Effect of cutting height and frequency on the above-ground biomass in a central Himalayan grassland in India

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Abstract

The seasonal changes in the biomass of top growth and litter in a temperate grassland with a 6-month growing season in the central Himalayan region were investigated. Treatments consisted of 2 cutting schedules (30 and 60-day intervals) and 2 cutting heights (5 and 15 cm) and an unclipped control. *Chrysopogon montanus, Heteropogon contortus* and *Eulalia trispicata* were the dominant grasses having 41, 12 and 33% respectively of the total basal cover, and contributed 72–77% of total above-ground biomass. Cutting at 5 cm height decreased net above-ground productivity compared with the unclipped control, whereas cutting at 15 cm produced an increase. Cutting at 30-day intervals reduced productivity compared with 60-day intervals when pastures were cut at 5 cm, but had less effect at 15 cm. Annual above-ground biomass ranged from 5730–8860 kg/ha. The best management option is to protect the grassland and cut-and-carry at the end of the growing season.

Resumen

Se investigaron los cambios estacionales en la producción de biomasa aérea y rastrojo en un pastizal templado de la región central de los Himalayas; dicha región tiene una estación de crecimiento de seis meses. Los tratamientos consistieron en: dos programas de corte (intervalos de 30 o 60 días) y dos alturas de corte (cinco y 15 cm) más un control sin cortar. Las gramineas dominantes fueron: Chrysopogon montanus, Heteropogon contortus *y* Eulalia trispicata, *las cuales tuvieron una cobertura basal de 41, 12 y 33%, respectivamente, y una contribución a la biomasa aérea total de 72–77%. Comparada con el control sin cortar, la productividad aérea neta fue reducida con el corte a 5 cm, pero incrementada con el corte a 15 cm. Cuando los cortes fueron hechos a una altura de 5 cm, los intervalos de 30 días resultaron en una menor productividad que los intervalos de 60 días; sin embargo los intervalos de corte tuvieron menos efecto cuando el corte se hizo a una altura de 15 cm. El rendimiento anual en biomasa aérea fue de 5730–8860 kg/ha. La mejor opción de manejo es permitir el crecimiento del pastizal hasta el final de la estación de crecimiento, y utilizarlo en la época de seca como forraje de corte y acarreo.*

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Introduction

Range management in the Himalayan region is difficult because of variable environmental and topographic factors. Also, little is known of the conditions that control growth of the different grass and forb species. The grassland resource could be better managed if the effect of different defoliation regimes on the amount of available forage at various seasons was known. Consequently, an investigation was conducted to evaluate the response of a central Himalayan grassland to different cutting regimes. The objectives were to optimise forage production and determine the appropriate cutting height and frequency.

Materials and methods

Study area and climate

The experiment was carried out in 1983–1984 on a temperate grassland at Tilkini (29° 55′ N and 78° 55′ E, altitude 2400 m) in the Garhwal (central) Himalaya, India. The climate of the study area is temperate and has 3 distinct seasons: rainy (June–September), winter (October–February), and summer (March–May). Precipitation was 1254 mm between May 1983 and June 1984, more than 75% of which was received during June to October 1983 (Figure 1). The mean minimum and maximum temperatures ranged from 4–19 °C and 14–28 °C, respectively (Figure 1). The soil of the study area is a clay loam. Soil temperature at 5 cm depth during the growth season ranged from 10–22 °C. This grassland was formed after clearing of the forest dominated by *Quercus leucotrichophora*, *Rhododendron arboreum*, and *Lyonia ovalifolia*. The selected grassland was characterised by a relatively uniform stand of *Chrysopogon montanus*, *Heteropogon contortus* and *Eulalia trispicata*. The site had been continuously and heavily grazed by cattle before 1983 when it was fenced.

Experimental design

There were 5 treatments consisting of 4 cutting treatments, which were a factorial combination of 2 cutting intervals (30 and 60 days) and 2 cutting heights (5 and 15 cm), and an unclipped control. The experiment was a randomised block design with 4 replicates and plots measuring 25 × 25 m.

Five quadrats (50 × 50 cm) were clipped from each plot at either 30 or 60 day intervals from May 1983 to May 1984. After each quadrat was sampled at the appropriate cutting height, the remaining stubble was cut to ground level. The remainder of the plot was then cut to the appropriate stubble height using a hand sickle. Five quadrats in the unclipped plots were also cut to ground level. The samples were hand sorted into green and dry components. Litter was collected from the soil surface when each quadrat was cut. Samples were subsequently oven dried

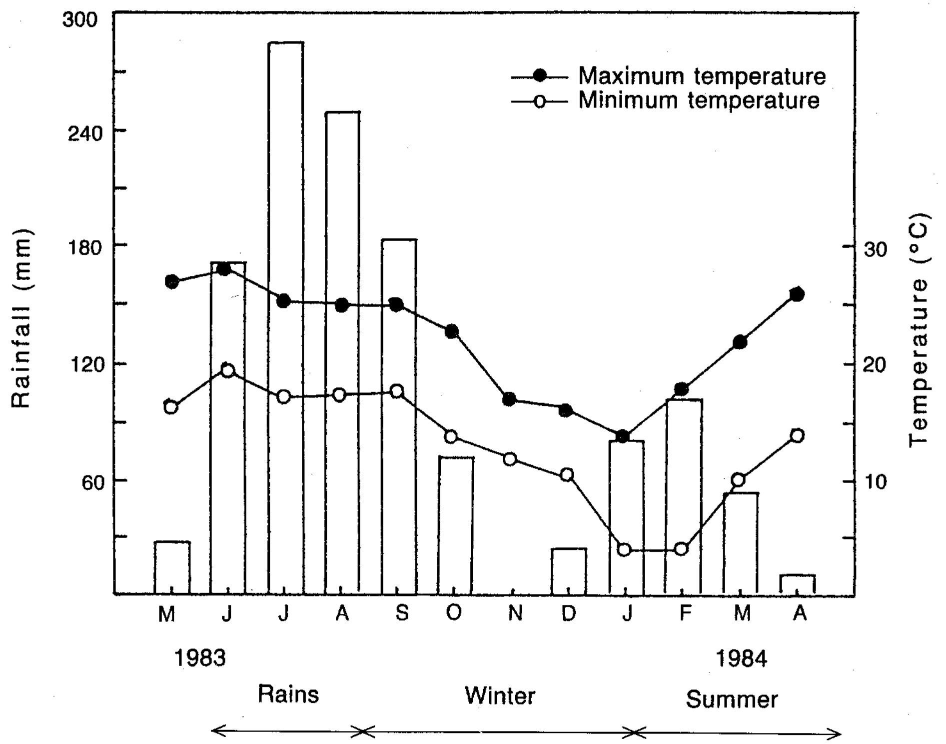

Figure 1. Monthly variation in rainfall and temperatures at the study site in the central Himalaya.

at 60 °C for 48 h to determine percentage dry matter. The basal cover of each species was recorded and expressed as a percentage of the total basal cover of all species (Misra 1968). Biomass data were analysed by standard analysis of variance procedures.

Phenological observations were made every 4 weeks for 8 grass species on both unclipped and clipped plots. Six growth stages were recorded: (1) initiation of growth, (2) green vegetative stage, (3) floral bud initiation, (4) full flower, (5) seed set and shatter, and (6) senescence. A phenological class was defined when more than 60% of tussocks were visually assessed as reaching that stage.

Results and discussion

Botanical composition

The basal cover throughout the study period averaged 40%, ranging from 36–44%. Cover was highest for *Chrysopogon montanus* (41% of the total basal cover) followed by *Eulalia trispicata* (33%). Among other species, *Heteropogon contortus* (12%), *Arundinella nepalensis* (4%) and *Cymbopogon distens* (3%) had some significant cover. Most of the species were perennial tussock grasses with a few forbs which were unpalatable to cattle. Most palatable forbs had been removed from the grassland by previous grazing.

Phenology

All species commenced vegetative growth at the start of the rainy season, with the exception of *Eragrostis gangetica*, and most of the species completed their vegetative growth by August (Table 1). In clipped plots, however, only a few tillers of each species flowered and most remained vegetative. Bertiller and Defosse (1990) reported similar results for *Festuca pallescens*. During the winter months most of the tillers in the protected plots remained reproductive. However, some tillers started to undergo senescence due to the rapid decrease in temperature and moisture content of the soil. Almost all vegetation was dry by the end of February.

Dynamics of above-ground biomass

Green biomass in unclipped plots attained its maximum value (*c*. 4400 kg/ha) in the late rainy season (Figure 2). Dead biomass peaked at 3200–3500 kg/ha in December and litter biomass increased after September and peaked in February. Litter disappeared rapidly in summer months due to increased biological activity. The trends in green, dead and litter biomass accumulations were similar to those reported for other temperate Himalayan grasslands (Tiwari 1986; Agrawal and Goyal 1987; Sah and Ram 1989). Peaks of green and dead biomass accumulation were delayed by about 40–60 days in clipped plots relative to the unclipped plots (Figure 3). *Chrysopogon montanus* produced about 22–33% and *E. trispicata* 23–30% of the total biomass, whereas forbs contributed only 3–5%.

Net productivity varied significantly between seasons ($P < 0.005$) and clipping treatment ($P < 0.005$). Productivity was reduced by 5–25% in plots cut at 5 cm, and increased by 5–15% by cutting at 15 cm as compared to the unclipped control (Table 2). Cutting at 30-day intervals resulted in an 18–29% decrease in yield as compared with cutting at a 60-day interval. Reduced productivity from frequent and close clipping of grassland has been recorded by many workers (Lawrence and Ashford 1969; Miller *et al.* 1990). If the time for recovery is short then clipping is less likely to increase the production (Osterheld and McNaughton 1991).

Practical implications

The yield of this central Himalayan grassland increased slightly with a 15-cm cutting height and a 60-day interval, but to follow the procedure in practice would require continuous checking and regulation. It is therefore most unlikely that villagers would follow this recommendation. At present villagers cut protected grasslands once every year at the end of the active growing season. Since controlled irrigation, fertilisation and management of the grasslands in the Himalaya is very difficult, this simple protection and cut-and-carry system at the end of each growing season perhaps is the best way to manage the grassland to obtain near-optimum production.

Table 1. Monthly variation in phenological events of the important species in unclipped and clipped grasslands at Tilkini in the central Himalaya. Phenological stages: 1 = Initial growth; 2 = Vegetative stage; 3 = Floral bud; 4 = Full flower; 5 = Seed set and shatter; 6 = Senescence; — Species absent.

Species	Treatment		Rains				Winter					Summer		
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Anthistiria	Unclipped	6	6, 1	1	1, 2	2, 3	3, 4	4	4, 5	5	5	6	6	6
anathera	Clipped	6	6	1	1	2	2	2, 3	2, 3, 4	2, 4, 5	4, 5	5	5	6
Arundinella	Unclipped	6	6	1	1, 2	2	2, 3	3, 4	4	4	4, 5	5	5, 6	6
nepalensis	Clipped	6	1	1	1, 2	1, 2	2	2, 3	3	4	5	5	6	6
Carex	Unclipped	1	1, 2	2, 3	3	3	3, 4	4	4, 5	5	6	6	—	—
condensata	Clipped	1	1	1, 2	2, 3	3	4	5	5, 6	6	6	6	—	—
Chrysopogon	Unclipped	1	1	1, 2	2	2, 3	3	4	4, 5	5	5, 6	5, 6	6	6
montanus	Clipped	1	1	1, 2	2	2	2	2, 3	2, 3	2, 4	5	5	6	6
Cymbopogon	Unclipped	6, 1	6, 1	2	2	2	3	3, 4	5	5	6	6	6	6
distens	Clipped	6	1	1	2	2	2, 3	2, 4	4	4, 5	5	5	6	6
Eragrostis	Unclipped	3, 4	4	5	5, 6	6	6	—	—	—	—	1	1	2
gangetica	Clipped	2, 3	3, 4	4	5	5, 6	6	6	—	—	—	1	1, 2	2
Eulalia	Unclipped	6, 1	1, 2	2, 3	3	3, 4	4, 5	5	5	5, 6	5, 6	6	6	6
trispicata	Clipped	6, 1	1	2	2, 3	2, 3	2, 3, 4	2, 4	2, 5	5, 6	5, 6	5, 6	6	6
Heteropogon	Unclipped	1, 2	2	2, 3	2, 3	3	3, 4	4	4, 5	5	5, 6	6	6, 1	1
contortus	Clipped	1	1, 2	2	2, 3	2, 3, 4	2, 3, 4	4, 5	4, 5	5	6	6	1	1

Table 2. Seasonal and annual variation in net above-ground productivity of grassland either unclipped or subjected to 2 cutting heights and 2 cutting frequencies.

Season	Plant component	Unclipped	Clipped at 5 cm		Clipped at 15 cm	
			30-day	60-day	30-day	60-day
			(kg/ha)			
Rainy	Green	4048	1474	1834	1906	2199
	Dry	850	496	320	809	516
Winter	Green	0	1576	2343	2316	2717
	Dry	2543	1009	1091	1655	1515
Summer	Green	175	416	543	301	339
	Dry	50	752	1171	1068	1569
Year	Green	4223	3466	4720	4523	5255
	Dry	3443	2257	2582	3532	3600
	Total*	7666ab	5723	7302ac	8055bcd	8855d

ANOVA F values for net productivity are significant between seasons ($P < 0.005$) and clipping treatments ($P < 0.005$). Interactions between seasons and clipping treatments are significant.
*Values followed by the same letter on the last line are not significantly different. LSD ($P = 0.05$) = 968.

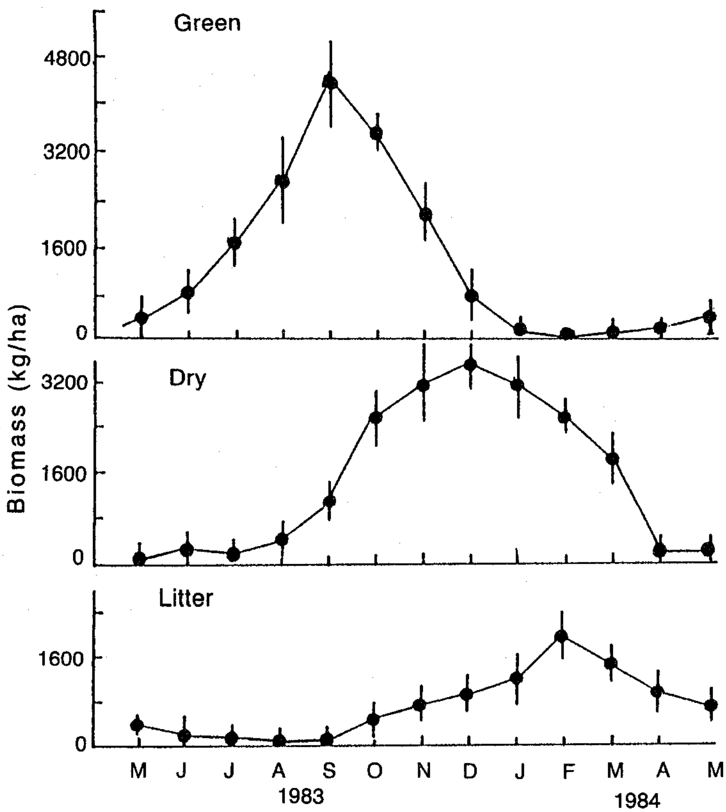

Figure 2. Changes in green and dry above-ground biomass and in litter biomass of unclipped grassland sampled at ground level. Vertical bars represent ± 1 SD.

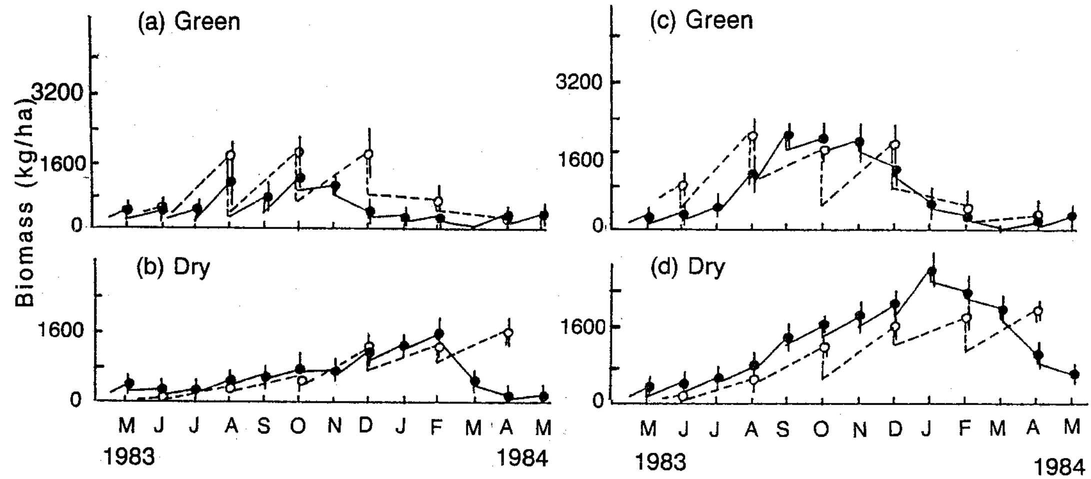

Figure 3. Changes in above-ground biomass (green and dry) sampled to ground level in plots clipped at 5 cm (a and b) and plots clipped at 15 cm (c and d) at 30-day (—●—●—) and 60-day (--o--o-) intervals at the Tilkini grassland site. Vertical bars represent ± 1 SD.

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References

AGRAWAL, A.K. and GOYAL, A.K. (1987) Effect of grazing on net primary production and system transfer function in a western Himalayan grassland community. *Tropical Grasslands*, **21**, 154–158.

BERTILLER, M.B. and DEFOSSE, G.E. (1990) Clipping effects upon primary productivity and senescence: study case on *Festuca pallescens* (St Yves) Parodi in a Patagonian semiarid grassland, Argentina. *Acta Oecologia*, **11**, 79–92.

LAWRENCE, T. and ASHFORD, R. (1969) Effect of stage and height of cutting on dry matter yield and persistence of intermediate wheatgrass, bromegrass and reed canarygrass. *Canadian Journal of Plant Sciences*, **49**, 321–332.

MILLER, R.F., HAFERKAMP, M.R. and ANGELL, R.F. (1990) Clipping date effects on soil water and regrowth in crested wheatgrass. *Journal of Range Management*, **43**, 253–257.

MISRA, R. (1968) *Ecology Workbook*. (Oxford & IBH: Calcutta).

OSTERHELD, M. and MCNAUGHTON, S.J. (1991) Effect of stress and time for recovery on the amount of compensatory growth after grazing. *Oecologia*, **85**, 305–315.

SAH, V.K. and RAM, J. (1989) Biomass dynamics, species diversity and net primary production in a temperate grassland of central Himalaya, India. *Tropical Ecology*, **30**, 294–302.

TIWARI, S.C. (1986) Variation in primary production of Garhwal Himalayan grasslands. *Tropical Ecology*, **27**, 166–173.

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