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Grazingland ecosystem in Garhwal Himalaya and fire effects on plant biomass

Ashita Saklani[1]* • Suresh Chandra Tiwari[1]
[1]*Department of Botany, Hemvati Nandan Bahuguna Garhwal University, Srinagar (Garhwal)-246174, Uttarakhand, India*

*Corresponding Author Email: chandolaashita@gmail.com

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Abstract: The study was conducted for Grazingland Ecosystem in Garhwal Himalaya using three experimental sites, one unburnt protected second burnt protected and third unburnt open grazingland. After burning treatment, the aboveground biomass (live and dead shoot) was found highest in August on burnt plot. Belowground biomass fluctuated quantitatively in the sampling months on all the plots. The litter biomass (dry matter) was found to be highest in May and lowest in July. Net primary production was found to be more in aboveground on burnt plot than on unburnt plot. Turnover rate of aboveground biomass was found to be higher on burnt plot while the below ground biomass and litter biomass was higher on unburnt grazed plot. Turnover time was found to be highest on burnt plot and lowest on unburnt protected plot. It has been shown to lead that the fire treatment increased the aboveground net production and decreased the belowground net production in a considerable way.

Keywords: Fire • biomass • net primary production • turnover rate • grazingland

Introduction

Human population is increasing at an alarming rate and the natural resources are limited. Green plants are the only convertors of solar energy into chemical energy in the form of complex chemical compounds commonly designated as food for all the hetarostorphs. Measurement of the amount and rate of fixation of energy by photosynthesis, as reflected by accumulation of organic matter, is an essential step leading to the understanding of functioning of the ecosystem (Lauenorth and Whitman, 1977). The energy stored by plants is not transferred as such to the hetarostorphs but a huge amount of this is lost in the process of respiration (Leith and Box, 1977). Gross primary production minus respiration, therefore, represents the food energy potentially available to hetarostorphs and is known as the net primary production. Furthermore, the biomass data provides a useful comparison of the actual quantities of plant material that can be harvested at a given time for different treatments. The total dry weight of organisms at any time per unit area is an ecosystem is known as biomass .The biomass, existing in the system at any given time is known as the standing crop, a term which is applied to both plants and animals of the community.

Furthermore, the ground vegetation plays a very important role in ecological characteristics and classification of the forest and grazinglands. In India, in teak plantation in Varanasi Saxena and

Singh (1980) studied the biomass structure of some forest grazingland vegetation in Kumaun Himalayas. Tiwari (1985) reflected variations in biomass and net productivity in Garhwal Himalayas grazinglands. The vegetation and biomass structure of grazinglands in Garhwal Himalaya, Tiwari (1986), Sundriyal (1986), Sahetel (1994) and Bawa (1995). Yet very little attention has been paid on the effects of fire on different landscapes of Garhwal Himalaya. However Tiwari (1980 and 1986) Tiwari et al. (1989); Rawat (1990); Mehra (1990); Semwal (1990) and Bhandari (1995); studied the effect of fire on vegetation on some forest and grazinglands of Garhwal Himalaya.

Materials and Methods

In the present investigation, the assessment of net productivity is based on the increase in plant biomass employing the short term harvest method (Odum 1960). This method measures directly the total net productivity and minus losses due to consumption by insects and decay.

Study area

The experimental plots, a grazingland of 2 – ha area in the University Campus at Chauras (Srinagar, Garhwal) at (30º 12 15 – 30º 15 N , lat , and 78º 50 E, long, and 550 m ams) has been selected .The study plot was divided into three sub plots, out of which , two were unburnt and third was burnt. One from each (control and burnt) was further protected against grazing or other anthropogenic disturbances and the other remained open for grazing by animals. The burnt plot experienced intentional surface ground fire on June 22, 1999.

Results and Discussion

1. Climate, geology and soil

Climatically, the valley exhibits submontane characters, which means, maximum temperature during the study period varied from January (18.80º) to May (35.84ºC) and minimum temperature from December (6.45ºC) to July (24.43ºC). The relative humidity was maximum (85.50%) in July and minimum (49.25%) in April. The maximum rainfall (207.5mm) was observed in June and the minimum (9.5mm) in December.

The area was constituted by the metasedimentaries of Kumaun super group with few linsaid bodies of limestone and dolomite. Mostly the study area is dominated by phyllite. The study area is covered by the terraces of river Alaknanda and by mainly three rock types of the upper proteozoie to lower palezoie ages (Valdiya, 1980).

The soil constitutes an intermixed texture of alluvial deposits. It is mostly sandy along the bank of river Alaknanda .It varies from sandy loam to clayey loam in open agricultural fields and grazinglands. In general, the soil contains 0.16 and 0.99 percent of organic carbon, exchangeable potassium between 108 and 276 kg/ha, while available phosphorus between 0.59 and 20.68 kg/ha and the ph ranges between 6.3 and 6.9 .

2. Sampling of biomass

The phytomass sampling was initiated in the second week of July 1999 and continued month wise for 13 months till July 2000. On each sampling data 10 quadrates of 50 × 50 sq. cm size, were laid down at random in the field. The size of quadrates was determined using species area curve method (Misra, 1968). Thus the total of 30 quadrats (10 quadrats on each plot) was harvested on each sampling data. All the plots were sampled within one week. Harvesting of the aboveground live and standing dead crop was performed at the ground level with the help of sharp scissor. The fallen dead material i.e., litter was collected separately after the plot had been harvested for aboveground live and standing dead vegetation. The aboveground plant material (harvested vegetated and gathered litter from each harvest plots) was packed separately and brought to the laboratory where shoot biomass was separated, species wise into live and dead components. Aboveground and belowground biomass with litter samples of each stand were accounted for fresh and dry weights. The oven-dry weight of samples of each component was computed for sample mean to get the values for total biomass and production. All the samples were put into hot-air oven at 80ºC until constant weight. After cooling, the oven dry weight of each sample was taken up to accuracy of 0.01gm. The dry-weight of all the samples were arranged and computed to gm^{-2}. The soil monoliths analysed for belowground biomass were brought to the laboratory, soaked in water for 24 hours, and washed with a fine jet of water.

The litter sample were washed through floatation and dried at room temperature. All the samples were put in hot-air oven at 80ºC until constant weight and after cooling in the oven dry-weight of every sample was taken up to an accuracy of 0.01gm. The dry-weight of all the samples were arranged to gm^{-2}.

In the present study, the net primary production has been computed using the following method.

The aboveground net primary production (ANP) was calculated as follows:

$$ANP = \sum_{i=1}^{n} \Delta GB + \sum_{i=1}^{n} \Delta DB$$

Where, GB is the positive increment in green biomass, and DB is the positive increment in the standing dead biomass summed over same sampling intervals (n). This method is that if both live and dead materials increased with the same sampling intervals obviously some new production was rapidly transferred from the green component to standing dead component. The method takes into account this transfer and at the same time produced and doubles addition Singh et al. (1975). The belowground net primary production (BNP) was calculated as:

$$BNP = \sum_{i=1}^{n} \Delta RB$$

Where, RB is positive increment in biomass of root over the sampling intervals (n). The total net primary production (TNP) was calculated as:

$$TNP = \sum_{i=1}^{n} \Delta GB + \sum_{i=1}^{n} \Delta DB + \sum_{i=1}^{n} \Delta RB$$

The turnover rate was calculated following the method given by Dahlman and Kucera (1956) as:

$$T = \frac{A}{B}$$

Where, T = Turnover rate, A = Annual increment and B = Maximum biomass. The turnover time = $\frac{1}{T}$

The turnover rate (TR) and turnover time (TT) was computed following the methods adopted by Agarwal and Tiwari (1988) as:

$$TR = \frac{A}{B} \times 100$$

Where, A= net primary production and B = maximum biomass of the period. Also,

$$TT = \frac{B}{A} \times T$$

Where, A and B are same as above and T = time of sampling period.

3. Periodic variation in aboveground biomass and net primary production

The positive increment in dry matter production of live shoot in June was 22.75 on CP and it declined to 15.08 in March to 12.48 in August. The production exhibited and negative value from September (-24.46) until January (-23). In February, it again positive value (1.86) followed by a negative value April (-7.36), May (-11.91) in the following months.

On BP, the dry matter production in live shoots was highest (18.39) in June and decreased the positive value (17.48 and 15.74) were noticed in March and August. The production value was (-37.64) negative in September and again positive in during October (3.16) and November (3.40). Thereafter, production value showed negative trend (-6.37) and January (-1.29) followed by a positive value (2.82) in February. It again showed negative value in April (-6.21) and May (-10.05) followed by primitive value of (2.66) in July' 2000.

On OP, the dry matter production was (24.77) in August and this value decreased to (13.21) in September. In October, it was (3.74) and there after decreased in the following three months (-2.65) and (-4.26) it showed negative values in April and May. In June (6.22) and July (1.86) was there were positive values (Table 1).

The positive increment in dry weight of standing dead crop on CP was (14.79) in September, which decreased to (9.12) in November. The value was negative in January (-3.37) and positive (7.29) in February. In March it again showed negative value followed by a (-7.55) positive value (1.99) in April and May (4.68). It was a negative trained during June (-7.81) and July (-1.96) 2000.

Table 1 Periodic variation in aboveground Net Primary Production of aboveground standing crop.

Month\Plot	Aboveground biomass (gm^{-2})								
	CP		BP		OP		Aboveground Net Primary Production		
	L.S	S.D	L.S	S.D	L.S	S.D	CP	BP	OP
July' 1999	-	-	-	-	-	-	-	-	-
August	12.48 (0.402)	-1.90 (-.061)	15.74 (0.507)	8.50 (0.274)	13.21 (0.426)	-5.03 (-0.162)	12.48 (0.402)	24.24 (0.781)	13.21 (0.426)
September	-24.46 (-0.815)	14.79 (0.493)	-37.64 (-1.254)	12.24 (0.408)	-14.77 (-0.492)	12.10 (0.403)	-24.46 (-0.815)	-37.64 (-1.254)	-14.77 (-0.492)
October	-6.54 (-0.211)	3.09 (0.099)	3.16 (0.101)	2.03 (0.065)	3.74 (0,120)	-10.78 (-0.347)	-6.54 (0.211)	5.19 (0.167)	3.74 (0.120)
November	0.05 (-001)	9.12 (0.304)	3.40 (0.113)	10.38 (0.346)	-1.13 (-0.037)	16.96 (0.565)	0.05 (-0.001)	13.78 (0.459)	-1.13 (-0.037)
December	3.76 (-.121)	-14.97 (-0.482)	-6.37 (0.205)	-16.11 (-0.519)	-4.1 (-0.132)	-16.65 (-0.537)	-3.76 (-0.121)	-6.37 (-0.205)	-4.1 (-0.132)
January, 2000	-0.23 (-0.007)	-3.37 (-0.108)	-1.29 (-0.041)	-10.92 (-0.352)	-4.86 (-0.156)	-1.35 (-0.043)	-0.23 (-0.007)	-1.29 (-0.041)	-4.86 (-0.156)
February	1.86 (0.066)	7.29 (0.260)	2.82 (0.100)	11.97 (0.427)	9.52 (0.340)	-3.4 -0.121	9.15 (0.326)	14.79 (0.528)	9.52 (0.340)
March	15.08 (0.486)	-7.5 (-0.243)	17.48 (0.563)	-3.86 (0.124)	5.23 (0.168)	-0.56 (-0.018)	15.08 (0.486)	17.48 (0.563)	5.23 (0.168)
April	-7.36 (-0.245)	1.99 (0.066)	-6.21 (-0.207)	-11.33 (-0.377)	-2.65 (-0.088)	2.31 (0.077)	-7.36 (-0.245)	-6.21 (-0.207)	-2.65 (-0.088)
May	-11.91 (-0.384)	4.68 (0.151)	-10.05 (-0.324)	-1.52 (-0.049)	-4.26 (-0.137)	-0.35 (-0.011)	-11.91 (-0.384)	-10.05 (-0.324)	-4.26 (-0.137)
June	22.75 (0.758)	-7.89 (-0.263)	18.39 (0,613)	1.56 (0.052)	6.22 (0.207)	1.69 (0.056)	22.75 (0.758)	19.95 (0.665)	7.91 (0.263)
July' 2000	4.18 (0.134)	-1.96 (-0.063)	2.66 (0.550)	17.05 (0.550)	1.86 (0.060)	3.50 (0.112)	4.18 (0.134)	19.71 (0.635)	5.36 (0.172)
Annual Net Production	56.35	40.96	63.65	63.73	39.78	36.56	63.64	115.14	44.96

Values in parenthesis indicate rate of production (gm^{-2} day^{-1}).

On BP, the positive value of dry matter of standing dead crop was highest (17.05) in July' 2000 and the second peak value (12.24) in September. In October, it increased to (10.38) in November. In December and January it showed negative trend of (-16.11) and (-10.92). It was positive (11.97) in February and decreased in the following three months. The dry matter production of positive values was followed by an increased in July, 2000 amounting to (17.05).

On Opted positive increment in dry weight of standing dead crop was (16.96) in November. In December, there was a negative value (-16.65) and April recorded (2.31) positive value. In May, it again negative value followed by a positive value (1.69) in June. Thereafter, it increased to (3.50) until July, 2000 (Table 1).

4. Periodic variation in net primary of aboveground standing crop production (ANP; gm^{-2})

It is evident from Table 1 that on CP, there were ANP (22.75) in June and secondly highest (15.08) in March. It decreased (-24.46) in September to January (-0.23). In February (19.15) it increased and again decreased April (-7.36) to May (-11.91). It followed by a positive increment (4.18) in July, 2000.

On BP, the highest production (24.24) in August and it decreased (-37.64) in September. In October (5.19) to November (13.78) it increased and again decreased December (-6.37) to January (-1.29). This value again increased (14.79) in February to March (17.48) and reduction in April (-6.21). The net primary production showed positive increment from June (19.95).

On OP, ANP was maximum (13.21) in August and declined (-14.77) in September. Positive increment was noticed in the month of October (3.74) which there was negative production in November (-1.13). Production declined thereafter, the following months up to January (-4.86).

In February, (9.52) increased its positive increment. Therefore, the net primary positive increment noticed in June (7.91). ANP was recorded on all plots (63.64) gm^{-2} y^{-1} on CP (115.14) gm^{-2} y^{-1} BP and (44.97) gm^{-2} y^{-1} on OP.

Table 2 Periodic variation in Net Primary production of belowground standing crop.

Month	Below Ground Net Primary Production (gm^{-2})		
	CP	**BP**	**OP**
July' 1999	-	-	-
August	9.56(0.308)	11.41(0.368)	1.93(0.062)
September	-0.88(-0.029)	6.11(0.203)	12.74(0.424)
October	1.22(0.039)	-8.73(-0.281)	-4.30(-0.138)
November	-4.72(-0.157)	-7.06(-0.235)	-2.51(-0.083)
December	-3.65(0.117)	5.04(0.162)	1.51(0,048)
January' 2000	6.80(0.219)	1.53(0.049)	2.09(0.067)
February	-11.51(-0.411)	-8.73(-0.113)	-6.15(-0.219)
March	7.42(0.239)	3.54(0.114)	0.55(0.017)
April	3.42(0.114)	5.60(0.186)	1.53(0.051)
May	4.14(0.133)	3.67(0.118)	3.19(0.102)
June	2.52(0.081)	1.98(0.066)	1.54(0.051)
July' 2000	2.52(0.081)	1.75(0.056)	7.20(0.232)
Annual Net Production	36.08	40.63	32.28

Values in parenthesis indicate rate of production ($gm^{-2}day^{-1}$).

5. Periodic variation in net primary production of belowground standing crop (BNP gm^{-2})

It is evident that the Table 2 show on CP highest belowground dry standing crop biomass production (BNP) was (9.56) August and reduced to (-0.88) in September. In November (-4.72) to December (-3.65) its value was regularly reduced and its positive increment was noticed in March (7.42). On BP, highest belowground dry matter production biomass (11.41) in August and in October (-8.73) to November (-7.06) notice their negative value.

In December, (5.04) recorded its positive increment thereafter, February observed its negative value (-8.73). March (3.54) to July 2000 (1.75) noticed regularly positive increment. On OP, peaked (12. 74) in September, and reduced that value (-4, 30) in October to (-2.51) November. In December (1.51) to January (2.09) increased its positive increment and just after, February (-6.15) noticed its negative value. In March (0.55) to July 2000 (7.20) was noticed gradually its positive increment.

On OP, peaked (12.74) in September, and reduced that value (-4.30) in October to (-2.51) November. In December (1.51) to January (2.09) increased its positive increment and just after, February (-6.15) noticed its negative value. In March (0.55) to July 2000 (7.20) was noticed gradually its positive increment. The BNP across the plots was noticed their positive increment (36.08) $gm^{-2}\ y^{-1}$ on CP (40.63) $gm^{-2}\ y^{-1}$ on BP and (32.28) $gm^{-2}\ y^{-1}$ on OP.

6. Turnover Rate

Table (4) indicates that turnover rate (percentage) for aboveground biomass which was highest on BP (96.77%) and lowest on CP (79.65%) for belowground biomass, turnover rate was maximum (76.18%) on OP, while minimum (70.62%) on BP.

Turnover rate for litter biomass was maximum (86.67%) on OP and minimum on BP (67.43%). Turnover time for aboveground biomass which was highest on BP (12.58) and lowest on CP (10.35) and belowground biomass time was maximum (9.90) on OP, minimum (9.18) on BP. Turnover time for litter biomass was highest (11.26) on OP and lowest on (8.76) on BP.

Table 3 Aboveground (ANP) Belowground (BNP) and Total net primary production (TNP) ($gm^{-2}\ y^{-1}$) in different grazinglands in response to fires treatment.

Plot	Treatment	ANP	BNP	TNP	Reference
Orissa	Burnt (May)	759.26	-	-	Malana and Misra, 1982
	Control	590.82	-	-	-do-
Pauri (Garhwal)	Burnt (November)	572	577	1149	Tiwari, 1980
	Burnt (Nov. + May)	564	586	1150	-do-
	Control	303	908	1211	-do-
Srinagar (Garhwal)	Burnt (December)	453	255	708	Agarwal, 1985
	Burnt (Dec. + June)	546	393	939	-do-
	Control	565	309	874	-do-
	Open	603	406	1009	-do-
Chauras (Tehri Garhwal)	Burnt (June)	127.38	40.63	168.01	Present investigation
	Control	97.31	36.08	133.39	-do-
	Open	76.34	32.28	108.62	-do-

Table 4 Maximum Standing crop, net primary production (NPP), turnover rates and turnover time for various components.

Plot	Maximum standing crop (gm^{-2})		Net Production ($gm^{-2}\ y^{-1}$)	Turnover Rate (%)	Turnover Time (Months)
CP	Aboveground	122.16	97.31	79.65	10.35
	Belowground	48.92	36.08	73.75	9.58
	Litter	43.94	36.95	84.09	10.93
BP	Aboveground	131.62	127.38	96.77	12.58
	Belowground	57.53	40.63	70.62	9.18
	Litter	58.16	39.22	67.43	8.76
OP	Aboveground	79.67	76.34	95.82	12.45
	Belowground	42.37	32.28	76.18	9.9
	Litter	40.23	34.87	86.67	11.26

Discussion

Increase in the live shoot biomass reflects active growth of species and decrease has been associated with the death of annual species as well as seasonal plant species of perennials following maturity.

Grazingland fire is characterised by a rather narrow zone of flames advancing across a more or less homogeneously dispersed fuel. The amount and rate of heat released as vegetation burns depend on weather conditions, topography and amount of fuel.

The aboveground biomass (live + dead shoot) and belowground biomass showed almost identical trends to all the plots. In the present investigation, the live shoot biomass was higher on BP than on OP. This is conformity with the observation of Rawat (1990); Mehta (1990) and Bhandari (1995). They observed higher biomass on BP than on CP for Garhwal Himalaya in grazinglands. Gupta and Singh (1995) reported that the aboveground and belowground biomass was higher on CP as compared to BP. In the present investigation, aboveground biomass was higher on BP than on CP.

Bhandari et al. (1999) reported that the greater number of species contributed to total herbage its peak growing month in August. Furthermore, the aboveground biomass values were higher on unburnt plot than on the related unburnt grazed plot (fig. 3). The litter biomass in the present study did not any significant difference on the CP and BP. This observation supports Semwal (1990) and Bhandari (1995) for the grasslands of submontane zone of Garhwal Himalaya, grassland of Garhwal Himalaya during the post burn of growing season. These factors pointed out the ultimate result of fuel loud present at the time of burn along with the amount of moisture percentage in the atmosphere.

The lower biomass on grazed plot was also observed by Agarwal (1985); Rawat (1990); Mehta (1990) and Bhandari (1995). Kala and Rawat (1999) reported the loss of biomass due to grazing by live stock. The belowground biomass during study period did not show any significant difference between unburnt and burnt plots. On the entire plot, the ANP was more than BNP. The belowground standing crop fluctuated quantitatively in the sampling months on all the plots. The minimum quantity of average belowground biomass on the grazed plot was due to replacement of aboveground parts during the use of herbivores which ultimately affected the translocation of food materials to the belowground parts.

Net Primary Production

The present investigation aboveground net production (ANP) and belowground net production (BNP) was maximum during post burn growing season on BP (Table 3). This result was also supported by Mehta (1990) for Garhwal Himalaya.

In the present study, protected plot had more ANP than on the grazed plot. The ANP higher on BP (127.38 gm^{-2}) than CP (97.31 gm^{-2}). Highest dry matter production occurred during rainy season on all the plots (Table 1). Sah et al. (1994), Rena and Richard (1994) and Bandar (1995) also observed the dry matter production was maximum in rainy season. The main growth period of the vegetation was the rainy season is reported by Sundaravalli and Paliwal (2000). The present investigation maximum ANP was found on burnt grazinglands than on unburnt one. Daubemnire (1968), Tiwari et al., (1989) Rawat (1990), Mehta (1990) and Bhandari (1995) observed that the fire increase ANP during post burn season.

Present Investigation on Fire

Treatment increased the aboveground net production and decreased the belowground net production. Malana and Misra (1982) also reported that once fire treatment increased the net production (Table 3).

In the present investigation, turnover rate of aboveground biomass (6.13) was higher on unburnt grazed plot followed by control plot. The turnover time inversely related to turnover rate.

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