Impact of *Vetiveria Zizanioides* (Vetiver Grass) Live Barriers on Maize Production in Honduras

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Abstract: Live barriers are promoted as an effective soil conservation strategy for tropical steeplands but farmer adoption rates are poor. Research in Honduras evaluated the performance of live barriers of *Vetiveria zizanioides* (vetiver grass) on steep slopes typical of those cultivated by small-holder farmers across Central America. Maize yields were measured for three years on 24 test plots (each 24m × 5m) through both harvests (*primera* and *postrera*) of a normal annual cycle. Local farmers were engaged to cultivate the test plots using traditional methods, sowing local maize varieties along the contour and using the same number of crop rows on each plot. Twelve test plots were planted with vetiver barriers at 6-m spacing. Results show no significant differences between per-row maize yields on control plots and those with live barriers. The one exception was the *postrera* harvest of 1997, during unusually dry conditions caused by *El Niño*, when maize yields in the rows immediately above the barrier were significantly greater those on the control plot. Vetiver barriers accumulated soil on their up-slope side, which helped store soil water. In drought conditions, this permitted an increase in productivity that was not evident at other times. To be attractive to farmers, soil conservation works must produce obvious benefits regularly. These may be limited when technologies, such as live barrier, are used alone.

Keywords: soil conservation, live barriers, farmer adoption, steeplands, maize yields, soil moisture storage

1 Introduction

Throughout the tropics, economically marginal subsistence farmers are being displaced from prime agricultural lands and forced to colonise steeplands. The consequence has been increased land degradation, loss of soil quality and accelerated erosion (Hurni *et al.*, 1996:11). This threat to sustainable agricultural productivity has lead to major investment in technologies intended to control runoff and erosion (Hudson, 1995:354). Cross-slope technologies such as live barriers, rock walls, infiltration ditches, terraces, and earth bunds have been widely promoted (Suresh, 2000). Farming communities have been encouraged to adopt these methods, but the response has been poor. Soil conservation works, implemented in the course of a development project, have often been abandoned when the project ends and funding dries up (Pretty, 1998: 293). Typically, such failures are blamed on the farmers, who may be labelled conservative, uncaring and poorly informed. Such accusations may, however, be misplaced (Chambers, 1993).

One rationale for soil conservation work is that there exists a direct relationship between erosion and declining soil productivity (Tengberg *et al.*, 1998). A huge research literature suggests that many soil conservation technologies both reduce soil loss and enhance productivity (Doolette and Smyle, 1990:51). However, most research is conducted on slopes <20% and it is possible that some cross-slope technologies are less effective on steeper slopes (Young, 1997:70). Additionally, much research comes from on-station trails, using soils that, having long been cultivated, fertilised and chemically-treated, may now bear little resemblance to those experienced by impoverished farmers colonising steep marginal lands (Suppe, 1988).

Research in Honduras attempted to move closer to the realities of subsistence smallholder farming by evaluating a widely-promoted soil conservation technology, live barriers of *Vetiveria zizanioides* (vetiver grass), to determine its impact on agricultural productivity. Research took place on land typical of that currently being brought into cultivation.

2 Methodology

Experimental plots should duplicate, as closely as possible, the conditions faced by resource-poor farmers (Bunch, 1982:133). The fields, used as test-plots in this trial, were established and cultivated by local farmers on steep, marginal, secondary-forest slopes, similar to those being colonised elsewhere in the region. The main differences were that this work was undertaken legally on land belonging to a forest research station near Choluteca, southern Honduras, and that the size and configuration of the fields was constrained by the needs of the research project.

The trial employed 24 (24m × 5m) research plots (see Hudson, 1993: 35). They were established on two adjacent steep hillsides (slope: 35%—45% and 65%—75%) by the clearance of dense, >3-m high, secondary forest. The trial applied two treatments, each replicated six times on each of the two slope categories. One series of plots, the control, was cultivated normally, while the other was planted with live barriers of vetiver grass at 6.0m intervals (*i.e*. three per plot). Research took place over a three-year period, 1996—1998.

During the trial, local farming practices, from clearance, through cultivation, seed selection to the timing of weeding and harvesting, were duplicated. Each plot was planted to maize twice a year, a *primera* crop was sown at the start of the May-October rainy season and harvested in September; the *postrera* was then planted and harvested in January. Farmers planted local variety maize, which was sown at a characteristic density along the contour. The research team enforced a standardised 32 rows per plot, including those plots with live barriers, so no land was lost to agricultural production. After five harvests, the project was terminated by landslide activity caused by Hurricane Mitch (Hellin and Haigh, 1999).

For assessment, each plot was divided into four sections (each 6m × 5m), with eight rows of maize per section. Maize yields were calculated for each crop row by weighing the maize cobs with a hand balance and multiplying this by the average dry weight of maize per cob. Results were analysed by a one way analysis of variance (ANOVA) and independent sample *t*-tests.

3 Results

In theory, live barriers improve agricultural productivity by keeping soil on site. There were highly significant differences in maize yields on the 35%—45% and 65%—75% slopes ($p < 0.0005$). Over a three-year period, the average yield per harvest on the 35%—45% slopes was 1,895 kg • ha^{-1} on the control plots and 1,876 kg • ha^{-1} on the live barrier plots. The figures for the 65%—75% slopes were 1,109 kg • ha^{-1} and 1,080 kg • ha^{-1} respectively (Hellin, 1999). However, the differences between the maize yields on the conventionally-farmed and live barrier plots were not significant for four out of the five harvests recorded. The exception was the *postrera* (the second harvest) of 1997, when maize yields on live barrier plots averaged 956 kg • ha^{-1} across both slopes whilst yields on control plots averaged only 775 kg • ha^{-1}. These differences were significant ($p = 0.004$).

Analysis of per-row maize yields demonstrates the relationship between live barriers and maize productivity. In 1996 and 1998, there was little pattern in per-row maize yields and no significant difference in the yields recorded on corresponding rows on control and live barrier plots (Hellin, 1999). However, in 1997, and particularly during the *postrera*, maize yields in live barrier plots varied systematically from a high immediately above the barrier to a low immediately below. There was no similar pattern on parallel control plots.

Table 1 shows per-row maize yields during the *postera* in 1997. These data come from all the plots but exclude data from the uppermost and lowermost four crop rows because there were no live barriers at either extreme of the plots. Maize yields in the four rows above the barrier (rows 5, 6, 7 and 8) were significantly greater ($p \leqslant 0.01$) than those from corresponding rows in the control plots. Yields in the four rows below the barrier (rows 1, 2, 3, and 4) were similar to those in the control plots.

Table 1 Maize yields (per 5-m crop-row) from *Postrera* harvest 1997. Compares yield from live barrier plots, row 1 (immediately below) through row 8 (immediately above a barrier) with yields on parallel conventionally farmed plots with no live barriers

Both slopes, *postrera* 1997 only	Live Barrier Yield (grams/row)	Control Yield (grams/row)	*t*-value	Significance *p* =
Row 1	262	321	1.587	0.177
Row 2	379	283	–2.581	0.012
Row 3	379	330	–1.505	0.137
Row 4	356	309	–1.387	0.170
Row 5	362	261	–2.989	0.004
Row 6	377	269	–3.076	0.003
Row 7	418	290	–3.270	0.002
Row 8	480	286	–4.338	0.000

Live barriers break up the slope and so reduce the capacity of runoff to move soil particles down the slope. Hence, there should be less soil movement between live barriers and mobilised soils should be trapped upslope of the barriers. Soil augur measurements towards the end of the experiment show, as expected, deposition of soil above the barriers. They also demonstrate that scouring occurred below the barrier (Photograph 1). The deposition and scouring effect was not evident in the control plots.

Photograph 1 Cross section of a vetiver grass live barrier on the 65—75 % slope at the end of the three year period. The photograph shows soil deposition above and scouring below the barrier

4 Discussion

Maize yield data suggest that, in 1997, the increased *postrera* maize yields from the crop rows above the live barriers were linked to soil accumulation. The special feature of 1997 was that it was an exceptionally dry year, caused by *El Niño*. Rainfall in 1997 was approximately 60% of normal annual rainfall. This suggests that it was soil moisture, held in soil accumulated above each live barrier, that was responsible for the increase in productivity. In 1996 and 1998, when rainfall was not a limiting factor, there were no significant differences in maize yields between live barrier and control plots. In 1997, productivity gains were more pronounced in the *postrera* than in the *primera* harvest because the former is sown just a month before the end of the rains. Hence, moisture availability was a limiting factor for a large proportion of the growing season.

These results illustrate one aspect of the difficulty of convincing farmers that it is in their best interest to establish and maintain soil conservation works. To be attractive to farmers, these technologies have to offer sufficient and obvious benefits (especially increased productivity) to compensate the farmers for increased labour input. These results demonstrate that these benefits may not be apparent routinely when technologies, such as live barriers, are used in isolation.

The loss of soil depth immediately below each live barrier is a concern. The barrier prevents soil transport from up-slope (Garrity, 1996; Lal, 1982). In 1997, skewed maize yields in the *postrera* come from reduced production in the upper crop rows where scouring had occurred and increased production in the lower crop rows (just above the barrier) where soil was deposited. Similar patterns have been reported in Ethiopia (Herweg and Ludi, 1999) and the Philippines (Garrity, 1996).

The key issue is the determination of those circumstances where yields below a barrier are so reduced that yield increases elsewhere on the plot are cancelled out, perhaps leading to an overall reduction in yields (cf. Garrity *et al.*, 1997). This was not apparent here, but elsewhere in Honduras, where soils are shallower and live barriers in operation for longer periods, the potential seemed greater. In Sumatra, Siebert and Belsky (1990) found that, under peanut cultivation, crop yield at the base of the bench-terrace riser was 4,112 kg • ha^{-1} • yr^{-1} compared to 8,160 kg • ha^{-1} • yr^{-1} on mid-bench sites.

Most soil conservation initiatives are based on the premise that soil productivity is equated with erosional losses (or gains) of soil particles and the nutrients within them (Hadda *et al*., 2000). In Honduras most erosion took place in 1996 and yet maize yields only became skewed in live barrier plots in the *postrera* in 1997, when there was much reduced rainfall. If soil fertility were the limiting factor, maize yields in crop rows immediately above a barrier should have been higher than those from corresponding positions in the control plots across all harvests. In four out of five harvests these differences were not apparent. So, in drought conditions, soil moisture rather than soil fertility proves the limiting factor to productivity (Shaxson, 1993).

Research in Honduras points to the need to focus less on capturing soil once it has been eroded and more on maintaining or enhancing the quality of soil in the entire inter-barrier area. The problems caused by soil redistribution in the barrier-protected plots might be offset by the use of productivity-enhancing and soil generating strategies such as cover crops and green manures.

5 Conclusion

In Honduras, cross-slope soil conservation technologies such as live barriers have little immediate benefit for agricultural production on steep slopes, except in drought conditions. Their main impact is to effect the redistribution of soil, increasing depth up slope and allowing decreases down slope of each barrier. In one out of five harvests studied, this resulted in a net increase in maize production of the barrier protected slope, which seems to be related to enhanced soil moisture conservation in a drought year. Cross-slope SWC technologies may have a role to play in preventing off-site sedimentation and the long-term loss of rooting depth, but they are better deployed as part of a package of measures that augment soil depth and enhance the biological, chemical and physical health of the soil. Since the live barrier *per se* does little to improve agricultural productivity, its opportunity cost to the farmer is high. It would be better if the barriers themselves contributed to farm income, for example, vetiver grass could be replaced by sugar cane and fruit trees.

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