Chapter 2

Effect of Contour Hedgerows of Nitrogen-Fixing Plants on Soil Erosion of Sloping Agricultural Land

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INTRODUCTION

Sloping agricultural land technology (SALT), or contour hedgerow intercropping (agroforestry) technology (CHIAT) as it is also known, was developed some twenty years ago as a new approach that combines the strengths of terracing with the strengths of natural vegetation to stabilise sloping land and make it available for farming.

This chapter describes the results of trials to test the effectiveness of contour hedgerows of nitrogen-fixing plants *(Alnus nepalensis* and *Indigofera dosua)* in soil conservation of sloping agricultural land: i.e., the extent to which they could reduce erosion of soil from the slopes. The study focused on rainfall induced soil erosion as this is the principal source of erosion in the mid hills of Nepal; wind plays a far less important role.

MATERIALS AND METHODS

Study site

The study was conducted at ICIMOD's Godavari Trial and Demonstration Site. The site characteristics are summarised briefly in Chapter 1. The experiment was carried out on newly-cleared land in an area of degraded forest with sandy loam soil.

Experimental design

The experiment consisted of five treatments, each with three replications, as follows.

Treatment 1 (T1) = Control – traditional practice of Nepalese farmers with up-and-down slope tillage operations and clean or weed-free cultivation of annual crops, without hedgerows but with application of organic fertiliser

Treatment 2 (T2) = As T1 – but with double hedgerows of *Alnus nepalensis* along slope contour lines and crop and weed residues and hedgerow clippings incorporated into the soil in the alleys between the double hedgerows

Treatment 3 (T3) = As T2 – without use of organic fertiliser

Treatment 4 (T4) = As T2 – but with hedgerows of *Indigofera dosua*

Treatment 5 (T5) = As T2 – but with peach trees planted in the hedgerow alleys intercropped with vegetables

Each experimental plot was 5m wide across the slope and 20m down the slope (0.01ha), plots were laid out side by side with galvanized iron plates separating them. The replicate plots were arranged as three groups of five different plot treatments with the order of treatments within the group determined by random sampling. The layout is shown in Figure 2.1.

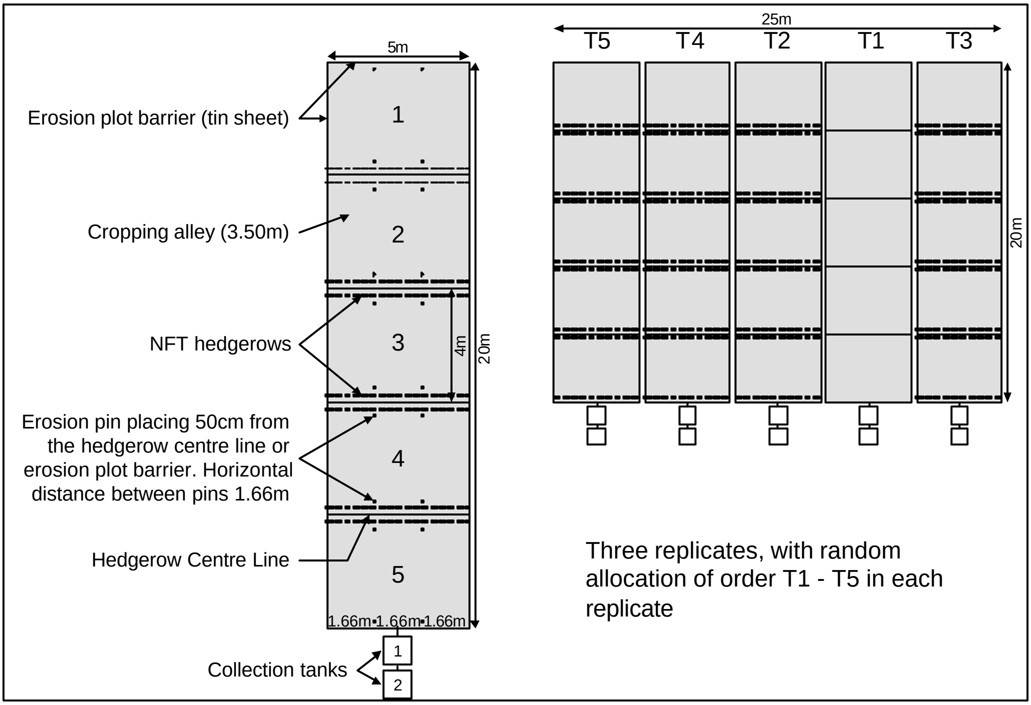

Figure 2.1: Layout of the research plot

The hedgerows were planted as five lines along contour lines at intervals of 4m down the slope: four double hedgerows with a single hedgerow at the bottom of the slope. Each double hedgerow was about 50cm wide and the intervening alleys were about 3.5m wide.

The hedgerows were established by transplanting seedlings using about 100 plants per 5m long double hedgerow. Each year any plants that had died were replaced with fresh seedlings. Planting of hedgerows was completed on 22 Jun 1995. The alleys were used for growing annual crops in T2, T3, and T4, and peach and vegetables in T5. The same crop was planted for the same cropping season in T1, T2, T3, and T4.

Management of the crops was similar except that no organic fertiliser was used in T3. The locally available concentrated organic fertiliser ‘kisan mal’ (3% N, 5% P_2O_5 and 2% K_2O) was applied throughout the experiment at a rate of 16t/ha once per cropping season (twice a year) for all treatments except T3. (Kisan mal is a concentrated organic fertiliser prepared from bone meal, chicken manure, and animal residues; the composition was confirmed by chemical analysis at the Soil Science Department of Tribhuvan University, Kathmandu.) The hedgerows were pruned once in 1996 and twice a year from 1997 onwards. The fresh trimmings were weighed and spread as mulch in the alleys. The twigs were placed within the double hedgerows.

Measurements

Measurements of surface runoff were carried out according to standard procedures (IBSRAM 1997). The surface runoff from each experimental plot was diverted through a gutter system into collection tanks. The first tank took all runoff water; a second tank received approximately 10% of any overflow from the first tank. The actual diverting coefficient was calibrated for each of the tanks. All the tanks were calibrated for volume calculated from the depth of water.

Data collection started on 26 June 1995, but the data for the first half year was not included in the calculations as the establishment activities caused frequent disturbances. The results reported here cover the period 1996 to 2000. Data for runoff and soil loss were collected on a daily basis during the monsoon season and on an event basis during the dry season. The height of the runoff collected in the tanks was recorded and the corresponding volume calculated with a computer programme.

Samples were taken for soil loss calculations when the water level in any one of the tanks reached or exceeded 5 cm. A sample volume of 500 ml was filtered in the field laboratory. Sediments were oven-dried and weighed. After recordings had been made, the tanks were emptied and cleaned in preparation for the next rainfall event.

A meteorological station was set up about 50m from the experimental plots. Air temperature, precipitation, evaporation, solar radiation, and sunshine duration were recorded manually on a daily basis, and on an hourly basis from an automatic weather station.

RESULTS

Rainfall characteristics

The rainfall characteristics of total rainfall, seasonal distribution, and rainfall intensity have a direct effect on soil erosion and these aspects were studied in detail. The monthly rainfall data for 1996 to 2000 are shown in Figure 2.2; the total days with different amounts of rainfall in Table 2.1; the total hours with different rainfall rates in Table 2.2, and the total annual rainfall and five highest daily rainfall events in Table 2.3.

The total number of days in a year with rainfall ranged from 178 to190. Of these, between 45 and 59 days per year had less than 1 mm of rainfall; these days were excluded from the analysis because of the negligible impact of such a small amount of rain on soil erosion. The total number of days in a year with rainfall over 1 mm ranged from 125 to 136 (Table 2.1), and the total number of hours with rain from 857 to 955 (Table 2.2). (The number of hours with rain in 2000 was excluded from the average as a result of problems with the data logger which led to uncertainty in these readings). Overall there was greater variation in the number of hours with rainfall than in the number of days with rainfall. The total annual rainfall ranged from 1,938 to 2,245 mm (Table 2.3), and the highest rainfall in a single day from

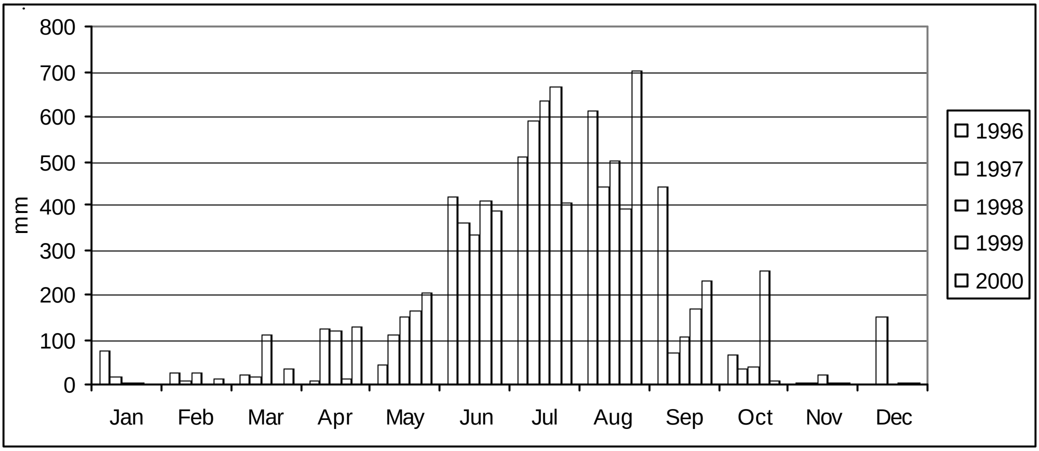

Figure 2.2: Monthly rainfall, 1996-2000

Table 2.1: Number of days with different ranges of rainfall, 1996-2000

Range (mm)	≥100	90-99.9	80-89.9	70-79.7	60-69.9	50-59.9	40-49.9	30-39.9	20-29.9	10-19.9	5-9.9	1-4.9	Total ≥1mm	<1	Total
1996	1	0	1	0	7	2	4	8	16	26	20	48	133	45	178
1997	0	0	2	1	2	3	3	7	10	29	32	47	136	54	190
1998	0	2	0	0	1	3	6	7	19	26	23	41	128	59	187
1999	2	0	0	0	3	2	8	11	7	25	25	46	129	54	183
2000	1	0	1	0	5	2	3	7	15	29	28	34	125	59	184

Table 2.2: Number of hours with different hourly rainfall range, 1996-2000

Range (mm)	40.0-49.9	30.0-39.9	20.0-29.9	10.0-19.9	5.0-9.9	1.0-4.9	<1.0	Total
1996	1	4	4	42	81	322	430	884
1997	0	1	4	32	76	315	429	857
1998	1	0	5	36	71	325	491	929
1999	0	1	4	29	100	341	480	955
2000*	0	4	4	24	55	230	373	690*

* Values affected by problems with the data logger

Table 2.3: Five largest daily rainfall events & total annual rainfall, 1996-2000 (mm)

	1st	2nd	3rd	4th	5th	Total annual rainfall
1996	125.8	85.0	66.1	64.7	63.0	2245
1997	89.2	87.9	76.9	69.7	63.9	1938
1998	97.1	93.2	68.1	57.2	53.7	2049
1999	112.8	108.0	65.8	62.0	61.0	2078
2000	109.8	84.8	65.8	64.2	60.4	2118
Variation (%)	41	27	17	12	19	2086

89.2 to 125.8 mm. In other words the inter-year variability of annual rainfall was moderate (16%) but the variability of highest rainfall in a day was high (41%). The maximum hourly rainfall rate also showed a high inter-year variability of 45% over four years (45.6 mm in 1996, 34.6 mm in 1997, 49.0 mm in 1998, 33.8 mm in 1999) (Table 2.2). In the different years, 78-85% of the days with rain had a rainfall of less than 20 mm, and around 51-55% had a rainfall of less than 5 mm (Table

2.1). There were between 3 and 9 days in each year with a high rainfall of more than 60 mm.

Around half of the hours with rain (49-53%) had a rainfall of less than 1 mm, and about 85-88% had a rainfall of less than 5 mm (Tables 2.2 and 2.4). Less than 5% of the hours with rain had a rainfall of more than 10 mm (likely to cause soil erosion).

Table 2.4: Proportion of rainy hours with different amounts of rain (%)

	>10 mm	>5 mm	<5 mm	<1 mm
1996	5.8	14.9	85.1	48.6
1997	4.3	13.2	86.8	50.1
1998	4.5	12.2	87.8	52.9
1999	3.6	14.0	86.0	50.3

Runoff and soil loss

The total average runoff (m^3/ha) and soil loss (t/ha) for each treatment in each of the five years from 1996 to 2000 are shown in Table 2.5 (averages calculated from the three replicate plot values) together with the averages for the whole period.

Over the five-year period, the four hedgerow treatments showed reductions in runoff compared to the control plot (T1), farmers' practice) of 38% (T2), 13% (T3), 33% (T4), and 37% (T5) (Table 2.5). The reduction in runoff increased with time for all treatments except T3 in 1999 and 2000, with runoff from T2, T4, and T5 in the fifth year approaching or less than half that from the control plot.

The annual soil loss for the control plots and the treatment plots is also shown in Table 2.5. The average soil loss in individual years from the control plots ranged from 2.8 t/ha in 1996 to 131.6 t/ha in 1998; the average annual soil loss over the five-year period was 39.4 t/ha. The average annual soil loss from the treatment plots over the five years was only 11% (T2), 30% (T3), 17% (T4) and 11% (T5) of the control values. T3, without use of organic fertiliser, showed the greatest soil loss

Table 2.5: Summary of runoff and soil loss from 1996-2000

	Runoff (m^3/ha)					Soil loss (t/ha)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
1996	802	604	757	641	644	2.8	0.4	1.5	0.7	0.6
Percent of T1		75	94	80	80		15	55	24	23
1997	495	361	426	380	367	3.9	0.2	0.9	0.4	0.2
Percent of T1		73	86	77	74		5	22	10	5
1998	1,401	876	1,075	924	833	131.6	19.8	46.8	29.8	20.5
Percent of T1		63	77	66	59		15	36	23	16
1999	643	341	547	376	375	8.3	0.0	1.0	0.1	0.2
Percent of T1		53	85	58	58		1	12	1	2
2000	873	419	870	501	445	50.5	1.4	8.7	2.4	1.1
Percent of T1		48	100	57	51		3	17	5	2
Average	843	520	735	564	533	39.4	4.4	11.8	6.7	4.5
Percent of T1		62	87	67	63		11	30	17	11

in each of the five years, mainly as a result of the extremely poor growth of crops with this treatment. The contour hedgerows of *Alnus nepalensis* (T2, T5) were slightly more effective than those of *Indigofera dosua* (T4) in reducing soil loss, largely because *Alnus nepalensis* grew better than *Indigofera dosua* under the local geoclimatic conditions.

The annual soil loss in 1998 was far greater than in all the other years, and those in 2000 somewhat greater than the other years apart from 1998. Soil losses were lowest in 1999 for all treatments except the control. Even in 1998, soil loss was considerably reduced in the treatment plots compared to farmer's practice (to between 19.8 and 46.8 t/ha, from 131.6 t/ha).

The monthly runoff and soil loss are shown in Tables 2.6 and 2.7 and the seasonal distribution of soil loss and runoff in Tables 2.8 and 2.9. The seasonal distribution of rainfall is shown in Table 2.10. In the two years when soil losses were high, 1998 and 2000, the greater part of the soil loss from the control plots (51 and 85%) occurred during the pre-monsoon period (April-May), even though only one-third of the runoff (37 and 29%) was observed during this period.

Table 2.6: Monthly runoff (m^3/ha) from 1996-2000

	1996					1997					1998				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
Jan	23	25	23	23	23	4	3	3	3	2	-	-	-	-	-
Feb	7	6	5	7	5	-	-	-	-	-	8	7	7	7	7
Mar	13	12	13	16	10	3	2	2	2	2	43	24	25	27	26
Apr	0	0	0	0	0	25	15	16	18	16	242	203	201	199	223
May	6	0	4	0	0	40	19	21	22	23	234	211	246	245	176
Jun	183	129	142	137	128	126	83	84	80	80	151	70	100	74	68
Jul	203	148	181	163	139	176	139	151	150	144	475	200	254	207	171
Aug	210	160	199	166	176	99	86	132	87	84	205	132	198	132	132
Sep	146	114	179	118	153	-	-	-	-	-	30	18	34	20	19
Oct	11	10	11	11	10	-	-	-	-	-	10	9	8	9	9
Nov	0	0	0	0	0	-	-	-	-	-	3	3	3	3	3
Dec	0	0	0	0	0	23	16	17	17	16	-	-	-	-	-
Total	**802**	**604**	**757**	**641**	**643**	**495**	**361**	**426**	**380**	**367**	**1,401**	**876**	**1,075**	**924**	**833**

	1999					2000				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
Jan	-	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	10	8	7	9	7
Apr	2	2	3	3	2	188	70	97	106	64
May	101	28	60	31	48	58	22	50	28	22
Jun	150	97	123	105	99	315	96	213	103	103
Jul	313	156	293	174	168	44	27	65	30	29
Aug	40	23	34	28	24	203	152	334	177	168
Sep	-	-	-	-	-	54	45	103	47	51
Oct	37	34	34	35	34	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-	-	-
Total	**643**	**341**	**547**	**376**	**375**	**873**	**419**	**870**	**501**	**445**

Table 2.7: Monthly soil loss (t/ha), 1996-2000

	1996					1997					1998				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Jan	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-
Feb	0.01	0.00	0.00	0.00	0.01	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Mar	0.13	0.03	0.05	0.08	0.03	0.01	0.00	0.00	0.00	0.00	2.47	0.02	0.03	0.03	0.03
Apr	-	-	-	-	-	0.11	0.01	0.01	0.02	0.01	37.75	16.86	23.85	15.80	15.09
May	0.01	-	0.02	-	-	1.43	0.02	0.05	0.14	0.03	26.44	2.69	19.97	13.90	5.30
Jun	1.94	0.15	0.40	0.32	0.16	0.70	0.04	0.07	0.04	0.04	23.75	0.14	0.81	0.04	0.01
Jul	0.46	0.11	0.71	0.14	0.11	1.51	0.10	0.46	0.14	0.06	40.81	0.03	1.60	0.03	0.02
Aug	0.18	0.10	0.22	0.08	0.15	0.07	0.03	0.26	0.02	0.03	0.30	-	0.43	0.00	-
Sep	0.06	0.02	0.13	0.03	0.17	-	-	-	-	-	0.04	-	0.07	-	-
Oct	0.01	0.01	0.01	0.01	0.00	-	-	-	-	-	0.01	0.01	-	0.01	0.00
Nov	-	-	-	-	-	-	-	-	-	-	0.01	-	0.01	-	-
Dec	-	-	-	-	-	0.04	0.00	0.02	0.00	0.00	-	-	-	-	-
Total	**2.80**	**0.42**	**1.53**	**0.66**	**0.64**	**3.88**	**0.19**	**0.87**	**0.37**	**0.18**	**131.59**	**19.75**	**46.77**	**29.80**	**20.46**

	1999					2000				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Jan	-	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	0.03	0.00	0.01	0.01	0.01
Apr	0.01	0.00	0.00	0.01	0.00	42.65	0.86	1.56	2.09	0.44
May	3.25	0.03	0.28	0.09	0.09	0.59	0.00	0.49	0.01	0.00
Jun	1.33	0.01	0.04	0.01	0.03	6.87	0.27	4.08	0.10	0.07
Jul	3.72	-	0.63	0.00	0.03	0.02	0.01	0.27	0.00	0.00
Aug	0.00	-	-	-	-	0.21	0.14	1.45	0.13	0.42
Sep	-	-	-	-	-	0.07	0.07	0.86	0.03	0.11
Oct	0.02	0.00	0.00	0.01	0.00	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-	-	-
Total	**8.33**	**0.04**	**0.96**	**0.11**	**0.16**	**50.45**	**1.35**	**8.71**	**2.36**	**1.06**

Table 2.8: Seasonal distribution of runoff in percent 1996-2000

	1996					1997					1998				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Premonsoon	2	2	2	3	-	14	10	9	11	11	37	50	44	51	51
Monsoon	93	91	93	91	94	81	85	86	83	84	62	48	55	47	47
Postmonsoon	1	2	1	2	2	-	-	-	-	-	1	1	1	1	1
Wintenr	4	5	4	5	4	5	5	5	5	5	1	1	1	1	1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

	1999					2000				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Premonsoon	16	9	11	9	13	29	24	18	29	21
Monsoon	78	81	82	82	78	71	76	82	71	79
Postmonsoon	6	10	6	9	9	-	-	-	-	-
Wintenr	-	-	-	-	-	-	-	-	-	-
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 2.9: Seasonal distribution of soil loss in percent, 1996-2000

	1996					1997					1998				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
Premonsoon	5	7	5	3	5	40	12	9	44	23	51	50	94	100	100
Monsoon	94	89	95	91	92	59	86	86	55	74	49	48	6	0	0
Postmonsoon	0	3	0	2	1	-	-	-	-	-	0	1	0	0	0
Winter	1	1	0	5	2	1	2	5	1	3	0	1	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

	1999					2000				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
Premonsoon	39	81	30	82	57	86	64	24	89	43
Monsoon	61	12	70	12	43	14	36	76	11	57
Postmonsoon	0	6	0	6	1	-	-	-	-	-
Winter	-	-	-	-	-	-	-	-	-	-
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 2.10: Seasonal distribution of annual rainfall

	Pre-monsoon	Monsoon	Post-monsoon	Winter	Total
1996	3	89	3	5	100
1997	13	76	2	9	100
1998	19	77	3	1	100
1999	8	79	12	1	100
2000	17	81	1	1	100
Average	**12**	**80**	**4**	**3**	**100**

Discussion

Reduction of soil loss

The results show that all the hedgerow treatments considerably reduced soil loss from the second year of planting, and that the effect increased overall with time, and suggest strongly that contour hedgerows could be a useful tool to reduce soil loss from sloping agricultural land.

The pronounced effect of the contour hedgerows in reducing soil erosion results from a combination of factors. The hedgerows function as physical barriers to soil movement, and can function like a sieve to filter out sediment from surface runoff. They also decrease the velocity of the surface runoff by reducing the length of the slope through the formation of almost flat terraces separated by steep steps, thus reducing the amount of soil the water takes with it. At the same time, they reduce the total amount of runoff by slowing the water and allowing it time to penetrate the soil and by providing a thickly rooted area that can act as a sponge. Thus surface water runoff is slower, there is less of it, and it has a lower concentration of sediment, all of which mean markedly reduced soil erosion.

Runoff and soil loss from the Treatment 3 plots – hedgerows of *Alnus nepalensis* but without application of organic fertilisers – were higher than for the other three treatments although still lower than the control values. The main difference in the T3 plots was the very poor growth of crops. In all three replicates, the planted crops showed only moderate germination and growth in 1996, and very poor germination or growth from 1997 onwards. The vegetative cover in T3 was thus much lower than in the other plots. The reasons for this very poor growth are not entirely clear, but the results indicate that land cover per se is also very important for soil conservation. The T3 alleys were almost bare during the cropping season, but even then the soil loss was much less than from the control, which again illustrated that contour hedgerows can be very effective in reducing soil loss.

The soil loss from the control was actually very low in three of the five years studied, only around 3-8 t/ha, much lower than the generally accepted average level of 12 t/ ha. In the other two years (1998 and 2000), however, it was very high – 131.6 and 50.5 t/ha – giving an average of nearly 40t/ha for the five years. This reflects the typical challenge for mountain agriculture: unpredictable downpour and cloudburst events that are localised and infrequent but can have a devastating impact when they occur.

Rainfall, runoff and soil loss

The annual variations in soil loss and runoff did not correlate with total annual rainfall. For example, although 1998 had by far the highest values for runoff and soil loss, the annual rainfall in this year was the second lowest.

Soil loss did appear to be associated with intense rainfall events, but only at certain times of year. Much of the massive soil loss in 1998 was caused by a single rainfall event of 49 mm/hour on 26 April and two premonsoon events of 18 and 20 mm/hr on 30 June and 1 May, although the control plots continued to lose soil thereafter, particularly in a series of events in July. Similarly most of the soil loss in 2000 was caused by several rainfall events ranging from 4.2 to 12.8 mm/hour during late April. However, a rainfall event with 45.6 mm/hour on 10 September 1996 did not cause much soil loss, and although over the five years there were many rainfall events with an intensity of more than 20 mm/hour during the monsoon period, soil loss from these was extremely low compared with the soil loss caused by events of only 4.2-12.8 mm/hour in April 2000. The main reason for this difference is probably the difference in land cover. The land was almost bare in the pre-monsoon shortly after planting maize (March 1998 and April 2000) and very susceptible to erosion as the plants were not fully established, but there was good crop cover during the monsoon.

The total runoff also tended to be higher for rainfall that fell during the premonsoon season. For example, although only 19% of the rainfall fell in the premonsoon season in 1998 it caused 37-51% of the annual runoff (depending on the treatment), whereas the 77% of rain that fell in the monsoon season caused only 47-62% of the annual runoff. In the years when there were fewer premonsoon rainfall events (1996, 1997, 1999), the monthly runoff and soil loss were more closely related to the monthly rainfall pattern.

The results suggest that the pre-monsoon period, especially April, is a very critical season for soil conservation of sloping agricultural land in the mid hills. At this time one or two critical rainfall events can cause a large proportion of the annual soil loss, and higher losses altogether than in years where a plot is not affected by heavy rain during this period. This confirmed the findings of Carver and Nakarmi (1995) who observed two critical events to produce 50-90% of annual total soil loss from sloping land.

Vegetation cover and soil loss

The results of this study, in which higher soil losses were observed from the plot with poor crop development and from bare land in the pre-monsoon, confirm the common belief that land surface cover plays a very important role in soil conservation. Maintaining sufficient surface cover is important for the reduction of soil erosion.

Contribution of largest erosion events to annual soil loss

The total number of soil erosion events varied from 34 in 1999 to 60 in 1996 with around 40 in 1997, 1998, and 2000. Of these events, the five largest contributed between 75 and 90% of the total annual soil loss in the different treatment plots; and the largest 10 events contributed between 90 and 100% of total annual soil loss. This confirms the observations by Nakarmi et al. (2000) that around ten events generated 90% of annual soil losses from a rainfed agricultural terrace. This has important implications for erosion research and mitigation. Data collection for plot-based soil erosion research is a resource intensive activity. In the experiments described here, at least four persons had to work full time on data collection for the fifteen soil erosion plots during the monsoon season. If a way can be discovered of capturing the most important 5 to 10 erosion events, and ignoring the other 30 or more, then it may be possible to perform such research, and investigate mitigation approaches, much more effectively.

Conclusions

The reported rates of soil loss from sloping agricultural under farmers' practice (similar to the control used in the trials) vary greatly, from 1 to 120 t/ha/year, but mostly seem to lie at around 20-60 t/ha/year (Partap and Watson 1994). In the present study, the average annual loss from the control plots was 39t/ha/year. These rates of soil loss have a marked negative impact on mountain agriculture. The results of this study, using hedgerows of *Alnus nepalensis* and *Indigofera dosua,* indicate that sloping agricultural land technology or SALT can greatly reduce soil loss from the second year of planting if the contour hedgerows are properly maintained. Properly managed, hedgerows can reduce soil loss by 80 to 99% from the fifth year on. The significant reduction in soil loss in the hedgerow plots was apparent both in terms of a substantial decrease in sediment concentration and in a reduced runoff velocity, which was the result of the hedgerows functioning as barricades. Total runoff was also reduced, although less markedly because of the high infiltration rate of the soils. These results suggest that SALT offers a potential alternative to traditional farming practices: using contour hedgerows, it should be possible to introduce continuous and sustainable cultivation of sloping land.

This study also demonstrated that SALT can be used in subtropical and temperate regions, not only in the tropical regions for which it was first developed. However, it is important to select appropriate hedgerow species (see Chapter 3). The species *Alnus nepalensis* used as the main demonstration species in these trials is not recommended as a hedgerow species for practical field applications because of the problems it poses when grown. The seeds are tiny and direct seeding is extremely difficult. Hedgerows can only be established by transplanting, and although successful, this technique is time consuming and resource intensive, and special care and techniques are needed to raise seedlings. Selection of appropriate hedgerow species is discussed in the fourth book in this series (Tang Ya 2004).

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The three replicate plots for soil erosion and soil fertility studies as described in the next chapter. The different fertility levels of the parallel strips with five different treatments (four with hedgerows, one without) are clearly visible.