Agroforestry System Combining *P. juliflora* and Buffel Grass in the Brazilian Semi-Arid Region
Preliminary Results

Jorge Ribaski
Forester, EMBRAPA
Agriculture and Livestock Research Center for the Semi-Arid Tropic
Petrolina

Introduction

The exploitation of the plant resources in the Brazilian semi-arid region boils down to extracting timber for farming use and for commercial purposes, as well as to using native fodder species for feeding livestock.

This exploitation is performed without any management criteria, thus bringing about degradation of the plant cover.

Cattle farming, predominant in the region, shows low productivity as a result mainly of the scant fodder available during the dry season. During this period, the pastures cultivated with grasses, mainly buffel grass *(Cenchrus ciliaris* L.) frequently do not offer a protein level sufficient for the animals to maintain or gain weight.

Prosopis juliflora (Sw) DC is grown in the region as a fodder tree and for afforestation. The advantages this xerophyte offers for afforestation are its precociousness, drought hardiness, good-quality wood for a variety of end uses, production of highly palatable and nutritive pods, and bearing of fruit during the dry season.

The use of this leguminous tree in afforestation for timber and fodder production purposes through silvopastoral systems constitutes an economically and socially important alternative for the region.

The purpose of this research was to study the technical viability of a silvopastoral system combining *P. juliflora* and *C. ciliaris* cv. Gayndah.

Review of Literature

In silvopastoral systems, it is important to stress the fact that the tree, on account of the functions it performs, must be the basic structural element. The tree component constitutes an important soil stabilization factor, as it affords protection against direct raindrop impact, sunlight, water runoff and wind erosion, minimizing the damage caused by leaching (Galvão, 1978). In these systems, the tree cover can modify the microclimate, allowing better nutrient recycling by natural processes, through organic matter originated from dead plants and animal faeces (Weaver, 1979).

According to Azevedo (1982), *Prosopis juliflora* in association with grasses produces beneficial effects. Soil temperatures are lower as a result of shading, reducing thereby the humus oxidation rate. Leaf litter and root nodules contribute to increasing nitrogen content and of other minerals in the soil.

When the tree cover is not very dense in terms of canopy, thereby permitting solar radiation to reach the ground, as in the case of *P. juliflora,* the grasses beneath the canopy keep their protein levels longer and are more digestible than those out in the open (Karlin and Ayerza, 1982).

Christie (1975) reports that cultivation of *Cenchrus ciliaris* cv. Gayndah under an overstory of adult *Eucalyptus populnea* in low-fertility soils of the semi-arid region of Queensland, Australia, produced a threefold increase in dry matter yield as compared to that of grass planted among the trees, outside the natural micro-habitat existing beneath the trees. This was explained by the different concentration of phosphorus in each case. The forest species contributed, under these conditions and through nutrient recycling, to increased soil fertility, particularly as regards phosphorus content.

The presence of a tree component in silvopastoral systems contributes to reducing evapotranspiration from the soil and leaves of plants cultivated in combined crops, as well as reducing extreme temperature oscillation. By reducing evapotranspiration, the water economy of the system is generally improved, a very important factor in regions affected by scant water resources.

Theoretically, better use of water and soil nutrients can be achieved with a silvopastoral system when the combined species have different growth habits, i.e. water consumption peaks at different times of the year and different nutritional requirements. This benefit can also result from the arrangement of the root systems in the different strata of the soil profile, enabling better water tapping and nutrient uptake.

Work performed at the Brazilian semi-arid region found that the introduction of *Cenchrus ciliaris* cv. Gayndah into an area planted with *Eucalyptus camaldulensis* and *Mimosa caesalpiniaefolia* was not significantly detrimental to either growth or survival rates of the tree species. On the contrary, this intercropping system contributed to a better utilization of the soil's productive capacity, offering greater fodder supply to animals during the dry season (Ribaski, 1985).

The forest stocking rate in silvopastoral systems bears upon the greater or smaller fodder output and, consequently, on the grazing pressure to be exerted on the area. As the forest develops, integration with animals can become problematic, as the fodder supply decreases in line with the increase in basal area of the plantations (Clary *et al.,* 1975)

Another important factor to be considered in intercropping is competition which, in global terms, refers to a decrease in the availability of total water, nutrients, light, carbon dioxide, etc., for every individual. Competition between crops and weeds is more serious when the crop is young, and is stronger among individuals or species with similar characteristics in terms of growth habit, production, etc. This competition decreases when the requirements of each species are different (Oliva, undated).

The use of silvopastoral systems must be tailored to every local bioclimatic condition, and establishing one requires basic knowledge on the species to be used for intercropping. If not managed properly, they can bring about failure of the whole system.

Material and Methods

This research project was carried out in an experimental plot belonging to the Agriculture and Livestock Research Center for the Semi-Arid Tropic (CPATSA), of the Agriculture and Livestock Research Agency (EMBRAPA) in Petrolina, Pernambuco.

Geographical location

The experimental area is located at the Petrolina district, Pernambuco, at 09° 09' south lat., 40° 22' west long., at an altitude of 365.5 m above sea level.

Trial establishment

The trial was established in January 1983, with a wholly randomized linear experimental layout with five replications and four treatments:

1. *P. juliflora* planted in an area free of buffel grass, using normal cultural procedures.
2. *P. juliflora* planted in an area containing buffel grass, hoeing a 2-m-diameter clear space around the seedling.
3. *P. juliflora* planted in an area with buffel grass, hoeing a 1-m-diameter clear area around the seedling.
4. *P. juliflora* planted in an area with buffel grass, without any cultural practices.

Buffel grass establishment

Buffel grass was sown in November 1981, at the onset of the rainy season, in fifteen 192-m^2 plots (12 m × 16 m), leaving the remaining five plots, of equal size, without sowing. Sowing was made manually in furrows and at a spacing of 0.5 m, using 10 kg of seeds per hectare, applying no fertilizer.

P. juliflora planting

After buffel grass establishment, *P. juliflora* was planted using seedlings raised in the CPATSA forest nursery, previously selected with a view to the greatest homogeneity in terms of healthiness and vigor.

Fertilization and phytosanitary treatments were performed at planting, applying 100 kg of NPK in 5-14-3 proportion and 100 g of aldrin, to prevent termite attack. Both the fertilizer and the prophylactic element were applied in pits dug for the purpose in plots with and without buffel grass.

The spacing used was 3 × 4 m, with 16 seedlings per experimental unit, but only the four central ones were measured later for statistical analysis purposes.

Cultural practices

Approximately 20 days after *P. juliflora* planting, cultural practices were carried out, with manual hoeing and weeding, with the purpose of defining the treatments set forth. Thereafter, systematic hoeing was practiced every four months.

Data collection

Data collection for *P. juliflora* was made quarterly starting on the date of trial establishment and up to twelve months of age. Thereafter, measurements were made at 19 and 30 months of age, when the trees were felled to quantify the biomass produced. In all these periods survival assessments were made, measuring also collar diameter, height, crown diameter and number of stems and branches up to 1/3 of total plant height.

The buffel grass was mown thirty months after trial establishment, measuring its biomass.

Some of the mineral elements contained in buffel grass and *P. juliflora* biomass were also measured, performing also a water balance.

Results and Discussion

P. juliflora behavior during the first year

Table 1 shows the quarterly survival rates for *P. juliflora,* up to 12 months of age. Table 2 shows the dendrometric data of the species, at three and six months of age.

TABLE 1

***P. juliflora* Survival Rates 3, 6, 9, and 12 Months After Establishment in an Area with Buffel Grass, Using Different Cultural Practices**

Treatments	Survival (%)			
	Three months	Six months	Nine months	Twelve months
Normal cultural practices (Area without buffel grass)	100	100	100	100
2-m-diameter hoeing (Area with buffel grass)	100	95	90	85
1-m-diameter hoeing (Area with buffel grass)	100	50	30	20
No cultural practices (Area with buffel grass)	100	10	10	5

TABLE 2

Mean Values for *P. juliflora* Collar Diameter (Cd), Height (H), and Crown Diameter (CD) at 3 and 6 Months of Age

Treatments	Three months			Six months		
	Cd (cm)	H (cm)	CD (cm)	Cd (cm)	H (cm)	CD (cm)
Normal cultural practices (Area without buffel grass)	1,4	92	129	2,1	105	225
2-m-diameter hoeing (Area with buffel grass)	0,8	73	67	1,0	82	88
1-m-diameter hoeing (Area with buffel grass)	0,5	61	30	0,5	61	26
No cultural practices (Area with buffel grass)	0,4	58	16	0,4	58	17

Figure 1 illustrates the water balance for the 12-month period, beginning on the date of trial establishment.

From the water balance data, it may be seen that total rainfall in 1983 was 553 mm, concentrated in January, February and March. Thereafter, a marked water deficiency period set in, lasting until year's end. It eased off somewhat in November, when a total of 100 mm rainfall occurred. The trial area soil had sufficient moisture storage capacity to make moisture in its profile available for plant use during the months of April, May and June. That year was characterized by absence of hydric excess.

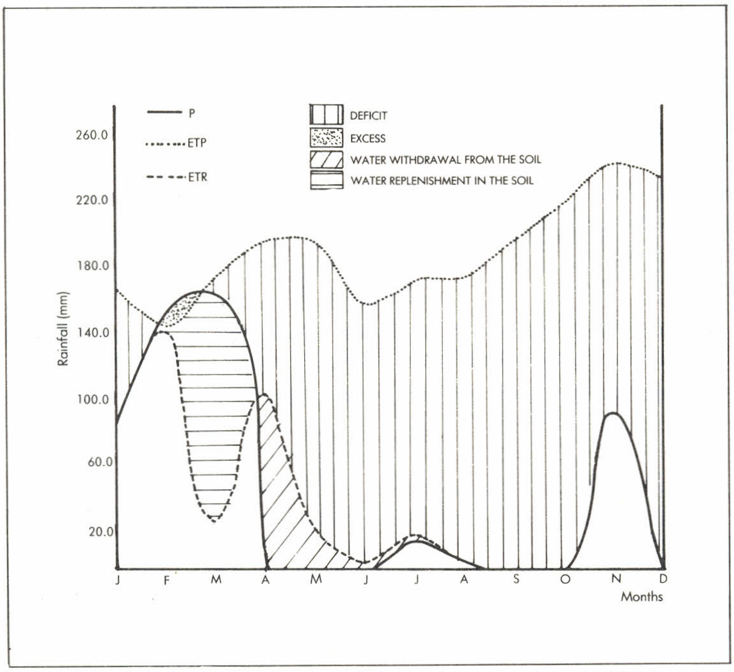

Figure 1. Water balance of the experimental site in 1983.

Comparing the data in Table 1 with the water balance (Figure 1), it may be seen that as the water availability in the soil decreased, *P. juliflora* survival rates were also affected. With the exception of the treatment were *P. juliflora* was not associated with buffel grass, all the other treatments exhibited a drop in survival rates, particularly in the treatment exempt from cultural practices.

At three months of age, 100% of the initial seedlings still survived in all treatments. This was also the period with the highest rainfall. However, the dendrometric data in Table 2 show that in spite of the cultural practices performed on the associated crops, the maximum increases attained by *P. juliflora* were always lower than those for *P. juliflora* planted alone. The same table shows that, between three and six months of age, the parameters measured for *P. juliflora* in the treatments less favored with cultural practices exhibited no increase.

Table 3 shows the effect of the treatments on survival rates and *P. juliflora* development in terms of collar diameter, height, crown diameter, number of stems and number of branches up to 1/3 of total plant height, at thirty months of age.

The analysis of the data in Table 3 show that single *P. juliflora* keeps 100% survival at 30 months of age. When associated with buffel grass, only those seedlings where hoeing had been performed in a 2-m-diameter area around the plant survived, with 15% mortality. Despite the high survival rate in this treatment, the data obtained from measuring the different parts of the plant were always smaller and statistically different from the treatment where *P. juliflora* was planted alone, with the exception of the number of stems.

Table 4 shows dry matter production for *P. juliflora* and buffel grass and the amounts of nitrogen produced 30 months after trial establishment.

TABLE 3

Mean Values for *P. juliflora* Survival (S), Collar Diameter (Cd), Height (H), Crown Diameter (CD), Number of Stems and Number of Branches up to 1/3 of Total Tree Height, at 30 Months of Age

Treatments	S (%)	Cd** (cm)	H* (m)	CD** (m)	Number of stems	Number of branches
Normal cultural practices (*P. juliflora* planted alone)	100	8.0 a	3.78 a	3.89 a	2.2 a	14.4 a
2-m-diameter hoeing (*P. juliflora* × buffel grass)	85	4.9 a	2.58 b	2.58 b	2.0 a	7.6 b
1-m-diameter hoeing (*P. juliflora* × buffel grass)	0	—	—	—	—	—
No cultural practices (*P. juliflora* × buffel grass)	0	—	—	—	—	—

* & ** Figures followed by different letters are significantly different as per T test at 5% and 1% probability level, respectively.

TABLE 4

***P. juliflora* and Buffel Grass Biomass Production and Amount of Nitrogen Exported Under the Different Treatments**

Treatments	Dry matter (kg/ha)			Nitrogen (kg/ha)		
	P. juliflora	Buffel	Total	*P. juliflora*	Buffel	Total
P. juliflora planted alone (Normal cultural practices)	17,669	—	17,669	160.4	—	160.4
P. juliflora × buffel grass (2-m-diameter hoeing)	2,757	8,736	11,493	27.0	59.8	86.8
P. juliflora × buffel grass (1-m-diameter hoeing)	—	9,871	9,871	—	70.4	70.4
P. juliflora × buffel grass (No cultural practices)	—	10,050	10,050	—	59.0	59.0
Buffel grass planted alone*	—	7,373	7,373	—	44.0	44.0

* Data gathered at an area adjacent to the experimental plot.

The results obtained for *P. juliflora* biomass production (Table 4) evidence the sensitivity of this species to competition when associated with buffel grass. Meanwhile, in nutritional terms, nitrogen does not appear to be one of the limiting elements for *P. juliflora* development in this association, as, despite the differences in the amount of this element produced by *P. juliflora* planted alone (160.4 kg/ha) and in association (27.0 kg/ha), the proportion of N for both biomasses was similar, staying around 1%.

The production of buffel grass biomass (Table 4) follows certain logic; the smaller the clearing around *P. juliflora,* until total absence of any cultural procedure, the greater the buffel grass biomass production, resulting from the increasingly greater area it then occupies.

The treatment with no cultural practices showed the highest dry matter output (10,050 kg/ha), but *P. juliflora* presented 90% mortality after the first six months (Table 2). The proportion of N found in the biomass was similar to that found in the plot with buffel grass alone.

In the combined crops with clearings 1 and 2-m in diameter around *P. juliflora,* respectively, the proportions of nitrogen found in the biomass were higher that in the trial with no cultural procedures.

The findings presented in Table 4 suggest that *P. juliflora* contributed considerably to increasing the N content in buffel grass biomass, thereby increasing its nutritive value.

General Considerations

It may be seen from these findings that *P. juliflora* showed sensitivity to competition when cultivated in association with buffel grass. This competition appears to be more marked during the first year after plantation establishment, mainly for the water available.

Other variables are under study, such as soil moisture content and fertility, basal coverage of buffel grass, nutrients produced by *P. juliflora* and buffel grass biomass, and the root system of both species, with the purpose of better explaining *P. juliflora* performance in intercropping and verifying the feasibility of this silvopastoral system.

References

AZEVEDO, C. F. de, 1982: "Potencialidade da algaroba no Nordeste," In: *Algaroba,* Empresa de Pesquisa Agropecuária do Rio Grande do Norte, Natal, RN, pp. 283-299.

CHRISTIE, E. K., 1975: "A note on the significance of *Eucalyptus populnea* for buffel grass production in infertile semiarid rangelands," Tropical Grasslands, 9 (3): 243-6.

CLARY, W. P.; KRUSE, W. H. and LARSON, F. R., 1975: "Cattle grazing and wood production with different basal areas of *Ponderosa pine,"* Journal of Range Mangement, 28 (6): 434-437.

GALVAO, A. P. M., 1978: "Agrosilvicultura," In: *Proceedings,* Encontro Nacional dos Reflorestadores, 5. Canela, pp. 27-28.

KARLIN, U. O. and AYERZA, R., 1982: "O programa da algaroba na República Argentina," In: *Algaroba,* Empresa de Pesquisa Agropecuária do Rio Grande do Norte, Natal, RN, pp. 146-197.

OLIVA, M.: "Ecofisiología vegetal," (no further data) 250 p.

RIBASKI, J., 1985: "Pesquisa agro-silviculturais em andamento na região semi-árida brasileira (resultados preliminares)," In: *Florestas plantadas no Neutrópico como fonte de energia,* Proceedings of Symposium UFV/MAB/IUFRO; IUFRO SI, Working Group, February 1983. Universidade Federal de Viçosa, Minas Gerais, pp. 286-295.

WEAVER, P., 1979: "La agri-silvicultura en la América Tropical," Unasylva 31 (126): 2-12.