Indian Journal of Animal Sciences **82** (11): 1392–1397, November 2012

Silvipastoral approach to improve productivity of native pastures for improved livestock production in mid hills of Western Himalaya

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Received: 22 September 2011 ; Accepted: 1 February 2012

ABSTRACT

Animal husbandry, an integrated component of hill agriculture has caused severe land degradation due to continuous grazing and massive reduction in the vegetation cover. The feeding of livestock depends primarily on natural resources, viz. grasslands, forests, cultivated fodder, field bunds, crop residues, weeds and fodder trees. The silvipasture laid out at 3 sites, viz. Ghanetta (1100 m above msl), Dagoh (1020 m above msl) in Kangra district and Jogindernagar (1175 m above msl) in Mandi district of Himachal Pradesh had a slope of 15–35%, 25–60% and 15–30%, respectively. Silipastures were laid out with active participation of native beneficiaries. Survival rate of *Bauhinia variegata, Morus alba* and *Grewia optiva* was highest (90% and above) at all the 3 sites. Growth in terms of height gained by the fodder trees was similar at all the 3 sites. At the end of third year, the 2- year-old saplings transplanted at all the 3 sites, *Albizia* attained a height of about 200 cm, *Artocarpus* (110 cm), *Bauhinia* (150 cm), *Grewia* (120 cm) and *Morus* (130 cm). During third year of the study fresh biomass of 31.6, 28.6 and 30.8 t/ha were harvested from Ghanetta, Jogindernagar and Dagoh with dry matter yield of 8.67, 6.98 and 7.62 t/ha, respectively. Crude protein was in the range of 12.33 to 13.46% due to grass legume mixture. The average body weight gain ranged from 358.50 to 388.53 g/day in indigenous male cattle. Runoff (% of rainfall) was higher at Jogindernagar (33.4%) followed by Dagoh (29.9%) and Ghanetta (20.4%) owing to their land slopes. Cut and carry system was most efficient at all the sites allowing only 15.8% runoff compared to 20.6% and 27.1%, respectively under controlled and traditional grazing. Among the resource conservation measures, trenching in combination with vegetative barrier allowed only 6.8% of rain as runoff compared to 38.9% under control (no measure). Trenches formed in upper, middle and lower parts along the slope retained on an average 13.9, 16.6 and 19.1 cm sediments, respectively. Among the sites, the sediment retention was highest at Dagoh (18.7 cm) followed by Joginder Nagar (16.9%) and lowest at Ghanetta (14.0 cm). Therefore, silvipasture seems to be one of the best options for regenerating and improving the Himalayan grasslands. The system can enhance the forage availability many fold, which can assure the sustainability of on-going livestock rearing and in the process the resource base gets conducive inputs for its conservation.

Key words: Herbage, Fodder trees, Livestock, Silvipasture

Animal husbandry, an integrated component of hill agriculture has caused severe land degradation due to continuous grazing (Thakur 1996). In Himachal Pradesh, the productivity of grassland/pastures has carrying capacity of only 1.31, 1.21 and 0.64 ACU/ha/annum for subtropical, temperate and alpine areas, respectively (Katoch and Dogra 1999). The gap between demand and supply of green and dry fodder is 26.0 and 54.0%, respectively, in Himachal Pradesh (Dev *et al*. 2006). The arable agriculture is not very remunerative; therefore farmers rear sheep, goats, cattle etc. to supplement family income. Fodder trees/shrubs have always played a significant role in feeding domestic animals. However, indiscriminate use of fodder trees/shrubs has resulted in critically low biomass availability. Silvipasture, a system of integrating fodder trees or MPTs (multipurpose tree species) with the native grassland/pastures has proved to be an efficient system for achieving higher and sustained forage production (Chen *et al*. 1991). The silvipasture

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systems are also suitable tool to arrest the eco-environmental degradation (Pathak and Roy 1994). Therefore, the present study was undertaken to check the environmental degradation of hill ecosystems and achieve a sustained fodder production through establishment, management and utilization of silvipastoral system in the Himalayan hills.

MATERIALS AND METHODS

The establishment of the silvi-pasture and soil conservation measures was preceded by conducting several participatory rural appraisal (PRA) exercises at the study sites. During the interactions with the farmers, the benefits of silvipasture establishment were brought to their notice and they got convinced to spare community grasslands for the establishment of the silvi-pasture models. The silvipasture were laid out during 2003 at Ghanetta (1100 m above msl with 15–35% slope), Dagoh (1020 m above msl with 25–60% slope) in Kangra district and Jogindernagar (1175 m above msl 15–30% slope) in Mandi district of Himachal Pradesh with active participation of native beneficiaries. At each sites, 4 paddocks measuring 1 ha each were planted with fodder trees and introduced grasses/legumes. These paddocks were put under cut and carry, controlled and traditional grazing systems. Each paddock/grazing system further had four treatments of natural resource conservation (trenching, vegetative barriers, a combination of trenching and vegetative barrier and control i.e. no measures).

Two years old saplings of *Artocarpus chaplasha*, *Albizia lebbeck*, *Bauhinia variegata*, *Morus alba* and *Grewia optiva* were transplanted at 5m × 5m spacing with cultivated grasses i.e., *Cenchrus ciliaris, Guniea* grass and *Congosignal* grass**.** *Siratro*, *Stylo***,** *Lotus* and white clover were the legumes introduced. Under cut and carry system, the cattle were offered fodder @ 3 kg DM/100 kg body weight. Four growing indigenous male cattle of farmers of age 7 to 10 months with an average body weight of 52–60 kg were taken at each site for feeding trial to record feed intake and daily body weight gain (g/day). The feeding of cattle was undertaken during the monsoon season (July to August) for 60 days during 3rd year. The mixture of grasses from the silvipastoral system at each site were harvested, chaffed and fed to the animals at *ad libitum*. An adoption period of 15 days was allowed for the cattle to get used to the diet. Herbage mixture fed to the animals was evaluated for its chemical composition. The mixture of grasses offered and refusal were recorded on daily basis to estimate voluntary dry matter intake by the animals at each site. The animals were provided *ad libitum* water daily. Body weight of animals was recorded fortnightly for daily weight gain (g/day) before offering morning feed and water. Daily weight gains in animals were recorded according to the method described by Brody (1945). A self recording rain guage, 3 h-flumes with stage level recorders and 12 multislot devisors with runoff collection tanks were installed at each of the three sites for recording event based rainfall and runoff data. The observations were recorded on survival (%) and growth performance of fodder trees. The data on number of regenerated species, herbage production, animal productivity and impact of soil and water conservation measures were recorded. The data were subjected to simple mathematical and statistical analysis.

RESULTS AND DISCUSSION

Survival of fodder trees

Survival rate of *Bauhinia variegata, Morus alba* and *Grewia optiva* was highest (approx. 90% and above) at all the 3 sites, whereas *Artocarpus chaplasha* had the least survival (63% at Dagoh, 61% at Jogindernagar and 39% at Ghanetta). *Albizia lebbeck* showed highest survival (96%) at Jogindernagar during third year (Table 1).

Growth performance of fodder trees

The observations recorded on growth parameters viz., plant height, no. of branches, leaves/branch and leaf area in fodder trees at Ghanetta, Jogindernagar and Dagoh are presented in Tables 2, 3 and 4.

Plant height

Height attained by fodder trees is presented in Table 2, 3 and 4 (Fig.1). At all the 3 sites, height attained by fodder plants at the end of third year of study were respectively, *Albizia* (179–194 cm), *Artocarpus* (81–97 cm), *Bauhinia* (145–148 cm), *Grewia* (110–131 cm) and *Morus* (121 to 161 cm) at Ghanetta. Height attained by *Albizia* plant at the end of third year varied from 171 to 190 cm; *Artocarpus* (83 to 96 cm); *Bauhinia* (131 to 147 cm); *Grewia* (118 to 133 cm) and *Morus* (129 to 141 cm) at Jogindernagar. At Dagoh

Table 1. Survival (%) of trees at three sites

Site/Tree	Survival (%)		
	1st year	2nd year	3rd year
Dagoh			
Grewia optiva	83.56	90.70	94.18
Morus alba	90.50	91.20	95.00
Artocarpus chaplasha	81.81	72.60	63.40
Albizia lebbeck	91.54	83.29	60.78
Bauhinia variegata	89.12	91.23	97.42
Jogindernagar			
Grewia optiva	83.46	95.28	91.34
Morus alba	87.50	89.71	94.12
Artocarpus chaplasha	88.89	79.63	61.73
Albzzia lebbeck	90.57	97.48	96.23
Bauhinia variegata	88.19	97.22	95.14
Ghanetta			
Grewia optiva	89.25	83.87	78.50
Morus alba	94.17	86.41	81.56
Artocarpus chaplasha	92.31	90.38	39.42
Albizia lebbeck	88.89	77.78	51.11
Bauhinia variegata	88.89	87.88	88.85

Table 2. Growth performance of fodder trees at Ghanetta

Fodder Tree	Parameters	1st year		2nd year		3rd year		Av. increase/annum	
		B1	B2	B1	B2	B1	B2	B1	B2
Albizia lebbeck	Plant ht. (cm)	21.9	20.6	80.1	71.8	92.2	87.1	64.73	59.83
	No. of branches	1.0	1.1	1.4	1.2	1.8	2.2	1.40	1.50
	Leaves/branch	2.5	1.9	4.1	4.8	5.6	6.2	4.07	4.30
	Leaf area (cm^2)	7.5	8.6	13.4	14.1	14.6	17.9	11.83	13.53
Artocarpus chaplasha	Plant ht. (cm)	21.1	20.4	27.4	37.5	32.7	38.9	27.07	32.27
	No. of branches	1.2	1.1	1.4	1.6	1.8	2.1	1.47	1.60
	Leaves/branch	2.7	1.6	4.7	3.8	5.2	6.8	4.20	4.07
	Leaf area (cm^2)	13.3	11.6	38.4	45.5	58.6	61.8	36.77	39.63
Bauhinia variegata	Plant ht. (cm)	34.6	40.9	48.5	43.6	65.5	60.4	49.53	48.30
	No. of branches	1.2	1.7	1.8	2.0	2.9	2.8	1.97	2.17
	Leaves/branch	2.3	2.1	4.8	3.6	6.2	7.4	4.43	4.37
	Leaf area (cm^2)	38.3	34.5	51.5	61.6	91.1	84.3	60.30	60.13
Grewia optiva	Plant ht. (cm)	29.1	31.9	38.3	34.5	42.5	64.7	36.63	43.70
	No. of branches	1.1	1.0	1.4	1.8	1.6	2.1	1.37	1.63
	Leaves/branch	2.4	3.9	5.9	6.2	9.4	11.2	5.90	7.10
	Leaf area (cm^2)	11.3	13.7	21.8	23.4	37.1	39.8	23.40	25.63
Morus alba	Plant ht. (cm)	32.5	43.9	37.4	48.6	51.2	68.7	40.37	53.73
	No. of branches	1.0	1.0	1.8	1.7	2.1	2.3	1.63	1.67
	Leaves/branch	1.6	1.9	4.2	5.8	9.8	11.9	5.20	6.53
	Leaf area (cm^2)	25.3	27.4	36.9	41.4	71.2	82.1	44.47	50.30

B1, Fodder trees + introduced grasses + soil and water conservation and cut-and-carry; B2, fodder trees + introduced grasses + soil and water conservation and animal grazing.

Table 3. Growth performance of fodder trees at Joginderanagar

Fodder Tree	Parameters	1st year		2nd year		3rd year		Av. increase/annum	
		B1	B2	B1	B2	B1	B2	B1	B2
Albizia lebbeck	Plant ht. (cm)	26.9	32.6	61.7	68.8	82.4	88.9	57.00	63.43
	No. of branches	1.0	1.1	1.6	1.8	2.0	2.2	1.53	1.70
	Leaves/branch	2.1	2.8	3.9	4.6	6.4	7.6	4.13	5.00
	Leaf area (cm^2)	8.4	9.2	12.4	14.2	18.7	20.3	13.17	14.57
Artocarpus chaplasha	Plant ht. (cm)	17.2	19.4	29.3	34.7	36.8	42.1	27.77	32.07
	No. of branches	1.3	1.1	1.3	1.7	2.1	1.9	1.57	1.57
	Leaves/branch	1.9	2.2	3.9	4.2	4.9	5.8	3.57	4.07
	Leaf area (cm^2)	10.6	12.8	41.6	38.1	40.1	60.2	30.77	37.03
Bauhinia variegata	Plant ht. (cm)	29.7	34.8	41.4	43.6	60.2	68.7	43.77	49.03
	No. of branches	1.0	1.2	1.7	1.8	2.2	2.1	1.63	1.70
	Leaves/branch	1.9	1.7	3.9	5.1	5.9	6.0	3.90	4.27
	Leaf area (cm^2)	27.6	24.2	36.5	47.2	71.4	75.6	45.17	49.00
Grewia optiva	Plant ht. (cm)	31.7	33.2	37.2	41.2	49.4	58.2	39.43	44.20
	No. of branches	1.0	1.2	1.4	1.7	1.9	2.0	1.43	1.63
	Leaves/branch	2.6	3.4	4.9	5.8	8.7	10.8	5.40	6.67
	Leaf area (cm^2)	10.8	12.1	20.4	22.2	31.8	38.2	21.00	24.17
Morus alba	Plant ht. (cm)	38.5	31.7	42.1	40.3	60.4	56.8	47.00	42.93
	No. of branches	1.1	1.3	1.6	1.6	2.2	2.1	1.63	1.67
	Leaves/branch	2.1	1.8	5.4	4.7	8.4	7.9	5.30	4.80
	Leaf area (cm^2)	22.4	26.2	40.4	37.3	68.6	61.3	43.80	41.60

B1, Fodder trees + introduced grasses + soil and water conservation and cut-and-carry; B2, fodder trees + introduced grasses + soil and water conservation and animal grazing.

Albizia attained height in the range of 182 to 205 cm; *Artocarpus* (93 to 106 cm); *Bauhinia* (139 to 148 cm); *Grewia* (125 to 127 cm) and *Morus* (130 to 134 cm).

Increase in number of branches/plant at all the three sites is presented in Tables 2, 3 and 4. Increase in number of branches at the end of 3rd year were respectively in *Albizia*

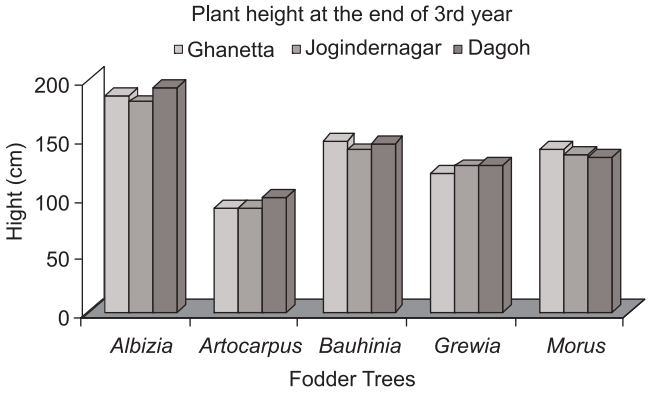

Fig. 1. Height of fodder trees at three sites

(4.2–4.5); *Artocarpus* (4.4 to 4.8), *Bauhinia* (5.9 to 6.5), *Grewia* (4.1 to 4.9) and *Morus* (4.9 to 5.0) at Ghanetta. At Jogindernagar the number of branches/plant were respectively in *Albizia* (4.6–5.1), *Artocarpus* (4.7), *Bauhinia* (4.9–5.1), *Grewia* (4.3–4.9), *Morus* (4.9–5.0) at Jogindernagar. The number of increase in branches during third year were respectively in *Albizia* (4.9–5.1), *Artocarpus* (5.1), *Bauhinia* (4.6–4.7), *Grewia* (4.7–5.1), *Morus* (4.8–5.0) at Dagoh.

Leaves/branch

The data presented in Tables 2, 3 and 4 depicted that number of leaves at the end of third year increased from 12 to 13, 12, 13, 17 to 21 and 15 to 20, respectively in *Albizia, Artocarpus, Bauhinia, Grewia, Morus* at Ghanetta. The leaves/branch ranged from 12 to 15, 10 to 12, 11 to 13, 16 to 20 and 14 to 16, respectively in *Albizia, Artocarpus, Bauhinia, Grewia, Morus* at Jogindernagar during third year. The no. of leaves/branch increased in the range of 13 to 17, 12 to 14, 12 to 16, 14 to 16 and 14 to 15, respectively in *Albizia, Artocarpus, Bauhinia, Grewia* and *Morus* at Dagoh during third year. The maximum number of leaves/branch were observed during June to August at all the 3 sites during 3 years. After September till January there was constant decline in number of leaves and the bearing on leaves started gaining after February.

Leaf area/plant

Data presented in Tables 2, 3 and 4 reveals that increase in leaf area ranges from 35 to 40 cm^2, 110 to 119 cm^2, 180 to 181 cm^2, 18 to 21 cm^2 and 15 to 20 cm^2, respectively in *Albizia, Artocarpus, Bauhinia, Grewia* and *Morus* at Ghanetta during third year. Leaf area increased in the range of 39 to 44 cm^2, 92 to 111 cm^2, 135 to 147 cm^2, 63 to 73 cm^2 and 125 to 131 cm^2, respectively in *Albizia, Artocarpus, Bauhinia, Grewia* and *Morus* at Jogindernagar during third year. Leaf area increased from 44 to 52 cm^2, 97 to 125 cm^2, 125 to 141 cm^2, 60 to 68 cm^2 and 119 to 130 cm^2, respectively in *Albizia, Artocarpus, Bauhinia, Grewia* and *Morus* at Dagoh during third year. Leaf area being direct function of no. of leaves/branch increased or decreased as number of leaves/plant

Table 4. Growth performance of fodder trees at Dagoh

Fodder Tree	Parameters	1st year		2nd year		3rd year		Av. increase/annum	
		B1	B2	B1	B2	B1	B2	B1	B2
Albizia lebbeck	Plant ht. (cm)	31.9	34.7	59.8	71.2	90.1	98.7	60.60	68.20
	No. of branches	1.1	1.0	1.8	1.7	2.2	2.2	1.70	1.63
	Leaves/branch	2.4	3.1	3.8	5.2	7.2	8.9	4.47	5.73
	Leaf area (cm^2)	9.5	10.4	13.7	17.4	21.2	24.3	14.80	17.37
Artocarpus chaplasha	Plant ht. (cm)	21.4	24.6	31.6	36.9	40.2	44.5	31.07	35.33
	No. of branches	1.2	1.1	1.7	1.6	2.2	2.4	1.70	1.70
	Leaves/branch	2.0	2.4	4.3	5.1	5.6	6.2	3.97	4.57
	Leaf area (cm^2)	11.7	13.4	42.7	47.3	42.3	64.2	32.23	41.63
Bauhinia variegata	Plant ht. (cm)	36.6	32.7	42.7	44.6	69.3	62.4	49.53	46.57
	No. of branches	1.1	1.0	1.5	1.7	2.0	2.0	1.53	1.57
	Leaves/branch	2.1	2.0	4.7	4.2	5.7	5.9	4.17	4.03
	Leaf area (cm^2)	26.4	28.3	38.4	42.6	60.2	69.8	41.67	46.90
Grewia optiva	Plant ht. (cm)	34.3	32.2	39.7	40.2	51.3	54.2	41.77	42.20
	No. of branches	1.1	1.2	1.6	1.7	2.0	2.2	1.57	1.70
	Leaves/branch	3.1	3.6	4.2	5.1	6.8	7.2	4.70	5.30
	Leaf area (cm^2)	12.3	13.9	18.4	20.2	29.3	34.4	20.00	22.83
Morus alba	Plant ht. (cm)	30.6	34.7	41.3	38.6	58.4	61.3	43.43	44.87
	No. of branches	1.0	1.1	1.8	1.6	2.2	2.1	1.67	1.60
	Leaves/branch	1.7	2.4	4.8	5.2	7.4	7.6	4.63	5.07
	Leaf area (cm^2)	21.8	28.9	38.7	41.3	58.9	60.2	39.80	43.47

B1, Fodder trees + introduced grasses + soil and water conservation and cut-and-carry; B2, fodder trees + introduced grasses + soil and water conservation and animal grazing.

increased or decreased as per the seasonal variation.

Regenerated fodder trees

From the first year of establishment of the silvipastoral system, regeneration (No. of plants/ha) of native trees started at all the 3 sites and at the end of third year of study, *Syzigium cuminii* (22), *Emblica* (22), *Bauhinia* (33), *Albizia lebbeck* (40), *Albizia chinensis* (28), *Grewia* (25), *Morus* (15) regenerated at Ghanetta. At Jogindernagar *Celtis* (27), *Albizia* (24), *Ficus* (19), *Morus* (6) were the fodder trees regenerated. *Emblica* (19), *Celtis* (15), *Albizia* (43), *Ficus* (56), *Grewia* (35), *Terminalia* (6) and *Bauhinia* (12) were the species regenerated at Dagoh by the end of third year.

Biomass production, nutritional composition and livestock productivity

Herbage availability during November to March at all the 3 sites was meager. Availability of herbage was highest during June to September. The data on herbage availability is presented in Table 5. Fig. 2 depicted the grass and fodder tree introduction at Ghanetta. During third year fresh biomass of 31.6, 28.6 and 30.8 t/ha was harvested from Ghanetta, Jogindernagar and Dagoh having dry matter production of 8.67, 6.98 and 7.62 t/ha, respectively. Pathak and Roy (1994) have also reported enhanced biomass production from the silvipastoral system. Higher biomass production at Ghanetta could be attributed to better establishment of perennial grasses and legumes and physiographic factors. Higher crude protein in the range of 12.33 to 13.46% was due to

Table 5. Biomass production, nutritional composition and livestock productivity

Herbage production	Ghanetta	Jogindernagar	Dagoh
Biomass production (FW) t/ha			
1st year	18.5 (*4.44*)	15.3 (*3.83*)	17.4 (*4.04*)
2nd year	23.1 (*5.75*)	21.4 (*5.32*)	22.8 (*4.39*)
3rd year	31.6 (*8.67*)	28.6 (*6.98*)	30.8 (*7.62*)
Figures in the parenthesis are DM production t/ha			
Nutritional composition of herbage during feeding trials (% DM basis)			
DM	94.62	92.16	94.47
CP	13.21	12.33	12.46
NDF	69.27	72.54	73.08
ADF	32.65	35.31	35.80
Ash	14.71	12.46	10.36
Livestock productivity			
Initial body wt. (kg)	69.438	69.500	68.560
Final body wt. (kg)	72.750	91.010	91.923
DMI (kg/head/day)	2.267	2.062	2.103
DMI (kg/100 kg)	3.176	2.882	2.896
Av. body wt. gain (g/day)	388.53	358.50	377.72

DM, Dry matter ; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; DMI, dry matter intake.

Fig. 2. Grass and fodder tree introduction at Ghanetta

combination of grass legume mixture. The findings are in corroboration with Gabra and Sherif (1985) and Tripathi (1989). The ADF content in herbage mixture ranged from 32.65 to 35.80 suggesting that the herbage mixture was palatable, nutritious and digestible.

The dry matter intake in cattle was 2.267, 2.062 and 2.103 kg/100kg body weight, respectively at Ghanetta, Jogindernagar and Dagoh. The DMI of grass was higher than the reported value by Shivaramaiah and Samapth (1981), which may be due to grass legume mixture. The dry matter intake was in the range as reported by Shrama and Thakur (1991), who reported that under thermoneutral conditions, the DMI ranged from 2.0 to 4.0 kg/100 kg body weight. The average daily body weight gain ranged from 358.50 to 388.53 g/day. The maximum live weight gain was recorded at Ghanetta, which may be due to better availability of grass and legume herbage mixture. It could be assumed that DMI of herbage mixture by the cattle were adequate to meet their requirements for growth.

Soil and water conservation

The rainfall during the rainy season (June to October) was highest at Ghanetta (1552.8 mm) followed by Jogindernagar (1259.1 mm) and least at Dagoh (846.3 mm). However, the runoff (% of rainfall) record was higher at Jogindernagar (26.6%) followed by Dagoh (26.4%) and Ghanetta (13.9%) owing to their land slopes of 99–148% (Jogindernagar), 85–127% (Dagoh) and 54–108% (Ghanetta). Among the grazing systems, cut and carry was most efficient at all the sites allowing only 15.8% runoff, compared to 20.6% and 27.1%, respectively under rotational and traditional grazing systems (Table 6). Among the resource conservation measures, trenching in combination with vegetative barrier was the most effective and allowed only 6.8% of rain as runoff compared to 38.9% under control (no measure). Classification of rainfall events as per rainfall amount received, revealed that rainfall events of more than 50 mm contributed 16.4 – 37.6% to the total runoff, though their number and rainfall amount was quite less as compared

Table 6. Effect of grazing systems and resource conservation measures on runoff (mm) at the three silvipastoral sites during 3rd year

Treatments	Ghanetta	Jogindernagar	Dagoh	Mean
Rainfall (mm)	1552.8	1259.1	846.3	1219.4
Grazing systems				
Traditional grazing	316.4 (20.4)	420.4 (33.4)	253.1 (29.9)	330.0 (27.1)
Cut and carry	149.8 (9.6)	241.3 (19.2)	187.6 (22.2)	192.9 (15.8)
Rotational grazing	183.1 (11.8)	342.4 (27.2)	229.9 (27.2)	251.8 (20.6)
Mean	216.4 (13.9)	334.7 (26.6)	258.2 (26.4)	
Resource conservation measures				
Trenching	69.6 (4.5)	174.4 (13.9)	87.2 (10.3)	110.4 (9.1)
Vegetative barriers	326.4 (21.0)	467.6 (37.1)	296.0 (35.0)	363.2 (29.8)
Trenching + Veg. Barrier	53.2 (3.4)	132.0 (10.5)	64.4 (7.6)	83.2 (6.8)
Control (No measure)	428.8 (27.6)	611.2 (48.5)	384.8 (45.5)	474.4 (38.9)
Mean	219.5 (14.1)	346.3 (27.5)	208.1 (24.6)	

Figures in parenthesis indicate the runoff as % of rainfall.

to the events of less than 50 mm (5.1 – 24.3%) at all the sites. Trenches formed in upper, middle and lower parts along the slope retained on an average 13.9, 16.6 and 19.1 cm sediments, respectively. Among sites, the sediment retention was highest at Dagoh (18.7 cm) followed by Jogindernagar (16.9 cm) and lowest at Ghanetta (14.0 cm).

Therefore, silvipasture seems to be one of the most viable options for regenerating and improving the Himalayan grasslands. Rai *et al*. (1999) have reviewed the silvipature research in India and have described the benefits of silvipasture. Trees and shrubs contribute, *inter alia*, to sustainable agriculture and provide a high value fodder for livestock. The system can enhance the forage availability many fold, which can assure the sustainability of on-going livestock rearing and in the process the resource base gets conducive inputs for its conservation.

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