EFFECT OF GRAZING MANAGEMENT AND FERTILIZER APPLICATION ON VEGETATION AND SOIL PROPERTIES OF A MOIST TEMPERATE FOREST RANGE IN SIRAN VALLEY (MANSEHRA), NWFP.

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ABSTRACT

Uncontrolled heavy grazing in blanks of moist temperate forests of the mountaineous tract of NWFP is a common practice of the local and nomad livestock herders. These blanks have been created as a result of compaction and trampling by livestock. This study was carried out in two blanks in moist temperate forest range at Kuṇd, Mansehra during June, 1989 and was maintained for 5 years. It study aimed at investigating the effects of grazing management and application of fertilizer on forage production, cover percent, soil protective cover, soil infiltration rate and soil bulk density. Three major treatments namely; one clipping (no grazing), two clippings (simulated rotational grazing) and conventional grazing (continuous seasonal grazing) were applied randomly in 3 plots of 10 x 10 meter size. Similarly, three sub plots of 10 x 5 meters size were fertilized with single dose of NPK (l:2:2) at the rate of 100 Kg N + 200 Kg P + 200 Kg K per ha. in split plot design. Ten permanent sample plots of 1 x 1 meter size (Braun - Blanquet's method) in each sub plot were established for estimation of forage production by clipping method, cover percentage and percentage soil protective cover. The study revealed 2.3 times improvement in forage production at present production level through protection (zero grazing) and fertilizer application. The percentage vegetation cover percentage and soil protective cover have also shown manyfold increase in the treated plots. Further the study revealed appreciably higher soil porosity through decrease in soil bulk density and increase in water intake capacity (infiltration rate) with grazing management and application of fertilizer.

INTRODUCTION

Forest grazing, a conventional resource use, centuries old use of the forest land in Pakistan. Almost all types and legal categories of forests are burdened with unspecified grazing rights and privileges. The grazing pressure is increasing with the increase in human and livestock population. Consequently, uncontrolled heavy grazing is causing great damage to soil and vegetation due to compaction and trampling. This creates gaps in the forests and retrogression in certain localities has already set-in.

Summer grazing both by local and nomadic livestock is very common in the moist temperate forest ranges in the northern mountainous tract of the NWFP. These forests are mostly located between 2000 to 3000 meters elevation above sea level. Where, due to favourable moisture and temperature conditions, luxurious ground vegetation, perennial and annual grasses, legumes and forbs, grow. However, heavy uncontrolled grazing causes considerable damage both to the forest and range vegetation.

It has been established that heavy grazing has detrimental effects on soil properties due to compaction. Similarly, trampling reduces plant cover and changes floristic composition. Johnsten et al (1971) have observed changes in physical and chemical properties of soil due to heavy grazing. According to their study soil temperature and pH values of soil increase, while soil moisture contents, N,P and $NaHaCo_3$ decrease. Further they reported that vegetation cover decreases and species composition changes, where in grasses are replaced by *Trifolium* spp. The compaction due to heavy grazing increases the soil bulk density and reduces the water infiltration capacity of range soils (Rauzi et al 1966, Rhodes et al 1964 and Meeuwig, 1965). However, changes in the soil bulk density due to grazing in arid rangelands depend on seasonal variation in soil moisture contents (Laycock et al, 1967).

Trampling reduces the quality of ground vegetation cover and increases the size of bare soil openings. This in turn increases water runoff and soil erosion (Packer, 1953). The indigenous species on heavily grazed area are particularly replaced by invading pioneer vegetation (Steinbrenner, 1951). Similarly, heavy grazing causes reduction in protective cover, forage production and litter (Meeuwing, 1965).

On the other hand range improvement activities like protection from grazing and application of fertilizer enhances vegetation cover percentage, forage production, soil protective cover and infiltration rate. Consequently, surface runoff is reduced and soil erosion is controlled. The scientific grazing under multiple land use concept may not be undesirable altogether. In a socio-economic environment where animal husbandry is integrated to subsistence farming and provides income and security to small farmers, forest grazing cannot be eliminated altogether. There is need to recognize forest grazing as an objective of resource management and adoption of scientific management practices to improve range vegetation and soil properties.

This study was Primarily carried out to evaluate the range productivity potential of grazing spots (forest blanks) in moist temperate forests through grazing management and application of fertilizer. In addition data on soil infiltration rate and soil bulk density in ungrazed and grazed (fertilized and unfertilized) plots were also collected for comparison.

MATERIAL AND METHODS

i. Site Description

Two sites located along Kund-Shaeed Pani Road on a ridge, a watershed divide of Siran and Kunhar vallies, were selected. Both sites are located in a narrow blank strip which in used as grazing ground by local livestock and as grazing and resting camp by the nomadic livestock. The moist temperate mixed coniferous forests are found along the eastern and western direction of both the sites. Site-I is located at foot of a spur in compartment No.11 (ii) Punjul Reserved Forest (RF) at an elevation of 2500 m above sea level. Site-II is located at flat ridge top in compartment No.10 (i) Punjul R.F. at an elevation of 2650 m.

Both study sites receive more than 1700 mm annual rainfall, of which major part falls in monsoon season (July to September). July is the wettest month. Winter receives snowfall and ground remains covered with snow from December till April, which are also coldest months. June is the hottest month with mean maximum temperature of 22°C. The short growing season consists of May to September (Haq, 1992).

Soil of the experimental sites is blackish brown loamy silt and moderately acidic. Organic matter contents and total soil Nitrogen are high with moderate level of Potassium. However, available Phosphorus level is low (Table 1).

Table 1: Physical and chemical soil properties of study sites[1].

Properties	Units	Value			
		Site-I		Site-II	
		a_1	a_2	b_1	b_2
E.C. (1:5)	dS m^{-1}	0.48	1.02	0.23	0.26
pH	-	5.14	5.51	5.37	5.08
O.M.	Percent	11.39	20.70	15.40	13.50
AB-DTPA Ext. P.	Mg Kg^{-1}	4.80	5.70	5.00	4.40
AB-DTPA Ext. K	Mg Kg^{-1}	188.00	192.00	160.00	136.00
Total N	Percent	0.57	1.04	0.77	0.68
Sand	Percent	43.20	38.00	37.20	33.20
Silt	Percent	54.80	60.00	60.80	60.80
Clay	Percent	2.00	2.00	4.00	6.00
Texture class	-	Silt loam	Silt loam	Silt loam	Silt loam

1.Soil analysis was carried out by Professor Dr. Abdur-Rashid, Chairman, Department of Soil Science, NWFP, Agriculture University, Peshawar.

ii. The Study:

The experiment was laid out during third week of May, 1989 using both randomized complete block (RCB) design and split plot design at both the sites. Three main variables namely; A= control (one final clipping), B= simulation rotation grazing (two clippings) and C= conventional grazing (continuous grazing) were tested. Three contiguous plots of 10x10 m size were demarcated at both sites. The major variables were assigned randomly to each plot. The plots having variable A and B were fenced and C was kept open to conventional grazing. Each plot was divided into two sub plots of equal size of 10 x 5 m. Accordingly, there were 6 sub plots viza viz. a_1, a_2, b_1, b_2, c_1 and c_2 at each site. Ten permanent quadrats of 1 x 1 m size were laid out in each sub-plot for vegetation analysis. A uniform single dose of NPK (1:2:2) at the rate of 100 kg N, 200 Kg P and 200 Kg K per hectare was applied to a_1, b_1, and c_1 during mid July each year under split-plot design. The fertilizer was applied for 3 years only, however, its carry over effect was evaluated for next 3 years.

iii. Data Collection

There were 120 permanent sample plots of 1 square meter in all the 6 plots of 10 x 10 m size at both the sites. First time data from sample plots were collected during last week of June, 1989. Subsequently, Ist. week of August and 3rd week of September were scheduled for clippings and vegetation surveys. Similarly, Ist. week of July was scheduled for application of fertilizer in the designated subplots. Except minor deviation in calendar of activities, mostly due to poor access to experimental sites or bad weather conditions, the schedules were adhered to. The following data were collected regularly from all the sample plots:

i. Vegetation Survey:

	Activities	Schedule	
a.	Percentage cover of each species (twice)	Ist to 2nd week of August.	End of growing season(3rd week of September to Ist week of October).
b.	Percentage surface material distribution. (Plant base, Litter Cover, Rock pavement, Cryptogams and Bare soil). (twice)	-do-	-do-
c.	Clippings (twice)	-do- (B variant only)	-do- (A+B+C variants)
ii.	SOIL ANALYSIS		
d)	Soil Nutrient Analysis (once)	August, 1993	-
d)	Soil bulk density and moisture contents (once)	October, 1993	-
e)	Infiltration rate (once)	August, 1993.	-

Mixed ground vegetation from the entire surface of the sample plots was clipped at 2.5 cm above ground level. Since all the species, open to grazing plots, were found grazed by livestock so the entire clipped material was considered consumable forage and was included in forage production estimate. The fresh weight was recorded in the field while airdried (AD) weight was recorded after about 7 days of drying the samples in the open air.

RESULTS AND DISCUSSION

i. Forage Production:

The simulation grazing management treatments and application of chemical fertilizer have appreciable and significant effect on forage production. The average forage production values over 5 years period indicated 2.3 times increase in forage production under fertilized and one clipping treatments (zero grazing). Similarly, 1.6 to 1.9 times increase in forage was obtained after two clippings (rotational grazing) and fertilized treatments. On the other hand one clipping gave 1.2 times more forage than two clippings in a season (Table 2).

Table 2: Seasonal forage production under different grazing intensities and fertilizer application.

kg/ha (DM)

Year	Site - I				Site - II			
	A		B		A		B	
	One Clipping		Two clippings		One clipping		Two clippings (SRG)	
	No Grazing)		Simulation Rotational Grazing		(NG)		(NG)	
	a_1	a_2	b_1	b_2	a_1	a_2	b_1	b_2
1989	7895	4095	7580	5399	3350	2775	8334	4210
1990[1]	12116	4819	9130	4950	8445	2353	5767	2737
1991	7350	2875	5300	2705	6600	2210	4300	2410
1992[2]	5000	2650	3920	3370	1550	1020	2530	1612
1993	3650	1310	3395	1965	1810	1120	2680	1385
Average	7202	3150	5865	3678	4351	1896	4722	2471
Ratio (F:UF)	2.3 :	1	1.6 :	1	2.3 :	1	1.9 :	1

Note: 1. Material clipped in June, 1991 was also included in the estimate.
2. Some plots were partially grazed by stray cattle.

This study showed that site variation within same ecozone has differential effect to the tune of 1.3 times on forage production under similar treatments viz-a-viz protection and one clipping and fertilization. Other treatments have also shown similar trend. This proves that site selection plays important role in the success of different range improvement activities like fertilization and grazing management.

The results are also indicative of the fact that application of fertilizer holds good for one growing season only. Results indicated large decreases in forage production after discontinuation of fertilizer treatment. Though the carry over effects of fertilizer application were there but were not significant.

ii. Vegetation Cover Percentage

Application of fertilizer and two clippings had appreciable positive effect on cover percentage of grass species and negative effect on forb species. However, protection from grazing over a period of 5 years had positive effect on the cover percentage of both grasses and forbs. More than two times increase in grass cover under fertilized and two clippings treatments was obtained as compared to conventional grazing. Similarly, more than 1.4 times decrease in cover percentage of forbs was observed under fertilized and one clipping as compared to conventional grazing. The observed grass cover was slightly higher under protection and clippings treatments as compared to conventional continuous grazing. However, forb cover percentage was more than 1.5 times in the continuously grazed plot than protected, fertilized and clipped plots. Accumulated cover percentage was more than 1.5 times higher in fertilized and two clippings treatments as compared to conventional grazing. There was no appreciable difference in total cover percentage under fertilized and one clippings, and fertilized and two clipping treatments (Table 3).

Table 3: Average vegetation cover percentage values under different grazing intensities and fertilizer application.

Parameters	One Final clipping		Two clippings		Conventional grazing	
	a_1	a_2	b_1	b_2	c_1	c_2
Grasses	73.1	42.8	74.7	39.4	46.8	36.3
Forbs	20.6	46.6	27.0	47.0	27.6	30.4
Accumulated total	93.7	89.4	101.7	86.9	74.4	66.7

iii. Soil Protective Cover

Percentage area covered under plant bases, litter, and cryptogams was much higher in fertilized and clipped plots as compared to continuously grazed plots. Consequently bare soil was about 1.3 times less in the fertilized and clipped plots (Table 4). These results clearly indicate that protection from grazing and application of fertilizer provided more protection to the soil from erosion. It is evident that these two range improvement activities help improve protective cover which in turns protects soil from direct effects of raindrops and hence reduce soil erosion.

Table 4: Effect of grazing management and fertilizer application on surface material distribution.

Surface features	One Final clipping		Two clippings		Conventional grazing	
	a_1	a_2	b_1	b_2	c_1	c_2
Plant base cover	18.4	15.1	15.4	14.3	10.6	10.8
Litter cover	32.3	25.7	25.3	29.6	20.6	21.6
Cryptogams cover	1.1	1.2	1.1	0.8	0.5	0.4
Bare Soil	48.2	58.0	58.2	55.3	68.3	67.2

iv. Soil Bulk Density:

Soil samples were collected once during September, 1993 from study area. A metal soil sampler, of 311.72 cm^3 volume (5.9 cm long x 8.2 cm inner dia meter), was driven into soil at one point selected randomly in a subplot. The lower end of soil core was cut flushed. The fresh weight of the soil sample was recorded with spring balance in the field. The undisturbed sample was labelled and packed in poly-bags and brought to PFI laboratory. The soil was oven dried at 105°C for 24 hours. Its oven dry weight was measured with spring balance. The percent moisture content (Fresh weight-oven dry weight x 100/oven dry weight) and bulk density (Oven dry weight/volume of soil sample) were determined for surface layer upto 5.9 cm depth only.

Results indicated that soil moisture contents were lower in the conventional grazing plots at both the sites. Similarly, bulk density was higher in conventionally grazed plots (Table 5). The study showed that both soil moisture retention capacity and soil porosity of temperate rangelands could be improved through protection from grazing and application of fertilizer. In other words zero grazing and light grazing improves the hydrologic values of soil while heavy grazing deteriorates the soil characteristics. The results of this study are consistent with the results of the studies of

Johnston et al (1971), Laycock et al (1967) and Rauzi and Hanson (1966).

Table 5: Effect of grazing intensities and fertilizer application on soil bulk density.

Parameter	One Final clipping		Two clippings		Conventional grazing	
	a_1	a_2	b_1	b_2	c_1	c_2
Site-I						
M.C. (percent)	68.5	54.4	52.3	59.8	46.4	53.6
Bulk density (gms/cm^2)	0.77	0.78	0.83	0.80	0.96	0.86
Site-II						
M.C. (percent)	51.3	50.4	46.7	55.2	51.9	45.0
Bulk density (gm/cm^3)	0.70	0.83	0.87	0.80	0.90	0.91

v. Infiltration Capacity:

Double ring infiltrometer, with 3 cm head maintained in each ring, was used for data collection. The inner diameter of the inner ring was 21.5 cm and the inner dia meter of the outer ring was 30.5 cm. Hence the surface area of the soil in the inner ring was 363.21 cm ^{2}. First of all outer ring was driven in soil and then the inner ring using hammer and crow-bar (for uniform driving in the soil and least soil disturbance) at randomly selected points in the sub plots. Clean spring water was poured in the rings. In the inner ring measured quantity of clean water was added. The readings were recorded after every minute during the first 5 minutes period. Afterwards readings were recorded at interval of 10,30 and 60 minutes. Hence at each point 8 readings were recorded for total of 105 minutes duration. Based on field data infiltration rate in cm/hr. were calculated for each treatment and site separately.

Results indicated differential infiltration rates at both the sites and under similar and different treatments. Maximum infiltration rate of 16.6 mm/minute during Ist minute was recorded at site-1 under fertilized and one clipping treatments. while the minimum infiltration rate was 5.5 mm/minute for first minute under two clippings and protected plots and under fertilized and grazed plot. At site II maximum infiltration rate was 11.9 mm/minute under two clipping and protected area. The lowest rate was 1.8 mm/minute under continuously grazed plot. Mean highest infiltration rate of 11.9m m/hour was recorded under two clippings and fertilized plot. The lowest infiltration rate of 1.8 mm/hr was recorded under continuously grazed and fertilized plots at site-II (Table 6).

The study showed that infiltration was lowest under heavy grazing (continuously grazed plots) as compared to zero grazing (one final clipping) and light rotational grazing (two clippings). These results were consistent with the results of studies conducted elsewhere by Rauzi and Hanson (1966), Rhodes *et al* (1964) and Meeuwig (1965).

Table 6: Effect of grazing intensities and fertilizer application on soil infiltration capacity

Time interval (minutes)	Infiltration capacity mm/minute					
	One Clipping		Two clippings		Conventional grazing	
	a_1	a_2	b_1	b_2	c_1	c_2
Site-I						
Ist.	16.6	7.0	10.1	5.5	5.5	8.9
2nd.	0.6	0.3	1.1	0.6	0.4	0.4
3rd.	0.6	0.1	0.8	0.3	0.4	0.3
4th	0.3	0.1	0.3	0.3	0.1	0.1
5th	0.1	0.1	0.1	0.3	0.05	0.05
10	0.04	0.06	0.03	0.06	0.04	0.04
30	0.04	0.04	0.03	0.01	0.04	0.04
60	0.02	0.01	0.02	0.01	0.04	0.04
Per hour	10.4	4.4	7.1	4.0	3.8	5.6
Site-II						
Ist.	2.8	9.0	9.7	11.9	2.7	1.8
2nd.	0.8	0.7	0.5	2.6	0.1	0.8
3rd.	0.7	0.4	0.2	2.1	0.1	0.3
4th.	0.3	0.3	0.2	1.7	0.1	0.3
5th.	0.1	0.3	0.2	1.7	0.08	0.1
10	0.06	0.04	0.2	0.4	0.06	0.05
30	0.03	0.02	0.2	0.2	0.05	0.01
60	0.02	0.01	0.1	0.2	0.05	0.01
Per hour	2.7	6.2	6.5	1.9	1.8	1.9

CONCLUSION

Productivity of temperate grazing lands can be enhanced more than double at current production level through appropriate improvement practices such as application of fertilizer and exclosure for a minimum period of 5 years. The scientific grazing plans such as zero grazing (one final clipping) and light rotational grazing (two clippings) improves the vegetal cover and forage production. Further light grazing and/or no grazing improve the soil porosity, water intake rate and water retention capacity. Light grazing improves the soil protective cover which in turns improves the water intake rate. Surface runoff is reduced and soil erosion is controlled.

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