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# "Maravillas" agroforestry system: an alternative for sustainable soil management in tropical steeplands

## Abstract

Anagroforestry system was established in steeplands of the municipality of Tezonapa Veracruz, Mexico, with objective of evaluating its efficiency in soil conservation. The component species of the system were mahogany (*Swietenia macrophylla*), cedar tree (*Cedrelaodorata*), teak (*Tectonagrandis*), orange (*Citrus sinensis*), lemon (*Citrus latifolia*), cinnamon (*Cynnamomunzeylanicum*), corn (*Zea mays*), and biological barriers to the contour (BBC) of vetiver grass (*Vetiveria zizanioides*). In agroforestry system, the annual soil erosion rate was reduced by 66% compared to the traditional system used for maize production.

**Keywords:** shifting cultivation, soil conservation, agroforestry

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## Introduction

In Mexico, steeplands (lands with a slope greater than 8%) occupy approximately 70% of the total area of the country.[1] Shifting cultivation is the main agricultural system practiced in these areas, and one of the most important corn production systems for self-consumption.[2] In the past, this agricultural system characterized by land use during 2 to 3 years and a longer rest period(also called "fallow"), was efficient in maintaining the soil and its productivity[3] and enabled poor farmers to be self-sufficient in the production of their basic food requirements. However, in recent decades the increase in population and the need for more farmland to meet the increasing demand for food, forces farmers to reduce rest periods or extend cultivation periods, regains its natural fertility.[4] Consequently, the productivity of this system is low, with maize yields between 700 - 800 k ha$^{-1}$or even lower.[4] In addition to the above, the unfavorable slope conditions and high rainfall intensify the erosive processes of the soil.[5] In Mexico, an average of 22.3 million de ha (11.9% of the national area), is affected by water erosion.[6] The problem is even more critical in steeplands where clearing of forest for agriculture can increase soil erosion by 5to 20 fold.[7] The above situation prevails in many of steeplands of the humid tropics of Mexico, where the common landscape is made up of soils without vegetation cover and with rocky outcrops that show a high degree of erosion.

In the context of this problem, several studies indicate that agroforestry is a viable alternative to reduce soil erosion and increase its productivity. Agroforestry involves growing trees with crops, and sometimes animals, in interacting combinations in space or time dimensions to produce food, wood, and otherproducts.[8,9] Agroforestry have benn promoted as a appropriate land use systems specially in the tropics, asa tool for reducing poverty, improving food self-sufficiency for farmers, and increasing the productivity and income for small-scale farmers.[10,11] In accordance to mentioned before, an agroforestry system was established in tropical steeplands, with the purpose of evaluating its efficiency in soil conservation and productivity and developing a productive alternative that allows farmers:

I. Reduce soil erosion rates;
II. Diversify its economic-productive activities;
III. Reforest with forest species of high commercial value:
IV. Increase the production and productivity of corn, and
V. Eliminate the practice of burning in traditional corn production system.

## Materials and methods

The agroforestry system was established on an area of 0,6 ha with a slope of 28%,in the "Ejido Maravillas" (common land), located in The Municipality of Tezonapa, Veracruz, Mexico at 320 m altitude. The climate is hot humid with rains in summer. The average annual precipitation is 2915 mm. The average annual temperature is 25.4 °C. The soils are rendzinas. The relief is inclined with slopes>20%. In the highest areas the land is used for coffee crops associated with banana as a shade of coffee. In the lowest areas, the land is used for corn crop in a shifting cultivation system, with periods of 1-3years with agriculture and 2-3 years of fallow, and average yields of 800 k/ha$^{-1}$.

The component species in agroforestry system are: mahogany (*Swietenia macrophylla*), cedar tree (*Cedrelaodorata*) teak (*Tectonagrandis*), orange (*Citrus sinensis*), lemon (*Citrus latifolia*), cinnamon (*Cynnamomunzeylanicum*), corn (*Zea mays*) and biological barriers to the contour (BBC) of vetiver grass (*Vetiveria zizanioides*). Forest species were established in the highest part of the area. Two rows of cedar tree and two of mahogany were planted at 2 x 2 m between rows and plants, with a total of 49 trees/row. Each row of cedar tree and mahogany was established between two rows of teak, with the purpose of inducer of vertical growth of teak. In the middle part, two rows of orange and two of lemon were established, at 7 x 6 m between rows and plants respectively. A strip 2 m wide and 75 m long of cinnamon was established, at distances of 0.40 m between rows and plants. The lower part was used for corn crop in no-tillage system. Two corn crops were obtained per year. The vetiver grass barriers were established at contour lines at distances of 6 m between barriers, according to the angle of the slope of the terrain (Figure 1).

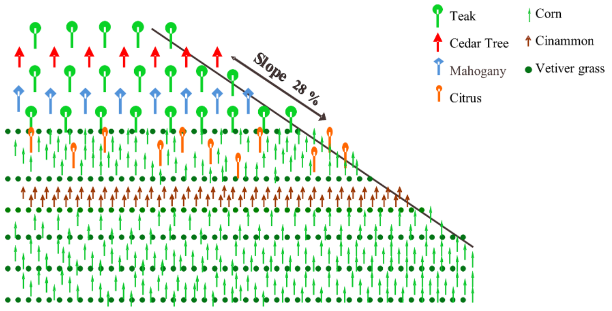


**Figure 1** Representation of the "Maravillas" agroforestry system "Maravillas".

The design system was based on the mechanics of erosion and the potential of agroforestry practices to conserve the soil and its productivity. The forest and fruit trees and fact as a cover that reduces the direct impact of raindrops on the ground, reducing the erosion. The cinnamon and vetiver grass act as a barrier to reduce the speed and erosive capacity of surface runoff and promoted water infiltration in the soil.

The soil erosion rates were tested in eight runoff lots installed five years after been established the system components. Six runoff lots were installed in the agroforestry system (two in the forestry lot; two in the fruit lot and two in the corn-vetiver grass barriers lot). Two runoff lots were installed in a plot with corn traditional system production on a similar slope (control). A daily record rain gauge and a rain gauge were installed to measure distribution, quantity and intensity of rain. In the runoff batches, the total volume of drained water was measured and recorded the weight of the sediments by rainfall event. Soil sediments were dried to estimate their dry weight, and calculated the volume of soil loss ha$^{-1}$ by precipitation event. Whit accumulated of precipitation events values, annual erosion rate was quantified in the components of the agroforestry system and control plot.

## Results and discussion

Five years after establishment of the agroforestry system, soil erosion rates registered were 1.8 t ha$^{-1}$ year$^{-1}$, 66% less compared to erosion rates in the plot control with corn traditional system production (Table 1). These results are similar to 2 tons ha$^{-1}$ year$^{-1}$ reported in agroforestry plots whit *Leucaena leucocephala* and maize in a subhumid climate in Malawi.[12] and confirms that soil loss can reduced by 50% under agroforestry in <5 years.[13]

**Table 1** Annual erosion rates in components of the agroforestry system and plot control

| Component | Erosión rates (t ha-1year−1) |
|---|---|
| Forest species | 0.6 |
| Corn-citrus-vetiver grass barriers | 0.2 |
| Corn-vetiver grass barriers | 1 |
| Plot control (traditional corn system) | 5.4 |

## Conclusion

The agroforestry system evaluated decreases soil erosion and represents an alternative for sustainable soil management in tropical steeplands.

## Acknowledgments

None.

## Conflicts of interest

Authors declare no conflict of interest exists.

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