Effects of Contour Hedgerows on Runoff Flow and Soil Erosion Control in a Dry Valley of the Jinsha River

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Introduction

The Chinese Himalayan region in western China is characterised by a high percentage of mountains. Population pressure is becoming increasingly serious in many parts of the region. To meet the population demands for survival and day-to-day life, agricultural and economic activities have been extending to very steep sloping lands. Owing to deforestation and extensive cultivation on sloping land, farmers in mountainous areas have been facing such problems as serious soil erosion, declining soil fertility, and environmental deterioration. For example, in Ningnan County, the experimental area of this study, about 56% of the total arable land has suffered from land degradation through water erosion. More than 10% of farmers still rely on lands with slopes exceeding 25°. Meanwhile, the crop yields on sloping land are low due to soil fertility degradation or seasonal drought.

Contour hedgerow intercropping technology has been identified as an effective method to control soil erosion and improve soil fertility in mountain farming systems (Kiepe 1995; Narain et al. 1998; Palmer 1997; Partap and Watson 1994). In 1991 the Chengdu Institute of Biology (CIB), in collaboration with ICIMOD, selected Tanguanyao and Masangping in Ningnan County as sites for demonstrating contour hedgerow intercropping. Since 1994, on-farm research has been carried out at two project sites to assess the effect of hedgerows on soil and water conservation in this region . After several years' experimentation, some obvious changes have been observed. This paper evaluates the effects of contour hedgerows on runoff and control of soil erosion.

Materials and Methods

Study area

Ningnan County, located in the hot and dry valley of the Jinsha River, is characterised by a subtropical monsoon climate. Two experimental sites were established in Ningnan County representing two typical agro-ecological areas. The major features of the sites are listed in Table 1.

Table 1: Main biophysical features of project sites

Sites	Tanguanyao	Masangping
Location	Pisha Township	Lutie Township
Elevation	1100-1203 m	1400-1485 m
Slope gradient (at plots)	18°	23°
Soil type	Dry red soils	Red-cinnamon soils
Annual mean temperature	19.3 °C	14.7 °C
Annual rainfall	970 mm	1100 mm
Rainfall distribution	91% in rainy season	88% in rainy season

Experimental Design

Fifteen soil erosion plots were established at the Tanguanyao and Masangping sites in 1995 and 1996. Rectangular erosion plots 20 m along slope and 5 m across slope were built. Five rows of N_2-fixing hedgerows were planted in each plot except for the control plot. Concrete barriers were inserted in the ground to check surface and near surface flow. Runoff from the plot was collected in a tank through a runoff gutter. One control tank with runoff gutter but without a plot was established at each site to reduce the error caused by rainfall collection of the tank and gutter and water evaporation. The cross-sectional area of each gutter was 2 m^2 (0.4 m×5 m), and the volume of each tank was 1 m^3 (1 m long, 1 m wide, and 1 m high). A scale line was marked from bottom to top at every centimetre near the corner of each tank. Tanks were calibrated for water volume at each water height by addition of water, and calibration curves were obtained for each tank.

Five treatments with three replications were used; the treatments were:

- T1: Farmer's practice (without hedgerows and with fertiliser),
- T2: *Leucaena leucocephala* hedgerow + annual crops without fertiliser,
- T3: *Leucaena leucocephala* hedgerow + annual crops with fertiliser,
- T4: *Tephrosia candida* hedgerow + annual crops with fertiliser,
- T5: *Leucaena leucocephala* hedgerows + mulberry trees with fertiliser.

At the Tanguanyao site, peanut was planted in the plots every year except 1998, when maize was grown. Maize was cultivated at the Masangping site except that peanut was cultivated in 1998. Superphosphate was applied at a rate of 30 kg/ha for peanut; 30 kg/ha of urea was used for maize. Day-to-day management of crops in plots followed local farmers' practice.

The water level in each tank was recorded after every rainfall, and the runoff was calculated using the tank calibration curves. The sediment was thoroughly mixed and a bottle (0.625 l) of samples was collected if the water level in the tank was greater than or equal to 5 cm. Then all the tanks were cleaned before the next storm. The sediment samples were filtered and sent to a laboratory for air-drying and oven drying at 65-70 °C. Net weights of sediment on the filter paper were calculated and soil loss in every rainfall event was calculated for each plot.

Results and Discussion

The amounts of runoff from 1997 to 1999 at Tanguanyao and Masangping are presented in Figures 1 and 2, respectively. The results show that the contour hedgerow system is very effective in controlling runoff. Three years after contour hedgerow establishment, runoff was reduced to 26-31% of that under farmers' practice at Tanguanyao. In Masangping, *L. leucocephala* hedgerows were more effective than *T. candida* hedgerows in reducing runoff. Runoff from treatments with *L. leucocephala* hedgerows was 31-41% of the control plot, and that from treatment with *T. candida* hedgerows was 47-60% of the control. The results indicate that almost half of surface water flow is intercepted into soil by contour hedgerows, which helps to alleviate temporary drought and topsoil erosion.

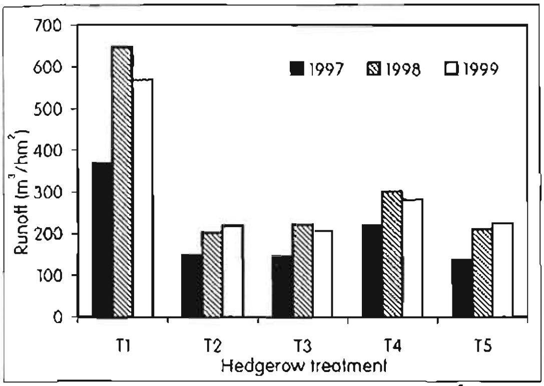

Figure 1: **Runoff at Masangping site**[1]

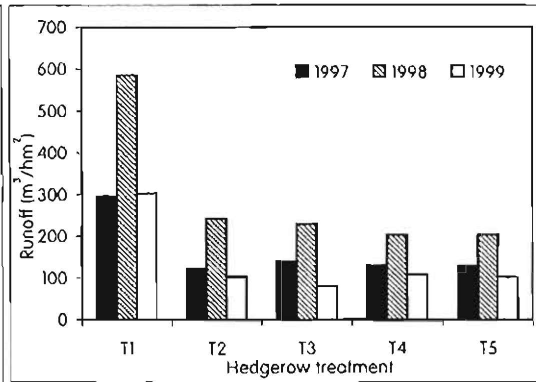

Figure 2: **Runoff at Tanguanyao site**[1]

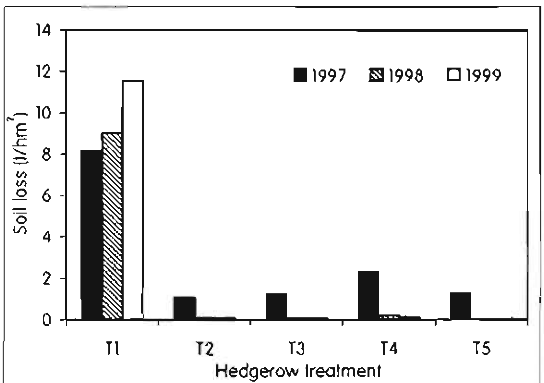

Figure 3: **Soil loss at Masangping site**[1]

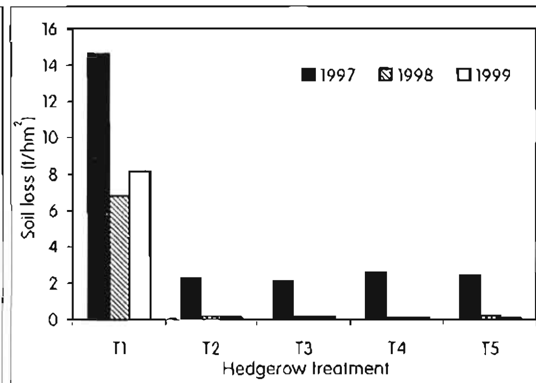

Figure 4: **Soil loss at Tanguanyao site**[1]

The soil loss is shown in Figures 3 and 4. The contour hedgerows were very effective in reducing soil erosion. Compared to farmers' practice, soil loss in plots with contour hedgerows was down to 2-5% of that from control plots 3-4 years after hedgerow establisment at both project sites. The effects of the contour hedgerows on controlling soil loss increased with time after hedgerow establishment.

Maintenance of hedgerows can gradually lead to the formation of terraces after several years' normal cultivation in the alleys. The slope gradients of alleys in each plot at two project sites measured in 1998 are shown in Table 2. The gradient of alleys in plots with hedgerows reduced from 17° to around 7°after seven years of cultivation at the Tanguanyao site, and from 23° to around 11° at the Masangping site after five years of cultivation. It is believed that the bio-terraces will be thoroughly formatted after a few more years of cultivation, the results confirmed that this kind of bio-terrace is easy to establish and manage, and is more stable than engineered terraces.

Table 2: Gradient changes of alley slope after hedgerow establishment

Site	T1 (Control)	T2	T3	T4
Tanguanyao (after 7 years)	17°12'	6°28' - 10°	6° - 8°25'	8°18' - 11°
Masangping (after 5 years)	23°	10° - 12°32'	9°50' - 12°20'	12°30' - 13°

[1]hm = ha (ed)

Ningnan County is located in the hot and dry valley of the Jinsha River with a typical monsoon climate; most runoff and soil loss occur in the rainy season from May to October. The temporal distribution of runoff and soil loss in control plots during the monsoon season in 1999 is presented in Table 3. At Tanguanyao, more than 80% of the runoff and more than 90% of soil loss occurred from June to August. At Masangping only 40% of the runoff occurred from June to August, and 60% from September to October; but 78% of total soil loss occurred from June to August.

Table 3: Temporal distribution of runoff and soil loss in control plots

Site	Period	Runoff (m^3/ha)	Soil loss (t/ha)	Soil loss/runoff
Tanguanyao	May	11.81	0.237	2.01%
	Jun.	78.62	3.055	3.89%
	Jul.	80.02	1.971	2.46%
	Aug.	93.57	2.404	2.57%
	Sep.	34.65	0.426	1.23%
	Oct.	4.73	0.062	1.31%
Masangping	May	0	0	–
	Jun.	60.13	2.77	4.61%
	Jul.	87.34	3.64	4.17%
	Aug.	81.13	2.63	3.24%
	Sep.	176.39	1.43	0.81%
	Oct.	163.87	1.06	0.65%

Agrochemical analysis indicated that erosion accelerates nutrient loss. Table 4 compares the nutrient contents of topsoil and erosion soil and shows that the total nitrogen and organic contents of the sediments at the two sites were between 2.5 and 4.2 times those of topsoil. This result clearly implies that a large amount of nutrients are lost to soil erosion.

Table 4: Comparison of nutrients of topsoil and erosion soil

Site		Sediment	Topsoil	Ratio
Tanguanyao	Total N (%)	0.143	0.053	2.3
	Organic matter (%)	3.272	0.780	4.2
Masangping	Total N (%)	0.172	0.069	2.2
	Organic matter (%)	5.236	1.912	2.5

Conclusions

The results demonstrate the effectiveness of contour hedgerows in soil conservation in the subtropical region. Maintenance of hedgerows can lead to formation of terraces after several years' normal cultivation in the alleys. This kind of bio-terrace is easy to establish and manage, and is more stable than engineered terraces. The contour hedgerow system shows great potential for conserving water and soil on sloping agricultural lands. It is recommended that contour hedgerow technology be applied in subtropical areas of the Chinese Himalayan region if proper hedgerow species are selected.

References

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