floor dynamics, Litterfall, Litter decomposition and Nutrient release in a Quercus semecarpifolia Smith forest of Kumaun Himalaya*, **PhD Thesis**, Kumaun University, Nainital, India, 1990.
[16] W.D. Billings, *Arctic and Alpine vegetations: Similarities, difference and susceptibility to disturbances*, **Bioscience, 23,** 1973, pp. 697-704.
[17] Y.S. Rawat, *Plant biomass, net primary production and nutrient cycling in Oak forests*, **PhD Thesis**, Kumaun University, Nainital, India, 1983.
[18] B.S. Rana, S.P. Singh, R.P. Singh, *Herb layer biomass and net primary productivity in different forest ecosystem of Kumaun Himalaya*, **Western Himalaya: Environment Problems and Development** (eds. Pangtey Y.P.S. and Joshi S.C.), Gyanodaya Prakashan, 1987, pp. 280-299.
[19] N. Lodhiyal, L.S. Lodhiyal, Y.P.S. Pangtey, *Structure and function of Shisham forests in Central Himalaya, India: Dry Matter Dynamics,* **Annals of Botany, 89** (1), 2002, pp. 41-54.
[20] G.C. Pathak, Vegetational Analysis and Productivity of *Shorea robusta* Gaertn. and *Pinus roxburghii* Sarg. *in Kumaun Himalaya*, **PhD Thesis**, Kumaun University, Nainital, India, 2008.
[21] B.S. Rana, *Biomass and net primary productivity in different forest ecosystem along an altitudinal gradient in Kumaun Himalaya*, **PhD Thesis**, Kumaun University, Nainital. India, 1985.
[22] R.K. Khanna, *Standing state of nutrients in different forest ecosystems of Kumaun Himalaya*, **PhD Thesis**, Kumaun University, Nainital, India, 1986.
[23] B.S. Adhikari, *Biomass, Productivity and Nutrient cycling of Kharsu Oak and Silver Fir Forest in Central Himalaya*, **PhD Thesis**, Kumaun University, Nainital. India, 1992.
[24] P.L. Sims, J.S. Singh, *The structure and function of the Western North American grasslands III. Net primary production, turnover and efficiencies of energy capture and water use,* **Journal of Ecology, 66,** 1978, pp. 573-597.
[25] R.C. Sundriyal, A.P. Joshi, *Effect of grazing on standing crop, productivity and efficiency of energy capture in an alpine grassland ecosystem at Tungnath (Garhwal Himalaya), India*, **Tropical Ecology, 31,** 1990, 84-97.
[26] K. Senthilkumar, S. Manian, K. Udaiyan, S. Paulsamy, *Elevated biomass production in burned natural grasslands in Southern India*, **Tropical Grasslands, 32,** 1988, pp. 50-63.
[27] F.B. Golley, *Structure and function of an old-field broom sedge community*, **Ecological Monographs, 35,** 1965, pp.113-137.

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