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FARMER ADAPTATION AND ADOPTION OF CONTOUR HEDGEROWS FOR SOIL CONSERVATION

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Abstract: After farmer-to-farmer training, farmers at an upland research site in the Philippines adapted and adopted contour hedgerows over a period of four years. They developed hedgerow establishment methods that required less labor, eliminated grasses too competitive with crops, stopped planting trees initially intended to produce green manure, and planted species with possible direct cash returns. The different systems equally and effectively controlled soil erosion, although grazing of neighbors' cattle on hedgerows was a problem.. Farmers who learned about the technology but did not establish contour hedgerows on their farms had higher proportions of flat land and/or off or non-farm income opportunities.

1. Introduction

Research on reducing soil erosion in the sloping uplands has evolved from mechanical means i.e., bench terraces [Hudson 1971, UACP 1987] through alley cropping in which tree biomass is used to cover and protect soil in addition to improving soil nutrient cycling [Huxley 1986, Kang and Wilson 1987, Young 1986 1987], to the use of contour hedgerows that may or may not include trees [Abujamin et al. 1985, ASOCON 1990, Fujisaka 1989a, Hudson 1990, Tacio et al. 1988], and even to the use of hedgerows planted to a specific grass [Grimshaw n.d.; Smyle and Magrath 1990]. Recent research has also examined farmers' indigenous soil conservation methods [MacKay 1990, Ramirez 1988], multiple functions of hedgerows [Kuchelmeister, 1989], and, as in this paper, roles that farmers can and should play in developing agroforestry or soil conservation technologies {Getahun and Njenga 1990, Pahlman 1990, and Rocheleau n.d.].

2. Site Description

Claveria, in Misamis Oriental Province in the Philippines, is an on-farm research site of the International Rice Research Institute (IRRI) and the Philippines' Department of Agriculture (DA) 390 to 550 m above sea level. Soil erosion is a problem in large part because 59% of the cropping occurs on lands with slope >15%. Soils are Oxic dystropepts ranging from clays to silty clay loams; these are acidic (pH 4.5-5.8) with low available P (1.3-4.7 $\mu g\ g^{-1}$), low CEC (6-12 meq 100 g^{-1}), high Al saturation (11-51%), low to moderate organic matter (3.16%), and low exchangeable K (113.1 $\mu g\ g^{-1}$). Rainfall occurs in 5 to 6 wet months (>200 mm $month^{-1}$) and 2 or 3 drier months (< 100 mm $month^{-1}$). Average rainfall is 2200 mm $year^{-1}$ with greatest rainfall from July to December.

3. Methods

Contour hedgerows seemed appropriate for soil erosion control. The technology harnesses erosive forces by forming terraces between planted strips and is appropriate for areas with sloping land, permanent plough agriculture, intense rainfall, and land scarcity. Farmer-to-farmer procedures were used to introduce the technology to Claveria farmers [Fujisaka 1989b]; farmers in a non-government project in Cebu demonstrated to six Claveria farmers and two IRRI technicians how to use an A-frame (a transit of wood or bamboo consisting of two 2 to 3 m lengths joined at an apex and connected by a crosspiece and, thus, shaped like an 'A'; and with a string and weight hanging from the apex to be aligned with the center of the crosspiece) to establish contour lines, how to construct contour bunds and ditches by plowing (animal and mouldboard plough) and shoveling, and how to plant hedgerows (spaced at 1 m vertical intervals) of fodder grasses (Napier *Pennisetum purpureum*) and legume trees (*Gliricidia sepium*). The initial farmer adoptors in Claveria trained 175 farmers from 1987 to 1989 using farmer-to-farmer techniques. Farmers and their fields were monitored from 1987 to 1990. Field area and slope, length of hedgerows, and area occupied by hedgerows were measured. Terracing and embankments were formed over time and were measured yearly. Labor required for establishment, farmers' technical changes and adaptations, and effectiveness of methods developed were recorded continuously by researchers living at the site. Farmers' perceived benefits, associated problems, and evaluations of technology components were obtained through open-ended interviews. Calculations of the slopes of alleys (areas between hedgerows) were based on measurements of the embankments, assuming that hedgerows were placed at 1 m vertical intervals. Farmers who did not adopt the technology after farmer-to-farmer training were interviewed about reasons for non-adoption. Slopes of the lands of adoptors and non-adoptors were measured and compared. Crop yields on farmers' fields with and without contour hedgerows were monitored in the wet season, 1991, a severe drought year, by taking crop samples. Additional data on yields and soil erosion rates with and without contour hedgerows were provided by other IRRI-DA researchers working at Claveria.

4. Results

Working as a group, farmers established some 7000 m of hedgerow on 10 parcels of land with mean size of 0.8 ha in the first year. The labour needed for establishment (average 29 + 13 days ha^{-1} with 55% for shoveling) and hedgerow density (673 to 1555 m ha^{-1}) depended on the field slope and the resulting variation in distance between strips. Farmers established 17 to 57 m $person^{-1}$ day^{-1} of hedgerow: the labour required to establish hedgerows was least on fields already ploughed after initial rains and greatest on grassy fallowed fields on which hedgerows had been established prior to the rains. Adoptors experimented with different combinations of hedgerow species, including grasses, perennials, or weeds, and with establishment methods [Fujisaka 1989b]. Farmers stopped using *P.*

No differences were found among farmers' various hedgerow establishment methods in terms of embankment formation and terracing, but establishment labour per ha decreased with increasing field size, suggesting some 'economy of scale'. Farmers continued to assess the technology and saw benefits in terms of reduction of soil erosion, flattening of alleys for cropping, and the ability to apply fertilizers without loss of such inputs from erosion, although neighbours sometimes allowed their cattle to graze the hedgerows, causing hedgerow and bund destruction (table 2).

Table 2. Evaluations by 64 farmer-adoptors regarding contour hedgerows, Claveria, 1990

	Number of observations
Positive evaluation	
Hedgerows control soil erosion	50
Fertilizer can be applied & not lost downslope	16
Alleys have flattened & bunds have strengthened	15
Soil & water are evenly distributed along bunds	13
Gully formation was minimized	10
Miscellaneous	15
Total positive observations	119
Problems associated with contour hedgerows	
Neighbors grazed animals on hedgerows, destroying bunds	10
Contouring without using the A-frame was not effective	4
Off-farm work competes with hedgerow maintenance	3
Missing hills within hedgerows channel erosion	1
Furrows in alleys are not equal in distance and length	1
Total negative observations	19

Although Napier grass controlled soil erosion and provided animal fodder, it was too competitive with the alley crop (table 3). While several farmers had learned that *G. sepium* was a source of organic fertilizer, no farmer incorporated tree leaves and only one farmer applied an unincorporated mulch because of the labour required for cutting and spreading the biomass.

Farmers continued their search for other hedgerow grass and tree species, especially those that could provide cash incomes. They were the most positive about mulberry (which 13 farmers adopted) when a silkworm project was initiated in the area (table 4), although the suitability of mulberry in terms of competitiveness with the associated alley crop was not known.

The original strategy for hedgerow establishment consisted of using the A-frame to determine contour lines, double ploughing to create a bund, shovel work to reinforce bunds, and planting of a double row of trees plus a single row of grasses. Farmers at Claveria subsequently developed ways to reduce the labor required from 14 hours per 100 meters of hedgerow in 1987 and 1988 to 10 hours in 1989 and 8 hours in 1990.

Table 3. Farmer evaluation of Napier grass (*Pennisetum purpureum*) and of *Gliricidia sepium* planted on hedgerows, Claveria, 1990

	Number of observations
Pennisetum purpureum	
Positive evaluation	
Controls soil erosion	15
Provides animal feed	11
Grows easily	4
Competition not a problem if maintained	1
Negative evaluation	
Crops near hedgerows were stunted and yellowed	11
Competitive and too vigorous	6
Roots spread into alleys and make plowing difficult	3
Deteriorate with constant pruning	2
Shelters rats	1
Total	54
Gliricidia sepium	
Positive evaluation	
Source of organic fertilizer	16
Improves the soil and gives a higher yield	1
Provides feed for animals	1
Reduces soil erosion	1
Negative evaluation	
Caused shading if not maintained	1
Difficult to plow when roots spread to the alley	1
Total	21

This was as a result of reduced ploughing, the virtual elimination of shovel work, the planting of either trees or grasses rather than a combination, or the staking out of contour lines (usually but not always bunded) which were then left to be covered by weeds or native grasses (*i.e.*, *Chromolaena odorata, Digitaria setigera, Imperata cylindrica, Paspalum conjugatum, Sorghum halepense,* and others). Farmers developed even less labor-demanding methods in 1989 and 1990. These (strategies 10 and 11 in table 5) involved contour lay out using the A-frame followed by land preparation in the alley for the crop and planting of a few widely (> 10 m) spaced trees in the hedgerows. The unploughed weedy strip 'bund' became terraced and started to form flat alleys after a second season's ploughing. Farmers who did not adopt the new procedures after attending farmer-to-farmer training sessions provided reasons for non-adoption.

Table 4. Farmer evaluations of other contour hedgerow species

	Number of observations
Mulberry prevents soil erosion and provides income	13
Will extend mulberry hedgerows to other parcels	2
Flemingia congesta does not compete with the alley crop and is easy to maintain	1
Grasses control soil erosion and provide fodder	5
Grasses hold the soil better than trees	2
Stylosanthes guayanensis is good, but competes with crops	1
Andropogon sp is good, but spreads into the alley	1
Roots of *Desmanthus virgatus* do not hold the soil	1
Pineapple holds the soil and provides cash and food	2
Taro holds the soil and provides cash and food	1
Sunflower holds the soil, provides green manure, but can be a weed problem	1
Total	30

Table 5. Labor requirement (days ha^{-1}) and number of farmers adopting different contour hedgerow strategies, Claveria, 1987-1990

Strategy	Labor requirement	Number of adopters 1987	1988	1989	1990
1. Plough + shovel + tree + grass	16	7	7	1	0
2. Plough + shovel + tree	16	2	2	7	1
3. Plough + shovel + grass	20	3	3	1	1
4. Plough + tree + grass	10	1	1	1	0
5. Shovel + tree + grass	25	0	0	1	0
6. Plough + tree	14	0	0	11	1
7. Plough + shovel + 'weeds'	14	0	0	2	0
8. Plough + grass*	12	1	0	1	1
9. Plough + weeds	11	0	0	2	0
10. Weeds	14	0	0	1	2
11. Weeds + trees	5	0	0	1	0
Total		14	13	29	6
Mean labor (hr 100 m^{-1})		14	14	10	8

*all strategies included use of the A-frame for contour layout; 'strategy 11' featured use of a few widely paced trees

These were lack of labor or draught animals or competing demands for labor on non-sloping areas for farmers with large proportions of such lands or for off-farm and non-farm activities (table 6). Although a few mentioned that their tenant status barred adoption, about 16% of adoptors were share tenants. In the light of the non-adoptors' responses, adoptors' and non-adoptors' lands were measured in terms of size and slope. Differences between total land holdings and between the

Table 6. Trained farmers' reasons for non-adoption of contour hedgerows

	Number of observations
Work demands on non-sloping or lowland parcels	40
High labor for contour hedgerow establishment	27
Off-farm and non-farm work opportunities	18
Lack of draft animal	16
Lack of capital for labor and inputs	12
Left the area	10
Does not own the land	7
Miscellaneous	10
Total	140

percentage of slope on sloping lands did not differ significantly between the groups, but a significantly higher proportion of adoptors' land was sloping (>7% slope) compared to non-adoptors' land (table 7). Yields of maize and rice on farmers fields with or without contour hedgerows were similar to the wet season of 1991, a year of severe drought (table 8). The lack of response to hedgerow construction was not discouraging because hedgerow species are substantially more competitive for

Table 7. Areas and slopes of lands of adoptors and non-adoptors of contour hedgerows, Claveria

	Adopter	Non-adopter
Total land area (ha)	1.70	1.68
Area of flat land (ha)	0.43	0.79
Slope of sloping land (%)	21	25

moisture than rice or maize in drought periods. Data from researcher designed and managed trials in Claveria also showed that cereal yields were similar with and without hedgerows when leaf prunings from the hedgerows were not applied to the crop, although there was a substantial maize yield increase following incorporation of *Senna spectabilis* biomass (Mercado et al. 1991). Soil erosion was monitored by other researchers in controlled experiments. In normal rainfall years, approximately 200 t ha^{-1} were lost on open slopes and 20 t ha^{-1} from fields with contour

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