# Agroforestry Systems in the Brazilian Semi-Arid Region

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## Abstract

This paper gives a brief overview of the Brazilian semi-arid region, presenting some of its problems, limitations and potentialities. Within this context, it emphasizes the urgent need of agricultural diversification due to the high risks to which rainfed agriculture is subjected. Based on the potentialities, and on the characteristics of the region, it is suggested the use of agroforestry systems as an important alternative for increasing and improving the regional agricultural productivity, minimizing ecological problems. Among the intercropping systems, the silvopastoral ones, that is, the association of forest and livestock activities, are presented as the most viable alternative for best utilizing the soil productive capacity, assuring a greater socio-economical stability to farmers. Another alternative presented is the utilization of trees as living fences and windbreakers. The latter has a great potential for irrigated areas. In addition, some research data are presented regarding agroforestry systems where emphasis has been given to the utilization of multipurpose tree species. Among the tree species studied so far, the genera *Prosopis, Leucaena, Mimosa* and *Eucalyptus* have been outstanding. Regarding the non-arboreal forage species, the genera *Cenchrus, Urochloa* and *Opuntia* have had more attention.

## Introduction

The agroforestry systems have lately been a subject of great importance due to soil productivity and social problems associated with wood production, food and ecological aspects. The Brazilian semi-arid region is a typical example, showing poor soils with low fertility, where there is a big pressure over the plant resources. The exploration of these resources has been inadequate and intensive, which has contributed for the vegetation degradation, endangering the unsafe ecological equilibrium of this region.

The interest on reforestation has greatly increased as a result of natural scarcity of wood as well as the regional look for forest products for use in farms and for fuel.

For the above reasons the agroforestry systems have large possibilities of use and can give significant contribution to a more coherent development of the region.

This paper shows the research lines in our Research Center and some of the main results along thirteen years of research. This research area began after the establishment of the National Forest Research Program in 1978, which had the important technical assistance of the International Council for Research in Agroforestry (ICRAF).

## Characterization of the Region

Northeast Brazil is situated between 1° and 18°30' South Latitude and between 34°30' and 48°20' West Longitude. It has an area of 1.55 million km², which represents 18.2% of the country area and covers nine States.

In this region, with diverse characteristics and potentialities, submitted to periodical droughts, there is a semi-arid area with about 115 millions hectares and a population of 24 millions inhabitants. It is about 70% of Northeast Brazil area and 13% of Brazil, holding 63% of Northeast Brazil population and 18.5% of the country. This huge area and large population, together with other restrictive factors, make limitations to actions of intervention which aim its development (SILVA, 1985).

According to IBGE (1980), 93% of the rural properties in Northeast Brazil have an area equal to or less than 100 ha and represent only 7% of the region, while 7% of the total rural properties have an area greater than 100 ha and represent 70% of the total area of the region, most of them being unproductive latifundia.

The rainfall distribution in the region is very irregular, with annual means varying from 250 to 1,000 mm, most falling between February and May (GOLFARI and CASER, 1977). Other

characteristics are: very intense insolation with annual mean of 2,800 hours; low relative humidity, with annual means around 60%, and high potential evapotranspiration, with an annual mean of 2,000 mm (EMBRAPA, 1979).

The region is also characterized by having sandy shallow soils with low water holding capacity, vulnerable to erosion and with low organic matter content (EMBRAPA, 1979).

The vegetation is composed of a group of trees and shrubs which receive the generic name of "caatinga", where there is a predominance of Leguminosae, generally thorny, with small and deciduous leaves which fall in the dry period (GOLFARI and CASER, 1977).

## Plant Resources Exploration System

The exploration of plant resources consists basically of wood extraction for general use in the farms and for commercialization, and also as native forage species for animal feeding. These resources become important sources of fuel and food for the maintenance and development of the rural areas. However, this exploration is made with no criterion.

In this region, the plant resources show low wood productivity with mean volumes between 15 and 20 $m^3$/ha (TAVARES et al, 1969; Tavares *et. al.*, 1970; Lima *et. al.*, 1978; IBDF, 1988). The use of these resources in an intensive way, with no reposition of explored trees, has caused the degradation of the vegetation.

On the other side, beef cattle raising in this region shows low productivity, mainly as a result of food scarcity in the dry period, when the availability of native forage is greatly reduced. The "caatinga" vegetation neither shows adequate characteristics for pasture nor provides the nutritional requirements of the animals during a long period of the year, due to its poor herbaceous stratum and its deciduous behaviour. Consequently, its carrying capacity is very low, around 13 ha/animal (SALVIANO, 1989).

## Potentialities and Possibilities of Uses of Agroforestry Systems in the Semi-Arid Region

The research works at Northeast Brazil, particularly at the Agricultural and Livestock Research Center for the Semi-Arid Tropic (CPATSA), which belongs to Agricultural Brazilian Research Agency (EMBRAPA), have tried to optimize and/or maximize the use of natural and socio-economic resources, seeking a better performance of the regional agriculture by increasing production, productivity, resistance to adverse climatic effects and improving the ecological equilibrium through adequate methodologies and technologies.

In the forest research area, the agroforestry systems constitute important alternative for the increase of the regional productivity and the exploration of degraded soils.

These systems have the objective of rationalizing the use of the soil, trying to increase its total productivity through the p73 sequential or simultaneous production of wood, food and forage in the same piece of land (BENE et al, 1977).

Statistical data show that in the Brazilian semi-arid region the probability of succeeding in dryland agriculture (rainfall dependent) is of 3 out of 10, i. e., three out of ten years. It shows the high risk of this activity, evidencing the need for agricultural diversity. According to FREIRE et al (1982), the farmers recognize this problem as they dedicate the largest areas for extensive cattle raising.

Several attempts of intercropping were made in the region, involving forest and crop species, having most of them showed to be unviable, mainly due to poor yields of the crop species as a result of climatic effects. Unfortunately, many of these experiences are not registered on the account of the negative results. So the agroforestry systems involving cattle raising seem to be the most viable way to better utilize the productive capacity of the soil and to assure the farmer more socio-economic stability.

On the other side, the trees in the agroforestry systems play another important function as besides yielding wood, fruits or forage they can also be used as living fences, windbreakers, support to apiculture and other uses in the farm.

The living fences are not frequently found in the Brazilian semi-arid (RIBASKI, 1986), although they are an important agroforestry option due to the natural lack of wood for barbed wire fences (the most common type in the region) associated with high costs. The living fences show more advantage than fences made with posts and stakes since they have lower costs, long life, ecological benefits and possibility of yielding economical by-products (BUDOWSKI, 1987).

In the irrigated areas, the use of windbreakers appears as an excellent alternative

for minimizing the undesirable effects of winds, which are very frequent in the region. These protection systems avoid crop lodging and damage, soil erosion and contribute to reduce evapotranspiration. In doing so, the water economy is improved in these areas, which is a critical point in the water lacking regions.

## Some Research Results in the Brazilian Semi-Arid Region

### Selection of potential tree species

The experimental trials with tree species aiming at identifying potential materials for use in agroforestry systems have given promising results. Twenty-five species and 160 provenances of the genus *Eucalyptus* were tested in the States of Pernambuco, Paraíba, Rio Grande do Norte, Ceará and Bahia. The species *E. camaldulensis* and *E. tereticornis* outstand the others, showing mean yields of 70 $m^3$/ha at seven years of age, which represents four times the mean yield of the native vegetation. Also, the species of the genera *Prosopis* (mesquite), *Leucaena* ("leucena"), *Mimosa* ("sabiá") and *Gliricidia* ("gliricidia") have shown a good performance, with the advantage of being multipurpose trees (fuel, charcoal, stakes, forage, living fences, windbreakers, nitrogen fixation, shading, etc) (RIBASKI and LIMA, 1982; SOUZA and CARVALHO, 1984; PIRES *et. al.*, 1985; SILVA, 1986; DRUMOND *et. al.*, 1989; OLIVEIRA and DRUMOND, 1989).

More than ten species of the genus *Prosopis* were introduced in the Brazilian semi-arid region. *P. juliflora, P. pallida, P. affinis, P. cineraria,* and *P. velutina* have been considered as potential species for contributing to increase the production of wood, fuel and food for the animals (LIMA, 1990).

### Shading forage palm wih *Prosopis juliflora*

In the Brazilian semi-arid region, intercropping *P. juliflora* with forage palm (Opuntia ficus-indica) is a well known practice among small and medium farmers and has contributed with them to maintain their livestock during the dry periods. Forage palm is a member of the Cactaceae family, used for feeding the animals in the dry period, rich in water (over 90%), mucilage and mineral salts, but poor in protein (COSTA et al, 1973).

ALVES (1982) states the hypothesis that shading forage palm with *P. juliflora* in a 5 m x 5 m spacing can give benefits to the forage palm, increasing its yield and longevity.

One experimental trial was carried out at CPATSA in order to study the influence of *P. juliflora* shading on forage palm. The shading intensity is a function of the row spacing (5 m x 5 m, 7 m x 7 m, 10 m x 10 m, and 12 m x 12 m). Forage palm was planted in a 2,0 m x 0,5 m spacing. The results of the first evaluation of palm yield, made after a cut at three years of age, showed no significant difference among treatments regarding dry matter yield. We should emphasize that in this period the trees were still in development, having a mean canopy area around 16 $m^2$ (ALBUQUERQUE *et. al.*, 1986).

### Intercropping *Prosopis juliflora* with buffel grass

Research works carried out in the dry areas of Northeast Brazil have shown that buffel grass (*Cenchrus ciliaris*) can increase food supply during the whole year and, consequently, improve livestock performance. However, other results show that during the dry period, the protein level of cultivated pastures, including buffel grass, is not always sufficient for maintaining and increasing the weight of the animals (SALVIANO, 1984).

Intercropping cultivated pastures with Leguminosae can overcome their nutritional deficiency. However, buffel grass is a very dominant species well adapted to regions of low rainfall and there are few species which can be intercropped under these conditions. AYERSA (1981) suggests the use of silvopastoral systems for these regions, indicating the tree species of the genera Acacia and *Prosopis* as the most promising ones.

Research works conducted at Petrolina-PE, Northeast Brazil, showed that *P. juliflora*, when planted in an area with buffel grass, suffered from the competition, especially for water consumption. At trirty months of age, *P. juliflora* total dry matter yield was 17.0 tons/ha and 2.7 tons/ha, respectively, single and intercropped. The proportional difference between these two treatments was 540%. However, positive tendencies were noted indicating that *P. juliflora* can improve the quality of buffel grass pasture in protein content due to greater nitrogen concentration found in the grass dry matter when intercropped with that species.

Aiming at establishing a silvopastoral system involving those two species, it is

recommended that *P. juliflora* should be planted two to three years before buffel grass, in order to assure a good initial establishment of the tree species. It is also advisable to avoid the presence of animals in the area during the initial development of the trees (RIBASKI, 1988).

**"CBL System" - an alternative for beef cattle raising in the semi-arid.**

CPATSA has been carrying out studies with the objetive of identifying beef cattle raising systems capable of significantly increasing meat production in the semi-arid region, which is a traditional importer of this product.

The "CBL System" ("Caatinga" vegetation + Buffel grass + *Leucaena*) makes the rational use of the "caatinga" associated with grazing in buffel grass area during the dry period and direct access to Leucaena paddocks followed by its consumption as hay. This system has the goal of reducing the slaughtering age from 4-5 years to 3 years, taking into consideration the regional mean of 320 kg of liveweight.

In the "CBL System" the buffel grass and Leucaena areas together represent approximately 10% of the "caatinga" area, being the Leucaena area 20% of the buffel grass area. This system was compared with the traditional sole "caatinga" system (C) and with the "caatinga" + buffel grass system (CB).

The partial results for weight gain show a significant better performance of the group of animals in the "CBL system" over the ones on the "C system", but a moderate performance over the group of animals in the "CB system". The average weight at the end of the third year for the animals in the "CBL system" was 342.7 kg, representing an increase of 220% with regard to the initial weight (107.1 kg), 48% greater than the increase obtained in the "C system" (158.5 kg), but only 16% greater than the one obtained in the "'CB system" (200.5 kg).

Although the economical analysis has not yet been run, the data apparently do not indicate advantage of the "CBL system" over the "CB". However, a small percent increase on the *Leucaena* area over the buffel grass area and the haymaking of the total *Leucaena* area before the end of the raining period allowed a significant difference in weight gain through a greater consumption of this species between the two groups (GUIMARθES FILHO, EMBRAPA-CPATSA - not published).

**Evaluation of a silvopastoral system involving the intercropping of *Eucalyptus camaldulensis* with forage grasses.**

The cultural practices for the maintenance of reforested areas are essential for a good initial development of the plants in order to obtain satisfactory results in the future production of wood and by-products. However, this activity is one of the most expensive in the process of establishment of forest populations, being even worse depending on the quality and quantity of the herbaceous stratum to be removed.

On the other side, this stratum which is to be removed, sometimes with difficulty through the use of hoes, clearing or herbicides, can be a potential source of food for livestock, mainly by its possible acceptance and proteic value. So, the practice of silvopastoral systems is an important choice not only because of minimization of labor costs for maintenance and protection of the reforested area but also because of better soil use, allowing the simultaneous yield of plant and animal outputs.

A research work is being carried out at CPATSA with the objective of testing the technical and economical viability of a silvopastoral system involving *E. camaldulensis* intercropped with forage grasses adapted to the region, as follows: urochloa grass (*Urochloa mosambicensis*), buffel grass (*C. ciliaris*) and sabi panic (*Panicum maximum*).

The *E. camaldulensis* population, at eight years of age, had part of its area (0.75 ha) wired in after having been invaded by the grasses. The evaluation of the ground cover showed an occupation of 63% of the area with grasses, represented by 90% of urochloa grass and 10% of buffel and sabi panic grasses, with an average of 8.75% of crude protein.

Thirty-month old animals weighting 230 kg were introduced in the experimental area two times (1991 and 1992), where they stayed for three months, in a stocking rate of 2.7 animals/ha. The results for weight gain in the two periods showed a mean increase of 60 kg/animal, corresponding to 600 g/animal/day. These values are equivalent to the average obtained with other animals with the same characteristics and in the same period, in pasture of buffel grass cv. Biloela, which is the most grown cultivar in the region (RIBASKI and OLIVEIRA, EMBRAPA-CPATSA - not published).

The volumetric yield of *E. camaldulensis* was significantly changed after the presence of the animals in the experimental area (T test, $P < 0,10$). The total increment (1990-1993) in the

silvopastoral system was 22% greater than in the conventional system with no grazing.

**Use of windbreakers in irrigated areas**

The expansion of irrigated areas in the region has caused some ecological problems. The areas which were before covered with native vegetation are being replaced by commercial planting of many different crops (tomatoes, watermelons, grapes, beans, mangoes, guava, bananas and onions) in continuous irrigation areas exposed to all different climatic and biological factors due to lack of natural protection from the native vegetation. This is a worrying situation, mainly in respect to wind action which is very frequent in the region. During the dry period, between July and October, wind can reach velocity superior to 250 km/day (AMORIM NETO, 1989), causing serious damage to agriculture.

The use of windbreak barriers turns out to be an important way to minimize those undesirable aspects and to promote agricultural yield increase. Four windbreakers were set up in experimental fields in Petrolina(PE) and Juazeiro(BA), where there is a predominance of *Eucalyptus tereticornis* due to its adaptation to the region and its architecture (large leaf area and uniform distribution of the branches along its trunk).

The measurements on one of the windbreakers at 17 months of age showed a mean height of 7.4 m and diameter of 7.5 cm for two rows of *E. tereticornis* in a spacing of 2.5 m (within the row) and 1.25 m (between rows). The evaluations of the influence of windbreakers on agricultural yield will only be made after the second year. However, it is important to point out the excellent performance of the *E. tereticornis* under these conditions, reaching an estimated mean yield of 50 $m^3$/ha/year (RIBASKI, EMBRAPA-CPATSA - not published).

These initial results become a new economical activity through the possibility of forest exploration in irrigated areas. The reforestation in narrow strips with four to five rows of *E. tereticornis* can be managed for wood production besides the use as windbreakers.

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