Forage production from degraded forest and pasture land under protected and grazed conditions in Nepal

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Abstract

Under Nepal's Hills Leasehold Forestry and Forage Development Project (HLFFDP), protection from grazing and the introduction of suitable improved forage species has been a successful strategy for re-integrating degraded areas into Nepalese farming systems, improving both the environment and potential livestock production. Dry matter production and botanical composition of the established forage was determined at 500 and 1100 m.a.s.l. in three contrasting management systems across Nepal. The Dry-Weight-Rank method was used for botanical composition and the Comparative Yield method was used to estimate herbage dry matter production. An interview survey of farmers was also carried out to study their perception of the sustainability of the system. Improved species gave significantly higher yield over local species but there was no significant differences between sites at different altitudes. Positive farmers' attitudes towards this changed management system could lead to the development of degraded areas in a way which is sustainable.

Additional key words: *dry matter yield, botanical composition, farmers' perception*, Melinis minutiflora, Stylosanthes guianensis.

Introduction

Hill farming systems in Nepal are based on strategies to manage forest, pasture and arable lands in an integrated fashion. The interdependency of these systems occurs through an increasing dependence on livestock, or through products and services offered directly by support land resources (Stevens *et al.*, 1996). The livestock sector contributes 17% of the GDP (Rajbhandari, 1987) and 30% of the individual farmers' incomes (Shah, 1980). Total livestock numbers include over nine million cattle and buffalo, and over six million sheep and goat (HMGN/DLS, 1992), which is a high density to be sustained by the carrying capacity of the grazing land. Both year-round grazing on communal lands and stall-fed (cut and carrying fodder) systems occur throughout the country. Crop residues contributes about half of the required feed and the remainder has to come from forest and grazing lands (FAO, 1983).

In Nepal, forest covers some 5.5 million ha. Out of this total area, 1.4 million ha (26%) is considered degraded, having less than 40% crown cover and 0.6 million ha (11%) is degraded shrubland (LMP, 1993). The country's animal feed deficit is estimated to be around 36% (Pariyar and Samuel, 1988). Most of the palatable plant species, including the leguminous components, are overgrazed and their existence is threatened (Rajbhandary and Pradhan, 1991; Anonymous, 1993; Pande, 1994; Basnyat, 1995).

The Leasehold Forestry and Forage Development Project (HLFFDP) was started in 1993 with the objective of improving and reintegrating a total of 13,513 ha of degraded area into the farming systems, using a farmers' participatory approach with 14,224 farm families during the eight year period of its execution. As part of the Project, farmers were expected to control or exclude grazing by planting live fencing, and by careful monitoring. In addition, improved varieties of legume and grass species were oversown in part of the protected area.

This research was carried out at two altitudes to assess the effects of grazing exclusion and introduced, improved species. This was done by (a) comparing species composition and dry matter yield of forage from protected improved (with introduced species) and unimproved (with local species) plots and (b) surveying families to evaluate their perception of the programme.

Materials and Methods

The study was conducted at 500 and 1100 m.a.s.l. These altitudes were chosen because some of the introduced species were not expected to perform well at the higher altitude with an annual mean temperature of 18°C (range: 2°C to 31°C) compared with an annual mean temperature of 24°C (range: 6°C to 37°C) at the lower altitude (CBS, 1998). At each altitude, six farms with the same management systems were selected for dry matter estimation and 15 farms for the species composition. On each farm three management regimes: protected from grazing and oversown with improved species (protected improved), protected from grazing but with existing local species (protected unimproved) and adjacent continuously grazed common land (grazed plots) were compared. The improved species in the protected plots had been introduced in 1994/95, two years previously. An area of about one hectare was allocated to each farm unit (farm family) and protected from grazing. A quarter of the area of each farm was oversown with improved species, which included the legumes *Stylosanthes guianensis*, *Vicia faba* and *Desmodium intortum*, and the grass, *Melinis minutiflora*. This was the improved protected area. The unimproved protected plots were elsewhere within the one hectare area and the grazed plots were on adjacent common land. This study was done in September, 1997.

Species composition

The Dry-Weight-Rank (DWR) method developed by 't Mannetje and Haydock (1963) and improved by Jones and Hargreaves (1979) was used to measure botanical composition. A quadrat measuring .50 x 0.25 m was randomly placed six times in the 400 m^2 pasture plots and all species present in each quadrat were recorded by visual estimation. The species were ranked first, second and third on the basis of their estimated dry weight. These rankings were multiplied by 70.2, 21.1 and 8.7 respectively, and summed to get the dry-weight percentages of each species. This method has been shown to give a good estimation provided that 1) at least three species were present in the majority of sample quadrats, 2) there was at least some variability between quadrats in the rank order of the species and 3) there was no consistent relationship between quadrat yield and the dominance of any one species. These conditions were met on the selected plots.

Forage Production (DM yield)

The Comparative Yield method developed by Haydock and Shaw (1975) was used to estimate herbage dry matter production. Six farms at each altitude were randomly chosen. Forage yield estimation of improved species and local species was measured in this study to see whether there was a significant difference in dry matter production between the improved and local species at two altitudes.

The quantity of herbage dry matter in each treatment plot was estimated against a set of five standard reference quadrats, which had been pre-selected in the field to provide a scale over the range of yields likely to be encountered and available for reference throughout the sampling. The five standard quadrats were selected carefully and rated 1-5 on a linear scale. A sample from each of the five reference quadrats was harvested only once in each treatment plot. All the reference quadrats were cut, weighed for green weight, dried in an oven for 24 h at a temperature of 70°C and weighed for dry matter yield. Fifty quadrats were visually rated against the given set of standards. The mean dry matter yield estimates of quadrat samples were used to calculate the dry matter production from each treatment plot. Analysis of variance was used to test the significance of differences of the average dry matter production between the improved and local species and within each species at the two altitudes.

Questionnaire survey

A questionnaire survey was carried out to understand farmers' perception of the programme. Both men and women from 20 farm families from the lower altitude and 19 farm families from the higher altitude were chosen randomly for the survey. The questions were focused on change in management issues, technical problems, labour, income and environmental issues. In total, each interviewee was asked 64 semi-structured and open-ended questions. A preliminary field survey was done for the selection of sites and respondents. The questions were pre-tested in the field.

Results

Species composition

There was no difference in species composition between the two altitudes and the data were subsequently pooled. In improved plots at each site, the oversown legume *Stylosanthes guianensis* and the grass *Melinis minutiflora* were the dominant species, accounting for 48% and 23% respectively of the total vegetation in terms of dry weight visual estimation (Table 1). Among other introduced species, *Vicia faba*, *Desmodium intortum*,and *Pennisetum perpureum* together totalled less than 3%. Native grasses, broad leaf species and a few undesired species (less than 5%) were found among rest of the species. In unimproved plots, *Imperata cylindrica* (31%), *Arundinella nepalensis* (13%), *Pogonatheram crinitum* (10%), *Heteropogon contortus* (10%) other natural grasses (13%), other broad leaf plants (19%) and *Epatorium adenophorum* (4%) were the main species. In grazed plots, local grasses and broad leaf weeds were the dominant species; *Imperata cylindrica* (18%), *Bidens biternata* (23%), *Cyperus rotundus* (15%), other natural grasses (15%), broad leaf species (24%) and *Eupatorium adenophorum* (5%). Improved species of legumes and grasses were absent in both unimproved and grazed plots since they were not oversown on these plots.

Forage production

There were significant differences in dry matter production between improved and local species at both altitudes. Introduced improved species had higher dry matter production (5.3 t/ha at the low altitude site and 4.8 t/ha at the high altitude site) compared to the local species (3.1 t/ha at the low altitude site and 2.4 t/ha at

Table 1. Species composition of protected improved plots, protected unimproved plots and the grazed plots (averaged over low and high altitude).

Plot	Group	Local Name	Scientific Name	Percentage Covered
Protected and improved	legumes (improved)	Stylo	*Stylosanthes guianensis*	47.7
		Vetch	*Vicia faba*	0.8
		Desmodium	*Desmodium intortum*	0.5
	grasses (improved)	Molasses	*Melinis minutiflora*	23.0
		Napier	*Pennisetum perpureum*	1.0
	local grasses	Siru	*Imperata cylindrica*	8.0
		Thatch grass	*Arundinella nepalensis*	7.0
		Others		2.0
	broad leaf	Satibayer	*Rhus parviflora*	6.0
		Banmara	*Eupatorium adenophorum*	4.0
Protected and unimproved	local grasses	Siru	*Imperata cylindrica*	31.0
		Khar	*Arundinella nepalensis*	13.2
		Musekhari	*Pogonatherum crinitum*	10.4
		Khar	*Heteropogon contortus*	9.5
		Babiyo	*Crysopogon aciculatus*	4.6
		Khar	*Pogonatherum* spp.	4.3
		Others		4.0
	broad leaf	Titepati	*Artemisia vulgaris*	6.5
		Banmara	*Eupatorium adenophorum*	4.0
		Dhurselo	*Solanum verbascifolium*	3.7
		Satibayer	*Rhus parviflora*	8.8
Grazed	Local grasses	Kuro	*Bidens biternata*	22.7
		Siru	*Imperata cylindrica*	17.5
		Mothe	*Cyperus rotundus*	14.8
		Others	(*Arundinella* spp. + others)	16.0
	Broad leaf	Angeri	*Lyonia ovalifolia*	9.5
		Satibayer	*Rhus parviflora*	7.3
		Titepati	*Artemisia vulgaris*	7.2
		Banmara	*Eupatorium adenophorum*	5.0

the high altitude site) in a single cut. Dry matter yield of improved and local species did not differ significantly within the species at the two altitudes because of large yield variation among farms at the same site.

Farmers' perception

Farmers reported, that after the project started in 1993, farmers' skill for management of forage production had changed as they became trained in land development and the introduction, establishment and use of improved species of legumes and grasses in the protected areas. They also reported that, among the introduced legumes, *Stylosanthes guianensis* was the most successful. Farmers considered that legumes have improved soil fertility and soil condition and helped the growth and production of neighbouring forage species in addition to providing good quality fodder. *Melinis minutiflora* was the most successful grass, but animals preferred the legumes. After every monsoon, the ground coverage of improved perennials and local palatable species in the protected areas increased, but the faster spreading habit and taller character of *Melinis minutiflora* was putting legumes and other species in danger. Table 2 shows the overall values of improved and unimproved forage species derived from the farmer interviews.

Farmers expressed that before the program started their animals were used to grazing in the degraded communal pasture and were surviving with supplied crop residues. They noted that it was very hard to feed the animals, especially during dry winters. Farmers reported that changed management systems with increased forage production had added value by improving animal health and improving milk and meat production. They concluded that, while they had not reached a level of enough forage to feed their animals for the whole year, they had reduced the feed shortage by more than 50%. Apart from the green fodder produced from the provided plot, farmers were also collecting feeds from other sources. About 20% of the feed was derived from crop residues and fodder tree loppings from their private land and 10% from nearby forest areas. They were also accustomed to preparing hay to feed their animals during the scarce period. A few of them are making full use of the forage produced, selling products like high quality fresh fodder, hay and seeds for cash.

Farmers reported that out of the one hectare received per farm family, about 25% of the area was covered by improved species, 50% by local species and the remaining 25% was covered by multipurpose and timber trees. The survey showed that chemical fertiliser was not used, but some farmers were using manure collected from their livestock as compost fertiliser on improved plots. According to the farmers, the natural palatable species with higher feed value had regenerated and increased in ground cover with each new rainy season, and changes in species composition improved the level and seasonal uniformity of forage production.

Farmers estimated that each household was producing about 1.5 t of forage DM from fodder trees, other multipurpose trees and shrubs. In total each household has produced about 6.2 tonne of forage DM from their leased land and about 1.3 t DM of crop residues and green fodder from their private land. With this forage production level, they can keep a milking Murrah buffalo and about three local goats. Survey data showed that the overall mean for livestock per household was three (c. 900 kg). Each household therefore will need 10 t DM/year to meet the feed requirement. There is a fodder deficit of about 4 t DM/household/year. Farmers reported that, to meet this feed shortage, about 25% of

Table 2. Value of dominant species in improved, unimproved and grazed plots as assessed by farmers. (+ + + = high value, + + = medium and + = low value)

Plot Name	Major Species	Intake	Milk, Meat Power & Manure Production	Environmental benefit	Farmers' Interest
Improved	1. *Stylosanthes guianensis*	+ + +	+ + +	+ + +	+ + +
	2. *Melinis minutiflora*	+	+ +	+ +	+ +
	3. *Pennisetum perpureum*	+ +	+ +	+ +	+ +
Unimproved	1. *Imperata cylindrica*	+ +	+ +	+ + +	+ +
	2. *Arundinella nepalensis*	+	+	+ + +	+ +
	3. *Pogonatherum crinitum*	+	+	+ + +	+ +
Grazed	1. *Bidens biternata*	+ +	+	+ +	+
	2. *Cyperus rotundus*	+	+	+	+

them grazed their animals for about 2 hours on the communal grazing lands and the others collected fodder from nearby forests.

Discussion

After protection from grazing, the productivity of degraded pasture has increased. Improved species in the protected plots in both low and high altitude sites r significantly increased average dry matter production from that of local species. At the same time, both improved and local species did not differ in dry matter production between the two altitudes. This study was applied to only those plots where chemical fertilizer was not used. There was evidence of significant difference ($p \leq 0.01$) in fertilized and non-fertilized plots with respect to plant height in *Stylosanthes guianensis* (Pariyar and Grinten, 1997). Farmers reported that they cut forage four times a year in the plots with improved species and three times a year in the plots with local species. If the total dry matter production at a single harvest at the peak growth period was similar in the ration between the improved and local species at other harvests, forage production can assumed to be 10.6 t DM/ha/year from improved plots at low altitude and 9.5 t DM/ha/year from improved plots at high altitude compared to 6.2 t DM/ha/year from plots with local species at low altitude and 4.8 t DM/ha/year from plots at high altitude. A study made by FAO (1983) suggested that unimproved pasture and continuously grazed land in Nepal can yield about 0.4 to 1.8 t DM/ha/year.

The successful introduction of improved species of legumes and grasses and natural regeneration of local species was worthwhile. Increased forage production helped to increase livestock production, which has the potential to help increase the incomes for small farm holders. If sound policies are adopted, this type of programme looks suitable to improve degraded areas and has a lot of potential to improve both the environment and the income of the people. However to be successful this technology depends on farmers' perceptions, which are needed to decide on the suitability of these technologies (Chamber *et al.*, 1989).

The extra quantity and better quality forage available will relieve fodder scarcity and increase livestock production. Farmers now have more quality animals than they had before. It is important to keep in mind, however, that well managed livestock production systems can also result in healthy, productive, biologically diverse environments. The key is the need to balance livestock numbers with the potential of the degraded land to produce fodder.

Conclusion

The introduction of suitable improved species, especially legumes (i.e., *Stylosanthes guianensis*) and natural regeneration of local palatable species after protection from grazing can boost fodder production. Despite the large altitude variation, introduced, improved species performed better than the local species. Degraded lands have the potential to produce considerably larger amounts of quality fodder in a sustainable way. Farmers' greater interest and their involvement in the introduced system has made it a success. As the current farmers' economic situation does not allow expenditure on chemical fertiliser, some alternative approach is needed to build up fertility as an input to meet the nutrient demand of highly productive forage. This study has shown that re-integrating degraded areas into farming systems holds promise and that this practice should be applied in general to improve the environment and increase income levels of the farmers.

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