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Phosphorus, Mineral Matter and Lignin in *Brachiaria* Forage Intercropping with *Eucalyptus* in a Silvopastoral System in the Brazilian Savannah Biome

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ABSTRACT

Silvopastoral systems have the potential to replace benefits of the current cultivated grassland ecosystems. The experiment was conducted in a silvopastoral system, located in a farm called Fidalgo in the county of Confins in Minas Gerais, Brazil. The pasture in the SPS and in the adjacent control area, were planted at the same time as the silvopasture establishment. This SPS was established in 1994, without the use of fire. The experimental area consists of 1.5 hectares. Cattle grazing practices depended on forage production during the seasons. The animals grazed for three days followed by a 30-day rest period. In the implantation of the experiment was done a cut for standardization of forage at 30 cm above soil. Twelve random points were selected in each system (SPS and pasture), with a total of 24 points. Conducted the evaluation bromatologic compositions of dry matter (DM), mineral matter (MM), phosphorus (P), and forage composition (lignin). Observed a significant effect on production in forage of lignin (LIG), mineral matter (MM) and phosphorus (P). MM, P and LIG were significantly higher in the SPS ($P<0.05$). This study suggests the presence of the tree species Eucalyptus did not interfere in Phosphorus Management. Periods of climatic variations observed promoted differentiation in forage production, and absorption of Phosphorus.

Keywords: tree species, fodder, degraded areas, shading, sustainability

1. INTRODUCTION

Silvopastoral systems have the potential to replace benefits of the current cultivated grassland ecosystems, which mostly consist of monocultures of grasses, making the activity more sustainable economically and environmentally (FRANKE et al., 2001). The Cerrado biome, which is sensitive to rainfall changes, could increase animal production by the use of SPS's (BRASSARD et al., 2005). However, the impact of animal production in AFSs on global climate change has not been investigated. Indeed, if sustainable silvopastoral systems could be developed as viable alternatives to conversion of forest lands to support animal production, the above-stated high levels of ''carbon footprint'' of animal production in developing countries could be reduced considerably (NAIR et al., 2008).

Highly weathered tropical soils have low P plant availability and very high inorganic phosphorus (Pi) adsorption capacity. Therefore, maintenance of organic sources able to supply P by mineralization is essential for P availability under highly weathered conditions. Organic matter cycling and tolerance to low P soil concentration of the plant community may guarantee sustainability in natural ecosystems (Cunha et al, 2007). In the forests, in particular, the availability of P in the soil does not reflect the accumulation of this element in the biomass, either the amount of P cycled annually (Novais & Smyth, 1999).

In tropical soils, the Po (P organic) can be greatly affected by the change of vegetation, altering the availability of P (Szott & Melendez, 2001, Solomon et al., 2002; Zaia, 2005). Thus, the characterization of Po consists of fundamental importance in understanding the cycle of P in soils advanced stage of weathering.

The objective of this study was to evaluate a SPS located in the Cerrado, in relation to values of phosphorus during the drought summer period and beginning of the rainy season.

2. MATERIALS AND METHODS

The experiment was conducted in a silvopastoral system, located in a farm called Fidalgo in the county of Confins in Minas Gerais, Brazil. The geographic coordinates of the experimental area of this typical Cerrado biome are 19º54'32" South and 43º58'18" West and the average maximum daily temperature in the SPS was 31.4ºC and relative humidity averaged 42%. The pasture in the SPS and in the adjacent control area, were planted at the same time as the silvopasture establishment. This SPS was established in 1994, without the use of fire.

The land was cleared, and eucalyptus seedlings were planted at a density of 150 trees/hectare.The trees used in the experiment were15 to 25 meters high, with diameter at breast height (DBH) of 40 to 60 cm. The soil in the SPS is classified as a

Latossolo Vermelho Amarelo (Oxisol), with 651 g/kg of clay, 211 g/kg of silt and 138 g/kg of sand.

The experimental area consists of 1.5 hectares. Cattle grazing practices depended on forage production during the seasons. The animals grazed for three days followed by a 30-day rest period. In the implantation of the experiment was done a cut for standardization of forage at 30 cm above soil. Twelve random points were selected in each system (SPS and pasture), with a total of 24 points. One meter squared collectors made of steel grids were used to prevent animal interference and were placed at each identified location for forage evaluation.

After collection, the forage was weighed, dry mass in an oven at 60ºC for 72 hours, and then ground to pass through a1 mm sieve. All bromatologic compositions of dry matter (DM), mineral matter (MM) (COMPÊNDIO…, 1998), phosphorus (P) were determined using permanganometric techniques, colorimetric and flame photometry, respectively. Forage composition was evaluated for lignin separately (ROBERTSON et al., 1982).

The test was conducted in a completely randomized design, arranged in a split plot, with six repetitions. The Lilliefors and Bartlett tests were performed to verify normality and homoscedasticity of data, respectively. Then an analysis of variance (ANOVA) model was fitted, and the means were tested. The Student Neuman Keuls (SNK) test was used to correct for the multiple testing problem. Statistical significance was determined at a familywise error rate at $\alpha = 0.05$.

3. RESULTS AND DISCUSSION

According to estimates of means of three periods of collection (beginning, middle or end of drought period), management (Table 1) had a significant effect on production in forage of lignin (LIG), mineral matter (MM) and phosphorus (P). MM, P and LIG were significantly higher in the SPS ($P<0.05$). The increase in MM and P (Table 1) levels are beneficial for animal nutrition, and can be related to a greater presence of organic matter, in SPS (5.71%) in relation to pasture (without trees) (3.94%), in the surface soil, as described in Prado (2010).

The amount of organic matter in the SPS promotes recycling of nutrients and increases the water content in soil in treeless areas. According to Nair (1993), the term nutrient cycling refers to the continuous transfer of nutrients that are already present within a soil-plant system, such as a farmer's field. According to Nair et al., (2008), the land-use systems that are structurally and functionally more complex than either crop or tree monocultures result in greater efficiency of resource (nutrient, light, and water) capture and utilization, and greater structural diversity that entails tighter nutrient cycles. While the above- and belowground diversity provides more system stability and resilience at the site-level, the systems provide

connectivity with forests and other landscape features at the landscape and watershed levels (NAIR et al., 2008).

Phosphorus absorption by the roots occurs through the diffusion of phosphorus that is dependent on the amount of water in the soil. Phosphorus is responsible for the photoenergetic, phosphorylation and photorespiration processes in plants (ARAUJO et al. 2006). The higher phosphorus absorption in the SPS promotes greater absorption of other nutrients, hence producing higher levels of dry matter and minerals. In treeless areas, lower soil moisture reduces the absorption of nutrients and affects the physiological and metabolic processes of the plant. Presence of trees changes the balance of photosynthetic active radiation and the behavior of winds on the surface area (MONTEITH et al. 1991; BRENNER, 1996), influencing the conversion of this radiation by the process of photosynthesis (ONG et al. 1996).

Most soils of Brazil presents deficient in phosphorus, including integration with grain crops, can partially meet the requirements of this nutrient, which is a strategy to increase productivity in areas of pasture system known as integrated crop-livestock . The integration system Silvopastoral contributes to increase moisture retention in the soil in the presence of trees can influence the higher retention of water, by shading, the reduction of soil moisture will impair the nutrient absorption, particularly nutrients are absorbed via mass flow and diffusion. The decrease in the incidence of winds will also reduce evapotranspiration (KANG and AKINNIFESI, 2000). And yet the system can benefit the growth of mycorrhizal fungi may assist in root interception. When silvopasture is established by integrating trees into grass vegetation of pasture systems, above- and belowground productivity, rooting depth and distribution, and the quantity and quality of organic matter inputs to soil will change (JACKSON et al., 2000)

TABLE 1: Means of lignin (LIG), mineral matter (MM) and phosphorus in the three periods of collection (beginning, middle or end of drought period) in both production systems. Confins, Minas Gerais, Brazil

Production Systems	Lignin	MM	P
Silvopastoral	12.38^{A}	8.29 ^{A}	0.18^{A}
Forage production system (treeless)	10.33^{B}	7.77 ^{B}	0.17^{B}
CV (%)	19.12	11.36	13.98

Means followed by different letters differ for the forage in the silvopasture and the pasture outside the silvopasture (P<0.05) by SNK test.

Phosphorus levels, were 5.9% higher (P<0.05) (Table 1) in the shaded forage system (SPS) in comparison to the forage production system (without trees)

treatment. Castro *el al*. (2001) noticed that *B. brizantha* P levels tended to increase as the light level was reduced. These authors explain that, in most plants, light stimulates absorption of H_2PO_4, nevertheless there is no consensus in literature if light changes concentrations of P, because there is a variation in P among forage species. On the other hand, levels found by Andrade *et al*. (2002) were numerically equal among shaded and not shaded forage, with a difference of only 0.14%. In this experiment, shading due to the presence of trees appeared to significantly increase the availability of phosphorus (Table 1).

The effect of time of sample collection (beginning, middle or end of drought period) were significant to lignin (LIG), mineral matter (MM), ether extract (EE), dry matter (DM) and phosphorous (P) (Table 2), independent the evaluated system. It verified the interaction effect between production system and months of collection to the variables ADF, NDF, CP and Ca. Generally, it was observed that LIG, MM and DM, were superior in July, followed by November (Table 2). Though, EE and P were smaller in the month of July ($P<0.05$).

Lignin content was higher in forage collected in the middle of the drought period in July (Table 2). The interval between the first and the second times of sampling were 60 days. During the drought period, forage in general, are already more fibrous and consequently, less digestible. In November, after the dry season and early rain, there was a decrease in the lignin content, because forages were fresh with new buds in the beginning of rain season. Thus, the lignin content of the organic material is considered to be the most important factor determining the rate of decomposition (JAMA and NAIR, 1996; MAFONGOYA and NAIR, 1997).

TABLE 2: Lignin (LIG), mineral matter (MM), ether extract (EE), dry matter (DM) and phosphorus in the three periods of collectings (beginning, middle or end of drought period), in the silvopasture and the open forage production systems. Confins, Minas Gerais, Brazil

Period	LIG	MM	EE	DM	P
May[1],	9.8965^{C}	7.6600^{B}	1.3575^{B}	31.1765^{C}	0.23^{A}
July[2],	12.8060^{A}	8.6175^{A}	1.1705^{C}	46.6395^{A}	0.14^{B}
November[3],	11.3575^{B}	7.8220^{B}	1.9410^{A}	31.3505^{B}	0.14^{B}
CV(%)	19.12	11.36	22.66	9.64	13.98

Lignin (LIG), mineral matter (MM), ether extract (EE), dry matter (DM) and phosphorous (P). Means of each variable followed by different letters differ ($P<0.05$) by SNK test. [1] beginning of drought; [2] middle of drought; [3] end of drought.

Ether extract (Table 2) is the nutrient which provides most energy to forage, followed by proteins and carbohydrates (BERCHIOELLI *et al*., 2006). Generally, the quantity of EE in forages is low, while the recommended value in total diet must be of 6% according to Prado (2009), and often times animals need supplementation,

due to this low energetic value. The results presented are in agreement with what happens to pastures, because during regrowth (November) there is a considerable increase of energetic quantity in younger plants (CARVALHO *et al*., 2005).

The DM content in July ($P<0.05$) is higher than during the other periods, because, forage collected in November (end of the drought period and early rain) have highest quantity of dry fiber (Table 2).

Tree litter and cattle manure concentrate nutrients in the SPS with the cattle congregating near trees to avail of the shade provided (DURR and RANGEL, 2002). However, in this work, the SPS has a high density of trees. So, the effect of concentration of cattle manure did not occur. The high levels of nutrients, observed in leaf analyze, MM, DM, LIG and P were most likely due to the presence of trees in the pasture.

B. brizantha cv. Marandu is a grass with average tolerance to shade (CARVALHO et al., 2005). These authors, found that grass production in the shade had inferior dry matter ($P<0.01$) compared to its production in full sun. Though, in periods of less rain, this forage tended to have higher DM production under trees. Douglas et al. (2006) explained that there are seasonal variations of water quantity in soils under trees, tending to be higher in drier periods of the year in areas with trees, while, in rainy periods, areas without trees tend to present a greater quantity of water due to the increase in consumption of water and interception of rain by trees at this time of the year. In this experiment, no difference was observed between the systems, but in collection periods (table 2).

According to Nair (1993), when tree biomass is used as a source of nutrients for crops, it is important to ensure synchrony between the release of nutrients (via decomposition) and their uptake by the crop. Daccarett and Blydenstein (1968) also did not find a reduction in dry matter of forage in the presence of different tree species. Also in this work did not present a difference in production of DM among SPS and forage production system (treeless).

4. CONCLUSION

This study suggests the presence of the tree species Eucalyptus did not interfere in Phosphorus Management. Periods of climatic variations observed promoted differentiation in forage production, and absorption of Phosphorus.

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