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# Rapid soil redistribution within alleys: why simple extension models for contour hedgerows may not be appropriate

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**Rapid redistribution of soil often occurs within the alleyways of contour hedgerow systems, resulting in quite dramatic yield reductions in the upper zones. Is this a threat to the sustainability of contour hedgerow systems? Recent work suggests that while it is a threat on strongly acidic soils, it ought to be a manageable one. Farmers who have encountered scouring have developed practical ways of coping. These are currently being validated experimentally. Robust management solutions will depend on a more fundamental understanding of the processes governing fertility resilience in contour hedgerow systems. Emerging models that include landscape aspects will assist us in achieving it.**

## Introduction

When farmers install contour hedgerow systems to help sustain annual cropping on sloping land they face many unusual management challenges. They must cope with the increased labour demands to prune and maintain the hedgerows. They may also need to make adjustments to minimize competition between the hedgerow species and the associated food crop. And often, they encounter accelerated soil deterioration in the upper zone of their alleyways. This soil deterioration is caused by the redistribution of topsoil within the alleyway, from the upper to the lower zones, as terraces naturally develop.

This contribution briefly reviews the nature of this scouring-deposition effect, discusses the challenges it poses to the sustainability of contour hedgerow systems, and dwells on why it has tended to be overlooked in the past. We examine how farmers react to the problem, and discuss the practical solutions that our preliminary research has identified and attempted to validate. We suggest how extensionists can guide farmers in awareness of the problem and applicable solutions. And finally, we suggest needed directions for further research to ensure that the phenomenon is well-enough understood that robust ways of coping with it can be developed for a wider range of environments.

## Soil redistribution within alleyways

Rapid soil redistribution within the alleyways of contour hedgerow systems was viewed very positively in the early literature on hedgerow research and extension. Biological barriers were very effective in creating permanent bunds. The land between the barriers may begin to flatten out within just a few years. The process leads to a reduction in slope and creates front-facing terraces. Thus, terrace development occurs as a by-product of normal tillage within the alleyway. There is no additional work and expense for soil excavation. The visual effect was often quite striking (Fujisaka *et al.*, 1995; Sajjapongse, 1992). The reduction in soil loss was typically also striking, often in the order of 50-90% (Garrity, 1994).

## Yield decline

We began to observe serious upper-alley yield declines within a few years of hedgerow establishment in a number of on-farm trials in Claveria, Philippines in the late 1980s (Garrity, 1994). The soil was an Oxic Palehumult which had physical and chemical properties fairly typical of the strongly acidic, low phosphorus status of some 186 million hectares of sloping upland soils in Southeast Asia (IRRI, 1986). At first it was assumed that the effect might be due to more intense competition exerted by the hedgerow toward the crop in the upper alleyway compared to the lower alley zone. Root barrier studies (Solera, 1993), soon discounted this hypothesis. However, soil analyses of affected fields consistently showed that soil organic carbon, total N, and available phosphorus had declined substantively in the upper zones, while they increased in the lower zones (Agus, 1993; Samzussaman, 1994; Garrity *et al.*, 1995). The Claveria farming system was one of double-cropping of maize using animal draft for tillage. Similar soil spatial changes were reported in hand hoe cultivation systems in Uganda (ICRAF, 1994) and on an Ustic Kandihumult in Thailand (Turkelboom *et al.*, 1993).

As the picture emerged of how serious these upper-alley yield declines could be, and that they most likely resulted from the degradation of the upper-alley soil environment, we grew very concerned that the phenomenon might call into question the sustainability of cropping in contour hedgerow systems at least on some major classes of soils in the tropics (Garrity, 1994). Were hedgerow systems causing more problems than they would presumably solve? Why had the effect gone unreported until recently? How would farmers react to it? And, above all, how could it be avoided or overcome?

We now suspect that previous studies on hedgerows may have not observed the

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phenomenon for two reasons: most of the alley cropping work done on slopes (at least in Southeast Asia) was done on young, deep volcanic soils with moderate to high available phosphorus levels (e.g. MBRLC, 1988). Topsoil scouring in these soils would not be expected to degrade the soil environment in the upper-alley zones to the extent that it would in strongly acidic, P-deficient soils. However, sloping soils with these latter constraints are much more dominant geographically. The frequency of tillage is also a factor. When minimum or zero tillage is practiced the rate of soil redistribution is much slower. Unfortunately, reduced-tillage is often difficult for smallholders. Where animal or hoe tillage is practiced several times in a year for weed management to accommodate intensive cropping systems, as is commonly observed, the redistribution process is greatly accelerated, and soil degradation proceeds more rapidly.

## Farmers solutions

Many farmers had developed their own practices to overcome the scouring problem

How do farmers react to the problem? Fortunately, we were in a good position to answer this question. In the vicinity of the Claveria research site, scores of farmers had gained experience with the installation of hedgerows on their farms during the late 1980s and early 1990s. We surveyed a representative group of 30 smallholders who had been practicing contour hedgerow farming for up to seven years. Most adopters had observed reduced crop yields on their upper alleyways. Interestingly, however, they did not perceive the scouring effect to be a serious constraint, or a permanent one (ICRAF, 1997). They noted yield increases on the lower zones that apparently offset the declines in the upper zones (Figure 1). They were confident of the satisfactory soil conservation effects of biological terracing, and pointed out that scouring also occurred on the whole of the upper part of unhedgerowed fields. Their perception was that the investment in the buffer strip system seemed to increase yields over the whole field. A telling finding was that more than half of the respondents estimated that installation of the hedgerow system increased their land values by more than 50%.

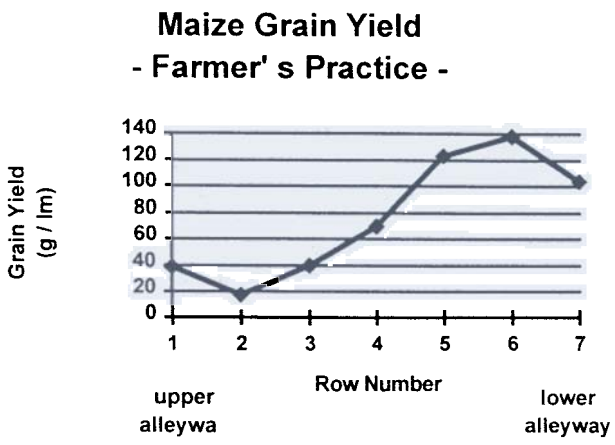


*Figure 1. Typical maize grain yield per linear metre across a single alleyway under farmer management on an acid upland soil (mean of three replications). Claveria, Philippines.*

Many farmers had developed their own practices to overcome the scouring problem. The most common of these was to apply more mineral fertilizer on the upper alleyway zones than on the lower zones (usually up to double on the upper zone). Also, farmers frequently applied hedgerow prunings selectively to the uppermost zone. A few even brought in additional biomass from off-field for the upper zone, or scraped soil from the bund down onto the upper alleyway. We have been conducting trials with hedgerow farmers during the past few years to validate these practices and to try to understand the underlying processes involved in rehabilitating the soils in upper alleyways. The results have tended to confirm the utility of skewing higher fertilizer applications toward the upper alleyway: these increase maize yields in these zones to levels similar to those in the lower zones. It appears, however, that uniform fertilizer applications give similar overall yields on a whole alley (or field) basis when applied at moderate levels.

## Future developments

What is the key to sustaining good crop yields as terraces develop behind vegetative buffer strips? In the short term, it appears that the importation of nutrients through manures and/or fertilizers containing adequate amounts of crop-available P, are essential in maintaining yields. In the medium-term, however, we hypothesize that rebuilding soil fertility in the upper alleyways depends on replenishing the soil organic matter levels in the topsoil of the scoured zones. More and longer-term field research is needed to validate these presumptions on strongly acid soils, and upon a much wider range of sloping lands in the tropics where farmers cope with the challenges of producing annual crops continuously. We are impressed (indeed fascinated) with the apparent resilience of the intensively managed ultisols and oxisols of northern Mindanao. However, we suspect that the shallow, calcareous soils typical of much sloping farmland of Southeast Asia will not be as forgiving as the deep, well-structured soils on which we have worked.

To be adequately predictive we will need to understand the fundamental processes governing soil fertility resilience in contour hedgerow systems. Modelling these systems will be crucial to sorting out the complex interacting processes that operate on

landscapes being transformed into terraces. Conventional crop and agroforestry simulation models have not yet been developed that adequately incorporate the key landscape-level issues that need to be addressed. Currently, however, the model on Water, Nutrient, and Light Capture in Agroforestry Systems (WANULCAS) is being adapted to these spatially zoned systems (van Noordwijk, 1997, pers. comm.) We look forward to rapid progress in this area in the near future.

Contour hedgerow systems continue to be adopted by increasing numbers of farmers in the vicinity of the research site in northern Mindanao. We estimate that some 500 farmers are now practicing the system. Many adopted spontaneously through a farmer-to-farmer diffusion process. An important factor in the spread was the shift to hedgerows composed of natural vegetative strips (NVS) in lieu of the pruned tree hedgerow systems conventionally recommended by extensionists throughout the region. NVS systems proved much more popular because they dramatically reduced the labour requirements for installation and maintenance, while their effectiveness in reducing off-field soil loss was superior (Garrity, 1994).

NVS systems do not fix and cycle nitrogen, as is attributed to hedgerows of leguminous trees. But in a P-limiting environment, tree-based hedgerows are themselves not effective in cycling adequate amounts of P to meet crop demand, and are therefore unable to sustain crop yields. Increasingly, the future for contour hedgerow systems looks certain to shift to low labour alternatives like NVS, with soil fertility being maintained by nutrient importation. The need for nutrient importation to balance crop off-take is not different than in most other types of agricultural systems, except that these systems make sustainable annual cropping possible on steeply sloping lands prone to severe erosion. Thus, they're not ideal, but they are pretty remarkable nonetheless.

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