

Feasibility of Agroforestry for Sugarcane Production and Soil Conservation in Brazil

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ABSTRACT

Brazil is the main world producer of sugarcane, growing it in a monocropping system with high input and technology. Its management plays an important role in conservation of soils and other natural resources and to the life quality of rural workers and urban communities. Due to law enforcement, the burning of cane before harvest has been eliminated and the harvest system has been mechanized. It has produced huge environmental and social impacts and the activity has become unviable for small producers and in areas with slopes higher than 12%. The features and potentials of this system are discussed, as well as the research needs and strategic priorities and actions to its adoption and success. Agroforestry systems with contour hedgerows are one of the most suitable options to make production and conservation possible in non-mechanized areas.

INTRODUCTION

Brazil is the main world producer of sugar cane, cultivating 5 million ha. The State of Sao Paulo is the principal national producer of the crop, with 2.7 million ha planted to sugarcane. The crop and its processing into sugar and alcohol are responsible for 368,000 employees and for the generation of an income of US\$ 1 billion every year in this State (Goncalves and Souza, 1998).

The farming system is based on monocropping in large farms (up to 100,000 ha) and high inputs and technology with an intense use of machines and agrochemicals. In addition, the system is labor intensive during the harvest season due to the current manual harvest system.

These features resulted in the concentration of land and richness, the high potential degradation of soils and other natural resources. From a social perspective, the sugarcane industry intensified the migration of temporary workers, in a cycle of deterioration of labor conditions (Scopinho and Valarelli, 1995).

Thus, the management of sugar cane plays a key role in the conservation or degradation of soils, water resources and native ecosystems, like the Atlantic Forest of Brazil. This is the tropical forest with the highest biodiversity in the country and more than 80% of its original area has been destroyed (São Paulo, 1992). Moreover, due to new restrictive environmental legislation, the burning of the crop before harvest has been prohibited in the State of Sao Paulo, producing critical changes in the cropping system. The main

change has been the mechanization of the harvest process, which is only possible with crops grown on slopes less than 12% (Sparovek et al., 1997) and areas with more than 500 ha of continuous land. The end of the pre-harvest burning will produce significant environmental benefits, such as the elimination of the emission of CO₂ and ozone into the atmosphere and the threat of forest fires. However, it will have as consequence the unemployment of 86,000 to 230,000 workers and will make the sugar activity uneconomical to many of the 11,000 small holders who grow sugar cane (Goncalves and Souza, 1998).

For example, the region of Piracicaba has 49% of its 160,000 ha planted to sugarcane (Sparovek and Lepsch, 1995) and 37% of these lands are located in areas unsuitable to mechanical harvest (Sparovek et al., 1997). These lands are primarily part of small holdings, with low fertility soils, steep slopes and increased susceptibility to soil erosion, which may cause severe environmental and social degradation.

It is necessary, therefore, to develop and evaluate alternative sugarcane management systems for areas unsuitable to mechanized harvests that can be used by small holders, considering their local ecological, economic and social conditions (Kruseman et al., 1996).

This paper aims to discuss the feasibility of agroforestry systems as an alternative to the current situation of sugarcane production in sloping lands.

Agroforestry

Agroforestry is a collective name for land-use systems and technologies where woody perennials are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence, having both ecological and economical interactions between their different components (Nair, 1989). This definition implies that always there are two or more outputs, the cycles are always longer than one year and that even the most simple agroforestry system is more complex, in ecological and economical terms, than a monocropping system. Also, due to its complexity and the production of different crops during the year, agroforestry systems may be used in many different regions and situations, but are specially recommended for providing benefits to small holders (Nair 1989).

The science in agroforestry should be based on competition for resources (light, water and nutrients),

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complexity (socioeconomic and ecological), profitability of the system and sustainability (soil conservation, biodiversity enhancement and CO₂ balance) (Sanchez, 1995). Although agroforestry has been practiced by indigenous and traditional peoples for a long time in Brazil, only recently has it been formally recognized as a system management that can play an important role in local agriculture and increasing its sustainability.

The main service function of agroforestry is soil conservation, combining it with production, shifting from an engineering to a biological approach of soil conservation, and emphasizing soil cover instead of barriers to control erosion (Young, 1988). Agroforestry can specifically lead to some improvement on the following aspects of agricultural management:

Erosion – alleys of trees and multistrata systems increase soil cover, reduce run-off, and increase the rate of water infiltration (Young, 1987, Lal, 1991).

Fertility and structure – low fertility is an important feature of tropical soils. Tree roots and recycling of nutrients have been proved to effectively contribute to maintenance and recovery of soil structure and fertility (Buresh, 1995). When leaves are returned to the soil, the adoption of leguminous nitrogen fixing trees may also contribute to soil fertility (Nair and Fernandes, 1984).

Sugarcane and contour hedgerows

Among the Agroforestry systems presently developed, it is necessary to identify the one that could best be applied to the present situation of the small holders that grow sugarcane in the State of Sao Paulo. Among the main systems, the adoption of contour hedgerows seems to be the best solution to the present problem.

Contour hedgerow is the principal agroforestry method of soil conservation with annual crops (Young, 1997). It involves growing hedgerows of trees, or a perennial crop, for use as a barrier along the contours of a slope, within the areas between the hedges used for agricultural production (McDonald et al., 1997). The desirable characteristics of the trees include a supply of viable seed, vigor, fast growth, nitrogen fixation, copious biomass production for use as mulch, manure, fodder, fuel wood and other useful by-products.

The main functions of the rows are to (Young, 1997):

- 1) Check soil loss through the cover effect,
- 2) Reduce run-off, increase infiltration and reduce soil loss through the effect of the barrier,
- 3) Maintain soil organic matter through leaves and root residues, and
- 4) Lead to the progressive development of terraces, through accumulation of soil upslope of hedgerows and stabilization of risers by stems and roots.

Contour hedgerows should be applicable to the following conditions and features desired in the system (Young, 1997, Fujisaka, 1997):

- I. Humid and subhumid environments where there is potential to combine erosion control with arable land use on gentle to moderate slopes,

- II. Supplementary use of trees to stabilize earthen structures and give producing useful biomass on the establishment and maintenance costs of hedgerow systems are almost certainly cheaper, in money or labor terms than that of earthen structures,
- III. Crop yields do not change significantly from monocrop systems, although sometimes there is a skewed crop distribution, highest on the lower part of the hedgerows and lower yields in the upper parts,
- IV. Where soils are relatively productive and erosion is a problem, and
- V. Local population and land availability is reaching the point where extensive land use is no longer possible.

We can conclude that contour hedgerows are compatible with the present natural and socioeconomic features of sugarcane in the State of São Paulo. The slope attenuation resulted from the presence of rows of trees and crop tillage in the alleys (Garrity, 1996, Young, 1997) may make mechanization possible under conditions that would not be possible in the present traditional system.

The adoption of agroforestry systems by sugarcane producers can also contribute to socio-economic development and conservation of other natural resources by:

- Recovery of native ecosystems and biodiversity (Vandermeer et al., 1998)
- Diversification of land use and landscape
- Generation of new income opportunities for small holders by the use of multipurpose trees (Wood and Burley, 1991).

FUTURE RESEARCH AND ACTIONS

There are studies about sugarcane intercropped, conducted mainly in India and regions of small scale production. These studies tested the viability of production intercropped with potato (Govinden, 1990), maize (Kwong et al., 1996), sunflower and beans (Sharma et al. 1997), and also beans in Brazil (De-Souza and De-Andrade, 1985). Zarin et al. (1998) evaluated sugarcane as one of the possible crops to be cultivated in slash and burn agroforestry systems in Amazon. However, there is lack of systematic research assessing the viability of sugarcane production with agroforestry systems (specifically alley cropping and contour hedgerows) in large scale.

Preliminary studies confirmed the erosion control efficiency of contour hedgerows for sugarcane cultivation in Piracicaba. Bernardes et al. (1998) estimated soil loss applying the Universal Equation of Soil Loss (Wischmeier and Smith, 1978) for sole and intercropped with perennials sugarcane. The soil loss was 20 Mg ha⁻¹ y⁻¹ for the intercropped system and 24 Mg ha⁻¹ y⁻¹ for the monocropping.

The adoption of agroforestry systems or any other system by the traditional monoculture producers will depend on a decision making process that considers a relation between production (economic viability and profitability) and conservation of resources (especially long-term soil conservation), besides the management implications of the system. Thus, the systems designed should maximize complementarily use of resources (Cannell et al., 1996) and

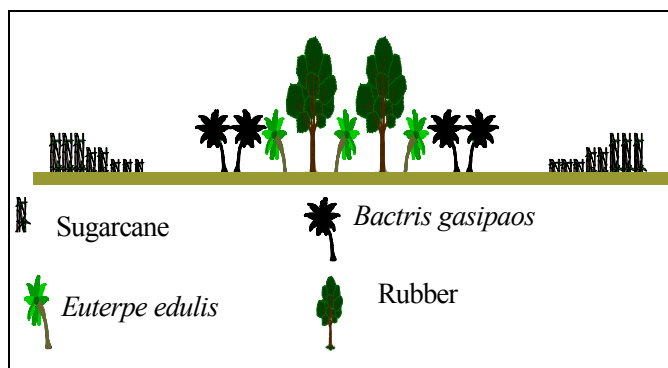


Figure 1. Alternative cropping systems of sugarcane with contour hedgerows for sloping lands.

focus on the yield of sugarcane as the main indicator of success.

To achieve the potential benefits that agroforestry can provide to the sugarcane industry in the State of São Paulo, certain criteria for the system need to be met.

First, the shrubs and tree species selected should: i) be adapted to the local soil and climate conditions, ii) have low demand for nutrients and be nitrogen fixing, iii) contribute to soil conservation and biodiversity, iv) be culturally accepted by farmers and v) provide economic products.

The interactions between the crop and trees should be evaluated for competition and resource usage. This should be done via field experiments designed to identify the best combinations of crops and trees by focusing on a balance between yields and soil conservation.

Finally, models should be used for guiding field research needs. This could be done by simulation with general models like WaNuLCAS (Noordwijk and Lusiana, 1998) and Scauf (Young et al., 1991). The models need to be calibrated for sugarcane under conditions typical of Sao Paulo and linked to the networks of other tree and crops models already available, like the Emb-Rubber (Bernardes et al., 1994).

A theoretical example of an agroforestry system to be analyzed is presented in Figure 1, where rows of rubber are associated with two palm tree species, and strips of sugarcane.

Despite all the potential benefits of the systems, McDonald et al. (1997) highlighted that barrier hedgerow systems have potential for use on sloping lands, but their adoption depends on the simplification of their establishment and their development into flexible systems for farmers. Research studies should be linked to other initiatives that would complement its effectiveness. It is necessary to implement demonstration areas with agroforestry systems in operational scale. These should be located on both research and farmers' fields to demonstrate their benefits and spread it to other local farmers, linking research and extension. Innovative and leading farmers must be identified to start this process of agroforestry research and promotion in the sugarcane industry in the State of Sao Paulo. Afterwards, the results should be diffused to other States of the country where sugarcane plays an important ecological, social and

economic role, like Parana, Pernambuco and Alagoas and to other crops in similar conditions.

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