Potential of environmental services of eucalyptus on integrated production systems

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Introduction

In order to help solving the serious environmental problems caused by inadequate pasture management, to diversify activities and intensify land use, reducing costs and increasing farm income, Crop-Livestock-Forest integrated systems have been developed (ICLF). In these systems, pasture-crop rotation cultivation between tree alleys, under proper management, promote consistent improvement of aspects like plant production, animal husbandry, environment and society.

Brazil has high potential for implementation of integrated production systems, which demonstrating high efficiency in improving the soil quality, control pests and diseases, control of weeds, in the use of by-products of different crops, in addition to making the cash flow more frequent, creating new jobs and giving greater sustainability in agricultural production.

The adoption of ICLF systems is one of the alternatives to achieve sustainability of production systems, especially with regard to the reduction of greenhouse gases (GHGs). This is due to the high production of tropical grasses and organic matter accumulation in the soil in recovered grazing systems. Another point is the introduction of tree component, which has high potential carbon sequestration and GHG

mitigation, which reflecting in higher use efficiency of land and environmental services.

Thus, the objective of this research was evaluated the productivity and the potential environmental services of the tree component in two spatial arrangements.

Material and Methods

The experiment was carried out at the Embrapa Beef Cattle research center in Campo Grande, Mato Grosso do Sul State, Brazil, located between the geographical coordinates: 20º27'02" S and 54º43'07" W.. Soil was a distroferric red latosol (LVdf), Climate under Köppen classification is a transition zone between Cfa and Aw wet tropical. Mean annual rainfall is 1,560 mm, with rainy summer and a dry light cold winter.

A randomized block design was used, with two treatments and four repetitions. Treatments consisted of two spatial arrangements: (1) single rows of eucalyptus trees with 14 meters between rows and 2 meters between trees in the row (14 m × 2 m), totaling 357 trees ha^{-1} and (2) single rows of eucalyptus trees with 22 meters between rows and 2 meters between trees in the row (22 m × 2 m), totaling 227 trees ha^{-1}.

Brachiaria brizantha cv. BRS Piatã was used as cattle pasture between *Eucalyptus urophylla* x *Eucalyptus grandis* trees (clone H13) in the rows. Prior to experiment implementation, there was *Brachiaria* sp. in the area, with low stocking rates. The area was reclaimed in September-October 2008 using crop-livestock-forest integration system (iLPF) with tillage and soybeans farming. Eucalyptus seedlings were transplanted in January 2009 and the Piatã grass was no-till sown over soybeans crop residues in April 2010.

Measurements of total height and diameter at breast height (DBH) were performed at 48 months after planting. From the height and DBH

data, the volume of timber per plant was calculated (using the form factor equal to 0.5, and commercial height of 75% total height) as well as was the volume of timber per hectare, using the equation proposed by Porfírio-da- Silva et al. (2009).

The carbon content on stem was determined using CN analyzer (Sumika Chemical Sumigraph CN 900), according to methodology employed by Kanda et al. (2004). CO_2 eq. was estimated using a conversion factor of 3.67. To determine the neutralizing capacity of the GHGs from cattle, it was considered that an animal unit produces 1.88t CO_2 eq per year.

Analysis of variance was carried out and, when there were significant differences up to 5% significance between means, these means were compared by Scott Knott test with 5% probability, using SISVAR software (Ferreira, 2008).

Results and Conclusions

Spacing arrangements did not affect individual production performance of trees until 86 months after planting (Table 1), therefore, there was no significant difference in the silvicultural performance characteristic. In general, increase in diameter is a highly responsive characteristic of spacing (Bernardo, 1995), however, when using broader spacing, as tested in this work, it is expected to detect the influence of these spacing on the DBH in older plants. The same author states that height has no direct correlation with spacing as there are cases where there is increased when larger spacing and others in which the result is the opposite. In this work, there was not detected influence of spacing on height measurements until 86 months after planting s, probably due to large distance between tree rows adopted.

The volume of timber per plant is highly influenced by the height and DBH characteristics, no differences were evident for these two

characteristics, so no statistical differences in the volume of timber per plant.

Table 1. Averages of diameter at breast height (DBH), height, volume of timber per tree (Vol./tree) and volume of timber per hectare (Vol./hectare) for different eucalyptus genotypes in Campo Grande-MS, Brazil.

Systems	DBH (cm)	Height (m)	Vol./tree (m^3 $tree^{-1}$)	Vol./hectare (m^3 ha^{-1})
14 m x 2 m	24.00 a	26.98 a	0,43 a	153,50 a
22 m x 2 m	24.50 a	26.21 a	0,41 a	92,37 b
CV (%)	4.69	5.23	10.84	17.51

Means followed by the same letter in the column are not different by Scott Knott test (P> 0.05).

Analyzing the volume of timber per hectare there is influence of tree stand. Timber yield was larger with higher density arrangement (14 m x 2 m).

Among benefits provided by trees in ICLF system, the positive impact on the microclimate variables and carbon sequestration can be mentioned, expanding the possibilities of use in climate change scenarios (Almeida et al., 2011). But a effectively measured benefit is the carbon sequestered by trees and consequently the equivalent CO_2 neutralization potential regarding GHG emissions from cattle (PNEB), as demonstrated by the results shown in Table 2.

Table 2. Averages of carbon (C) fixed on trees, equivalent in CO_2 eq. and neutralization potential for GHG emissions from cattle (PNEB) by eucalyptus tree by integrated Crop-Livestock systems under different tree arrangements in Campo Grande-MS, Brazil.

Sistema	C (t ha^{-1})	CO_2eq. (t ha^{-1})	PNEB (UA ha^{-1})[1]
14 m x 2 m	44,20 a	158,97 a	90,58 a
22 m x 2 m	40,1 b	95,66 b	54,51 b
CV (%)		17.51	

[1] AU = an adult cattle (450 kg)

Means followed by the same letter in the column are not different by Scott Knott (P> 0.05).

Higher tree density provides higher carbon fixation, and therefore, the greater will be the mitigation of the GHGs produced by cattle. In the 14 m x 2 m spatial arrangement, carbon fixed until 86 months was sufficient to neutralize the greenhouse gas emissions from 12.7 animals (weighting 450 kg LW) per hectare per year. For the 22 m x 2 m spatial arrangement, carbon fixed is enough to mitigate the

greenhouse gases emission from 7.6 animals (with 450 kg) per hectare per year. In this context, since degraded pastures have average stocking rates under 1.0 animal unit per hectare per year, there will be a carbon surplus set by integrated systems.

Thus it can be concluded that the spatial arrangements used did not influence individual development of eucalyptus trees until 86 months after planting and tree density increased wood productivity per area and consequently the potential for environmental services in agroforestry systems.

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