Integrating Cash Crop Hedgerows and Balanced Fertilization to Control Soil and Water Losses from Sloping Farmlands

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Based on several years of research and demonstrations, adopting cash crop hedgerows and balanced fertilizer technology to combat soil erosion has proven very practical and applicable. It not only reduces soil erosion from sloping farmlands, but also increases crop yield and farmers' income. This integrated new technology has realized the goal of combining social, ecological, and economic benefits, and can thus safeguard sustainable agriculture on sloping lands.

Uplands prevail in the upper reaches of the Yangtze River, making the region prone to severe soil erosion due to a high cropping index, over-grazing, high rates of soil erosion, and a fragile ecology. Annual runoff and silt discharged into the Yangtze River are estimated at 440 billion m^3 and 530 million metric tons (M t), respectively (Yichang Hydrologic Station). Sloping farmlands in the upper reaches account for only 5.5 M ha (16% of total farmland), but contribute 380 M t of soil loss or 44% of total erosion. It is obvious that these regions are the major origin of sediments feeding to the water courses of the Yangtze River. Thus, it is important to seek applicable agronomic measures to prevent soil erosion.

Bio-terracing (left) can significantly reduce soil erosion as an alternative to down-slope cultivation (right).

The traditional technology used over the past 20 years in China for soil and water conservation on sloping lands is engineered terracing. Due to its high cost, the technology cannot be adopted by farmers without financial support from government. In order to reduce the cost of soil conservation, a new method of 'cash crop hedgerows' (CCH) was developed and has been tested since the late 1990s in China's southwest provinces of Sichuan, Yunnan, and Guizhou.

The amount of runoff and soil loss from corn fields with farmers' practice (FP) are closely correlated to intensity and quantity of each rainfall, and both reach peak values in June when the soil surface is not fully covered by the crop canopy and the soils are loose and susceptible to erosion (**Table 1**). After June, though rainfall produces rather large runoff, soil loss is not observed. This is because: 1) with time, topsoil becomes more compact due to root penetration and an increase in soil cohesion; and 2) flourishing crop growth provides full shading that prevents raindrops from directly hitting the soil surface.

Table 1. Results of soil erosion and runoff under farmers' practice (down-slope cultivation) and precipitation in Luodian, Guizhou, 2001.

Month	April	May	June	July	August	September	Total
Rainfall, mm	225	1,569	6,420	444	1,514	308	10,479
Run-off, t/ha	23	661	2,258	36	162	28	3,167
Soil loss, t/ha	0.2	25.8	76.3	nil	nil	nil	102.3

In Yunnan, field experiments were conducted in Xiangyun and Fuming counties, representing two typical erosive soils in the province. Experiments consisted of five treatments including FP (down-slope cultivation), FP + balanced fertilization (BF), FP+BF+Chinese prickly ash tree+Chinese day lily (CCH), contour cropping (CC)+BF and CC+BF+CCH. Amounts of soil lost varied from year to year and were positively correlated to annual rainfall. Any practice that could maximize soil coverage and stabilize topsoil would significantly reduce soil erosion (**Table 2**). On average, FP+BF reduced soil loss by 21%, and this was further reduced by 52% with CCH in the 4-year experiment in Xiangyun County. Compared to FP, soil loss was reduced by 82% under CC+BF and by 88% under CC+BF+CCH. A similar trend was observed at Fuming, but with less overall soil loss.

In Guizhou, field experiments were conducted in Luodian County, including five treatments of FP, FP+BF, wild buckwheat+plum tree (CCH1), Chinese day lily+Chinese prickly ash tree (CCH2), and engineered terracing (ET). Results were similar to those observed in Yunnan, with the reduction of runoff being in the order of CCH1+BF > CCH2+BF > ET+BF > BF > FP, while for erosion the order of reduction was CCH1+BF > ET+BF > CCH2+BF > BF > FP (data not shown). Results illustrate that BF integrated with CCH technology can better maintain sustainable agriculture on these sloping farmlands.

In Sichuan, a number of CCH patterns were selected and tested, including: Chinese toon, loquat tree+day lily, pear tree+day lily, Chinese prickly ash tree, mulberry tree, eulaliopsis (a raw material for paper-making), and honeysuckle. At Jianyang, the best CCH strategy was pear tree+day lily. Similar to Yunnan and Guizhou, this hedgerow pattern has significantly reduced soil loss since 1997. The influence of CCH on soil and water losses was variable, but as amounts of rainfall in-

Table 2. Soil losses (t/ha) in Xiangyun and Fuming counties from May to October (2000 to 2003).

Site	Year	Rainfall, mm	FP	FP+BF	FP+BF+CCH	CC+BF	CC+BF+CCH
Xiangyun	2000	827	5.6	2.3	3.2	1.6	0.9
	2001	1078	42.8	37.4	14.8	6.9	6.5
	2002	959	18.8	11.9	4.8	2.0	1.5
	2003	982	50.2	41.1	9.3	10.6	5.3
	Mean	962	29.4	23.2	8.0	5.3	3.5
	Reduction vs. FP	-	-	-6.2	-21.3	-24.1	-25.8
	Soil loss, %	-	-	-21.1	-72.7	-82.0	-87.9
Fuming	2000	775	12.0	11.9	12.3	0.7	1.0
	2001	879	5.8	3.8	2.3	2.7	0.5
	2002	777	11.7	9.0	8.5	4.2	1.6
	2003	665	2.3	0.8	0.6	0.5	0.2
	Mean	774	8.0	6.4	6.2	2.0	0.8
	Reduction vs. FP	-	-	-1.6	-1.8	-5.9	-7.1
	Soil loss, %	-	-	-20.0	-22.4	-74.3	-89.6

Table 3. Impact of different treatments on crop yield (t/ha) in Yunnan.

Site	Year	FP	FP+BF	FP+BF+CCH	CC+BF	CC+BF+CCH
Xiangyun	2000	6.09	7.04	6.12	7.16	7.06
	2001	6.08	6.32	6.87	6.90	7.02
	2002	6.97	7.18	6.84	7.86	7.53
	2003	5.66	6.14	6.07	6.72	6.90
	Average yield	6.20	6.67	6.47	7.16	7.13
	Yield increase vs. FP (%)	-	7.5	4.4	15.4	15.0
Fuming	2000	4.76	6.01	5.46	10.25	9.84
	2001	3.79	4.48	4.82	4.65	5.14
	2002	7.62	7.73	6.84	8.75	8.63
	2003	5.90	6.44	5.18	6.90	6.78
	Average yield	5.52	6.17	5.58	7.64	7.60
	Yield increase vs. FP (%)	-	11.8	1.1	38.4	37.7

creased the effect of CCH adoption became more pronounced.

All hedgerow crops had an influence on crop yields. The magnitude depended on type and variety. In Yunnan, crop yields under BF alone in both Xiangyun and Fuming were consistently higher than under FP (**Table 3**). Even though CCHs occupied 10% of the field area, crop yields were not negatively impacted. To the contrary, yields were higher than FP – an effect attributed to reduced soil erosion and soil fertility maintenance.

The effect of BF on grain yield trends at Guizhou was similar to that in Yunnan. Although Chinese day lily+Chinese prickly ash tree occupied 17% of the land area, this treatment produced higher corn yields than the FP treatment for 4 years straight (data not shown). Corn yield began to decline from the third year onwards for the CCH treatment using wild buckwheat+plum tree. This influence became more pronounced as plum trees grew larger and is attributed to a larger canopy and a more extensive rooting system for plum which together imposed more shade and competition with corn for soil nutrients.

The effect of CCHs on crop yields in Sichuan was somewhat different from the other two provinces and was possibly due to the two harvests per year at the site. In the first 2 years, pear tree+day lily increased all crop yields, but total annual crop yield started to decline in the third year. A considerable yield reduction was observed on summer corn and sweet potato rather than winter wheat and barley (**Table 4**). This can also be attributed to canopy shading and competition for nutrients from pear tree with summer crops. Since

Table 4. Crop yield (t/ha) response to different treatments in Jianyang, Sichuan (1997 to 2003).

			CCH + CC		CCH+ CC+BF	
Year	Crop	FP (CK)	Yield	vs. CK, ±%	Yield	vs. CK, ±%
1997-2000	Corn	5.1	4.3	-15.8	4.8	-4.6
	Sweet potato	11.4	9.8	-13.8	11.7	+3.1
	Wheat +barley	2.2	2.5	+16.9	3.3	+53.8
	Total yield	18.6	16.6	-10.2	19.9	+6.9
2001	Peanut	3.2	2.7	-16.9	2.8	-15.4
	Wheat +barley	2.4	2.5	4.2	2.5	6.3
	Chinese day lily	-	0.5	-	0.9	-
	Pear tree	-	4.2	-	5.0	-
2002	Peanut	3.2	1.6	-51.6	2.4	-26.3
	Wheat +barley	2.9	2.4	-18.0	2.6	-10.3
	Chinese day lily	-	0.4	-	0.4	-
	Pear tree	-	6.9	-	8.6	-
2003	Peanut	3.1	2.2	-30.5	2.3	-24.5
	Wheat	3.2	2.8	-13.9	3.0	-7.5
	Sweet potato	13.4	10.0	-25.3	11.2	-16.2
	Chinese day lily	-	0.4	-	0.4	-
	Pear tree	-	6.8	-	8.9	-

the trees are in dormancy in winter and bloom in spring, their effect on winter crops is much less significant. In the sixth year, both summer and winter crop yields were more influenced by the CCH as trees grew larger, but BF minimized this influence. For example, yields of three crops under CCH alone were 6% lower than FP, but yields under CCH+BF were 3% higher than FP.

Various crop combinations are being compared in cash crop hedgerows. This demonstration includes plum tree plus buckwheat (*Polygonum cymosum* Trev).

All trials agree that the BF and CCH treatments could increase farmers' income compared to FP. Higher costs were incurred to establish cash crop seedlings and the associated labor was much higher in the first year. CCH treatments began generating higher income streams from the third year onwards. At Jianyang in Sichuan, the CCH and CCH+BF treatments increased net income by US$1,623/ha and US$1,834/ha compared to FP, respectively (**Table 5**). During the 7 years of experimentation, the total increase in net income from CCH and CCH+BF was US$1,731/ha (+29%) and US$3,359/ha (+56%), respectively.

After several years of research, demonstrations, and extension, experts in Sichuan, Yunnan, and Guizhou have worked out several hedgerow patterns and selected a number of crop varieties suitable for local climate, slope gradients, and soils to meet local market needs. Presently, CCH patterns such as pear tree+day lily, Chinese toon, mulberry tree, eulaliopsis, honeysuckle, and Chinese prickly ash tree are used in Sichuan; pear tree+day lily, Chinese prickly ash tree, plum tree+wild buckwheat, and forage crops are used in Guizhou; and Chinese prickly ash tree+day lily, and forage crops are more suitable in Yunnan. Although great progress in CCH research and demonstration has been obtained, further efforts are needed to extend this technology to a larger scale. BC

Table 5. Net income as affected by different treatments in Jianyang, Sichuan.

	Net income, US$/ha		
Year	FP	CCH	CCH+BF
1997	446	-1,665	-1,646
1998	1,144	834	1,052
1999	686	889	1,018
2000	790	1,587	1,771
2001	900	1,625	1,895
2002	1,013	1,719	2,415
2003	998	2,721	2,832
Total net income	5,978	7,709	9,336
Increase vs. FP (%)	-	29	56

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*(Note: Additional information and photos are available at the website: >**www.ppi-ppic.org/ppiweb/swchina.nsf**<.)*